University-based initial teacher education aims at instilling in teacher candidates the idea of the interconnectedness of content, pedagogical and educational research knowledge by allowing meaningful interaction between teacher candidates and teacher educators. The theory-practice divide is presented in the literature as barrier to achieving this goal.

This mixed methods research study re-conceptualizes the theory-practice divide from a problem into an opportunity. Secondary school teacher candidates can use contradictions and tensions, surrounding the theory-practice divide, for synthesizing diverse perspectives on content, pedagogical and educational research knowledge. They can integrate this perspective in their practice teaching.

The study examined secondary school teacher candidates’ perspectives on the interaction of their content, pedagogical and educational research knowledge in practice teaching as well as factors contributing to these perspectives. The study found that participants’ different perspectives on their research pedagogical and content knowledge (RPACK) were associated with the different levels of their reform-mindedness in mathematics education as measured by a survey. The low, medium and high reform minded participants placed as the first priority pedagogical knowledge, content knowledge and educational research knowledge, respectively.
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Chapter One: Introduction

1.1 Introduction

In its *Accord on Initial Teacher Education*, the Association of Canadian Deans of Education (ACDE) states that the reason for initial teacher education to be university-based is to “allow the meaningful interaction of student-teachers with research-oriented faculty and to promote awareness of the interconnected nature of theory, research, and practice in the profession” (ACDE, 2005, p. 2). One of the principles of initial teacher education in Canada is the development of teacher candidates’ “pedagogical knowledge and academic content knowledge as well as an introduction to research and scholarship in education” (ACDE, 2005, p. 2). Understanding the nature and processes of educational research are “key to better conceptualizing, describing, and documenting its contributions” to teaching practice (ACDE, 2010, p. 2).

An effective initial teacher education program provides opportunities for teacher candidates to collaborate with teacher educators in “interweaving theory, research, and practice” and supports “a research disposition and climate that recognizes a range of knowledge and perspectives” (ACDE, 2005, p. 4). To fulfill these ACDE recommendations, it is crucial to add teacher candidates’ voices to the scholarly discourse on the role of subject-matter content, pedagogy and educational research in the process of learning to teach within Canadian initial teacher education programs. This chapter outlines the research context, the purpose of the study, the statement of the problem, the significance of the study, the background of researcher and the plan of the thesis.

1.2 Research Context

The study was conducted and completed in the context of a 9-month Intermediate/Senior (grades 7 – 12) consecutive (after-degree) initial teacher education (Bachelor of Education)
program at a large Canadian research university. According to the program requirements, applicants must hold an approved degree from an accredited university (or other degree-granting post-secondary institution) with at least a "B" range average in 15 full-year courses (or equivalent in half courses). As a rule, only applicants with a four-year bachelor or master or doctoral degrees are enrolled due to the high competitiveness of the program (normally about 4 applicants for each spot in the program). The program also admits a number of internationally educated teachers who either immigrated to Canada or came with student visas.

Using the online applicant profile, all applicants are to report their teaching and learning experience background providing a written reflection based on personal experiences that they believe have helped to prepare them for teaching. These experiences can take a wide variety of forms. What is most important is the ability to clearly articulate insights that have been gained from these experiences in terms of understanding of teaching and learning, and understanding of teachers’ roles in appreciating diversity and promoting equity and social justice.

In this program, all teacher candidates work on two subject-matter certifications. The university coursework includes both mandatory and elective courses. In particular, two teaching methods courses in two different subject-matter areas are mandatory. All teacher candidates have two practicums at schools and an internship.

Research is infused throughout every aspect of this initial teacher education program. Current research in teacher education informs the design and delivery of all courses. In this program, teacher educators have discretion to include inquiry and action research projects as course assignments. In particular, Science and Technology in Context elective course included teacher candidates’ involvement in action research projects as part of their course assignments.

Foundation courses and elective related studies courses in this program were taught by full-time research professors or by sessional lectures who were experienced teachers with an
earned Ph. D. in Education. In particular, Equity and Social Justice in Mathematics elective course was taught by the full-time research professor in mathematics education. Teaching methods in this program were taught in Curriculum and Instruction courses by experienced teachers.

Curriculum and Instruction courses emphasized relations between theory and practice. In particular, making teacher candidates’ familiar with current theory was one of the goals stated in the syllabus of the methods course in teaching secondary mathematics. All teacher candidates were required to attend at least one event or conference hosted by the Mathematics Education Forum or the Ontario Association of Mathematics Educators. Teacher candidates were involved in ongoing online discussions about connections between educational research and teaching practice based on reading articles from journals such as the *Ontario Mathematics Gazette* and the *Mathematics Teacher*.

Individuals, who are interested in more emphasis on educational research in their initial teacher education at this university, can apply to Concurrent Initial Teacher Education Program or to Master of Teaching Program with a teacher certification component. In the former program, all teacher candidates take Mentored Inquiry in Teaching course that provides an introduction to and an opportunity for inquiry into a particular school context, organization and setting. In the latter, all teacher candidates take Reflective Teaching and Inquiry into Research in Education course and conduct an action research project.

### 1.3 Purpose of the Study

Introducing educational research to teacher candidates is one of the principles of initial teacher education in Canada. Without this introduction it is difficult for teacher candidates to understand the contributions of educational research to teaching practice. An opportunity for a dialog between educational researchers and teacher candidates about the interconnectedness of
subject-matter content, pedagogy, educational theory, and research in teaching practice is one of the reasons for initial teacher education to be university-based.

The purpose of this mixed methods research study is to explore secondary school mathematics teacher candidates’ perspectives on their research pedagogical and content knowledge in an after-degree Bachelor of Education program at a large research university in Canada. This research seeks to identify factors influencing these teacher candidates’ perspectives on the interaction of these three types of knowledge in their practice teaching.

1.4 Statement of the Problem

Many competing agendas in initial teacher education (ITE) programs present an on-going challenge in Canadian initial teacher education for determining the core subject matter required for induction into the profession (Gambhir, Broad, Evans, & Gaskell, 2008). An extension of this problem is that “the space for teacher candidate voices is lost in the shuffle of trying to make sure that programs deliver the ‘right curriculum’ within the allotted time” (Gambhir et al., 2008, p. 16). In particular, while teacher candidates commonly report teaching practicum as a place where they learn the most about teaching, little is known about their perspectives on the role of educational research knowledge in their practice teaching of secondary school mathematics as well as about the factors contributing to these perspectives. For examining the interaction of teacher candidates’ knowledge of content, pedagogy and educational research, the conceptual framework was developed and named as Research Pedagogical and Content Knowledge (RPACK) conceptual framework. In Chapter Two, the more detailed description of this framework was given.

This study was motivated by a desire to understand more deeply the secondary school mathematics teacher candidates’ perspectives on interactions between their knowledge of content, pedagogy and educational research during teaching practicum at schools as well as to
identify factors influencing these perspectives. The following questions formed the basis for the focus of this study:

1. What are secondary school mathematics teacher candidates’ perspectives on their research pedagogical and content knowledge?

2. What factors influence secondary school mathematics teacher candidates’ perspectives on their research pedagogical and content knowledge?

1.5 Significance of the Study

Current research, that links student performance with specific teachers, has led educators and policymakers to the conclusion that the quality of the teacher is the most important factor in producing student achievement gains (Alliance for Excellent Education, 2004; Darling-Hammond, 1997; Ferguson & Ladd, 1996; Sanders & Rivers, 1996). Large-scale quantitative studies indicate that measures of the quality of teacher preparation and certification are the strongest correlates of student achievement in mathematics (Darling-Hammond, 1999). It is anticipated that results from this study will contribute to improving the quality of teacher preparation and certification.

In addition, teacher preparation programs may be modified to accommodate these perspectives to help teacher candidates to learn how to teach secondary school mathematics. Another significance of the study is developing the Research Pedagogical and Content Knowledge (RPACK) conceptual framework that may be used in further research on pre-service teacher education. The study has offered insight into the theory-practice divide in teacher candidates’ field experiences. In addition, the RPACK conceptual framework can be used by teacher educators as a lens for looking at teacher candidates’ experiences in their practice teaching.
1.6 Background of the Researcher

I graduated from the Lomonosov Moscow State University with an advanced degree in mathematics and specialization in the history of mathematics. I taught mathematics at various universities, colleges and schools in Moscow, Russian Federation, and Minneapolis, Minnesota, USA. While teaching mathematics in Minnesota, I completed a teacher education program and received a certification to teach grade 7-12 mathematics. I taught secondary school mathematics in Minnesota for a few years before immigrating to Canada in 2005.

I am a member of Ontario College of Teachers in good standing and certified to teach Intermediate and Senior Divisions, Mathematics, and Intermediate Division, Science-General. Prior to my doctoral studies in mathematics education, I taught secondary school mathematics in an adult learning center in Toronto District School Board (TDSB).

During my doctoral studies in mathematics education, I worked as a Teacher Education Program Assistant (TEPA) in the Intermediate/Senior mathematics methods courses of a consecutive and concurrent teacher education programs in Ontario. After observing practice teaching of more than hundred secondary school mathematics teacher candidates over a period of four and a half years of teaching assistantship, I developed an in-depth knowledge of their attitudes, dispositions, and challenges. I saw many high quality teacher candidates’ practice teaching performances that clearly stood out. During debriefings, I often found some evidence of educational research underlying the decisions of the teacher candidate.

I realized that what brought more educational background diversity to the student population in the Bachelor of Education program was the requirement for teacher candidates in Ontario to earn certification in two subject areas to be eligible to teach at secondary school level. I observed that many secondary school mathematics teacher candidates have a variety of majors such as physical education, music, art and English and bring multiple perspectives on learning to
teach mathematics, the perspectives that are often very different from those held by majors in mathematics and natural sciences.

Many teacher candidates often come to this after-degree program with a range of teaching experiences such as paid teaching assistantship in their masters’ and doctoral programs, teaching English as a second language abroad, volunteering at schools, tutoring school students, working with youth in community centers and summer camps as well as helping their own children with homework.

1.7 Plan of the Thesis

This thesis is organized into five chapters. Chapter One provides an introduction and the plan of the thesis. It articulates the purpose of the study and states the problem as well as informs the reader about the research context, the researcher’s background and discusses the significance of the study.

Chapter Two contains a literature review that examines the relevant literature for the secondary school mathematics teacher candidates’ perspectives on interaction between their knowledge of content, pedagogy, and educational research. The literature pertinent to the factors contributing to these perspectives is examined as well. The review is used for selecting within the literature preexisting codes and themes for data analysis in addition to the codes emerging from the data.

Chapter Three describes the research methods and instruments used in the study. Research design, sampling and ethical considerations are also reviewed. The issues of data collection and analysis are addressed as well.

Chapter Four has two parts. The first part provides the results from the anonymous online survey completed by the participating secondary school mathematics teacher candidates. The results of the survey were used to form three cases for individual interviews. The second
part of the chapter provides the rich in-depth description of three cases. The within-case analysis was done using emergent themes obtained from interview data.

Chapter Five revisits the two research questions and makes links between the findings and the literature. Suggestions for further research are given. Implications are discussed for providing learning opportunities for secondary school mathematics teacher candidates in consecutive initial teacher education programs. The limitations of the study are outlined.
Chapter Two: Literature Review

2.1 Introduction

The literature review identifies the gaps in the existing literature. The purpose of this literature review is to examine the relevant literature for the secondary school mathematics teacher candidates’ perspectives on interaction between their knowledge of content, pedagogy, and educational research during teaching practicum at schools. The literature pertinent to the factors contributing to these perspectives is examined as well.

A combination of factors often makes Canadian after-degree initial teacher education unique. First, while many countries experiment with alternative pathways to teacher certification (Zeichner, 2010), all of these programs in Canada are university-based (Falkenberg, 2010). Teacher candidates’ perspectives on their knowledge of content, pedagogy and educational research are especially important in understanding the process of their learning to teach (Cochran-Smith & Lytle, 2009). Emphasis on these three types of knowledge calls for a different conceptual framework for after-degree initial teacher education in Canada with a focus on interaction between teacher candidates’ content, pedagogical and educational research knowledge during their practice teaching.

Second, in the after-degree programs, “there tends to be a more diverse candidate population in terms of age, past careers, and expertise” (Gambhir et al., 2008, p. 10). In particular, it brings the diversity of teacher candidates’ educational backgrounds to university classroom. Many secondary school mathematics teacher candidates have a variety of majors such as physical education, music, art, and English and bring multiple perspectives on learning to teach mathematics, the perspectives that are often very different from those held by majors in mathematics and natural sciences (Gambhir et al., 2008).
Third, admissions requirements in Canada are significantly higher than in other countries (Crocker, 2008; Gopinathan et al., 2010; Organization of Economic Cooperation and Development, 2007). Applicants are to compete with others for each spot in Canadian after-degree initial teacher education programs. Admission to initial teacher education programs in Canada is so competitive that many unsuccessful applicants go to programs outside of the country (Gambhir et al., 2008). As a result, many teacher candidates in these programs have strong educational backgrounds. These teacher candidates often come to the after-degree programs with a range of teaching experiences that they must report on a pre-structured online survey as a pre-requisite for enrolment (Kosnik & Beck, 2011). Prior teaching experiences reported by these teacher candidates may include working as paid teaching assistants in their masters’ and doctoral programs, teaching English as a second language abroad, volunteering at schools, tutoring school students, working with youth in community centres and summer camps, as well as helping their own children with homework.

This review is intended to give focus and direction to the thesis by providing a theoretical framework for exploring and understanding teacher candidates’ experiences in the process of their learning to teach in the after-degree Bachelor of Education program at a large Canadian research university.

2.2 Knowledge for Teaching

The Association of Canadian Deans of Education (ACDE) articulates, as the principle of university-based initial teacher education, the instilling in teacher candidates the awareness of the interconnected nature of content, pedagogical, and educational research knowledge by allowing meaningful interaction between teacher-candidates and research-oriented faculty (ACDE, 2005). I will review the literature pertinent to these three types of knowledge in the following sections.
2.2.1 Content and Pedagogical Knowledge

A growing body of literature shows that teacher quality affects student learning and motivation (Hattie, 2009; Hattie & Ingvarson, 2008; McCaffrey, Lockwood, Koretz, Louis, & Hamilton, 2004). In particular, teachers’ content knowledge (CK) and pedagogical content knowledge (PCK) influence teaching practice in mathematics (Baumert et al., 2010; Hill, Rowan, & Ball, 2005; Kahan, Cooper, & Bethea, 2003). While teachers’ content knowledge (CK) is studied and learned in the disciplinary setting, pedagogical content knowledge (PCK) is understood as the fusion of content and pedagogy needed for teaching the subject (Shulman, 1986). Both CK and PCK are the key parts of teacher quality that affect student learning where CK is viewed as a prerequisite for PCK development (Kleickmann et al., 2013). However, PCK has stronger impact on teaching quality and higher predictive power for student mathematics achievement than CK despite the high correlation between them (Kleickmann et al., 2013).

Researchers agree on the importance of the strong subject-matter knowledge in teachers’ quality (Grossman, Schoenfeld, & Lee, 2005; Grossman, Stodolsky, & Knapp, 2004; Mewborn, 2003; National Mathematics Advisory Panel, 2008). However, they differ on the required breadth and depth of teachers’ mathematical knowledge (cf. Ball & Bass, 2003; Bransford, Brown, & Cocking, 2000; Bransford & Darling-Hammond, 2005; Deng, 2007; Kalyuga & Renkl, 2010; Shulman & Quinlan, 1996). There is no consensus on whether mathematics teachers need the academic research knowledge from university mathematics departments or mathematics specific pedagogical content knowledge from schools of education (Baumert et al., 2010).

Melville and Wallace (2007) point out that “teachers identify themselves as teachers of their subject” (p. 1194). In particular, “for science teachers, their training in the sciences gives them a sense of purpose as to what is important in their subject content, how it should be taught,
and why it should be taught” (Melville & Wallace, 2007, p. 1194). However, there is a diversity of perspectives among science teachers on various professional issues such as the understanding of good teaching or the nature of science (Wallace & Wildy, 2004). Similarly, the diversity of views on professional issues is common for secondary mathematics teachers who, for example, have different perspectives on research-practice relations (Groth & Bergner, 2007).

Hill, Rowan and Ball (2005) introduce the concept of mathematical knowledge for teaching (MKT) that means the “mathematical knowledge used to carry out the work of teaching mathematics” (p. 373). As Hill, Rowan and Ball (2005) explain, the examples of this work of teaching include:

explaining terms and concepts to students, interpreting students’ statements and solutions, judging and correcting textbook treatments of particular topics, using representations accurately in the classroom, and providing students with examples of mathematical concepts, algorithms, or proofs. (p. 373)

Bass (2005) emphasizes that, while mathematical knowledge for teaching can overlap with the knowledge of research mathematicians, MKT also includes specialized mathematical knowledge that is “not required or known in other mathematically intensive professions (including mathematical research)” (p. 429). To some extent, MKT can be viewed as an expanded intersection of CK and PCK when the content is mathematics.

On the one hand, the insufficient understanding of mathematical concepts reduces teachers’ ability to make them accessible to students and “cannot be offset by pedagogical skills” (Baumert et al., 2010, p. 138). On the other hand, CK does not guarantee powerful mathematical experiences for students (Kahan, Cooper, & Bethea, 2003) without PCK, “which involves bundles of understandings that combine knowledge of mathematics, of students, and of pedagogy” (Ball et al., 2001, p. 453). Teachers with similar CK can differ substantially in their PCK depending on their teaching experience (Schoenfeld, Minstrell, & van Zee, 2000). To some
extent, PCK may vary “independently of CK and to be a knowledge component in its own right” (Baumert et al., 2010, p. 139).

2.2.2 Educational Research Knowledge and Prior Disciplinary Research Knowledge

The Association of Canadian Deans of Education (ACDE) recommends that the programs of initial teacher education should introduce teacher candidates to “research and scholarship in education” (ACDE, 2005, p. 2). One of the ways to do that is to instruct teacher candidates on how to read and understand original educational research articles. In their textbook, designed specifically for the consumers of educational research, Creswell and Plano Clark (2010) emphasize the textbook focuses on “understanding [emphasis in original] research, not conducting research” and serves as a “guide [emphasis in original] that offers readers practical advice and strategies for learning to understand research” (p. v).

In contrast, other researchers suggested using teaching practice as a site for teacher candidates’ inquiry in order to introduce teacher candidates to educational research (Cochran-Smith, Barnatt, Friedman, & Pine, 2009; Cochran-Smith & Lytle, 2001, 2009). However, Cochran-Smith et al. (2009) found that assigning inquiry projects for teacher candidates to complete during practicum did not produce desired outcome. The authors pointed out that teacher candidates were ‘inquiring to the rubric’ by engaging in those aspects of inquiry that were spelled out on, and required by, the project’s assessment rubric rather than making inquiry an integral part of teaching itself.

While mathematics teacher educators have no consensus on the importance of undergraduate research in mathematics for prospective teachers (Baumert et al., 2010; Goos, 2004; Jaworski, 2006), science educators agree that it is crucial for science majors to have authentic scientific research experience during their undergraduate studies to avoid misconceptions about science and research (Cartrette, & Melroe-Lehrman, 2012; Jordan, 2005;
Sadler et al., 2010). Authentic research has been defined as doing what scientists do in the course of their research careers (Chinn & Hmelo-Silver, 2002; Dunbar 1995; Latour & Woolgar 1986).

The literature on the scientific research experiences of undergraduates pursuing teacher certification in secondary mathematics can help to understand their perspectives on educational research. Cartrette and Melroe-Lehrman (2012) found that the factors which most influenced undergraduate science students’ perspectives on research activity were “previous laboratory courses and instructors/advisors” (p. 1095). Cartrette and Melroe-Lehrman (2012) showed that undergraduate students, whose instructors used research-based rather than expository strategies in teaching science, demonstrated a “more mature notion of the question answering process involved in authentic research contexts” (p. 1096). Cartrette and Melroe-Lehrman (2012) found that even one inquiry-based open-ended experiment in the laboratory university course could bring an undergraduate student to a “more mature notion of the question answering process involved in authentic research contexts” (p. 1096).

2.2.3 Theory-Practice Divide

Houston (2008) points out that, in pre- and in-service teacher education, “the symbiotic relations between research and practice continues to be a Gordian Knot that has yet to be untied, although several generations of researchers have contributed to our understanding” (p. xxxi) of the theory-practice divide. The disconnectedness between teacher candidates’ university-based course work experiences and their school-based field experiences is generally conceptualized as the theory-practice divide (Falkenberg, 2010) or as the theory-practice gap (Korthagen, at al., 2001). The theory-practice divide and efforts to overcome it are ubiquitous and not new to teacher education where the attempts to address it can be traced back to the 1930s and 1940s.
(Bullock & Russell, 2010; Nuthall, 2004; Vanderlinde & van Braak, 2010; Van Diggelen & Overdijk, 2009; Vick, 2006).

Falkenberg (2010) recognizes that the theory-practice divide and teacher candidates’ pre-conceptions are commonly viewed by teacher educators as problematic. He adds, however, that by changing “our expectations for what pre-service teacher education can accomplish, what had to be seen before as a limit of field experiences can suddenly be perceived as an opportunity of field experiences” (Falkenberg, 2010, p. 23). He finds this conceptualization inadequate for two reasons. First, the university-based course work involves some forms of the practice of teaching. Second, teacher candidates and their associate teachers (ATs) theorize when they make sense of their field experiences regardless the kind of theorizing and the university teacher educators’ influence on it. In Falkenberg’s view, “the divide is about the dis-connectedness of different domains of teaching competencies [emphasis in original]” (p. 11).

Zeichner (2010) argued that the theory-practice divide in teacher candidates’ practicum experiences is a central problem of pre-service teacher education. The fundamental difference between researchers and teachers views of education contributes to this divide (Bulterman-Boss, 2008a). Labaree (2003) draws attention to “a cultural clash between the worldviews of the teacher and researcher” and argues that, for teachers to become researchers, they need to change their cultural orientation toward education “from normative to analytical, from personal to intellectual, from particular to universal, and from experiential to theoretical” (p. 13).

Bulterman-Boss (2008a) suggested that the top-down reforming of all educational research into clinical research “can contribute to the bridging of the research–practice gap” (p. 414). Her suggestion triggered a debate about the relationship between research and practice (Bulterman-Boss, 2008b; Labaree, 2008; Lagemann, 2008; Noffke, 2008; Wiliam, 2008).
Noffke (2008) argues that solution is not in assisting teachers in transition from the world of educational practice to that of academic research but in transforming “academic research to encompass research emanating from practice” (p. 430). Lagemann (2008) favored collaborative interdisciplinary partnerships among various university departments to “generate the full range of research that education demands” (p. 428). Wiliam (2008) proposed integrating clinical research with other methods of inquiry to make educational research more powerful.

Korthagen, Loughran and Russell (2006) wrote about the need to integrate practice-oriented and research-based perspective to arrive at a pedagogy of teacher education that is both empirically based and practically oriented. Labaree (2008) spoke in support for a productive ongoing dialog between practitioners in the two different spaces of expertise: school teaching and education research. Zeichner (2010) advocated a paradigm shift in the epistemology of teacher education programs by creating a ‘third space’ in the university-school partnerships, a hybrid of researchers’ and teachers worldviews, for teacher candidates to experience a dynamic interaction between research and pedagogy in practice teaching. Bhabha (1990a, 1990b, 1994) coined the term ‘third space’.

Bullock and Russell (2010) argue that the “teacher candidate will always be limited in some way by teaching in someone else’s classroom” (p. 98). Often the teacher candidate could never teach as he or she wanted because “his [sic] associate was ultimately responsible for the class” and because the teacher candidate “was told how to teach and was judged on his [sic] ability to mimic the behaviors his associate teacher expected of him” (Bullock & Russell, 2010, p. 98).

The literature on learning to teach suggests that many teacher candidates bring to initial education programs problematic preconceptions about teaching and learning (Hammerness, Darling-Hammond, & Bransford, 2005; Lorti, 1975; Richardson, 1996; Wideen, Mayer-Smith, &
Moon, 1998), the preconceptions that it is difficult to change (Britzman, 2003; Richardson & Placier, 2001; Wideen et al., 1998). Teacher educators consider these pre-conceptions as contributing to the theory-practice divide (Falkenberg, 2010; Kennedy, 1999). Some authors call these pre-conceptions ‘frames of reference’ (Kennedy, 1999) or ‘filters’ (Wideen et al., 1998, p. 145). According to the various forms of constructivism as a theory of learning, humans construct their own meaning for what they experience using their prior understandings or pre-conceptions (Falkenberg, 2010). In the case of teacher education, this constructivist idea can be exemplified by Lortie’s (1975) notion of the “apprenticeship of observation.”

Falkenberg (2010) points out that Lortie’s ‘apprenticeship of observation’ construct draws attention to the fact that, teacher candidates enter initial teacher education programs with preconceptions about teaching that they developed as K-12 students having about 15,000 hours of the observation of teaching in schools. The author emphasizes that teacher candidates have about 1,500 additional hours of the observation of undergraduate university teaching prior to entering consecutive teacher education programs.

Hammersley (2002) offered three models for describing views on research-practice relations: the engineering model, the strong enlightenment model, and the moderate enlightenment model. According to the engineering model, research should provide “specific and immediately applicable technical solutions to problems, in the manner that natural science or engineering research is assumed to do” (Hammersley, 2002, p. 38). This view is common to mathematics teachers and policymakers (Groth & Bergner, 2007).

According to the strong enlightenment model, research “can produce a comprehensive perspective on the world; rather than just specific items of knowledge, or perspectives useful for particular purposes” (Hammersley, 2002, p. 40). There is considerable overlap between the
strong enlightenment and engineering models in assuming that “scientific knowledge must necessarily replace and govern over practical knowledge” (Groth & Bergner, 2007, p. 822).

According to the moderate enlightenment model, “research is one among several sources of knowledge on which practice can draw; moreover, the use made of it properly depends on practical judgments about what is appropriate and useful” (Hammersley, 2002, p. 42). Groth and Bergner (2007) hold this view on research-practice relations and want all mathematics teachers to have this view. In their study, among participants they had the proponents of all three models. Groth and Bergner (2007) suggested that mathematics teachers with different views on research-practice relations can be engaged in productive dialogs as learning sites.

2.3 Research Pedagogical and Content Knowledge and Its Theoretical Foundations

In the literature on teacher education, we can see a move from the view of teacher candidates as passive recipients of teaching skills (Ewing & Smith, 2003; LeCornu & Ewing, 2008) and as “blank slates to be filled with the wisdom of both university faculty and supervisory” toward the view of a teacher candidate as an “active collaborator in the co-construction of knowledge” (Bullock & Russell, 2010, p. 92). More recently, teacher candidates are seen as “active participants in the learning process constructing through personal and social experiences” (LeCornu & Ewing, 2008, p. 1802).

As active collaborators, teacher candidates bring to after-degree initial teacher education programs a range of prior teaching experiences as well as a specific disciplinary culture in general and a distinct disciplinary research culture in particular. This different perception of teacher candidates as active collaborators calls for a different conceptual framework for initial teacher education, one that I will call the Research Pedagogical and Content Knowledge (RPACK) conceptual framework. This framework is introduced in the following section.
2.3.1 Research Pedagogical and Content Knowledge Conceptual Framework

The Research Pedagogical and Content Knowledge (RPACK) conceptual framework is designed to describe and provide understanding on how teacher candidates synthesize content, pedagogical, and educational research knowledge and integrate them into practice teaching secondary school mathematics in the process of learning to teach in the context of an after-degree initial teacher education program at a large research-intensive Canadian university. The RPACK conceptual framework can be visualized as a Venn diagram (Figure 1). In the process of learning, teacher candidates interact with social others (e.g., university teacher educators/researchers, associate school teachers, other teacher candidates and school students) and the environment. As a result of this interaction, all participants and the environment affect one another. During the process of this interaction, teacher candidates build their content, pedagogy and educational research knowledge as a tool for teaching.

Figure 1. The RPACK framework and its knowledge components.
In Figure 1, Pedagogical Content Knowledge (PCK) is the knowledge of a content specific pedagogy (Shulman, 1986, 1987). Research Pedagogical Knowledge (RPK) is the knowledge of how educational research can support pedagogical goals. Research Content Knowledge (RCK) is the knowledge of content specific educational research. Finally, the synergy and synthesis of all three types of knowledge produces teacher candidates’ RPACK as a tool for teaching.

The three-component RPACK’s frame structure was adapted from Koehler and Mishra’s (2009) Technological Pedagogical and Content Knowledge (TPACK) conceptual framework visualized as a Venn diagram (Figure 2). Both RPACK and TPACK draw on Shulman’s Construct of Pedagogical Content Knowledge (PCK) that is often used in research on teacher knowledge.

Koehler and Mishra (2005, 2006, 2009a, 2009b, 2010) and Niess (2005, 2006, 2007a, 2007b) used Shulman’s PCK construct in developing TPACK. The essence of TPACK is in integrating the three type of knowledge (technology, pedagogy, and content ) in teaching. In Figure 2, Pedagogical Content Knowledge (PCK) is the knowledge of a content specific

Figure 2. The TPACK framework and its knowledge components. Adapted from Koehler and Mishra (2009, p. 63).
pedagogy (Shulman, 1986, 1987). Technological Pedagogical Knowledge (TPK) is the knowledge of how technology can support pedagogical goals. Technological Content Knowledge (TCK) is the knowledge of how a subject matter is transformed by the application of technology. Finally, the integration of all three types of knowledge in teaching produces Technological Pedagogical and Content Knowledge (TPACK).

2.3.2 Teacher Candidates’ Reform Mindedness in Mathematics Education

This section starts with the outline of the concise history (Romberg, 1997) of reforms in mathematics education that lead to the development of the nine-dimension framework of standards-based teaching in mathematics (Ross et al., 2001-2002, 2002). I continue with the description of the Attitudes and Beliefs survey that measures individuals’ propensity towards reforms ideals in mathematics (Ross et al., 2003). I give a name to this propensity: reform mindedness. The nine-dimension framework of standards-based teaching in mathematics serves as a conceptual foundation for the Attitudes and Beliefs survey. At the end of the section, I introduce the notion of teacher candidates’ reform mindedness in mathematics education and its connections to the notions of collective learning, stages of learning, values, and integration of research.

In 1983, the A Nation at Risk and Educating Americans for the 21st Century report argued for higher expectations in mathematics achievements for students from all social, ethnic and economic backgrounds, not for elite students only (Romberg, 1997). This shift in expectations was informed by international comparative cross-cultural studies on economic competitiveness, mathematics achievement, curricula and schooling practices of other industrialized countries. These studies found that other industrialized countries developed schooling practices, rooted in the countries’ cultural heritage, that “provided all students with an opportunity to learn more mathematics and somewhat different mathematics – the major goal of the current reform efforts.

Publication of the NCTM’s Standards generated an outpouring of empirical studies on the impact of mathematics education reform implementation (Ross et al., 2003). Based on a review of NCTM teaching standards and the synthesis of 154 empirical studies conducted from 1993 to 2000 on the implementation of these standards, Ross et al. (2001-2002; 2002) generated the nine-dimension framework of standards-based teaching in mathematics. This framework includes the following dimensions: (1) program scope; (2) student tasks; (3) constructivist approach; (4) teacher’s role; (5) manipulatives and tools; (6) student-student interaction; (7) student assessment; (8) teacher's conceptions of math as a discipline; and (9) student confidence.

For each dimension, Ross et al. (2003) developed one or more statements (questionnaire’s items) that reflected the essence of the corresponding dimension. For example, the dimension 4 (teacher’s role) was connected to the following two statements (questionnaire’s items 5 and 17): I often learn from my students during math time because my students come up with ingenious ways of solving problems that I have never thought of (Item 5); and I teach students how to explain their mathematical ideas (Item 17). The questionnaire contains twenty 6-point Likert type items ranging from Strongly Agree to Strongly Disagree.

The notion of teacher candidates’ reform mindedness in mathematics education is defined by this 20-item survey’s questionnaire. This notion is operationalized by the levels of reform mindedness represented by the survey scores as their numerical characteristics. The higher survey score corresponds to the higher level of reform mindedness. In this study, the notion of a teacher candidate’s reform mindedness in mathematics education is viewed as the independent
variable while his or her RPACK is viewed as the dependent variable. In Chapter 3, the notion of reform mindedness is used to identify three cases of participants (low, medium and high reform minded teacher candidates) in order to interview them about their understandings and experiences with their RPACK in practice teaching.

The following four sections describe the notions of collective learning, stages of learning, values and integration of research. All these notions have connections with the notion of reform mindedness. The notions of collective learning and stages of learning are connected to the latter through the dimension 4: teacher’s role. According to the description of this dimension, the teacher's role in inquiry-oriented settings is that of co-learner and co-creator of a mathematical community rather than sole knowledge expert. Similarly, participants in collective learning are co-learners and co-creators. In the same way, the three-stage model of learning is used in the organizational knowledge creation theory in the context of co-learning and co-creating new knowledge by employees in an organization. Furthermore, the notion of the integration of research is from the knowledge mobilization theory that, in particular, promotes reform mindedness by addressing the theory-practice divide and strengthening connections between research and with the help of a third party or intermediary organization. Finally, teacher candidates’ reform mindedness is connected with their values simply because their values are embedded in all their activities including learning to teach.

There is also a theoretical rationale that justifies the use of multiple theories. In this study I use the researcher choice option for theorizing from qualitative data (Grbich, 2007). In the researcher choice option, can be used “the huge variety of conceptual models and theoretical ideas that exist across all available disciplines in order to provide a more abstract explanation” for research findings (Grbich, 2007, p. 186). The researcher should be “aware of the full range of theories that might be relevant” to the study (Yin, 2009, p. 37). Theory development is an
essential step in doing case study, “whether the ensuing case study’s purpose is to develop or to
test theory” (Yin, 2009, p. 37). In particular, “an exploratory case study should be preceded by
statements about what is to be explored, the purpose of the exploration, and the criteria by which
the exploration will be judged successful” (Yin, 2009, p. 37).

2.3.3 Balance of Diversity and Commonality in Collective Learning

McMurtry (2010) points out that, in education, a number of discourses “explored how
learning occurs beyond the individual level in complex and dynamic social settings” (p. 220)
such as collaborative learning teams, the discourses that include the communities of practice
(Wenger, 1998) and complexity theory with its notion of collective learning and the concept of a
collective learner (Davis & Sumara, 2006).

For nurturing collective learning, three complementary pairs of conditions are needed
with an appropriate balance between two parts in each pair (Davis & Sumara, 2006; McMurtry,
2008, 2010). These pairs are diversity and commonality, openness and constraints, and
decentralized interactions and organization (McMurtry, 2010). While the diversity of team
members’ professional and personal knowledge gives an opportunity for developing novel
approaches to practice, the commonality of knowledge, values, goals or experiences allows team
“members to ‘gel’ and work together effectively” (McMurtry, 2010, p. 223). Commonality is
understood as team members’ “consent to a certain course of action” rather than unanimity or
one mindedness (McMurtry, 2010, p. 225). Openness and constraints are about a balance
between “sufficient openness for diversity to express itself and for the system as a whole to
develop in innovative and unpredictable ways” and “the rules or boundaries necessary to orient
and sustain the coherence of a complex system” (McMurtry, 2010, p. 224). While decentralized
interactions mean that team “members’ different professional perspectives have an opportunity
to ‘bump up’ against one another,” organization ensures that team members make “coherent, collective decisions” (McMurtry, 2010, p. 224).

McMurtry (2010) applies the collective learner concept to describing the collaborative learning of interprofessional healthcare practices by the teams of students with diverse disciplinary backgrounds in an undergraduate course at the University of Alberta. Davis and Simmt (2003, 2006) apply the collective learner concept to teacher candidates’ learning mathematics for teaching.

Complexity theory can inform pedagogical practices by considering the complexity of educational environment not as a liability but as an asset (Axelrod & Cohen, 1999). From the complexity theory perspective, educational matters “might be or even need to be complexified [emphasis in original] rather than simplified [emphasis in original]” (Stanley, 2009, p. 1). According to the complexity theory, teachers should focus on the whole class and its activities in schools rather than on the individual students (Stanley, 2009, p. 1).

Davis and Simmt (2006) view groups such as all students in the classroom or all members of the research team as “collective learners [emphasis in original] rather than collections of learners [emphasis in original]” (p. 309). Over time, the collective learner as any other complex systems goes through the processes of adaptation to its environment under the governance of its own self-organizing, dynamic internal structures (Heylighen et al., 2007). These the collective learner’s processes of adaptation and self-organization can be interpreted as learning processes from the perspective of educators (Davis & Sumara, 2006; Davis, Sumara, & Luce-Kapler, 2008). These processes of self-organization and adaptation were described at the individual level by constructivists such as Piaget and Von Glassersfeld (Proulx, 2006).

McMurtry (2010) points out that, in addition to self-organization and adaptation, emergence is another important feature of the collective learner. He explains that emergence
means that the collective learner is more than the sum of its parts and that a group of people collaborating together can generate more possibilities than the same people working in isolation. McMurtry emphasized that there is a shift in the literature from just describing the collective learner to studying factors contributing to its emergence.

Davis and Simmt (2006) list conditions that nurture the emergence of the collective learner and prompt the transformation of the group into it:

- internal diversity;
- internal redundancy;
- decentralized control;
- enabling constraints;
- neighbor interactions. (p. 310)

The ‘internal diversity’ of the learners’ viewpoints increases the collective’s capacity to respond not just appropriately, but innovatively to new situation (Johnson, 2001). Diversity is the source of the collective learner’s intelligence (McMurtry, 2010). Diversity ‘‘expands a group’s set of possible solutions and allows the group to conceptualize problems in novel ways’’ (Surowiecki, 2004, p. 36). Along with diversity, some sameness (‘internal redundancy’) among learners (e.g., certain commonalities of experience, expectation, and purpose) is essential for triggering the transition of the collection of learners into the collective learner (Davis & Simmt, 2006). ‘‘Internal redundancy’ (Davis & Simmt, 2006) or commonality is the complement to diversity (McMurtry, 2010). The members of the collective learner should have some common ground, some similarities in knowledge, values, goals or experiences to be able to interact and work together effectively (McMurtry, 2010).

‘‘Internal redundancy’ of the collective is its capacity to maintain coherence (Davis & Simmt, 2006). Redundancy enables interactions among the learners in the collective and compensates for others’ failings (Davis & Simmt, 2006). There must be an appropriate balance between diversity and redundancy (McMurtry, 2010). When diversity or redundancy are “either
absent or are present in unbalanced ways (e.g., too much diversity, too little redundancy), the learning organization and the people therein are unable to share, adapt and evolve” (Stanley, 2009, p. 2).

‘Decentralized control’ and ‘enabling constraints’ are two other conditions of the collective learner that complement each other (Davis & Simmt, 2006). These two conditions provide an appropriate balance between openness and constraints (McMurtry, 2010). Davis and Simmt (2006) argue that ‘decentralized control’ is “only possible if the phenomenon is framed by constraints that enable unanticipated possibilities” (p. 311). Davis and Simmt (2006) clarify that “complex systems are rule-bound, but those rules determine only the boundaries of activity, not the limits of possibility” (p. 311). McMurtry (2010) adds that the balance between openness and enabling constraints is necessary to “orient and sustain the coherence of a complex system” developing in “innovative and unpredictable ways” (p. 224). McMurtry (2010) emphasizes that “paradoxically, many constraints can be seen as enabling [emphasis in original] creativity and freedom – for example, the way rules of grammar enable communication” (p. 224).

Davis and Simmt (2006) point out that “the constraints have to allow for appropriate neighbour interactions [emphasis in original]” (p. 312). Davis and Simmt (2006) emphasize that ‘neighbours’ in a knowledge-producing community are not necessarily physical bodies or social groupings but also ‘bumping’ against one another “ideas, hunches, queries, and other manners of representation” (p. 312). Talking about neighbour interactions, Stanley (2009) suggests abandoning more conventional teacher-directed/textbook-based approaches that break down mathematical concepts into “isolated ideas without real meaning and present them to students in a controlled and deliberate manner” (p. 3). Stanley (2009) argues that “rather than relying upon a single node in a web of connections to disseminate what is required,” mathematics teachers should present to students the whole web of ideas “contributing to growth in understanding” (p.
3). Viewing complexity as an asset rather than a liability, Stanley (2009) suggests that teachers should “create and use complexity rather than manage it, not just for their students’ benefit but for their own” (p. 1).

2.3.4 Stages of Learning

Feldman (2000) advocates a ‘creative’ organizational routine as a source of continuous change. Nonaka, Toyama and Hirata (2008) point out that the creative routine, in contrast to an ordinary one, “contains a continuous self-renewal process” (p. 43). Feldman (2000) explains that this continues self-renewal is based on an ongoing feedback from others and the environment, the feedback that allows identifying and modifying the differences between expected outcomes and reality. In this self-renewal process, continues modifications are produced “based on real-time feedback from the situation as it unfolds” (Nonaka, Toyama & Hirata, 2008, p. 43).

In this continuous self-renewal process, according to Nonaka, Toyama & Hirata (2008), individuals go through the three stages that these authors call from the lowest to the highest as the stage of learning, the stage of breaking, and the stage of creating. In application to initial teacher education, this three-stage model allows to identify the three stages of learning to teach. In the stage of learning, teacher candidates follow university- and school-based teacher educators, imitating their practices, embracing their values and techniques and mastering them as their own. In the stage of breaking, teacher candidates attempt to break from imitation and to creatively revise what they have learned. In the stage of creating, teacher candidates work on their own unique teaching approaches.

The three-stage model of learning is a part of organizational knowledge creation theory (Nonaka & Takeuchi, 1995). This theory emphasizes the importance of dialogue between participants in knowledge creating activities, values multiple perspectives brought by the multi-voiced participants of different traditions and interests, and encourages interactive networking.
Contradictions and tensions within the knowledge creating collectives are perceived as necessary conditions for creating new knowledge (Nonaka & Takeuchi, 1995). The three-stage model of learning (Nonaka et al., 2008) is developed in the context of collective learning with conditions similar to those in complexity theory such as a balance of diversity and commonality (McMurty, 2010).

Adopting a social constructivist view of knowledge, Tsoukas (1996, 2009) offers a dialogical approach to the creation of new knowledge in organizations. Nonaka and Takeuchi (1995) argue that knowledge creation involves the creation of new concepts through dialogue and the management of conversations. Organizational knowledge creation theory can provide both an integrative and a balanced view of an initial teacher education program within faculties of education as a knowledge-creating organization with its network of relations among university- and school-based teacher educators and teacher candidates as well as other stakeholders.

Any organization theory is based on some tacitly accepted ontological, epistemological and praxeological assumptions that can become questionable and come under scrutiny when “scientific practices stumble in their efforts to make sense of the empirical world and to ‘enlighten practitioners’” (Tsoukas & Chia, 2011, p. 13). While “ontology is concerned with the general structure of reality and epistemology is concerned with how scholars formulate and justify their knowledge claims, praxeology deals with how theory is related to action and, more specifically, how theory is related to practice” (Tsoukas & Chia, 2011, p. 12). Ontological, epistemological and praxeological assumptions can be questioned when tensions arise between theory and practice (Tsoukas & Chia, 2011).

Tsoukas and Chia (2011) distinguish externally and internally oriented praxeologies. Following the model of natural sciences, externally oriented praxeology emphasizes value-free
theory-to-practice or instrumental relations between theory and practice. In contrast, always influenced by the conceptions of ethics and the common good, internally oriented praxeology emphasizes that practitioners are inevitably shaped by their practice when they often unreflectively acquired and unconsciously internalized the vocabularies and traditions of it. Tsoukas and Chia state that, while often acting in a relatively unreflective manner, practitioners still have the innate ability for self-observation and reflexivity that enable them to change their practice to match particular contexts. The authors conclude that theories provide further vocabularies to practitioners to articulate in different ways what is only tacitly understood in their practices.

Recent developments in Nonaka’s (1995) theory of knowledge-creating organization are based on the balance between externally and internally oriented praxeologies and on the view of knowledge as the synthesis of contradictions accomplished by people with different subjective viewpoints in their interactions with one another and the environment (Nonaka, Toyama & Hirata, 2008). From the perspective of this theory, the differences in viewpoints and capabilities of university teacher educators, school associate teachers and teacher candidates are necessary for the process of knowledge creating. In particular, from this perspective, the theory-practice divide can be viewed not as a problem but as an opportunity and necessary condition for creating a knowledge base for initial teacher education.

Von Krogh, Nonaka and Rechsteiner (2012) point out that organizational knowledge creation integrates context, knowledge assets, and knowledge creation processes throughout the organization. They emphasize that all knowledge is situated within its social, historical, and cultural context. The authors define organizational context for knowledge creation as a shared space where participants interact with one another and the environment for meaning-making. The authors clarify that this space can be physical (e.g., classrooms), virtual (e.g., electronic
mailing lists) or mental (ideals or visionary ideas). Von Krogh et al. explain that the shared space contains both boundaries and possibilities (that can change over time) for knowledge creation through interactions between individuals. They state that knowledge assets include explicit knowledge articulated as documents and routines through images, symbols, and language as well as tacit knowledge such as individuals’ skills, experiences, values, and norms.

According to von Krogh, Nonaka and Rechsteiner (2012), new knowledge is created through the four phases of the socialization, externalization, combination, internalization (SECI) process of dialog and practice:

- **Socialization** represents the sharing and conversion of tacit knowledge through the shared experiences of individuals.
- **Externalization** represents the articulation of tacit into explicit knowledge.
- **Combination** represents the process of combining different strands of explicit knowledge to create more complex or systematic sets of knowledge.
- **Internalization** represents the process of embodying explicit into tacit knowledge.

(p. 242, emphasis in original)

The SECI process emerges in the shared space (the platform for the knowledge creation process) and is moderated by available knowledge assets creating value for the organization (von Krogh et. al, 2012).

### 2.3.5 Values

The human activities themselves embed values, norms and perspectives of those humans (Nazir & Hand, 2006). In particular, teacher candidates’ values cannot be separated from their learning to teach. Initial teacher education helps teacher candidates in assuming ethical responsibilities for student learning (Darling-Hammond, 2006). Values are important in organizations as well. According to the organisational knowledge creation theory, the purpose of the organisation is to create value (Nonaka, 2007). The values of the organisation’s members and their value-based decisions determine the way of life in the organization and the value the organization creates (Nonaka, Toyama & Hirata, 2008).
The knowledge-creating organization “creates value by constantly asking and answering on a daily operational basis the human ontological question ‘why do we exist?’ and the aesthetics question ‘what is good?’” (Nonaka, Toyama & Hirata, 2008, p. 3). Values, aesthetics, and ethics are always part of organisational knowledge creation because the essence of the organization is in pursuit of excellence that emerges with commitment and practice to serve the common good of the organization, its members, stakeholders, and the larger society (Nonaka, Toyama & Hirata, 2008).

A growing body of educational research addresses the role of values in teaching various school subjects. For example, Falkenberg and Noyes (2010) point out that “in recent years the mathematics education research community has undergone a social turn towards a greater interest in the values and broader educational purposes of mathematics education, including issues of social justice and citizenship education” (p. 949). In developing a conceptual framework that links the teaching of school mathematics with moral education, they draw on Johnson's (1993) notion of ‘moral understanding’ and Dewey's (1975) ‘moving ideas’.

Johnson (1993) views moral understanding as moral insightfulness and sensitivity. For him insightfulness is the ability to see the implications of our particular biases, judgments, and convictions. Citing Johnson, Falkenberg and Noyes (2010) define moral sensitivity as:

…ability to put ourselves in the place of another, [to] enlarge our own perspective through an imaginative encounter with the experience of others, [to] let our own values and ideals be called into question from various points of view. (Johnson, 1993, p. 199)

Falkenberg and Noyes (2010) state that “moral education, then, has the task of developing moral understanding in learners, thus, helping them to become morally insightful and sensitive” (p. 950). Based on Dewey’s (1975) reasoning for appropriating intellectual ideas “in such a vital way that they become moving ideas, motive-forces in the guidance of conduct” (p. 2),
Falkenberg and Noyes (2010) view “the development of intellectual ideas as centrally a moral endeavour” (p. 950).

### 2.3.6 Integration of Research

The literature describes many ways for integrating educational research into teacher candidates’ (TCs’) practice teaching such as allowing meaningful interaction between teacher candidates and research-oriented faculty (ACDE, 2005), preparing TCs as the consumers of educational research by instructing them directly on how to read and understand original research articles (Creswell & Plano Clark, 2010) as well as using teaching practice as a site for TCs’ inquiry into an educational problem of TCs’ own choice (Cochran-Smith & Lytle, 2009).

The integration of research into practice with the help of a third party or intermediary organization is suggested by a new field of inquiry, termed knowledge mobilization (KM), emerging to address the theory-practice divide and to strengthen connections between research, practice and policy across sectors, disciplines and countries (Cooper, Levin, & Campbell, 2009). Davies, Nutley and Walter (2008) label knowledge mobilization as ‘knowledge interaction’ to recognize interactive, iterative and contextual view of using research as well as to emphasize social, dialogical and interpretative ways of knowing.

Cooper (2012) points out that “practitioners rarely come into contact with primary research directly from academic journals or lengthy research articles” but “instead, educators engage with research indirectly through colleagues, professional development, the media, and often through various third party organizations” (p. 2). Cooper uses the “term ‘research brokering organization’ (RBO) to describe third party, intermediary organizations whose active role between research producers and users is a catalyst for research use in education” (p. 2). Cooper developed the typology of research brokering organizations (RBOs) and the description of their functions. Cooper found that RBOs and faculties of education have the higher levels of
involvement in integrating research into practice than school districts and ministries of education.

Cooper, Levin, and Campbell (2009) point out that the last decade can be characterized by a growing interest in incorporating research evidence into practice and policy. The authors state that increasing efforts to guide practice and public policy by evidence derived from research can be observed not only in education but in other services as well such as health care and criminal justice where evidence-based decision making became a primary concern.

Cooper et al. (2009) emphasize that third parties of various kinds play powerful roles in knowledge mobilization. The authors point out that most people, including most professionals, get their knowledge of research not from reading the original studies, but through various mediating processes including professional development events, publications of professional associations, materials provided by lobby groups of various kinds, the transmission of research through places of employment as well as the mass and trade media. Cooper et al. (2009) point out that the role of intermediary organizations is changing, and new ones are coming onto the scene.

To address the issue of the gap between evidence, policy and practice in education, several third party organizations have been created in Canada such as the Canadian Education Association, a few think tanks with explicit political positions, and Education Research Networks in Ontario and Manitoba (Cooper et al., 2009). The Ontario Education Research Panel (OERP) fosters collaboration among education stakeholders on research issues, advises various parties on education research priorities for Ontario, recommends opportunities for increasing the value and use of research, and organizes an Annual Ontario Research Symposium (Cooper et al., 2009). Several international organizations, such as the Organisation for Economic Cooperation
and Development (OECD) and the World Bank, support knowledge mobilization and produce analyses and articles on the importance of linking research to policy and practice (OECD, 2007).

2.4 Summary

This review outlined the literature relevant to teacher candidates’ perspectives on interactions between their knowledge of content, pedagogy, and educational research in practice teaching as well as the literature pertinent to the factors contributing to these perspectives. The researchers’ discussions on the three types of knowledge for teaching including content, pedagogical and educational research knowledge were described. The scholarly discourse on the theory-practice divide was illustrated. The writings on the stages of learning, a collective learner, values and the integration of educational research into teaching practice were presented. The research findings on the influence of individuals’ educational background and prior disciplinary research knowledge/experiences on their beliefs about research were reported. The Research Pedagogical and Content Knowledge (RPACK) conceptual framework was introduced.

One of the principles of university-based initial teacher education is instilling in teacher candidates the awareness of the interconnected nature of content, pedagogical and educational research knowledge by allowing meaningful interaction between teacher-candidates and research-oriented faculty. A growing body of literature shows that teacher quality affects student learning and motivation. In particular, teachers’ content knowledge (CK) and pedagogical content knowledge (PCK) influence teaching practice in mathematics. Both CK and PCK are the key parts of teacher quality that affect student learning where CK is viewed as a prerequisite for PCK development. However, PCK has stronger impact on teaching quality and higher predictive power for student mathematics achievement than CK despite the high correlation between them. To some extent, PCK may vary independently of CK and to be a knowledge component in its own right.
One of the goals of university-based initial teacher education is the introduction of educational research to teacher candidates. This goal can be achieved when teacher candidates have a course assignment of conducting an inquiry or an action research project during practicum as well as when they read, understand, and implement findings from the original educational research articles in their practice teaching.

The disconnectedness between teacher candidates’ university-based course work experiences and their school-based field experiences is generally conceptualized as the theory-practice divide. This divide and efforts to overcome it are ubiquitous and not new to teacher education. Theory-practice divide is commonly viewed by teacher educators as problematic. The fundamental difference between researchers and teachers views of education contributes to this divide. For overcoming the theory-practice divide, it is suggested to have a productive ongoing dialog between practitioners in the two different spaces of expertise: school teaching and education research.

Teacher candidates’ pre-conceptions about teaching and learning are viewed as contributing to the theory-practice divide as well. Teacher candidates develop these pre-conceptions as K-12 and undergraduate students who observe how their school teachers and university instructors teach. Secondary school mathematics teachers’ perspectives on research-practice relations may vary. Dialogs between mathematics teachers are suggested as learning sites that may help to clarify and bridge different views on these relations.

There is a move from the view of teacher candidates as passive recipients of teaching skills toward the view of them as active collaborators in the co-construction of knowledge. As active collaborators, they bring to after-degree initial teacher education programs a range of prior teaching experiences as well as a specific disciplinary culture in general and a distinct disciplinary research culture in particular. A combination of factors, such as the dominance of
university-based initial teacher education programs with teacher certification in two subjects for teaching at secondary school level and high competition for enrolment, often makes Canadian after-degree initial teacher education unique.

This different perception of teacher candidates as active collaborators and the uniqueness of Canadian after-degree initial teacher education call for a different conceptual framework for initial teacher education, the Research Research Pedagogical and Content Knowledge (RPACK) conceptual framework. This framework is designed to describe and provide understanding how teacher candidates integrate and synthesize content, pedagogical and educational research knowledge in the process of learning to teach in the context of an after-degree initial teacher education program.
Chapter Three: Methodology

In Chapter One, I stated that this mixed methods research examined secondary school teacher candidates’ perspectives on the interaction of their content, pedagogical and educational research knowledge in practice teaching as well as factors contributing to these perspectives. This chapter elaborates on the research approach and design of the study.

3.1 Research Design

Mixed methods research has been adapted in one form or another into virtually all the pure and applied social and behavioural sciences (Tashakkori & Teddlie, 2003, 2010a, 2010b). As an alternative to the traditional mono-method ways of conceiving and implementing inquiries, mixed methods research is increasingly being used in education (Biesta, 2010; Brewer & Hunter, 2006; Creswell, 2008; Creswell & Plano Clark, 2007; Greene, 2007; Tashakkori & Teddlie, 2010a, 2010b). The multidimensional nature of a social phenomenon such as pre-service teachers’ practice teaching experiences warrants the use of a mixed methods research design (Tashakkori & Teddlie, 2010b).

Mixed methods research practices have been strengthened by various mixed methods design alternatives that allow researchers to link the purpose of the research to methodologies and integrate findings from mixed methods (Caracelli & Greene, 1997; Creswell, 2008; Creswell & Plano Clark, 2007; Greene, 2006, 2007; Maxwell & Loomis, 2003; Nigla, 2010; Tashakkori & Teddlie, 2003, 2010a, 2010b). Caracelli and Greene (1997) proposed two broad categories of mixed methods research design alternatives: component designs and integrated designs. They pointed out that the component designs are distinguished from the integrated designs in that the different methods remain discrete through data collection and analysis and that mixing the methods takes place at the level of interpretation and inference. Caracelli and Greene (1997) explained that integrated mixed methods designs differ from the component designs in that
‘mixing’ takes place throughout the inquiry from data collection to analytic processes and to interpretation. They named an iterative (or developmental) design as an example of the integrated design. Caracelli and Greene emphasized that iterative designs allow researchers to move back and forth between quantitative and qualitative methods.

Mertens (2003) and Punch (2005) suggested that one of the viable reasons for engaging in mixed methods research is for the purpose of using quantitative data to inform further qualitative study that enables the extension of findings of the former. The sole purpose of the initial quantitative phase in a mixed methods research study can be to obtain some numerical characteristics of individuals to “guide the purposeful sampling of participants for a primarily qualitative study” (Creswell et al., 2003, p. 227). A mixed methods study in which the results of one method are used to inform the development of another “represents long-standing inquiry practice in multiple methodological traditions, now brought under the mixed methods umbrella” (Greene, 2007, p. 126). The present study utilizes a developmental design that uses the results of one method “to inform the development of the other method, where development is broadly construed to include sampling and implementation, as well as actual instrument construction” (Greene, 2007, p. 102). The design of this developmental mixed methods research study has a sequential two-phase structure (Creswell & Plano Clark, 2007).

In the first quantitative phase of the study, I obtained the numerical characteristics of participants to guide purposeful sampling in the second qualitative phase that is a case study. Purposeful sampling is the research term used for qualitative sampling (Creswell, 2012). Several qualitative sampling strategies exist. I use maximum variation cases sampling strategy (Creswell, 2012; Flyvberg, 2011; Patton, 2002). In this strategy, the researcher samples cases that “differ on some characteristic” (Creswell, 2012, p. 208). In my study, this strategy can be viewed as a combination of extreme case sampling and typical case sampling. Extreme case
sampling is a form of purposeful sampling in which the researcher studies “an outlier case or one that displays extreme characteristics” (Creswell, 2012, p. 208). The purpose of typical case sampling is to “describe and illustrate what is typical to those unfamiliar with the setting – not to make generalized statements about the experiences of all participants” (Patton, 2002, p. 236). Typical cases can be selected using a “survey data, a demographic analysis of averages, or other statistical data that provide a normal distribution of characteristics from which to identify ‘average-like’ cases” (Patton, 2002, p. 236).

In Phase 2, I have an instrumental case study (Stake, 1995) with the three cases. In an instrumental case study, “the researcher focuses on an issue” (Creswell, 2013, p. 99). In an instrumental case, the issue is central, and the case is secondary (Stake, 2005). In my thesis, the issue is the reform-mindedness of teacher candidates in mathematics education. The level of the reform-mindedness is described by a certain numerical parameter that is measured by a survey. The cases are bounded by this parameter that stays within the fixed 1-120 range of the scores according to the design of the survey. The system is a case when it “can be bounded or described within certain parameters” (Creswell, 2013, p. 98).

3.2 Data Collection

In this sequential two-phase mixed methods research design of the study, the quantitative and qualitative data were collected in Phase 1 and Phase 2, respectively. The survey scores obtained in Phase 1 were used for forming cases in Phase 2. The data in Phase 2 were collected through personal interviews.

3.2.1 Phase 1: Quantitative Strand: Survey

In Phase 1, the target population was comprised of secondary school teacher candidates who graduated in 2009, 2010 and 2011 from a 9-month after-degree Intermediate/Senior Bachelor of Education Program at a large Canadian research university. All teacher candidates
work toward teacher certification in secondary school mathematics and one other subject of their choice. Three full-year university courses in mathematics is a prerequisite for Intermediate/Senior Mathematics certification. However, up to one full-year course in statistics can be counted towards this prerequisite.

In this quantitative phase, a cross-sectional survey design was used to collect quantitative data from these teacher candidates. The survey was administered to 300 teacher candidates. Fifty three of them responded to the survey. I used Ross’s et al. (2003) 20-item questionnaire for measuring the teacher candidates’ reform mindedness in mathematics education. The questionnaire contains twenty 6-point Likert type items ranging from Strongly Agree to Strongly Disagree. To guard against response bias, seven items are negatively worded.

Ross et al. (2003) provided evidence of their instrument’s reliability. Using Cronbach’s $\alpha$, a measure of internal consistency, they obtained a reliability coefficient of $\alpha = 0.81$ in two independent studies. Ross et al. (2003) provided evidence of their instrument’s validity including evidence of predictive, concurrent, and construct validity. All 20 items of the questionnaire, the major instrument in the survey design, were used without any change. This 20-item questionnaire was already used and field tested by others (Bruce et al., 2010; Ross et al., 2003). The questionnaire was administered as an anonymous online survey. The survey results were used to select teacher candidates for participating in individual interviews.

The demographic section with nine questions was added to this questionnaire without a pilot testing (Appendix A). Punch (2003) points out that “the form and extent of the pilot testing that is required varies from situation to situation and is mainly a function of how much of the instrument is new” (p. 34). The pilot testing was not needed in this study because only basic demographic questions were new in the survey.
3.2.2 Phase 2: Qualitative Strand: Interviews

The sole purpose of the initial quantitative phase in this mixed methods research study was to obtain numerical characteristics of individuals (survey scores) to guide the purposeful sampling of participants for a primarily qualitative study that was a collective (instrumental) case study. The survey in the first phase was a purposeful sampling tool for the second phase. In Phase 2, ten participants (4 males and 6 females) were purposefully selected for case study interviews from the pool of survey respondents based on their questionnaire scores.

The choice of the type of interview among a number of approaches is “ultimately depend on the accessibility of individuals, the cost, and the amount of time available” (Creswell, 2012, p. 219). I tried to arrange one-to-one interviews, a popular but “the most time-consuming and costly approach” in educational research (Creswell, 2012, p. 218). However, I faced difficulties in doing that. Among 2009-2010 graduates, some candidates lived and taught secondary school mathematics in other provinces or countries (e.g., Alberta, Australia). The 2011 graduates were reluctant to agree for a one-on-one interviews citing busyness with the search for employment. In these circumstances, I decided to proceed with e-mail interviews (Anderson & Kanuka, 2003; Creswell, 2012).

E-mail interviews are “useful in collecting qualitative data quickly from a geographically dispersed group of people” (Creswell, 2012, p. 219). This form of interviewing provides a “detailed, rich text database for qualitative analysis” and facilitates asking follow-up questions for extending the understanding of the “central phenomenon being studied” (Creswell, 2012, p. 219).

In the first open-ended question in the e-mail interview, I asked participants questions about their perspectives on their research pedagogical and content knowledge. To facilitate their response, I unpacked the research question for them by clearly identifying the three components
in their knowledge (content, pedagogical and educational research) and asking about their perspectives on interaction between these three components in teaching secondary school mathematics (Appendix D).

After receiving responses to the first question from the participants, I emailed them the second question about educational research findings that they tried to apply to their lessons planning and implementing during their practice teaching secondary school mathematics. I asked them to specify the source of these educational research findings (e.g., original research paper, reference to research finding in their course work, internet search) and to describe the reaction of their students and their associate teachers to their attempts to apply these findings. I asked the participants about supports and/or barriers that they experienced in their attempts to apply these findings.

After receiving responses to the second question from the participants, I sent them a sequence of emails with some leading questions designed to check the consistency and “reliability of the interviewees’ answers” as well as to verify my interpretations (Kvale & Brinkmann, 2009, p. 172). In particular, I asked the participants about resemblance between educational research and everyday consumer research as well as everyday problem solving. I asked them whether they view routine formative classroom assessment as a type of quantitative (quiz and test scores), qualitative (checking student understanding through questioning and interviewing) or mixed methods (both quiz/test scores and questioning/interviewing) research. I asked the participants whether socializing teacher candidates into educational research would make them informed consumers of research. I asked them whether teacher candidates should be socialized into research culture in the same way as they socialized in to school culture.

3.3 Data Analysis

The data were analyzed in two steps. First, the survey data were analyzed. Next, the
individual interview data were analyzed from cases formed with the use of the survey data.

### 3.3.1 Analysis of Quantitative Data

The questionnaire data were examined to decide about the levels of respondents’ reform mindedness in mathematics education. SSPS software was used to compute respondents’ questionnaire scores on the online survey as well as standard deviation, mean, median, and mode. Next, cases for the qualitative phase were formed based on the distribution of observed questionnaire scores. Finally, demographic profiles by gender, educational background as well as prior disciplinary research knowledge and experiences were created.

### 3.3.2 Analysis of Qualitative Data

According to Erickson’s (1986), gathered information is not data but data sources from which data must be derived through analysis. There is a variety of approaches to the qualitative data analysis. Creswell (2013) points out that “forming codes” represents the “heart of qualitative data analysis” (p. 184). He states that preexisting or a priori codes from a theoretical model or the literature can be combined with the additional codes emerging from data analysis. Grabtree and Miller (1992) suggest a continuum of coding strategies ranging from “prefigured” to “emergent” codes (p. 151). On the next step, codes form themes. Creswell (2013) define theme (also called a category) as a broad unit of information that “consists of several codes aggregated to form a common idea” (p. 186).

Interpretation in qualitative research “involves abstracting out beyond the codes and themes to the larger meaning of the data” (Creswell, 2013, p. 187). A good case study involves a rich in-depth description of the cases (Creswell, 2013, p. 99). When more than one case is chosen, the themes are identified for each case in the study for conducting within-case analysis (Creswell, 2013). The thematic analysis across the cases (called a cross-case analysis) follows within-case analysis for identifying similarities and differences (Creswell, 2013).
To complete the data analysis, I started with some initial categories that were identified by the literature review. I used the categories of content knowledge, pedagogical knowledge and educational research knowledge. I looked for evidence of collaboration with the teacher, the value that the participants placed on research and how research was integrated into their teaching. After sorting the data according to these categories, I coded the data into more specific subcategories, focusing on how the participants described the major categories.

The qualitative phase of this study is a collective case study of three cases where each case is an instrumental one (Stake, 1995). Categorical aggregation and direct interpretation are the major strategies in analyzing data in a qualitative case study (Stake, 1995). Researchers reach new meanings about cases through “direct interpretation of the individual instance and through aggregation of instances until something can be said about them as a class” (Stake, 1995, p. 74). The search for meaning is often a “search for patterns, for consistency, for consistency within certain conditions, which we call ‘correspondence’” (Stake, 1995, p. 78). Stake (1995) explains:

Both categorical aggregation and direct interpretation depend greatly on the search for patterns. Often, the patterns will be known in advance, drawn from research questions, serving as a template for the analysis. Sometimes, the patterns will emerge unexpectedly from the analysis. (p. 78)

3.4 Validation Strategies

There were three validation strategies (Creswell, 2012, 2013) used in this study. First, the member checking was done that involved soliciting participants’ views about the credibility of the findings and interpretations. Second, the detailed and thick description of all three cases provided the readers with an opportunity to make their own decisions about transferability of the findings to other settings. Third, by identifying explicitly my influences and biases as a researcher, I clarified to the readers how my personal and professional experiences might affect my interpretation of data.
3.5 Ethical Considerations

Prior to data collection, I applied for the approval of this study to the Research Ethics Board of the University of Toronto and received the approval. To ensure anonymity, the pseudonyms were used instead of real participants’ names. The online survey participants could access survey questions only after reading the Letter of Information and Consent and accepting its terms and conditions. The participants were informed that they could terminate their participation at any time.

At the end of the anonymous online survey, another consent note was displayed with the request that participants enter contact information if they agree to a possible interview at a later date. The initial contact for the interview was always started with the confirmation of consent and that the respondent can terminate the interview and withdraw from the study at any time.

I did not have a supervisory or teaching relationship with any participants. All email communications were done through the official university email addresses. No personal email addresses were used. The invitation for an interview was emailed through the official university email service.

For the duration of the study, data collection and data analysis, and writing, all identifying information were changed to pseudonyms and electronically stored in the secure place. All data in paper form were stored and locked in a cabinet. All data will be destroyed within four years of publication of any report in thesis or journal form.
Chapter Four: Results and Findings

4.1 Introduction

This chapter has two parts. The first part provides the results from the anonymous online survey completed by the participating secondary school mathematics teacher candidates. First, descriptive statistics were reported such as standard deviation and measures of central tendency mean, median, and mode. Next, cases for the qualitative phase were formed based on the distribution of observed questionnaire scores. Finally, demographic profiles by gender, educational background as well as prior disciplinary research knowledge and experiences were presented. The second part of the chapter provides the rich in-depth description of three cases.

4.2 Survey Results

A total of 53 secondary school teacher candidates responded to the online survey. This is a response rate of 17.7%. The questionnaire scores in the survey had the bimodal (the modes of 87 and 92 with the frequencies of 6 each) negatively skewed frequency distribution with the mean $M = 88.40$, the median $Mdn = 89$ and the standard deviation $SD = 7.056$ or, rounded off to integers, $M = 88$, $Mdn = 89$, and $SD = 7$. The lowest and the highest possible scores were 20 and 120, respectively.

The observed scores were split into the three classes: (1) Class 1 of the scores below the number $81 (= M – SD)$, the number located one sample standard deviation ($SD = 7$) down from the sample mean ($M = 88$); (2) Class 2 of the scores $[81, 95] (= [M – SD, M + SD])$ within the distance of one sample standard deviation ($SD = 7$) from the sample mean ($M = 88$); and (3) Class 3 of the scores above the number $95 ( = M + SD)$, the number located one sample standard deviation ($SD = 7$) up from the sample mean ($M = 88$). According to these three classes, all 53 respondents were allocated into the three cases: Case 1 (the lower score case), Case 2 (the typical or modal score case) and Case 3 (the higher score case), respectively.
4.2.1 Educational Background and Prior Disciplinary Research Knowledge and Experiences

Table 1 shows the frequency and percent of the respondents’ highest earned degree overall and by case. Table 1 demonstrates that the majority of respondents held a bachelor as their highest earned degree. All doctoral degrees and the majority of master’s degrees were held by respondents in Case 2.

Table 1

<table>
<thead>
<tr>
<th>Reform-Mindedness</th>
<th>Overall</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest Earned Degree</td>
<td>Overall</td>
<td>Case 1</td>
<td>Case 2</td>
<td>Case 3</td>
</tr>
<tr>
<td>Ph. D.</td>
<td>3</td>
<td>5.7%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Master</td>
<td>13</td>
<td>24.5%</td>
<td>1</td>
<td>10%</td>
</tr>
<tr>
<td>Bachelor</td>
<td>37</td>
<td>69.8%</td>
<td>9</td>
<td>90%</td>
</tr>
</tbody>
</table>

Table 2 shows the frequency and percent of respondents who studied research methods and took part in conducting research in their discipline depending on their highest earned degree. The majority (35 of 53 or 66%) of survey respondents studied research methods in their discipline. Almost half (26 of 53 or 49.1%) of them both studied research methods and took part in conducting research in their discipline. More than the half (19 of 37 or 51.4%) of respondents with a bachelor as their highest earned degree studied research methods in their discipline.

Table 2

<table>
<thead>
<tr>
<th>Experience with research methods in their discipline</th>
<th>Highest degree earned</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Doctoral</td>
</tr>
<tr>
<td>Studied</td>
<td>3</td>
</tr>
<tr>
<td>Both studied and applied</td>
<td>3</td>
</tr>
<tr>
<td>Neither studied nor applied</td>
<td>0</td>
</tr>
</tbody>
</table>
Almost the half (9 of 19 or 47.4%) of those who studied research methods took part in conducting research. All respondents with doctoral degrees both studied and applied research methods in their discipline. All respondents with masters as their highest earned degree studied research methods in their discipline and the majority of them (10 of 13 or 76.9%) took part in conducting research.

Table 3 shows the overall and case-by-case frequency and percent of respondents who studied research methods and took part in conducting research in their discipline. Table 3 demonstrates that, overall, the majority of respondents (35 of 53 or 66%) studied research methods in their discipline, and almost half of respondents (26 of 53 or 49.1%) both studied and applied research methods. Moreover, the majority of those who studied research methods applied them as well (26 of 35 or 74.3%). Only 2 (22.2%) of 9 men and 6 (26.1%) of 23 women did not studied and/or applied research methods. In Case 2, there were the highest percentages of respondents who studied research methods (75% or 24 of 32) as well as who both studied and applied them (56.3% or 18 of 32). However, among those who studied research methods, respondents in Case 3 had the highest percentage of experience with conducting research (85.7% or 6 of 7). In Cases 1 and 2, these percentages were 50% (2 of 4) and 75% (18 of 24), respectively.

<table>
<thead>
<tr>
<th>Experience with research methods in their discipline</th>
<th>Overall</th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Studied</td>
<td>35</td>
<td>4</td>
<td>24</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>66%</td>
<td>40%</td>
<td>75%</td>
<td>63.6%</td>
</tr>
<tr>
<td>Both studied and applied</td>
<td>26</td>
<td>2</td>
<td>18</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>49.1%</td>
<td>20%</td>
<td>56.3%</td>
<td>54.5%</td>
</tr>
<tr>
<td>Neither studied nor applied</td>
<td>18</td>
<td>6</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>34%</td>
<td>60%</td>
<td>25%</td>
<td>36.4%</td>
</tr>
</tbody>
</table>
4.2.2 Demographic Profile: Gender

Table 4 shows the frequency and percent of men and women among respondents overall and by case. Table 4 illustrates that more than one and a half as many women than men responded to the survey. More than twice as many men than women were in Case 1, more than twice and a half as many women than men were in Case 2, and about the same number of men and women were in Case 3. All three doctoral degrees were held by men. Almost twice more as many women (8) than man (5) had masters as their highest degrees.

Table 4

*Frequency and Percent of Men and Women among Respondents by Case*

<table>
<thead>
<tr>
<th>Gender</th>
<th>Overall</th>
<th>Case 1 (lower)</th>
<th>Case 2 (average)</th>
<th>Case 3 (higher)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man</td>
<td>21</td>
<td>7 70%</td>
<td>9 28.1%</td>
<td>5 45.5%</td>
</tr>
<tr>
<td>Women</td>
<td>32</td>
<td>3 30%</td>
<td>23 71.9%</td>
<td>6 54.5%</td>
</tr>
</tbody>
</table>

Only one respondent (man) in Case 1 held a master’s degree. Only one man and one woman in Case 3 had masters.

More than half of men in Case 1 (4 of 7 or 57.1%) studied research methods in their discipline, and half of those who studied research methods (2 of 4 or 50%) took part in conducting research. None of women in Case 1 studied and/or applied research. In Case 2, the majority of women (17 of 23 or 73.5%) studied research methods, and the majority of those who studied (12 of 17 or 70.6%) were involved in conducting research in their discipline. The majority of men (7 of 9 or 77.8%) both studied and applied research methods in their discipline. Only 2 (22.2%) of 9 men and 6 (26.1%) of 23 women did not studied and/or applied research methods. In Case 3, one of six women (16.7%) and 3 of 5 men (60%) neither studied nor applied research methods. Two of 5 men (40%) and 4 of 6 women (66.7%) both studied and applied research methods in their discipline. One of 6 (16.7%) women studied research methods but did not take part in conducting research.
4.3 Case Studies

As was stated in the section 4.2, the cases for the qualitative phase of the study were formed based on the outcomes of the anonymous online survey. The observed scores were split into the three classes: (1) Class 1 of the scores below the number 81 ($= M - SD$), the number located one sample standard deviation ($SD = 7$) down from the sample mean ($M = 88$); (2) Class 2 of the scores $[81, 95]$ ($= [M - SD, M + SD]$) within the distance of one sample standard deviation ($SD = 7$) from the sample mean ($M = 88$); and (3) Class 3 of the scores above the number 95 ($= M + SD$), the number located one sample standard deviation ($SD = 7$) up from the sample mean ($M = 88$). According to these three classes, the three cases were formed. The survey respondents with the scores in the first, second, and third classes were invited for the interviews in Case 1 (the lower score case), Case 2 (the average score case), and Case 3 (the higher score case), respectively.

4.3.1 Case 1: The Lower Score Case

Following the maximum variation criterion, an effort was made to invite a survey respondent with the lowest observed survey score for an interview in the Case 1 (the lower score case). The respondent with the lowest observed survey score of 74, among those with the score below 81, declined to be interviewed. There were no survey respondents with the score of 75. The participant with the score of 76 and one of three participants with the score of 77 declined to be interviewed. Another participant with the score of 77 did not leave any contact information in the anonymous online survey. Leon, the third participant with the score of 77, agreed to be interviewed.
4.3.1.1 Educational Background and Prior Disciplinary Research Knowledge and Experiences

Leon (score 77) completed the consecutive initial teacher education program with certification in Intermediate/Senior (grades 9 – 12) mathematics and science (biology) in 2010. Leon holds a bachelor degree in biology. Before entering the initial teacher education program, he studied research methods but did not participate in conducting research.

With his prior background in scientific research, Leon felt comfortable to theorize about relations between educational research and practice teaching. When asked whether he could find some similarities between educational research and formative classroom assessment, Leon answered, “From my point of view, I do think that we can view formative classroom assessment as a type of mixed methods research (Interview, July 5, 2011).” Leon explained that short quizzes could provide some quantitative data about student learning, while questioning could be “used to qualitatively assess student understanding (Interview, July 5, 2011).”

Leon felt comfortable to theorize about similarities and differences between educational research and everyday consumer research as well. He was asked about similarities between educational research and everyday consumer research where the consumer was searching and analyzing either some numerical characteristics and customer ratings of the product (quantitative research) or customer reviews and friends/relatives’ interviews about the quality of the product (qualitative research) or both (mixed methods research). In Leon’s opinion, educational research “does indeed resemble everyday consumer research in those three ways (Interview, July 5, 2011).”

Furthermore, in his theorizing about research, Leon discussed the advantages and disadvantages of different types of research based on his prior knowledge of scientific research.
In particular, he points out that, while “standardized tests are theoretically useful for quantitative data analysis (e.g., multiple choice tests)”, there are some disadvantages in their use:

I personally feel that standardized tests are fundamentally flawed in that they assume the persons writing the test are from similar backgrounds as well, and that there are no appreciable differences in socioeconomic status, immigration history, etc. that might affect test scores. (Interview, July 5, 2011)

Leon clarified:

On the other hand, education also involves uniquely personal and non-duplicable situations between specific students and specific teachers, and thus there is a very anecdotal and qualitative element to teaching that must also be addressed. For some issues, it is difficult to get quantitative data in education, and thus research may rely on teacher feedback. Education, then, can involve any of quantitative, qualitative and mixed methods approaches. (Interview, July 5, 2011)

4.3.1.2 Knowledge Prioritization

Leon formally acknowledged the importance of all three types of knowledge (three factors) – content, pedagogy and educational research – in secondary school mathematics practice teaching by stating that “the three factors all have unique, yet integrated roles to play in the delivery of secondary mathematics (Interview, June 28, 2011).” However, he prioritized pedagogical knowledge by pointing out that if he had to arrange them in the order of priority, he would put first “pedagogical knowledge as the highest priority (Interview, June 28, 2011).”

Leon justified his choice as follows, “I placed pedagogical knowledge as the highest priority as I believe it is the ability of the teacher to inspire and motivate and create engaging lessons that is the heart of good teaching, including the teaching of mathematics (Interview, June 28, 2011).”

While prioritizing pedagogical knowledge, Leon recognized the importance of content knowledge placing it second:

The core or base of this delivery of mathematics is the teacher's content knowledge. A strong content knowledge is a basic necessity to teaching math, as proper mathematics instruction cannot happen without this. Next, content knowledge is the foundation upon
Explaining why he placed content knowledge after pedagogical knowledge, Leon pointed out:

The content may vary little from classroom to classroom, or year to year, but it is in the pedagogical knowledge where a teacher can truly bring math to life, make the subject shine, and reach out to varied types of learning styles and learners. (Interview, June 28, 2011)

Further clarifying his choice, Leon added:

I did not place content knowledge the highest because I believe that, though some teachers may struggle with this initially, we have all been through high school and learned this material at some point or another, and it will only take a teacher 1-2 years to relearn any missing knowledge and become well versed in the content again. (Interview, June 28, 2011)

As to educational research, Leon placed it third after pedagogical and content knowledge (the first two factors):

Thirdly, a candidate's research knowledge lies peripheral to the first two factors. If I had to arrange them in order or priority, I would arrange research knowledge as being the lowest in priority. (Interview, June 28, 2011)

While emphasizing that the knowledge of educational research is not necessary in practice teaching mathematics, Leon recognized its importance for pedagogical knowledge:

Knowledge of educational research is, I believe, not necessary in teaching mathematics, but it is necessary to reform and modify pedagogical knowledge to improve upon existing practices and enhance the ability to reach out to all types of learners. (Interview, June 28, 2011)

To check the strength of Leon’s belief that the knowledge of educational research is not necessary in practice teaching mathematics, I ask him a leading question where offered Leon the ideas about aligning graduate research programs with B. Ed. program to contribute to this socializing teacher candidates into research including the suggestions that research professors should teach math methods courses or at least often come to methods courses as guest speakers and invite teacher candidates to active involvement in educational research projects as research assistants during a month-long internship. Leon regurgitated these ideas back to me:
However, I do not think it would be enough for researchers to merely visit as guest speakers, (or even teach math methods courses) for this to happen. I think that, for students to truly be immersed in and appreciate the inner workings of research, they would have to be actively involved in research themselves. I suppose a research component as a requirement for graduation from the B. Ed. program might help, where students might have to study, shadow or assist a researcher for a month or something to that effect. (Interview, July 5, 2011)

However, when I continued to pressure him into accepting the importance of educational research in practice teaching, Leon expressed disagreement with my ideas. In particular, he stated that “education is partly an art form that has been practiced for thousands of years with no perfect solutions (Interview, July 5, 2011).” To my questions ‘Without experimental educational research, how would we know that a specific teaching strategy produces a desired student learning outcome?’ and ‘How can a teacher know that a specific teaching strategy produces a desired student learning outcome?’ Lee responded:

Anecdotal evidence from a teacher's own experiences could yield such knowledge about the value of a teaching strategy. Also, collaboration with other teachers might provide such information as well. This may lend itself to teachers, departments and schools developing "best practices" based on a lot of individual observations. (Interview, July 5, 2011)

4.3.1.3 Balance of Diversity and Commonality in Collective Learning

Although, most of the time, Leon’s associate teacher pushed him to “maintain the schedule of topics, chapters and sections to be covered”, occasionally she shifted the leading role to him allowing to “take risks and try anything” he liked. Leon shared:

Interestingly, the supports and barriers in planning and implementing this clinometer lesson both came from my associate teacher. On the one hand, she encouraged me to take risks and try anything I liked, but on the other hand, she was adamant that I maintain the schedule of topics, chapters and sections to be covered, which she laid out for me (which sometimes provided minimal flexibility for innovation and experimentation with the content). (Interview, June 28, 2011)

Although Leon’s associate teacher did not actively collaborate with him in the process of modifying traditional well-known teaching practices, she respected his efforts in doing this:
My associate teacher was very impressed by the clinometer activity lesson, as well as my practicum teaching in general. I believe she respected my efforts to use a wide variety of teaching methods in order to deliver the content in refreshing ways (and to multiple types of learners). (Interview, June 28, 2011)

During practicum, Leon noticed that his modified teaching techniques positively affected the level of student engagement in the whole class:

The students also seemed to enjoy the lesson. They were not necessarily vocally appreciative about this style of lesson, but I did notice that most or all of the class was on-task and quite engaged while the activity was taking place. I also noticed that some of the typically shy and less active students were much more engaged in their learning while working in small groups on the tasks in the activity. These types of students also responded well to novelties, such as being willing to come up and play around with the smart board technology. (Interview, June 28, 2011)

4.3.1.4 Stages of Learning

Although Leon recognized that the depth and width of content knowledge “beyond the curriculum” is a “huge bonus”, he postponed the implementation of this strategy to the “years to come”:

Having additional content knowledge above and beyond the curriculum is, however, a huge bonus to pedagogical knowledge, as the teacher can use the depth of mathematics to tease and inspire students about topics in the years to come, as part of teaching methods. Or, the teacher could also teach sophisticated yet underrepresented areas in the curriculum to spice up units, such as proof-making, abstract math, topology, etc. (Interview, June 28, 2011)

Teaching younger students during practicum, Leon focused on a variety of engaging activities rather than on the depth and width of content knowledge in his lessons. Leon shared:

One of my creative lessons during my mathematics practicum was a small group, hands-on investigation of trigonometry in and around the classroom environment. Students were given only a string of known length and a homemade clinometer, with which they had to solve questions (such as finding the height of the teacher, the height of the clock on the wall, the height of the roof outside the window) creatively and indirectly. The activity worked like a bell ringer. (Interview, June 28, 2011)

During this Leon’s lesson, the small groups of students moved from one station to the next at the sound of a bell ringer.
Leon wanted his lessons to be engaging. It was not good enough for him just to copy mechanically the practices and techniques of his teacher educators. Modeling his lessons based on the ideas learned from his teacher educators and other colleagues, Leon tried to modify these ideas. Leon stated:

The resources I used to gather pedagogical and instructional knowledge for this lesson were, predominantly, ideas from my mathematics methods course. My mathematics instructor at the university taught us a variety of ways to deliver mathematics instruction, and I had modeled my clinometer lesson after some of his ideas. Additionally, some of my other creative lessons and ideas throughout the trigonometry unit, such as an Geometer’s Sketchpad class investigation into the sine function, as well as Bingo Review and discovery of the trigonometric functions in groups, were also either based on some of the methods learned from my mathematics methods class or learned from discussing some strategies with other colleagues/instructors face-to-face. I did also draw upon some interesting lesson ideas from the textbook for the discovery of trigonometric functions lesson. (Interview, June 28, 2011)

4.3.1.5 Values

Bringing up the issues of values and teachers’ responsibility for students’ learning triggered Leon’s theorizing about relations between educational research and practice teaching from a different point of view. When asked whether he sees the differences in the research-practice relations in education and health care and whether teachers should be sued for malpractice as physicians who do not follow the research-based procedures in a treatment of a patient, Leon answered:

Pharmaceuticals are expected to be applied in a one-size-fits-all scheme, and physicians are expected to use them accordingly. As well, physicians are responsible for overseeing patients' lives and health. Thus, educators should not be sued for malpractice for not following a research-based procedure, because the environment and classroom/school culture in which a teacher practices can be very different from classroom to classroom, as well as from teacher to teacher. No teacher teaches the same way as any other teacher, nor would a teacher apply the exact same approach from classroom to classroom. A one-size-fits-all approach would not work. Similarities may exist, but these, I would argue, could even be much more varied than the (often predictable) biology of patients. As well, teachers are not in such a precarious position as to be overseeing students' lives, as doctors are, to warrant an external body creating such a pressure on the profession. (Interview, July 5, 2011)

Leon had many questions about this topic:
What right would such a body have to impose lawsuits anyway? How could they justify malpractice? Can they conclusively show that harm is being done? Would it not be in some cases okay for a teacher to lecture, if students are able to learn well from that teacher's storytelling? There is likely no practical way for outside observers to assess malpractice without very detailed observation of all the details and particulars, and even then, who is considered to be right, for education is partly an art form that has been practiced for thousands of years with no perfect solutions. (Interview, July 5, 2011)

To the question ‘How can a teacher know without research that a specific teaching strategy produces a desired student learning outcome?’ Leon responded:

Anecdotal evidence from a teacher's own experiences could yield such knowledge about the value of a teaching strategy. Also, collaboration with other teachers might provide such information as well. This may lend itself to teachers, departments and schools developing best practices based on a lot of individual observations. However, there is a significant risk that - due to a teacher’s specific flaws in the teaching style, biases, lack of the objective perspective, and unfamiliarity with research – the teacher may report negatively on one teaching strategy for not producing a successful outcome, and overlook the fact that the fault may lie with another factor entirely, such as classroom management. Similarly, the teacher may mistakenly relate a positive/successful learning outcome to some teaching strategy. Thus, educational research is definitely valuable in this regard. (Interview, July 5, 2011)

4.3.1.6 Integration of Research

When asked whether the process of socializing teacher candidates into educational research culture would make them better informed consumers of research, Leon answered:

I think this is likely true. If teachers were active participants of educational research programs, they would be given an intimate understanding of the workings of, and importance of research to educational practice. This experience would give them some knowledge of the value, and limitations/pitfalls, of research in general as well. I do think that research culture socialization can help make these soon-to-be teachers more likely to implement some newer research-based ideas and innovations in their classroom, (such as using social constructivist, student-centered learning environments or using guided inquiry labs, for example). Otherwise, it is possible that teachers may ignore much of the recent developments in education that explain methods of more effective teaching than current norms. Thus, I do believe socialization into research culture can be recommended. (Interview, July 5, 2011)

During his studies in the after-degree initial teacher education program, Leon had no opportunity to interact regularly with graduate research students. He felt that graduate research students and teacher candidates lived in parallel worlds. Leon did not recall any invitations to
participate in open research workshops for graduate students. Although Leon studied scientific research methods prior to entering the after-degree Bachelor of Education program, he was not sure whether his knowledge of disciplinary research would provide some commonality with the research backgrounds of the workshop’s participants, the commonality that was sufficient for benefiting from the attendance of such research workshops. Leon explained:

I would occasionally meet an MA student through some odd circumstance (to me, it seemed anyway), and would otherwise not interact with them regularly. This reminds me of tracking in public schools. I may have been invited to the research workshops for teachers pursuing research degrees, but I am not sure if I was, and do not recall such an invitation in any case. I do not know how fundamentally such workshops would change my understanding of educational research, as the workshops likely focus on specific topics, and I might not get a complete sense of the whole process of research.

(Interview, July 5, 2011)

4.3.2 Case 2: The Average Score Case

For Case 2, interviewees were invited from the pool of participants with the observed survey scores within the segment \([M – SD, M + SD] = [81, 95]\). The criterion subsampling was applied for selecting interviewees. The \([81, 95]\) segment of 32 observed scores was split by the median of 89 into the 80s and 90s subsegments of 17 and 15 observed scores, respectively. This proportion 17/15 of observed scores in the subsegments or, approximately 4 to 3 (17/15 = 1.333… = 4/3), guided the number of selected interviewees: 4 in 80s and 3 in 90s.

While the majority (10 of 13) of frequent scores (occurred 3 or more times) in 90s are clustered around the mode of 92, only half (8 of 16) among frequent scores in 80s are clustered around the mode of 87. Taking in account this pattern, 3 interviewees were selected with more narrow spread in scores’ frequencies in 90s. They were Kara (modal score 92, frequency = 6), Sean (score 92, modal frequency = 6), and Tina (score 93, f = 4). Four interviewees were selected with wider spread in scores’ frequencies in 80s. They were Megan (score 83, frequency = 2), Stacey (score 85, frequency = 2), Nina (score 89, frequency = 2), and Sam (modal score 87, frequency = 6). In Case 2, the total number of the interviewees was 7.
4.3.2.1 Educational Background and Prior Disciplinary Research Knowledge and Experiences

Internationally trained professional, Megan (score 83) completed the consecutive initial teacher education program with certification in Intermediate/Senior (grades 9 – 12) mathematics and science (chemistry) in 2009. Her first practicum was in mathematics. Megan holds a master degree in chemical engineering. Before entering the initial teacher education program, she studied research methods in her discipline and participated in conducting research.

Although Megan played the computer game Tetris “long, long time ago”, the metaphor of the “game of Tetris came to mind as soon as” she encountered the question about her perspective on the interrelations between the knowledge of content, pedagogy and educational research (Interview, June 29, 2011). Neither her strong background in chemical engineering (master’s degree) nor her knowledge and experience of scientific research served as the source of this metaphor. Megan explained her choice of this metaphor:

Long, long time ago, when I played Tetris for the first time in my life, I did it just for the fun of it, like everybody else. However, the fact that one derived satisfaction from this game by making things 'fall in place' started to intrigue me (mostly in the back of my mind), and I found myself quite often thinking about the embedded philosophy of Tetris. (Interview, June 29, 2011)

Megan described her perspective in the following way:

I think there is a strong parallel between being a successful teacher and playing a Tetris game, as childish as this might sound. I could see the three elements of teaching (content knowledge, pedagogical methods, and educational psychology research) reproduced in Tetris: first of all, you must have the right shapes falling, then know how to best place them to be able to advance, and finally, you must have some skills in moving them around efficiently. (Interview, June 29, 2011)

Stacey (score 85) completed the consecutive initial teacher education program with certification in Intermediate/Senior (grades 9 – 12) mathematics and English in 2010. Her second practicum was in mathematics. Stacey holds an undergraduate double major in mathematics and Spanish with honors as well as a master degree in mathematics. Before entering
the initial teacher education program, she both studied research methods in her discipline and participated in conducting research.

Her strong mathematical background made it natural for Stacey to prioritize secondary school mathematics content. She completed an undergraduate double major degree in mathematics and Spanish with honors. For her master’s degree, Stacey continued to work with the same combinatorial game theory professor and studied a “game on a network/graph called Chip Firing, but with a different goal than the original (Interview, July 25, 2011).” When asked to give more details about her background, Stacey stated, “I took a number of applied courses, such as differential equations, and ‘very large networks’ as well as more abstract courses including functional analysis and discrete structures. I like combinatorics because is quite ‘pure’ or abstract and yet also hands-on (Interview, July 25, 2011).”

Stacey experienced some difficult moments in her academic studies but overcame and resolved difficulties. This success enhanced her confidence in her knowledge of secondary school mathematics content:

I struggled to find a focus in my undergraduate degree. I first intended to do a double major in math and physics, but found the course work very difficult and became discouraged. In my last year I spent a semester in Mexico studying Spanish and history, before coming back to write my honors project. I worked with our Combinatorial Game Theory professor to study the traditional African game Mancala or Wari. I got a double major in Spanish and Math. (Interview, July 25, 2011)

Stacey studied disciplinary research methods and participated in disciplinary research prior to entering the after-degree Bachelor of Education program:

I worked at the department of physiology with a team that included my husband, who was working on his own masters there (in math). I was mostly helping with gathering background literature for the project, including medical research literature. (Interview, July 25, 2011)

Also, Stacey worked with 3D modeling software that included finding transformation and inverse matrices. She conducted her own research for her honors and masters theses.
An internationally trained professional, Nina (score 89) completed the consecutive initial teacher education program with certification in Intermediate/Senior (grades 9 – 12) mathematics and science (biology) in 2010. Her first practicum was in mathematics. Nina holds a master degree in biology. Before entering the initial teacher education program, she studied research methods in her discipline but did not participated in conducting research. Despite her knowledge of scientific research, Nina found the most confidence and comfort in her knowledge of secondary school mathematics because the ongoing review of the content helped her to “figure out the best ways to teach the students” (Interview, June 22, 2011).

An internationally trained researcher in physics, Sam (score 87) completed the consecutive initial teacher education program with certification in Intermediate/Senior (grades 9 – 12) mathematics and science (physics) in 2010. His first practicum was in mathematics. Sam holds a bachelor degree in electrical engineering. Before entering the initial teacher education program, he neither studied research methods in his discipline nor participated in conducting research. As Nina, Sam found the most confidence and comfort in his strong knowledge of secondary school mathematics that he viewed as the “must” for teacher candidates (Interview, June 22, 2011).

An internationally trained professional, Kara (score 92) completed the consecutive initial teacher education program with certification in Intermediate/Senior (grades 9 – 12) mathematics and science (physics) in 2009. Her first practicum was in mathematics. Kara holds a bachelor degree in mathematics with minor in physics. Before entering the initial teacher education program, she neither studied research methods in his discipline nor participated in conducting research. Similar to Nina and Sam, Kara found the most confidence and comfort in her strong knowledge of secondary school mathematics explaining that “students and your associate teacher
can see through your knowledge” and that “students would not have confidence in you, if you hesitate on a concept” (Interview, July 2, 2011). Kara shared:

For my first practicum, I was teaching a grade 12 U course, I was very comfortable with this course and felt that the students were confident in my content knowledge. At the end of the practicum, the feedback that I received indicated that this was important to the students. (Interview, July 2, 2011)

An internationally trained researcher in physics, Sean (score 92) completed the consecutive initial teacher education program with certification in Intermediate/Senior (grades 9 – 12) mathematics and science (physics) in 2009. His second practicum was in mathematics. Sean holds a doctoral degree in physics. Before entering the initial teacher education program, he both studied research methods in his discipline and participated in conducting research. Sean believes that his teaching assistantship experience in the doctoral program was sufficient for his success during practicum. Sean emphasized that he gained his instructional ideas from his “own previous teaching experience (Interview, January 5, 2012).”

Tina (score 93) completed the consecutive initial teacher education program with certification in Intermediate/Senior (grades 9 – 12) mathematics and science (physics) in 2009. Both her first and second practicums were in mathematics. Tina holds a master degree in physics. Before entering the initial teacher education program, she both studied research methods in her discipline and participated in conducting research. Despite her knowledge of and experience in scientific research, Tina found the most confidence and comfort in her strong knowledge of secondary school mathematics arguing that “content knowledge affects what the students are to learn (Interview, June 22, 2011).”

4.3.2.2 Knowledge Prioritization

Stating her perspective on her research pedagogical and content knowledge (RPACK), Megan prioritized content knowledge:

Summarizing it, I believe that the content knowledge is the most important of all, and
must be treated very seriously when certifying a teacher, especially in math. A teacher with a limited understanding of math concepts could mark the future of many, many students in an unfortunate way, and I think that this is not fair for the students. (Interview, June 29, 2011)

Megan gave more arguments to support the priority of content knowledge in practice teaching:

I believe that the most important element of teaching secondary math is the content knowledge. The confusion that can be generated by teaching the 'wrong math' could ruin the progress in math of cohorts of students. I strongly believe that only teachers that have a deep understanding of math should seek to teach it - you must have the right shapes falling if you want to have a chance to score well in Tetris. (Interview, June 29, 2011)

Megan believed that the after-degree Bachelor of Education program gave teacher candidates sufficient pedagogical and educational research knowledge:

The other two elements of teaching are important as well, but since they are taught extensively in Teacher's College, I believe that most new teachers are well prepared in these areas when they start teaching. (Interview, June 29, 2011)

Megan acknowledged the importance of pedagogical knowledge as well:

Of course, understanding math does not mean you are also able to teach it efficiently: the pedagogical knowledge is important too, just like in Tetris, where you need to know how to place the shapes in order to score. There are many strategies one math teacher can use, some are intuitive, some are learned in Teacher's College, some (most, I would say) are learned by trial and error while teaching. A math teacher that is a poor pedagogue is not completely disastrous, in my opinion, but I think that the repercussions are that students struggle much more than necessary to grasp math concepts. Of all the three elements, I believe that this one (the knowledge of pedagogical methods) is easier to fix through professional courses offered by boards, or by mentoring within the department. (Interview, June 29, 2011)

Megan formally recognized the importance of educational research, too. However, she narrowly viewed it as “educational psychology research” and focused on efficient “process of conveying knowledge”:

The knowledge of educational research on teaching and learning (I understand by this knowing about the various types of learners and using this in designing the lessons) is important too, because no matter how much mathematical and pedagogical knowledge a teacher has, what is ultimately important is to be aware of the abilities of the students that are taught. The lessons we teach do not have a life on their own, but they become alive when reaching the students, where they are decoded and absorbed, based on their
individual skills. When we find various ways to teach a math concept to different types of learners, we are increasing the efficiency of the process of conveying the knowledge. The Tetris pieces fall all in place at a steady pace, as they should. (Interview, June 29, 2011)

Summarizing her perspective on the role of three factors – content, pedagogy and educational research – in practice teaching, Stacey prioritized content knowledge:

With regards to the three factors described, I think that a teacher's attitude will direct his use of any knowledge he has with regards to content or methods; only when he has the right inner frame of mind can he actually use the knowledge he has. However, I believe that the best teacher will have an expert, deep and broad knowledge of his subject area (factor 1) so that he may show the subject in all its facets, answer the questions of his most curious students and inspire his less curious students to engage with the subject in a new way. (Interview, July 24, 2011)

Stacey gave more arguments to support the priority of content knowledge in practice teaching:

Ultimately, however, the core of the course is mathematics as it is understood by the student and the instructor, and students must be inspired by the content more than anything else. I think that a deep understanding of the mathematics and an enthusiastic, open and caring attitude will best serve the teacher and the students. (Interview, July 24, 2011)

Stacey acknowledged that subject expertise should be supplemented with the knowledge of pedagogy and research. She espoused a belief that “the teacher needs to understand something of best practices” as they have been “researched” to “connect and communicate” her content knowledge to her students in the best possible way (Interview, July 24, 2011). Similarly, Stacey espoused a belief that, for the same purposes, the teacher must know the best content specific pedagogy developed by other teachers, “However, the teacher needs to understand something of best practices as they have been developed and researched (factors 2 and 3) to best connect and communicate his knowledge to his students (Interview, July 24, 2011).”

Stacey emphasized, “I believe that a teacher needs to be always developing his teaching methods and maintaining a personal connection with his students to best understand their needs in the classroom (Interview, July 24, 2011).” As to the ways to achieve the above-mentioned...
goals, Stacey stated, “An important part of this is to continue learning and reflecting on current research and pedagogy (Interview, July 24, 2011).”

Nina prioritized content knowledge by pointing out that she always needed “to review the content of the math by solving the questions” herself (Interview, June 22, 2011). She espoused a belief that all three types of knowledge – content, pedagogy and research – “interact with one another” and “continuously changing”:

My teaching methods and strategies are continuously changing and further shaping into what best suits the students’ needs. I believe all three factors (especially pedagogical and research knowledge) will forever be changing and adapting to the students best interests. (Interview, June 22, 2011)
While formally acknowledging that all three types of knowledge are “greatly important”, Sam prioritized content by stating that content knowledge “is a must (Interview, June 22, 2011).” He believed that gaining pedagogical knowledge “requires practice and reflection on the part of the teacher (Interview, June 22, 2011).” Kara prioritized content knowledge by stating that it is “very important” (Interview, July 2, 2011). Although she acknowledged the importance of pedagogical knowledge as well, Kara thought that “you learn it as you start teaching” (Interview, July 2, 2011). In the same way, she believed that educational research knowledge “you learn along your teaching experience (Interview, July 2, 2011).”

Sean prioritized content knowledge by emphasizing its high importance:

In my opinion, teacher candidate’s content knowledge of secondary school mathematics is highly important. Teacher candidate’s content knowledge is especially important when teaching Grade 11 Math and Grade 12 Advanced Functions, Grade 12 Calculus courses. (Interview, January 5, 2012)

Sean believes that pedagogical knowledge important for teaching younger students, “Teacher candidate’s pedagogical knowledge and teaching experience is very important when teaching Grade 9 Math. Grade 9 Math lessons should mostly be interactive games, interactive activities using, for example Smart board, rather than pure academic lessons (Interview, January 5, 2012)” However, during practicum, Sean found a niche for himself in teaching advanced
mathematics. Exploiting his prior teaching experience, he could be successful in this niche without learning much about pedagogy and educational research.

Sean believes that teacher candidates’ research knowledge is not actually important, “I do not think that teacher candidate’s research knowledge is actually important. Teacher candidate can learn more by collaborating with more experienced teachers (Interview, January 5, 2012).”

When asked about his resources for pedagogical and instructional ideas that he used in planning and implementing his lessons during the practice teaching secondary school mathematics, Sean answered:

I never consulted any educational research works or articles. I gained all of my instructional ideas from my own previous teaching experience and from professional discussions with my associate teachers. The associate teachers from all my practicums were department heads, which left no reason for consulting educational research articles. (Interview, January 5, 2012)

When asked about the supports and/or barriers in the process of planning and implementing his lessons and about associate teachers’ and students’ reaction to his lessons, Sean shared:

My associate teachers always gave me complete freedom in preparing lesson plans and they always praised my methods of teaching. This helped me in developing my own vision of how to conduct a lesson. The reactions of my students and associate teachers were always better than I expected. The response to my lessons was usually overwhelmingly positive. (Interview, January 5, 2012)

Listing the three types of knowledge in the order of importance, Tina placed content knowledge first arguing that “content knowledge affects what the students are to learn” (Interview, June 22, 2011). Ranking the three types of knowledge in the order of importance, Tina placed pedagogical knowledge second and educational research third. She explained:

Pedagogical knowledge provides the tools for the teacher candidate to present the content knowledge in a more effective manner. I believe there is a significant interaction between these two factors. Research knowledge on the other hand, I believe has a limited effect for the teacher candidate especially when they are doing a short-term practicum. (Interview, June 22, 2011)
Tina thought that educational research knowledge is more important for curriculum leaders and administrators:

I see research knowledge used by curriculum leaders and the administrators to help to implement policy. For example, research knowledge can be used to help purchase a new technology should the research show that this new technology improves student learning. Therefore the teacher candidate can benefit from the research knowledge, but it does not directly interact within the classroom. (Interview, June 22, 2011)

When asked about possible similarities between educational research and everyday consumer research, Tina declined to articulate an opinion about this pointing out that she was “not familiar enough with the methods, techniques and results of market research.” Tina believed that routine formative classroom assessment can be viewed as some form of educational research. However, Tina clarified that the justification of such a viewpoint “is dependent upon the reasons for said research and the value you as a researcher place on it.” Tina stated about the role of educational research:

In my opinion, teacher candidates need to be aware of the research, however, I believe that the purpose of teacher training is to become a better teacher not to be a research analyst. I believe it is up to the professor to decide what research to provide to help the teacher candidate become a better teacher. If a teacher candidate is interested in educational research then they should be invited as a research assistant. I do not believe teacher candidates are the primary consumers of research. Research is more relevant in the world of policy and decision making for educational systems not at the classroom student level. (Interview, June 24, 2011)

While acknowledging the role of educational research, Tina believed that initial teacher education should be school-based:

In my opinion it would be better for teacher candidates to receive their certification in a school-based program rather than a research university. Having qualification received through research universities creates nothing but over-educated unemployable teacher candidates who may understand the theory behind teaching but not its application. This is one of the contributing factors as to why there are so many unemployed qualified teachers. I speak from experience. (Interview, June 24, 2011)
Megan viewed her university mathematics methods instructor, who was an experienced school teacher, as the Mentor with the capital letter and did not have any tensions or contradictions in her professional relations with him. Similarly, Stacey felt that she “was so lucky” to have a “kind and enthusiastic” associate teacher with 40 years of experience. She did not have any tensions or contradictions in her professional relations with her associate teacher as well. Stacey shared that book reading was a valuable resource for instructional ideas:

I have a number of math textbooks that I refer to. Some of them are from courses I took (e.g., Problem Solving, Geometry, Graph Theory, Game Theory). I read a lot of books about child development and learning, for professional interest as well as for my own children. Before practicum, I was reading "Overcoming Math Anxiety" for ideas, but my favorite book like this has been "The Myth of Ability", which I used a number of times to help my grade 10 students who were struggling with fractions. I also like historical trivia that I think spices things up a bit. I was reading "The Man Who Knew too Much" about Alan Turing and "Fermat's Last Theorem" which was a sweeping history of math. (Interview, July 25, 2011)

Stacey took part in a couple of a mathematics education forum’s meetings where she “got some ideas for different approaches to group work in class.” Also, Stacey found useful the forum’s website where “they post a lot of creative problems” (Interview, July 25, 2011).

Stacey acknowledged professional support from her husband, a mathematician:

My husband and I talk through a lot of math ideas, which often lets me see problems in different ways. I try to encourage students to see that there are different ways to solve problems, and not to get discouraged with first tries that don't work. He helps me to see these alternative approaches so that I can show these to the students. (Interview, July 25, 2011)

Stacey emphasized that the “hardest part is finding time to plan and prepare lessons that are different from the material in the textbook.” (Interview, July 25, 2011). Stacey stated that students’ reaction to her inquiry-oriented lessons was mixed:

Some students find it hard to focus on a lesson that follows a different rhythm, and get distracted or left out in group work. They have a difficult time finding enthusiasm for the subject. Many students are excited about the opportunity to do creative group work,
or an ongoing project or question that they need to work on over time. (Interview, July 25, 2011)

Stacey shared that her perspective on educational research was influenced by her participation in the meetings of a mathematics education forum, the coursework in her B. Ed. program and her personal readings:

It is clear that educational research is very much based in case study/observation methods, as well as longer term analysis of data and meta-analysis studies. This is so different from a lot of what I did for research, as that was a very internal process, with limited tools, and few real-world subjects to observe. Even at the Department of Physiology, we had only data from actual people, not the people themselves. It is difficult for me to leave the logic and self-centeredness of mathematics, when looking at research from other fields. (Interview, July 25, 2011)

Nina, Sam, Kara, Sean and Tina did not have any tensions or contradictions in professional relations with their associate teachers. Sam “simply conforms to how other teachers are teaching, rather than critically analyzes their own and their peers’ pedagogical methods” (Interview, June 22, 2011).” Nina likes to “take into account what strategies other teachers might have used (Interview, June 22, 2011).” Kara wanted to get along with her associate teacher and tried to “match her teaching style (Interview, July 2, 2011).” Sean perceived his practicum as success because his associate teacher “always praised” him and reacted to his teaching methods “overwhelmingly positive” and “always better” than expected (Interview, January 5, 2012).

Tina believes that “it is up to the professor to decide what research to provide to help the teacher candidate become a better teacher” and does not see herself among the “primary consumers of research (Interview, June 24, 2011).” Tina would prefer to receive teacher certification from a “school-based program rather than a research university” arguing that, from her experience, the latter prepares theoretically “over-educated unemployable teacher candidates” who “may understand the theory behind teaching but not its application (Interview, June 24, 2011).”
4.3.2.4 Stages of Learning

Case 2 interviewees felt the most confidence in their content knowledge, the knowledge of secondary school mathematics. Both their university methods course instructors and associate teachers were experienced classroom teachers. All of the seven interviewees followed these experienced teachers’ directions, imitated their practices, embraced their values and techniques and mastered them as their own.

In her journey to learn to teach, Megan was under the great influence of her university mathematics methods instructor who was an experienced classroom teacher:

He is one of the teachers/human beings that left deep and important marks on me with regards to my profession. I truly believe that his enthusiasm, kindness, helpfulness, dedication to all his students, is unparalleled: in my mind and for me, he embodies the Mentor at his best (the capital letter is meant to symbolize the many other wonderful things I did not mention here about him). (Interview, July 29, 2011)

Megan never questioned his instructions.

Stacey was under the great influence of her experienced associate teacher. Stacey stated that she “was so lucky” to have a “kind and enthusiastic” associate teacher with 40 years of experience who “was full of great ideas, especially for incorporating kinetic activities into the class (Interview, July 25, 2011).” Stacey shared about her associate teacher:

I also loved to see all the ways she has engaged in her work as an educator; writing textbooks, creating volunteer opportunities for her students in the community, facilitating scholarships and more. She really saw the potential and value in every student, whether they got great marks and came every day or if they were really struggling. We all hope to do this, but she was truly engaged and it showed. (Interview, July 25, 2011)

Stacey did not question her associate teacher’s instructions. Stacey came to the after-degree Bachelor of Education program with some prior teaching experience, “For three years, I worked at the learning center at the school, where we tutor students and offer other support for the math department's courses. I also did some marking and general help around the department
Stacey did not claim that she used any innovative teaching techniques at the learning center.

Nina often used online searches to learn from teaching experiences of other teachers:

I also take into account what strategies other teachers might have used for the more basic concepts. For instance, when introducing algebra to my year 8 students, rather than starting with x and y variables, I just used boxes as the students were very familiar with the concept of putting a number in the empty box to make the equation true, we then slowly transformed the box into x and y variables. (Interview, June 22, 2011)

Formally espousing a belief that all three types of knowledge are “greatly important”, and that the acquiring of pedagogical “requires practice and reflection on the part of the teacher” (Interview, June 22, 2011), Sam conformed to teaching styles of teachers at practicum school instead of critically analyzing their own and their peers’ pedagogical methods citing the insufficient support from university teacher educators:

Unfortunately, there does not seem to be much support for teachers wishing to better their pedagogical techniques once in the classroom. One of the results ends up being that the teacher simply conforms to how other teachers are teaching, rather than critically analyzes their own and their peers pedagogical methods. (Interview, June 22, 2011)

Kara “used jigsaw activities, round robin, etc.” in her practice teaching. Kara shared that she learned about these activities from the coursework and that she “implemented and molded” them according to the needs of the students in her class. However, being aware about differentiated instruction techniques and the issues of equity and social justice in mathematics, Kara “did not use much of this during practicum” because she “tried to match” her teaching style with the style of her associate teacher:

I did not try any of these techniques during my practicum because my associate teacher was more of a chalk and talk teacher and was uncomfortable trying other ideas. So I tried to match her teaching style. But now in my classroom, I do use these techniques, students usually love these, get excited, work in pairs, are engaged and their understanding of a particular concept is higher as compared to the conventional method. (Interview, July 2, 2011)
As the source for teaching strategies during practice teaching, Kara named the “resources in the mathematics department” and the opportunities of “talking to other teachers about ideas (Interview, July 2, 2011).”

When asked about his resources for pedagogical and instructional ideas that he used in planning and implementing his lessons during the practice teaching secondary school mathematics, Sean answered:

I never consulted any educational research works or articles. I gained all of my instructional ideas from my own previous teaching experience and from professional discussions with my associate teachers. The associate teachers from all my practicums were department heads, which left no reason for consulting educational research articles. (Interview, January 5, 2012)

Finding a niche in teaching advanced mathematical courses to older students and perceiving his practice as a complete success, Sean did not feel the need for any pedagogical modifications or innovations:

My associate teachers always gave me complete freedom in preparing lesson plans and they always praised my methods of teaching. This helped me in developing my own vision of how to conduct a lesson. The reactions of my students and associate teachers were always better than I expected. The response to my lessons was usually overwhelmingly positive. (Interview, January 5, 2012)

While formally acknowledging the need for teacher candidates to be aware of educational research, Tina does not believe that they should be the primary consumers of research who apply research finding to research practice:

In my opinion, teacher candidates need to be aware of the research, however, I believe that the purpose of teacher training is to become a better teacher not to be a research analyst. I believe it is up to the professor to decide what research to provide to help the teacher candidate become a better teacher. If a teacher candidate is interested in educational research then they should be invited as a research assistant. I do not believe teacher candidates are the primary consumers of research. Research is more relevant in the world of policy and decision making for educational systems not at the classroom student level. (Interview, June 24, 2011)

Tina believes that initial teacher education should be school-based:
In my opinion it would be better for teacher candidates to receive their certification in a school-based program rather than a research university. Having qualification received through research universities creates nothing but over-educated unemployable teacher candidates who may understand the theory behind teaching but not its application. This is one of the contributing factors as to why there are so many unemployed qualified teachers. I speak from experience. (Interview, June 24, 2011)

4.3.2.5 Values

By prioritizing content knowledge, Megan, Stacey, Nina, Kara, Sam, Sean and Tina made an implicit statement that their strong knowledge of secondary school mathematics fulfills their ethical responsibility for student learning. For Megan, the core of teacher candidates’ ethical responsibility for student learning is in the solid knowledge of content that is the “most important of all, and must be treated very seriously when certifying a teacher, especially in math (Interview, June 29, 2011).” She believes that it is “unfortunate” and “not fair” for students to have a “teacher with a limited understanding of math concepts (Interview, June 29, 2011).” Megan argues that “wrong math could ruin” the future of the students (Interview, June 29, 2011). She insists that only teachers who have a “deep understanding of math should seek to teach it (Interview, June 29, 2011).”

In contrast, in Megan’s opinion, a “math teacher who is a poor pedagogue is not completely disastrous” because, although students would “struggle much more than necessary to grasp math concepts,” they eventually would understand them (Interview, June 29, 2011). Despite her knowledge of and experience in scientific research, Megan values more teacher candidates’ mostly “intuitive” and “trial and error” teaching strategies rather than those based on the findings of educational research that she narrowly views as “educational psychology research (Interview, June 29, 2011).” Furthermore, for her, student learning occurred when students “decoded and absorbed” knowledge conveyed by the teacher using “their individual skills (Interview, June 29, 2011).”
Stacey thinks that a “teacher's attitude will direct his use of any knowledge he has” and “only when he has the right inner frame of mind can he actually use the knowledge he has” (Interview, July 24, 2011).” Although Stacey formally espouses a belief that teacher candidates should “continue learning and reflecting on current research and pedagogy” to increase student learning, according to her “inner frame of mind,” the best teacher must have an “expert, deep and broad knowledge of his subject area” in order to “show the subject in all its facets, answer the questions of his most curious students and inspire his less curious students to engage with the subject in a new way (Interview, July 24, 2011)” She insists that “students must be inspired by the content more than anything else (Interview, July 24, 2011).” Stacey shares that it is difficult for her to “leave the logic and self-centeredness of mathematics” and to accept educational research with its “case study/observation methods” because this is “so different” from a lot of what she did for research that was a “very internal process with limited tools (Interview, July 25, 2011).”

Although Nina espouses a belief that “all three factors (especially pedagogical and research knowledge) will forever be changing and adapting to the students best interests,” she does not see herself as an active participant in this process preferring to “take into account what strategies other teachers might have used (Interview, June 22, 2011).”

In Sam’s opinion, the issue of equity and social justice are the most important aspects of education. Sam believes that that the issue of applying educational research to teaching methods is the issue of teachers’ ethics, “There is even, in my opinion, an ethical/moral argument to be made to the importance of this since those who may be being deprived or oppressed are innocent children who end up falling victim to bad teaching (Interview, June 22, 2011).” While saying ‘yes’ to socializing teacher candidates into educational research to make them better informed
consumers of research, Sam insists that it should be done in “non-paternalistic way”, “Yes, but again, how can we do this in a non-paternalistic way (Interview, June 30, 2011).”

He asks whether researchers should be socialized in classroom teaching practice to be able to produce research finding useful for practitioners, “Also, a corollary question: Would socializing educational researchers to engage with students in a classroom (or elsewhere) setting help direct and refine their ability to produce educational research? How can teachers help do this? (Interview, June 30, 2011)”

Sam struggles with the notion of teacher candidates and teachers as the consumers of educational research because he sees the problem of power relations here:

I find it difficult to think of teachers as having to be consumers of educational research the same way I would find it difficult to think of grade 10 students as being consumers of mathematics. There is a power dynamic that exists between students and teacher, where the power to choose, as the term consumer would apply, does not really exist. (Interview, August 3, 2011)

For the benefit of “innocent children who end up falling victim to bad teaching”, Sam eventually agreed that the use of research findings in teaching should be mandatory for teachers. However, he believes that researchers should share this responsibility with teachers:

I am entertaining the idea in my mind that teachers should learn from educational material the same way students are mandated to. I do feel there is a lot of responsibility on researchers, which may, for me, result in challenging our current paradigm of what research is and what the role of the research is. (Interview, August 3, 2011)

For Sam, the way of representing the educational research findings to him is really important. Sam explained:

This is what triggered the prejudice/paternalism issue for me. My question would be to unpack the motivation for this dumbing down of the material. If, in fact, it is done in the spirit of dumbing down then it really disturbs me. But I also believe that it can take place with a spirit of empowerment. And this is how it must be done. (Interview, June 30, 2011)

Sam felt that the lack of communication between graduate research students and teacher candidates is similar to “tracking in schools (Interview, June 30, 2011).” Moreover, he
compared disconnect between graduate research students and teacher candidates as well as tracking in schools to the “relationship between early Africans and the European colonizers (Interview, June 30, 2011).” Sam explained, “The reason for bringing up the issue of colonization was that I felt the same patterns, the same social dynamics that existed there (Interview, June 30, 2011).” Sam clarified, “My thoughts run here since I just returned from living in Zambia for the past 8 months (Interview, June 30, 2011).” Sam continued:

Generally speaking, most, if not all, of the people I met in Zambia appreciated all the work that the Muzungu's (white faced people) were doing for them in their country. They just wished that they would treat them as equals. In summary, my stance is that colonization would not have been so bad if it was not accompanied by such prejudice. If all forms of prejudice, racisms and its subtle counterpart paternalism were obliterated then, perhaps, colonization would not have been so bad! It could have even had the potential to be empowering! Many of the repercussions that these colonized countries now face are rooted to prejudice and racism, some of which (but not all) was brought over by the Europeans. (Interview, June 30, 2011)

Kara felt that her strong knowledge of secondary school fulfilled her ethical responsibility for student learning because, at the end of the practicum, she received feedback indicating that her confidence in teaching advanced mathematical course was “important to the students (Interview, July 2, 2011).” However, Kara admitted that she did not implement differentiated instruction strategies and equitable mathematics ideas in her practice teaching to increase student learning because she wanted to get along with her associate teacher and “tried to match her teaching style (Interview, July 2, 2011).”

Sean is confident in student learning in his class because both students’ and the associate teacher’s reaction to his practice teaching is “overwhelmingly positive” and “always better than expected” (Interview, January 5, 2012). Despite her knowledge of and experience in scientific research, Tina does not try to make connections between her prior research and educational research arguing that her teacher educators should “decide what research to provide to help the
teacher candidate become a better teacher” and does not see herself among the “primary consumers of research” (Interview, June 24, 2011).

4.3.2.6 Integration of Research

Megan, Stacey, Sam, Nina, Kara, Sean and Tina did not use original research articles in their practice teaching. They expected educational research findings to be embedded in pedagogical knowledge and preferred to have access to new pedagogical knowledge through intermediaries. Megan believes that teacher candidates should receive new pedagogical and educational psychology research knowledge from third parties: pre-service and in-service professional development programs as well as from mentors at schools.

While Stacey formally espouses a belief that teacher candidates should “continue learning and reflecting on current research and pedagogy,” she points out that it is sufficient to “understand something of best practices as they have been developed and researched” by others (Interview, July 24, 2011). However, Stacey is not comfortable with reading original research articles because it is difficult for her to “leave the logic and self-centeredness of mathematics when looking at research from other fields” including educational research (Interview, July 25, 2011). Similarly, while Nina espouses a belief that all three types of knowledge and especially pedagogical and research knowledge “will forever be changing and adapting to the students’ best interests,” she does not see her active role in this process, and prefers to look online for “other ways teachers teach the content to their students (Interview, June 22, 2011).”

Sam learned about knowledge mobilization from his wife who worked for health nongovernmental organization in Africa focusing on knowledge translation (the term for knowledge mobilization in health care):

Over the past year was in Africa volunteering in educational development projects. My wife accompanied me, and she was involved with a health NGO that focused on Knowledge Translation (KT). KT is a process where law makers, physicians and the general public are trained in the latest scientific research knowledge with the intent of
influencing policy such that policy actually lines up with the latest scientific research. Example: Men's involvement in reproductive health in Zambia (my wife's research subject). Generally put, research shows that male involve is extremely important and beneficial in the comprehensive reproductive process, yet policy is such that male accompaniment to the hospital birthing room is not allowed. The purpose in applying KT to this example would be to change policy such that it would support male involvement. (Interview, June 22, 2011)

Making connections between knowledge translation in health care and knowledge mobilization in education, Sam argues that there is the need for intermediaries between researchers and teacher candidates:

In regards to education, I believe there is a lot of research available, which if properly translated would greatly improve our education system. Teacher candidates’ research knowledge is very important, but raw research is generally cryptic to most teacher candidates which seem to cause them to turn away from it. There needs to be systems/processes in place that educate teachers in the importance of applying research to their teaching methods. (Interview, June 22, 2011)

Sam admits that that formative assessment in a classroom has some similarities with educational research, but he emphasizes that these two activities differ in their scopes. While having some doubts about the concept of consumer research where he sees the issue of power relations, Sam eventually agrees that teacher candidate should be consumer of research. Saying ‘yes’ to the training of teachers to become the consumers of educational research, Sam argues that this training should start at the Bachelor of Education program:

Basically, yes. Teachers must be trained to be consumers of educational research. The source of the educational research could be from anywhere, as long as it is actually useful. A great first step in building interest in this would be to offer educational research in the B. Ed. program. (Interview, August 3, 2011)

Sam believes that communication with research graduate students would help teacher candidates to be socialized into educational research discourse. However, he had no opportunity to do that. When asked to what extent the university community involved him and others in the events relevant to educational research, Sam replied that he viewed himself “more informed than others” about the life of the university community because of his active role in the Student
Teachers’ Union. However, he added that even he “did not know of many things that were happening; furthermore, even the Student Teachers’ Union’s events really only reached out to the 10% of the teacher candidates (Interview, June 30, 2011).”

Being passionately against tracking in public schools, Sam linked tracking with the fact that he was never invited to open research workshops, “I think my experience is similar to many of those who are tracked. They do not really know what is going on until someone shines a flashlight on it. Why the heck was I not invited to the free workshop for teachers pursuing research degrees!!? (Interview, June 30, 2011).”

Sam suggests that the consumer research training should continue at schools:

For example, perhaps each school could have a research department, where teachers wishing to take part could do so by taking special courses in research (the way one might take special courses for ESL). Then each school could perform research and those in the department could be responsible for disseminating the research and advising the principal. Teachers could be given more compensation and a lighter teaching load (perhaps 2 classes to teach instead of 3) to make up for the extra time they spend doing their research. (Interview, August 3, 2011)

About learning pedagogical and educational research knowledge, Kara says that you learn it “as you start teaching” and “along your teaching experience (Interview, July 2, 2011).”

Among the ways to learn pedagogy and research findings, Kara named the “resources in the mathematics department” and the opportunities of “talking to other teachers about ideas (Interview, July 2, 2011).” She did not mention original research articles readings as her source for research findings. Similarly, Sean “never consulted any educational research works or articles” during practice teaching gaining all his instructional ideas from his “own previous teaching experience” and from “professional discussions” with his associate teacher who was the head of mathematics department at school (Interview, January 5, 2012).

While formally acknowledging that “teacher candidates need to be aware of the research,” Tina does not see herself among the “primary consumers of research” (Interview, June
She believes that her teacher educators should decide “what research to provide to help the teacher candidate become a better teacher” (Interview, June 24, 2011). Tina sees curriculum leaders, administrators and policymakers as primary consumers of research because they can help to implement the research-based policy. She emphasizes that this way teacher candidates “can benefit from the research knowledge, but it does not directly interact within the classroom (Interview, June 22, 2011).”

4.3.3 Case 3: The Higher Score Case

Following the maximum variation criterion, an effort was made to invite a survey respondent with the highest survey score for an interview in the Case 3 (the higher score case) where the participants’ scores above the number 95 (= M + SD), the number located one sample standard deviation (SD = 7) up from the sample mean (M = 88).

There were three observed scores of 100 out of possible 120 points, three scores of 98, two scores of 97 and three scores of 96. Out of three participants with the highest observed score of 100, two did not leave any contact information in the anonymous online survey, and one participant declined an offer to be interviewed. Out of three participants with the second highest observed score of 98, only one participant, Tim, agreed to be interviewed. Both participants with the score of 97 did not leave any contact information in the anonymous online survey. Because of the closeness of 96 and 98 scores and their identical frequency of 3, I decided to offer an interview to the two participants with the score of 96 who left their contact information in the anonymous online survey. Only one of them, Susan, agreed to be interviewed. I, therefore, interviewed Tim and Susan for this case.
4.3.3.1 Educational Background and Prior Disciplinary Research Knowledge and Experiences

Susan (score 96) completed the consecutive initial teacher education program with certification in Intermediate/Senior (grades 9 – 12) mathematics and science (biology) in 2011. Her first practicum was in mathematics. Susan holds a bachelor’s degree in nutritional sciences and human biology with minor in sociology. Before entering the initial teacher education program, she studied research methods in his discipline but did not participate in conducting research.

Susan valued her socializing into the methods of scientific research that occurred during her undergraduate studies. Susan believed that, similarly, the socializing of teacher candidates into educational research would definitely make them better informed consumers of research:

Yes, definitely. For example, I did my undergraduate degree in science and in my upper year courses our readings were all based on original research articles and reviews. Thus, I am quite familiar with how research is conducted in science and the limitations of this research. So, when I see on the news that a particular was study done, I critically evaluate the validity and reliability of the results. A person, who has had no experience with science research, most likely will believe the results of the study right away without questioning it. (Interview, June 24, 2011)

Susan’s knowledge of science research influenced her perspective on the role of educational research:

Similar situation is with educational research. Graduate students who have had more experience with educational research will react to new research differently than a B.Ed. student. I am not sure whether it is true for every B.Ed. and every graduate student, but I think the general trend would be something like that. (Interview, June 24, 2011)

Susan stated that B. Ed. students with more exposure to educational research would “form a different view of educational research (Interview, June 24, 2011).” At the same time, Susan anticipated some challenges in the socializing of teacher candidates into educational research:

The B.Ed. program gives teacher candidates the tools to teach and so they become teachers who follow Ministry of Education guidelines and do not really question the process. The Ministry of Education has policy makers who look at the research and write
policy documents. So, perhaps, more attention should be paid to research at this level and not necessarily at the level of individual teachers. I think, in Ontario, teachers do not really have that much freedom, and a lot of their work is controlled by policy documents, school boards, principals and department heads. (Interview, June 24, 2011)

Tim (score 97) completed the consecutive initial teacher education program with certification in Intermediate/Senior (grades 9 – 12) mathematics and economics in 2011. Both his first and second practica were in mathematics. Tim holds a bachelor’s degree in economics with minors in psychology and mathematics. He reported in the survey that, before entering the initial teacher education program, he neither took a course in research methods in his discipline nor did he participate in conducting research.

However, Tim received some exposure to research while studying psychology, “I do not want to say that my psychology degree is responsible for my views because I found the program to be quite positivist as well (Interview, June 26, 2011).” The dominance of positivistic approaches in his psychology courses, taking prior to the entering the Bachelor of Education program, encouraged him to look for alternatives.

4.3.3.2 Knowledge Prioritization

Susan acknowledged the importance of all three types of knowledge – content, pedagogy and educational research. She prioritized educational research because it can influence both content and pedagogical knowledge:

Research knowledge can influence pedagogical knowledge by expanding and improving it. For example, research that offers new teaching methods or evaluates already existing ones. Research knowledge can also influence content knowledge at the Ministry of Education level by showing evidence that mathematical curriculum should be changed in some way in order to better prepare students for life beyond secondary school. (Interview, June 19, 2011)

Susan provided additional arguments for prioritizing research:

Teacher candidates’ research knowledge is important for professional development of teachers and has effects on teachers’ practice. Research knowledge can also have a direct effect on pedagogical knowledge. For example, reading research that shows the effectiveness or ineffectiveness of certain teaching methods can determine whether a
teacher will try a particular method or not. I see research knowledge as being more
dynamic than content or pedagogical knowledge. Research is constantly progressing,
whereas content knowledge is more static and pedagogical knowledge is more
cumulative. Also, the teaching of content knowledge is under the control of the Ministry
of Education so teachers do not have much say in what content to teach students.
However, teachers have more or less full liberty to determine how they will teach the
content (pedagogical knowledge) and this can be influenced by research knowledge.
(Interview, June 19, 2011)

While prioritizing educational research knowledge, Susan recognized the importance of
content knowledge as well. She stated, “Content knowledge has a central role to play in the
teaching of mathematics at the secondary school level. If the teacher does not know the concepts
and skills, they will not be able to teach the students the bare content (Interview, June 19,
2011).”

Susan believes that content knowledge goes beyond just knowledge of concepts and
skills:

However, mathematical knowledge goes beyond just knowledge of concepts and skills. These
must be effectively used in new applications (to the real world or hypothetical
problems), in problem solving, and in critical thinking. Lastly, mathematical knowledge
also includes the ability to communicate effectively about mathematical thinking
(process) and answers (product). Thus, teachers must also be able to apply knowledge,
problem solve, think critically and communicate effectively in mathematics in order to
teach students how to do all of these things. (Interview, June 19, 2011)

Susan believes it is helpful for a teacher candidate to have mathematical content
knowledge that goes beyond the secondary school level:

As well, I think that it is useful for a teacher to have mathematical content knowledge
that goes beyond the secondary school level. This can help the teacher to prioritize the
curriculum and place more emphasis on certain concepts and skills over others that are of
particular importance in advanced mathematics (i.e. university level). However, this
would not apply as much to workplace or college level streams where students are not
interested in university level mathematics. (Interview, June 19, 2011)

While prioritizing educational research knowledge, Susan recognized the importance of
pedagogical knowledge as well. She stated:

In my opinion, pedagogical knowledge is just as important as content knowledge. It is
one thing to have the content knowledge of secondary school mathematics, but it is
another thing to be able to teach others this same knowledge. Pedagogical knowledge can be quite nuanced and complex. The ability to know how to teach a particular concept or skill to a particular group of students comes from experience or good pedagogical knowledge of a teacher. This gets complicated because teachers are dealing with a different group of students every class and every year. These students have different prior knowledge, abilities, interests and goals. A teacher must also differentiate his/her teaching methods based on all of the mentioned student factors. (Interview, June 19, 2011)

Susan believes that pedagogical knowledge is also closely related to technological knowledge:

Pedagogical knowledge is also closely related to technological knowledge. Today, technology plays a big role in teaching and learning at schools. Technology can aid the teaching of mathematics. Again, the teacher must consider which concepts and skills are better taught with technology and which ones with “traditional” (non-technology) teaching methods. (Interview, June 19, 2011)

Susan explains how content and pedagogical knowledge interrelate and interact in practice teaching:

In my perspective, content knowledge is the basis (the what) of teaching secondary school mathematics. Pedagogical knowledge is the how of teaching secondary school mathematics. Content knowledge influences pedagogical knowledge because particular mathematical concepts or skills can be taught in a limited number of ways. Pedagogical knowledge also includes differentiation and must be student-centered. (Interview, June 19, 2011)

Tim acknowledged the importance of all three types of knowledge – content, pedagogy and educational research. He prioritized educational research as influencing both content and pedagogical knowledge. Tim stated that “research is critical to both mathematics and to pedagogy (Interview, June 13, 2011).” He added:

Research is also important for pedagogy because it informs my pedagogy. I can discover new instructional strategies. I can experiment with different faces of mathematics and its models to instill in my students a passion for exploration and learning. (Interview, June 13, 2011)

Tim emphasized the importance of pedagogical knowledge:

Pedagogy is extremely important for all teachers. I believe that teaching mathematics is not really about teaching mathematics. Unless students go into programs that use pure and complicated mathematics regularly, the high school math they learn is more or less useless. I think of mathematics as my medium to teach my students how to become critical, engaged citizens. It is important for teachers to use strategies to reach as wide a
spectrum of students as possible. In other words, high school teachers need to make math attainable for their students, using a variety of strategies. (Interview, June 13, 2011)

4.3.3.3 Balance of Diversity and Commonality in Collective Learning

Susan shared that her efforts to connect mathematical concepts to the real life in her teaching required a lot of time because she did not receive much support from her associate teacher in doing this:

The biggest barrier I have experienced is time constraint. When connecting certain concepts and skills to the real world, I sometimes had to research these connections myself before presenting them to the students. As well, I have limited first-hand experience applying mathematics in the real world so I have to put a lot of effort in finding out the applications of mathematics beyond school. My associate teacher was not particularly supportive of my attempts at connecting mathematics to the real world. However, he was not disapproving either. I would describe his reaction as just neutral. (Interview, June 27, 2011)

Susan experienced more difficulties in her efforts tried to apply research findings from the literature on literacy in mathematics in her practice teaching:

I experienced more barriers with literacy in mathematics. First of all, my associate teacher dismissed this concern as not important. He said that he had the Ministry of Education documents in case some asked about them, but he never utilized them in his own classroom or cared much about it. He said that I could use these documents during my teaching block if I wished, but he would not recommend it. I also experienced time constraints with teaching the curriculum and focusing on teaching literacy in mathematics. (Interview, June 27, 2011)

Susan viewed the dominance of the traditional methods of assessment as another problem in her practice teaching:

Another barrier I experienced is the traditional methods of assessment, such as tests and quizzes that rely heavily on reading and writing abilities. Other non-traditional forms of assessment were not welcomed in the department of mathematics where I had my teaching block. (Interview, June 27, 2011)

Summarizing the reaction of her associate teacher to her efforts to apply research findings to the lesson planning and implementing during her practice teaching secondary school mathematics, Susan shared:
My associate teacher was quite skeptical of my attempts at incorporating literacy in the mathematics classroom and making connections between math and real world applications. My associate teacher had an established style of teaching and he stuck to it without much will to better it. (Interview, June 27, 2011)

In Susan’s opinion, students’ reaction to her efforts to apply research findings in her teaching was different:

The students, however, were welcoming and appreciative of real-world connections in mathematics. I think it made mathematics more real to them, allowed them to see it in a different light and added some fun to the class. I am not sure how the students perceived the literacy component. It was not explicit so they probably perceived as just my teaching style. However, on my last day of practicum, the students commented that they really enjoyed my teaching, the slow pace and lots of explanation on everything. (Interview, June 27, 2011)

Tim was not happy with his mathematics methods course instructor’s approach:

My mathematics methods course instructor at the university was quite nerdy. It was kind of off-putting for me. He had a binary watch and talked in circles, and I just thought "Do I have to love binary numbers to be a math teacher? Should I be able to read a binary watch?" I wish he would have incorporated some more human lessons, like maybe tell us who invented binary numbers and for what reasons s/he did that. (Interview, June 22, 2011)

Practice teaching secondary school mathematics during both of his practica, Tim did not feel comfortable with the approach of his associate teacher during one of these practica as well:

On one of my practicums, my associate teacher was a math guy. He would often go off on tangents that were mathematically complex - set theory, etc. He thought the kids found it fun to see more challenging math, or extensions. I asked a student how they felt about some of the concepts he presented and it was completely over his head. I think that the teacher does not realize that math gets more fun when it is concrete and applicable, not abstract. (Interview, June 22, 2011)

When asked about the reason for choosing the elective course in equitable mathematics, Tim answered, “It was exactly the name of the course and its description that really attracted me to this course. I was curious about what equitable mathematics could look like. It was fate for me to be in that class. That is the class that I made a concerted effort not to be late ever (Interview, July 5, 2011).”
When asked about supports and/or barriers in the process of planning and implementing a lesson based on the ideas from the equitable mathematics course, Tim answered:

There are a lot of supports available. There are books and online resources. For example, the website www.radicalmath.org is amazing. The difficulties I had were internal. Sometimes I felt as if mathematics was not really coming out, or I felt as if I was forcing mathematics. But then I just took a step back and asked: what is the big picture? And whose mathematics am I teaching? My first associate teacher was incredibly supportive. My second associate teacher was a nice man, but did not really get it. (Interview, July 5, 2011)

When asked about the reaction of his students and associate teachers to his lessons, Tim answered:

My associate teachers were both really impressed by my passion and my commitment to equitable mathematics. My first associate was also a strong supporter of more equitable mathematics, and I used many of her ideas. She was amazing because I really got to see how equitable mathematics looks in a classroom, on a practical level. Students really, really appreciated it. They told me, “We like when you get political - it makes mathematics more interesting” (Interview, July 5, 2011)

4.3.3.4 Stages of Learning

Susan stated that she tried to apply educational psychology research findings to her lesson planning and implementing during her practice teaching secondary school mathematics:

In psychology class, we learnt from our readings in the textbook that a part of effective teaching is connecting classrooms to the outside world, helping students to understand how, when and why particular facts, knowledge and skills are useful. In my practice teaching of grade 10 Academic and grade 11 University/College classes, I have always tried to connect the concepts and skills in each lesson to real-world applications. For example, when introducing grade 10 to parabolas and reviewing quadratic functions with the grade 11, I showed pictures of parabolas that we can see in the real world, such as bridges, cave openings, McDonald’s ‘M’ sign, architectural designs, etc. As well, student always asked where they might use what they are learning in math in real life and I try to make connections with different professions (e.g., engineering, architecture, construction, etc.) as much as possible. (Interview, June 27, 2011)

Susan tried to apply research findings from the literature on literacy in mathematics in her practice teaching:

I have also read some original research articles and a bunch of Ministry of Education documents about literacy in mathematics. The research findings so far are limited, but some connections have been made between literacy abilities and success in mathematics.
Thus, I am always aware of my language and the literacy demands I am placing on my students when I am teaching a lesson, when they are answering questions or completing an assessment task. When teaching, I try to use mathematics terminology and explanations in a simpler language so that a greater array of students understands the material. In assessment, I am mindful of proper use of terminology and students’ abilities to explain their thinking in any way they can. (Interview, June 27, 2011)

Unsatisfied with mathematics methods course instructor’s approach, Tim looked for alternatives and found an elective course in equitable mathematics, taught by the university professor-researcher who specialized in the studies of equity and social justice in mathematics education. Tim shared that taking the elective course in equitable mathematics education really helped him to “see the world of mathematics in a broader sense (Interview, June 26, 2011).”

This course was Tim’s “favorite course” in his B. Ed. program. Tim planned to assist that professor in conducting research during his internship but found a place in the Equitable and Inclusive Schools Program. He did not want to miss this “great opportunity.” Tim shared that he “would have been interested in doing research” during his B. Ed. program (Interview, June 26, 2011). If the program had the research cohort, he would have enrolled in it.

Tim read a number of research articles in the equitable mathematics course, “We had the opportunity to read many research papers. We also watched a research video. It really enriched the learning experience because, coming from a more ‘science-y’ background, I could appreciate the value of research (Interview, July 5, 2011).”

Tim applied many pedagogical and instructional ideas from this course during his practice teaching:

I actually base my mathematical pedagogy off many ideas from this course. It really convinced me about the value of group work, community building, differentiated instruction. During practice teaching, I was notorious for group work and for doing more creative and artistic mathematics. (Interview, July 5, 2011)
Taking their ethical responsibility for student learning seriously, both Susan and Tim prioritized educational research knowledge and used it in their practice teaching research findings from the original research articles to increase student achievement in secondary school mathematics.

In all of her lessons, Susan utilized educational psychology research findings that the connecting of classrooms to the outside world contributes to student learning. Despite the fact that she did not receive any support from her associate teacher in her efforts to connect mathematical concepts to the real life in her practice teaching, Susan spent plenty of time to “research these connections” before “presenting them to the students” and to finding out about the “applications of mathematics beyond school” (Interview, June 27, 2011).

Similarly, she used in her practice teaching research findings about connections between literacy abilities and success in mathematics. Susan experienced even more difficulties in her efforts to apply these research findings in her practice teaching because her “associate teacher dismissed this concern as not important” and “never utilized” the Ministry of Education documents about literacy in mathematics in “his own classroom or cared much about it” (Interview, June 27, 2011). Despite her associate teacher’s disapproval of Susan’s interest in literacy in mathematics, she “read some original research articles and a bunch of Ministry of Education documents” about this topic and applied the findings in her practice teaching (Interview, June 27, 2011).

As another barrier in student learning, Susan viewed the dominance of the traditional methods of assessment at practicum school where tests and quizzes relied “heavily on reading and writing abilities” of the students and “other non-traditional forms of assessment were not welcomed in the department of mathematics” (Interview, June 27, 2011). To facilitate student
learning, Susan was always aware of her language and the literacy demands placed on her students in teaching a lesson, questioning them and assessing their assignments. When teaching, she always tried to use “mathematics terminology and explanations in a simpler language (Interview, June 27, 2011)” to help all students to understand the material. In her assessments of student learning, Susan was “mindful of proper use of terminology and students’ abilities to explain their thinking (Interview, June 27, 2011).”

Tim believes that teaching mathematics at the secondary school level should not be reduced to teaching subject content only. He thinks of mathematics as his medium to teach his students how to “become critical and engaged citizens” (Interview, June 13, 2011.) Tim believes that it is the ethical responsibility of “teachers to use strategies to reach as wide a spectrum of students as possible” and to make mathematics “attainable for their students using a variety of strategies” (Interview, June 13, 2011). He thinks that teachers should approach secondary school mathematics from the perspective high school students to make it attainable for them. Tim points out that “there are plenty of high school teachers” who are “bragging about how much they know instead of facilitating others' learning” and who “make their knowledge unattainable for their students” (Interview, June 13, 2011).

Tim believes that there can be many ways of doing secondary school mathematics to make it accessible to all students. He disagrees with the positivistic views of teachers and teacher candidates who see only one way of doing mathematics and who force their students to “achieve this pre-existing concept of higher-level math” (Interview, June 22, 2011). Considering mathematics, “this seemingly objective field,” as “socially constructed,” Tim strives to expand the definition of mathematics to fit his “students' abilities, instead of trying to narrow” his students’ views to “fit them into the definition of math” (Interview, June 22, 2011).
4.3.3.6 Integration of Research

Both Susan and Tim chose active participation in knowledge mobilization by reading original research articles and applying educational research findings in their practice teaching. In her attempts to apply research findings from the literature on literacy in mathematics in her practice teaching, Susan “read some original research articles and a bunch of Ministry of Education documents about literacy in mathematics” (Interview, June 27, 2011). In all of her lessons, Susan tried to apply educational psychology research findings that a “part of effective teaching is connecting classrooms to the outside world and helping students to understand how, when and why particular facts, knowledge and skills are useful” (Interview, June 27, 2011). Responding to students’ inquiries, she searched for information about mathematics “connections with different professions (e.g., engineering, architecture, construction, etc.) as much as possible” (Interview, June 27, 2011).

Prioritizing educational research knowledge, Susan believes that, to some extent, formative assessment “for learning and of learning” can be viewed as a type of research that teachers routinely do (Interview, June 24, 2011). In particular, Susan thinks that teachers’ research methods are similar to those of educational researchers “in the way data is obtained.” However, she acknowledges that the analysis of data is “the key here” and that “educational research analysis of data is more rigorous and critical than simply forming an opinion.” Susan explains:

How teachers process the information they get from students is important? Do they modify their instruction and further assessment based on the research data they collected or do they repeat the same things year after year no matter who the students are? (Interview, June 24, 2011)

Tim’s disagreement with the dominance of positivistic approaches in his psychology courses, taking prior to the entering the Bachelor of Education program, encouraged him to look for alternatives in educational research studies, “There was a lot of reliance on quantifying
human behavior, which I do not think is always appropriate and possible (Interview, June 26, 2011).”

Tim’s active role in knowledge mobilization was evidenced in criticizing positivistic approaches to teaching secondary school mathematics by some university instructors of mathematics methods courses, associate teachers at practicum schools and teachers candidates. Tim sums up the difference of his perspective on mathematics from the positivist viewpoints of others as the “clash of worldviews” (Interview, June 26, 2011).

Tim argues that “research is critical to both mathematics and to pedagogy” (Interview, June 13, 2011). He clarifies that educational research is important because “it informs pedagogy”, helps to learn about “new instructional strategies” and allows to “experiment with different faces of mathematics and its models” to instill in students a “passion for exploration and learning” (Interview, June 13, 2011).

4.3.4 Summary

All of the ten case study participants had prior educational backgrounds in mathematically intensive professions. In Case 1, Leon holds a bachelor’s degree. He studied research methods but did not conduct research. In Case 2, Sean holds a doctoral degree. Megan, Stacey, Nina and Tina hold master’s degrees. Sam and Kara hold bachelor’s degrees. Sean, Megan, and Tina studied research methods and conducted research. Nina studied research methods. Sam and Kara neither studied research methods nor conducted research. In Case 3, Susan and Tim hold bachelor’s degrees. Susan studied research methods. Tim neither studied research methods nor conducted research.

All participants formally acknowledged the importance of three types of knowledge – content, pedagogy and educational research – in practice teaching secondary school mathematics. Although they were not asked to rank the importance of these three types of
knowledge. Case 1 and Case 2 participants placed them in the order of priority. Case 1 participant placed pedagogical knowledge in teacher candidates’ practice teaching as the first priority, content knowledge as the second priority and educational research knowledge as the third priority.

Case 2 participants placed content knowledge in teacher candidates’ practice teaching as the first priority, pedagogical knowledge as the second priority and educational research knowledge as the third priority. While prioritizing educational research knowledge as directly influencing content and pedagogical knowledge, Case 3 participants emphasized the importance of synthesizing all three types of knowledge in practice teaching secondary school mathematics.

Leon (Case 1) reported borrowing pedagogical ideas from his university methods course instructor, associate teacher and other teachers at practicum school. These individuals were experienced school teachers. Leon argued that scientific quantitative research methods and generalizations were less suitable for supporting instructional decisions in teaching where specific educational situations often differ from one another in many ways. While Leon modified existing teaching strategies learned from other teachers, his modifications were not based on reading original educational research articles.

While Case 1 and Case 2 participants had an opportunity to interact with educational researchers who taught foundation courses, they did not report such interactions. They did not report such interactions with mathematics education researchers. Case 1 and Case 2 participants did not report reading original educational research articles in their foundation courses either. They had no access to pedagogical ideas from original educational research articles in mathematics education. Furthermore, they were not interested in getting such access. Teaching advanced mathematics courses during practicum was often a niche for Case 2 participants where they could experience success based on their prior knowledge of mathematics and instructional
approaches in their disciplines without substantial knowledge of K-12 pedagogy and educational research. Case 2 participants preferred to get along with their associate teachers without problematizing differences in perspectives on teaching and learning.

Both Case 3 participants, Susan and Tim, read original educational research articles for supporting their instructional decisions in practice teaching. While prioritizing educational research knowledge as influencing content and pedagogy, they synthesized these three types of knowledge in their practice teaching. They were able to convince their associate teachers to allow them to implement teaching strategies based on reading original research articles.

In modifying instructional strategies, Leon’s goal was to make them more attractive and engaging for students. In doing this, Leon used ideas from his university mathematics methods course, taught by an experienced classroom teacher, as well as face-to-face discussions with instructors at university and colleagues at school. During the practicum, Leon taught applied level mathematics to younger students. His strategy of utilizing a lot of engaging activities worked well for this student population.

While Case 2 participants followed their associate teachers’ pedagogical advice to get along with them, they relied on their prior training in mathematically intensive professions in making instructional decisions as well. In their practice teaching, Case 3 participants they used teaching strategies developed based on original educational research articles. Prioritising educational research knowledge, both Susan and Tim found inspiration in innovative research-based teaching methods and had courage to implement these methods during practicum.

Leon (Case 1) believed that anecdotal evidence from a teacher’s own experiences could yield the knowledge about the value of a teaching strategy. Leon added that collaboration with other teachers might provide more reliable information about the value of a specific teaching strategy rather than an opinion of one teacher. He believed that teachers, departments and
schools could develop best teaching practices by synthetizing a lot of individual teachers’ observations. Case 2 participants shared a belief that their strong knowledge of secondary school mathematics fulfilled their ethical responsibility for student learning. Taking their ethical responsibility for student learning seriously, both Susan and Tim (Case 3) used in their practice teaching pedagogical strategies that increase student achievement in secondary school mathematics according to the findings of empirical educational research.

While Leon (Case 1) respects other teacher candidates’ perspectives on educational research integration, he believes that their educational research knowledge is peripheral to the other two types of knowledge and is not necessary in teaching mathematics. Although Leon likes to modify existing teaching strategies, his modifications are based on anecdotal evidence from his own teaching experience about the learning outcomes of these modified strategies. He never tried to modify existing teaching strategies based on reading original educational research articles. Leon is convinced that education involves uniquely personal and non-duplicable situations between specific students and specific teachers. He believes that there is a very anecdotal and qualitative element in pedagogical issues that would be difficult to address relying only on data obtained by university researchers without consulting with practicing teachers about these data interpretation.

In contrast, Case 2 participants do not share Leon’s strong skepticism about the educational research findings of university researchers without direct involvement of practicing teachers. Although Megan, Stacey, Sam, Nicole, Kara, Sean and Tina did not use original research articles in their practice teaching, they expected that the integration of educational research into teaching practice should be done by intermediaries. In Case 3, both Susan and Tim chose active participation in the integration of educational research into teaching practice by
reading original research articles and applying educational research findings in their practice teaching.
5.1 Introduction

This chapter answers the research questions that guided the study. The research questions frame the discussion and findings’ interpretation of both survey and interview data including a cross case analysis. The chapter reveals the links between the findings and the literature. Suggestions for further research are given. Implications are discussed for providing learning opportunities for secondary school mathematics teacher candidates in consecutive initial teacher education programs in large research universities.

5.2 Research Questions

This study was motivated by a desire to understand more deeply the secondary school mathematics pre-service teachers’ perspectives on interaction among their knowledge of content, pedagogy, and educational research during teaching practicum at school as well as to identify factors influencing these perspectives. The following questions formed the basis for the focus of this study as outlined in Chapter One:

1. What are secondary school mathematics teacher candidates’ perspectives on their research pedagogical and content knowledge?

2. What factors influence secondary school mathematics teacher candidates’ perspectives on their research pedagogical and content knowledge?

5.2.1 Cross Case Analysis of Research Questions

I report my case study findings in the form of a narrative discussion that is “the primary form for representing and reporting findings in qualitative research” (Creswell, 2012, p. 254). This narrative is organized around the following categories of discussion: Knowledge Prioritization, Educational Background and Prior Disciplinary Research Knowledge and
Experiences, Balance of Diversity and Commonality in Collective Learning, Stages of Learning, Values, and Integration of Research.

5.2.1.1 Knowledge Prioritization

In this section, I analyze participants’ knowledge prioritization. All participants acknowledged the importance of three types of knowledge – content, pedagogy and educational research – in practice teaching. Although they were not asked to rank the importance of these three types of knowledge, Case 1 and Case 2 participants placed them in the order of priority. In particular, the Case 1 participant placed pedagogical content knowledge (PK) in teacher candidates’ practice teaching as the first priority, content knowledge (CK) as the second priority and educational research knowledge as the third priority.

Figure 3. The teacher candidates’ RPACK model in Case 1.

Case 2 participants placed content knowledge in teacher candidates’ practice teaching as

Figure 4. The teacher candidates’ RPACK model in Case 2.
the first priority, pedagogical knowledge as the second priority and educational research knowledge as the third priority.

While prioritizing educational research knowledge as directly influencing content (e.g., curriculum) and pedagogical knowledge, Case 3 participants emphasized the importance of synthesizing all three types of knowledge in practice teaching secondary school mathematics.

![Figure 5. The teacher candidates’ RPAC model in Case 3.](image)

With his lowest awareness of research-based mathematics teaching, Leon (Case 1) gives the highest priority to pedagogical knowledge because he believes that pedagogical knowledge is needed for creating engaging lessons to inspire and motivate students to learn mathematics. While recognizing the significance of content knowledge as basic necessity for teaching math and as foundation for knowledge of methods to teach mathematics, Leon ranks content knowledge second by importance arguing that the twelve years of learning mathematics at school are sufficient to a teacher be able independently upgrade his or her content knowledge as needed. While both CK and PCK are the key parts of teacher quality that affect student learning (Baumert et al., 2010; Hill, Rowan, & Ball, 2005) and CK is viewed as a prerequisite for PCK development (Kleickmann et al., 2013), pedagogical content knowledge has stronger impact on
teaching quality and higher predictive power for student mathematics achievement than content knowledge despite the high correlation between them (Kleickmann et al., 2013).

While downplaying the role of the knowledge of secondary school mathematics content, Leon views additional content knowledge beyond the school curriculum as a bonus to pedagogical knowledge and believes that the depth of mathematical knowledge can help the teacher to spark students’ interest in learning mathematics by enhancing lessons with the elements of underrepresented topics such as proof-making, abstract mathematics, and topology. Leon’s seemingly contradictory perspectives on the role of content knowledge, where he recognizes the value of additional content knowledge beyond the school curriculum while stating that the knowledge of high school mathematics is sufficient for good teaching, are in line with previous research. While researchers agree on the importance of the strong subject-matter content knowledge in teachers’ quality (Grossman & Schoenfeld, 2005; Mewborn, 2003; National Mathematics Advisory Panel, 2008), they differ on the required breadth and depth of teachers’ mathematical knowledge (cf. Ball & Bass, 2003; Deng, 2007; Shulman & Quinlan, 1996). There is no consensus on whether mathematics teachers need the academic research knowledge from university math departments or mathematics specific pedagogical content knowledge from schools of education (Baumert et al., 2010).

Leon gives the lowest priority to educational research knowledge. He believes that knowledge of educational research is helpful but not absolutely necessary for teaching mathematics. Leon argues that knowledge of educational research is only necessary for reforming and modifying pedagogical knowledge to improve teaching practices and enhance teachers’ ability to meet educational needs of students with different learning styles. He prefers to learn about research findings indirectly from experienced teachers. Leon’s perspective on the role of research is in line with research that found that practitioners rarely come into contact with
primary research directly from academic journals but instead educators engage with research indirectly through colleagues, professional development, the media, and often through various third party organizations (Cooper, 2012).

All of the seven Case 2 interviewees, Megan, Stacey, Nina, Sam, Kara, Sean and Tina, prioritized the knowledge of secondary school mathematics content. Their experiences support research that finds that teachers identify themselves as teachers of their subject (Melville & Wallace, 2007). Subject training gives them a sense of purpose as to what is important in their subject content, how it should be taught, and why it should be taught (Melville & Wallace, 2007). The Case 2 participants experiences is in line with research that shows a positive association between prospective secondary school mathematics teachers’ college study of mathematics and the mathematics learning of their high school students (Cochran-Smith & Zeichner, 2005).

Having educational background in mathematics, science or engineering, all of the seven Case 2 interviewees, Megan, Stacey, Nina, Sam, Kara, Sean and Tina, gave the lowest priority to the knowledge of educational research, which they viewed as predominantly qualitative. Their experiences are in line with research that shows that mathematics/science educational background includes deep enculturation into a powerful worldview that favors an objective approach to interacting with and making sense of the natural world and, by logical extension, the social world (Taylor & Wallace, 2007). Many individuals with this background feel that qualitative research is not really legitimate (Taylor & Wallace, 2007).

Megan gives the highest priority to secondary school mathematics content knowledge as the most important of all knowledge. She strongly believes that only teachers with the deep understanding of math should teach it because the incorrect math, taught by a teacher with a limited understanding of mathematical concepts, can ruin the mathematical progress of many
students and jeopardize their future. Megan argues that it is not fair for the students to place them to the classroom of the teacher with poor content knowledge. Megan’s experience is supported by research that found that the insufficient understanding of mathematical concepts reduces teachers’ ability to make them accessible to students and cannot be offset by pedagogical skills (Baumert et al., 2010).

While prioritizing content knowledge, Megan recognizes the importance of pedagogical knowledge, too. However, in contrast to her view of the role of content knowledge, she does not consider as completely disastrous situation where a mathematics teacher is a poor pedagogue. She points out that this deficiency can be easily fixed by taking professional courses offered by school boards or by mentoring within the department. Megan believes that students would eventually learn mathematical concepts from a teacher with strong content knowledge but poor pedagogical content knowledge. While stating that the extensive studies of pedagogy in the after-degree Bachelor of Education program prepare teacher candidates for teaching, Megan clarifies that only some of the pedagogy is learned from university coursework. She believes that pedagogical content knowledge is mostly learned intuitively by trial and error in the process of teaching.

While prioritizing content knowledge, Megan recognizes the importance of educational research knowledge, too. However, she narrowly views it as educational psychology research. In particular, the knowledge of educational research on teaching and learning that Megan understands as focusing on knowing about the various types of learners and then using this knowledge in designing lessons. Megan believes that the goal of finding various ways to teach mathematical concepts to different types of learners is to increase the efficiency of the process of conveying knowledge.
Stacey prioritizes content knowledge stating that the core of any mathematical course is mathematics content and that students must be inspired by the content more than anything else. She adds that the best teacher is one who has deep and broad knowledge of her subject area so that she may show the subject in all its facets, answer the questions of her most curious students and inspire her less curious students to engage with the subject in a new way. In contrast to her enthusiastic sharing information about her strong background in mathematics, Stacey formally acknowledged that subject expertise should be supplemented with the knowledge of pedagogy and research. She espoused a belief that the teacher needs to understand something of best practices as they have been developed and researched. Stacey added that teachers need to develop their teaching methods by continually learning and reflecting on current research and pedagogy.

Sam prioritized content by stating that strong mathematics content knowledge is a must. While admitting that gaining pedagogical knowledge requires practice and reflection on the part of the teacher, he is concerned about the lack of support for this reflection from teacher educators. Sam argues that, as a result, teacher candidates simply conform to how other teachers are teaching, rather than critically analyzes their own and their peers’ pedagogical methods.

Nina prioritizes mathematics content knowledge stating that the ongoing review of the content and solving problems before offering them to students helped her to figure out the best ways to teach. She shares that her teaching methods and strategies are continuously changing into what best suits the students’ needs. In her efforts to figure out the best ways to teach the students, Nina often looked online to find other ways teachers teach the content to their students.

Kara prioritizes content knowledge as very important because students and the associate teacher recognize the lack of content knowledge. Although she acknowledges the importance of pedagogical knowledge as well, Kara thinks that people learn it when they start teaching.
Similarly, she believes that educational research knowledge is something that is learned through teaching experience.

Sean prioritizes content knowledge as highly important especially in teaching advanced mathematics in Grade 11 and 12. He thinks that a teacher candidate’s pedagogical content knowledge is important in teaching younger student such as Grade 9 students. Sean believes that mathematics lessons for younger students should be mostly based on interactive activities using, for example, the Smartboard rather than pure academic lessons. He believes that teacher candidates’ research knowledge is not actually important because they can learn more by collaborating with more experienced teachers. Sean shared that he never consulted any educational research works or articles. Instead he gained all of his instructional ideas from his own previous teaching experience and from professional discussions with his associate teachers.

Sean emphasized that there was not any reason for consulting educational research articles because the associate teachers from both his practicums were department heads. He pointed out that his associate teachers always gave him complete freedom in preparing lesson plans and always praised his methods of teaching. Sean emphasized that this freedom helped him in developing his own vision of how to conduct a lesson. He added that the reaction of his students and associate teachers to his lessons was usually overwhelmingly positive and was always better than he expected.

Ranking three types of knowledge in the order of importance, Tina places content knowledge first. She prioritizes content knowledge because it affects what students can learn from a teacher. Tina places pedagogical content knowledge second because it provides the tools for the teacher candidate to present the content knowledge in a more effective manner. She places educational research third. While recognizing a significant interaction between content knowledge and pedagogical knowledge, Tina believes that educational research knowledge has a
limited effect on teacher candidates’ practice teaching because the practicum is very short within
the after-degree Bachelor of Education program.

Tina believes that research knowledge is more important for administrators and
curriculum leaders because it can help them in developing and implementing policy. For example, she argues that research showing that some type of technology improves student
learning can be used by school administrators for justifying the implementation of new policy
that, in turn, enables teacher candidates to benefit from research indirectly by using this
technology in their classrooms. When asked about possible similarities between educational
research and everyday consumer research, Tina declined to articulate her opinion pointing out
that she was not familiar enough with the methods, techniques and results of market research.

Tina believes that routine formative classroom assessment can be viewed as some form
of educational research depending on the reasons for this research and the value assigned to it by
the researcher. Admitting that teacher candidates need to be aware of the research, she argues
that the purpose of teacher training is to become a better teacher and not to be a research analyst.
Tina believes that it is up to the professor to decide what research to provide to help the teacher
candidate become a better teacher. While she agrees that a teacher candidate who is interested in
educational research should be invited as a research assistant, Tina does not believe that teacher
candidates are the primary consumers of research.

Tina insists that research is more relevant in the world of policy and decision making for
educational systems not at the classroom student level. While acknowledging the role of
educational research, she believes that initial teacher education should be school-based stating
that it would be better for teacher candidates to receive their certification in a school-based
program rather than at the research university. Tina argues that her own personal experience
convinces her that having qualification received through research universities creates nothing but
overeducated unemployable teacher candidates who may understand the theory behind teaching but not its application.

Both Case 3 interviewees, Susan and Tim, prioritized educational research knowledge. Their research disposition can be explained by their positive experiences with authentic research under the guidance of their instructors who were researchers. Susan was influenced by a researcher in science during her undergraduate studies. Tim was influenced by mathematics education researcher while taking her elective course in the Bachelor of education program. Cartrette and Melroe-Lehrman (2012) found that course instructors/advisors have the most influence on their students’ perspectives on research.

Susan prioritizes educational research arguing that it can influence both content and pedagogical knowledge. She clarifies that research can influence pedagogical knowledge by expanding and improving it. Susan states that research can offer new teaching methods or evaluate already existing ones. In particular, she points out that reading research that shows the effectiveness or ineffectiveness of certain teaching methods can determine whether a teacher would try a particular method or not. Susan emphasizes that research can also influence content knowledge at the Ministry of Education level by showing evidence that mathematical curriculum should be changed in some way in order to better prepare students for life beyond secondary school.

Susan provides additional arguments for prioritizing research. She argues that teacher candidates’ research knowledge is important for professional development of teachers and has a direct effect on teachers’ practice. Susan sees research knowledge as being more dynamic than content or pedagogical knowledge. In her opinion, research is constantly progressing our understanding of teaching and learning, whereas content knowledge is more static and pedagogical knowledge is more cumulative. While prioritizing educational research knowledge,
Susan recognizes the importance of content knowledge as well. She states that content knowledge has a central role to play in the teaching of mathematics at the secondary school level because, if teachers do not know the concepts and skills, they will not be able to teach the students the mathematics content. Susan believes that content knowledge goes beyond just knowledge of concepts and skills. She points out that these concepts and skills must be effectively used in new applications in problem solving and in critical thinking.

Susan emphasizes that mathematical knowledge also includes the ability to communicate effectively about mathematical thinking (process) and answers (product). She concludes that teachers must be able to apply knowledge, problem solve, think critically and communicate effectively in mathematics in order to teach students how to do all of these things.

Susan believes that it is helpful for a teacher candidate to have mathematical content knowledge that goes beyond the secondary school level. In her opinion, deeper and wider content knowledge can help the teacher to prioritize the curriculum and place more emphasis on certain concepts and skills over others that are of particular importance in advanced mathematics (i.e. university level). However, she admits that this would not apply as much to workplace or college level streams where students are not interested in university level mathematics.

Susan recognizes the importance of pedagogical knowledge as well. In her opinion, pedagogical knowledge is just as important as content knowledge. Susan emphasizes that it is one thing to have knowledge of secondary school mathematics, but it is another thing to be able to teach others this same knowledge. She points out that pedagogical knowledge can be quite nuanced and complex. Susan argues that the ability to know how to teach a particular concept or skill to a particular group of students comes from experience or good pedagogical knowledge of a teacher. She argues that it can be difficult to deal with a different group of students every class
and every year because these students have different prior knowledge, abilities, interests and goals.

Susan believes that pedagogical knowledge is also closely related to technological knowledge because technology plays a big role in teaching and learning at schools. She points out that technology can help in teaching mathematics. Susan emphasizes that the teacher should be able to decide which concepts and skills would be better to teach with technology and which ones without it.

Susan explains how content and pedagogical knowledge interrelate and interact in practice teaching. For her, content knowledge is the basis (the what) of teaching secondary school mathematics while pedagogical knowledge is the how of teaching secondary school mathematics. Susan emphasizes that content knowledge influences pedagogical knowledge because particular mathematical concepts or skills can be taught in a limited number of ways. She believes that differentiated instruction and student-centeredness are important features of pedagogical knowledge.

Tim prioritized educational research arguing that research is critical to both mathematics and to pedagogy. In particular, knowing that mathematics is socially constructed, he strived to expand the definition of mathematics to fit his students' abilities, instead of trying to narrow his students’ views to fit them into the definition of mathematics. Tim emphasizes that research is important for pedagogy because it informs the pedagogy and helps to come up with new instructional strategies. He argues that because of research he can experiment with different faces of mathematics and its models to instill in his students a passion for exploration and learning.

While prioritizing educational research knowledge, Tim emphasized the importance of pedagogical knowledge as well. He believes that teaching mathematics is not just about teaching
mathematics. For him, mathematics is his medium to teach his students how to become critical and engaged citizens. Tim points out that it is important for teachers to use strategies to reach as wide a spectrum of students as possible. He emphasizes that high school teachers need to make math attainable for their students using a variety of strategies. Tim believes that content knowledge should be accessed from the perspective of a high school student.

He thinks that many secondary school teachers make their content knowledge unattainable for their students. Tim feels that those teachers are bragging about how much mathematics they know instead of facilitating student learning. He believes that there could be many ways of doing secondary school mathematics. In his view, some teachers and teacher candidates have an opinion that there is a particular way to do math and that the students should aim to achieve this pre-existing concept of higher-level math. In contrast, Tim sees mathematics, a seemingly objective field, as bounded by social constructs. Knowing that math is socially constructed, he strives to expand the definition of mathematics to fit his students' abilities, instead of trying to narrow his students’ views to fit them into the definition of mathematics.

In summary, this study found that participants’ different perspectives on their research pedagogical and content knowledge (RPACK) were associated with the different levels of diversity in teacher candidates’ and their associate teachers’ perspectives on learning and teaching. More specifically, while all participants acknowledged the importance of three types of knowledge – content, pedagogy and educational research – in practice teaching, they prioritized one of them. The different levels of diversity in teacher candidates and their associate teachers’ perspectives on learning and teaching were associated with the different levels of the participants’ awareness of research-based teaching strategies.

In particular, a lower level of diversity between the Case 1 participant and his associate teacher’s perspectives on learning and teaching was associated with placing pedagogical
knowledge as the first priority by this teacher candidate. Placing pedagogical knowledge as the first priority was associated with a lower level of this teacher candidate awareness of research-based teaching strategies. Content knowledge was placed as the second priority. Educational research knowledge was placed as the third priority.

Furthermore, an average level of diversity between Case 2 participants and their associate teachers’ perspectives on learning and teaching was associated with placing content knowledge as the first priority by these teacher candidates. Placing content knowledge as the first priority was associated with an average level of the teacher candidates’ awareness of research-based teaching strategies. Pedagogical knowledge was placed as the second priority. Educational research knowledge was placed as the third priority.

Finally, a higher level of diversity between Case 3 participants and their associate teachers’ perspectives on learning and teaching was associated with placing educational research knowledge as the first priority by these teacher candidates. While prioritizing educational research knowledge as directly influencing content and pedagogical knowledge, Case 3 participants emphasized the importance of synthesizing all three types of knowledge in practice teaching in secondary school mathematics classrooms. Placing educational research knowledge as the first priority was associated with a higher level of the teacher candidates’ awareness of research-based teaching strategies.

5.2.1.2 Educational Background and Prior Disciplinary Research Knowledge and Experiences

In this section, I analyze participants’ educational background and prior disciplinary research knowledge and experiences. In Case 1, Leon’s mathematically intensive undergraduate studies of science (biology) and scientific research methods convinced him that scientific quantitative research methods and generalizations were less suitable for supporting instructional
decisions in secondary school teaching where specific educational situations often differ from one another in many ways. He deliberately chose to immerse himself into secondary school teaching practices and to rely less on his prior educational and scientific research background. As a result, there was a lower level of diversity between Leon’s and his associate teacher’s perspectives on learning and teaching. In Case 1, there was a lower level of awareness of research-based teaching strategies.

With his prior scientific research knowledge, Leon felt comfortable to theorize about the relationship between educational research and practice teaching. He could find some similarities between educational research and formative classroom assessment. Leon viewed tests/quizzes and the process of questioning students as the sources of quantitative and qualitative data, respectively. He recognized the resemblance between consumer research and mixed methods research. However, Leon assigned the lowest priority to teacher candidates’ educational research knowledge and the highest priority to their pedagogical knowledge due to his specific perception of the relationship between his prior educational and research background on the one hand and secondary school teaching practices on the other hand. This result supports research finding that developing pre-service teachers’ educational research disposition can be difficult (D’Ambrosio, 1998).

Leon believes that there is likely no practical way for outside observers to detect a reduction in student learning when a teacher utilizes a teaching strategy that is different from a research-based one. To justify this belief, he argues that environment and classroom/school culture in which a teacher practices can be very different from classroom to classroom, as well as from teacher to teacher. Leon points out that those different teachers do not teach the same way. He adds that the same teacher does not apply exactly the same approaches in different contexts either.
In his opinion, it is anecdotal evidence from a teacher's own experiences not educational research findings that could help to assess the value of a teaching strategy. Even better, Leon emphasizes that collaboration with other teachers might provide such information as collaboration produces best practices based on a lot of individual observations. He concludes that it is difficult to say who is right and who is wrong in each specific situation because education is partly an art form that has been practiced for thousands of years with no perfect solutions.

Five of the seven Case 2 participants had mathematics or science educational background, and two had engineering training on the border with science: chemical and electric engineering. Five of the seven Case 2 participants studied scientific research methods, and four of them took part in conducting research in their discipline.

In contrast to Leon, all seven of the Case 2 interviewees, Megan, Stacey, Nicole, Sam, Kara, Sean and Tina, deliberately chose to avoid full immersion in secondary school instructional culture during their practice teaching. Instead, they synthesized their prior research and/or educational background perspectives on teaching and learning with secondary school teaching practices.

As a result, Case 2 participants were able to achieve an average level of diversity between their and their associate teachers’ perspectives on learning and teaching. While Case 2 participants followed their associate teachers’ instructional advice to get along with them, they heavily relied on their prior training in mathematically intensive professions in making decisions about what is important in their subject content, how it should be taught, and why it should be taught (Bass, 2005; Melville & Wallace, 2007). In Case 2, there was an average level of the participants’ awareness of research-based teaching strategies. This result supports research
finding that socializing teacher candidates into educational research can be challenging (Levin & Rock, 2003; Smith & Sela, 2005; Valli, 2000; Kotsopoulos, Mueller, & Buzza, 2012).

Describing his prior psychology program as quite positivist, Case 3 teacher candidate Tim emphasized that he was not satisfied with a lot of reliance on quantifying human behavior which he did not think was always appropriate or possible in education. As a result, he started to look for alternatives and found an elective course in equitable mathematics taught by a mathematics education researcher, and made a decision to prioritize educational research knowledge.

In contrast to Case 1 and Case 2 participants, Susan’s scientific educational and research background influenced her decision to prioritize educational research knowledge because she had experience with authentic scientific research during her undergraduate studies. In her upper year science courses, Susan was actively engaged by her instructor in reading original research articles and reviews. This result supports Cartrette and Melroe-Lehrman (2012) finding that the factors which most influenced undergraduate science students’ perspectives on research activity were previous laboratory courses and instructors/advisors. Cartrette and Melroe-Lehrman (2012) showed that undergraduate students, whose instructors used research-based rather than expository strategies in teaching science, demonstrated a more mature notion of the question answering process involved in authentic research contexts.

An emerging finding in this study is that teacher candidates with similar educational backgrounds in mathematically intensive disciplines can have different perspectives on relations between content, pedagogical and educational research knowledge in practice teaching in secondary school mathematics. This finding adds new knowledge to the literature on learning to teach that suggests that many teacher candidates bring to initial education programs problematic preconceptions about teaching and learning (Hammerness, Darling-Hammond, & Bransford,
2005; Lorti, 1975; Richardson, 1996; Wideen, Mayer-Smith, & Moon, 1998) and that preconceptions of teaching are difficult to change (Britzman, 2003; Richardson & Placier, 2001; Wideen et al., 1998).

The two Case 3 participants’ educational backgrounds influenced their decision to prioritize educational research knowledge as contributing to the development of content and pedagogical knowledge. In contrast to the teacher educators’ views that teacher candidates’ preconceptions are problematic and contribute to the theory-practice divide (Falkenberg, 2010; Kennedy, 1999), Case 3 participants used contradictions and tensions surrounding the theory-practice divide to synthesize diverse perspectives on content, pedagogical and educational research knowledge and to integrate them into their practice teaching in secondary school mathematics.

Another emerging finding in this study is that secondary school teacher candidates’ often come to the after-degree bachelor of education programs with the knowledge of mathematics acquired for working in mathematically intensive professions, a knowledge that overlaps with mathematical knowledge for teaching (MKT) as defined by Hill, Rowan and Ball (2005). This study suggests similar overlap between teacher candidates’ prior knowledge of mathematics and mathematical knowledge for teaching (MKT).

This suggestion helps to understand why Case 2 participants earn achieve survey scores that are higher than the score of Leon (Case 1). In answering the survey, Case 2 participants relied on their prioritized mathematical knowledge partially overlapping with mathematical knowledge for teaching (MKT). In contrast, Leon immersed himself in prioritized secondary school teaching practices by placing content knowledge after pedagogy.

This study suggests that the theory-practice divide is a continuum rather than a dichotomy. In particular, the Case 1 participant is located on one end of this continuum with his
practice-oriented perspective of secondary school teachers on the relationship between the knowledge of content, pedagogy and research. The Case 3 participants are located on the other end of this continuum with their research-based perspective of on the relationship between these three types of knowledge. The Case 2 participants are located in the middle of this continuum with their perspective of being prepared for working in mathematically-intensive professions. This perspective partially overlaps with two other perspectives: practice-oriented and research-based perspectives.

In contrast, the literature views the theory-practice divide as a dichotomy. Bullock and Russell (2010) write about the need to integrate practice-oriented and research-based perspective to arrive at the pedagogy of teacher education that is both empirically based and practically oriented. Labaree (2008) writes in support of an ongoing dialog between practitioners in the two different spaces of expertise: school teaching and education research. Zeichner (2010) advocates a paradigm shift in the epistemology of teacher education programs by creating a ‘third space’ in the university-school partnerships, a hybrid of researchers’ and teachers’ worldviews, for teacher candidates to experience a dynamic interaction between research and pedagogy in practice teaching.

In summary, this study found that participants’ educational background and prior disciplinary research knowledge and experiences became factors contributing to teacher candidates’ RPACK perspectives and influencing conditions for overcoming theory-practice divide in their instructional decisions in various educational situations during practice teaching. More specifically, their different perceptions of the relationship between their prior educational and research background on the one hand and secondary school teaching practices on the other hand were associated with the different levels of diversity between participants and their associate teachers’ perspectives on learning and teaching. These different perceptions were
associated with the different levels of the participants’ awareness of research-based teaching
strategies.

5.2.1.3 Balance of Diversity and Commonality in Collective Learning

In this section, I analyze conditions for teacher candidates and their associate teachers’
collective learning about educational situations in practice teaching in secondary school
mathematics classrooms and the conditions that can influence teacher candidates’ instructional
decisions. I focus on one pair of complementary conditions called diversity and commonality
(McMurtry, 2010) or internal diversity and internal redundancy (Davis & Simmt, 2006).

Leon (Case 1) reported borrowing pedagogical ideas from his university methods course
instructor, associate teacher and other teachers at practicum school. These individuals were
experienced school teachers. There was a lower level of diversity between Leon and these
experienced teachers’ perspectives on teaching and learning because Leon immersed himself in
school teaching practices. He deliberately chose to rely less on his prior perspectives gained in
the mathematically-intensive undergraduate studies of science (biology). Leon argued that
scientific quantitative research methods and generalizations were less suitable for supporting
instructional decisions in teaching where specific educational situations often differ from one
another in many ways. In Case 1, the lower level of diversity in perspectives on teaching and
learning was associated with the lower awareness of research-based strategies in teaching
mathematics.

While some diversity of Leon and his teacher educators’ professional and personal
knowledge provided an opportunity for Leon to revise and modify instructional strategies learned
from them (McMurtry, 2010), this diversity was not sufficient to encourage him to synthesize all
three types of knowledge in his practice teaching according to the principle of the interconnected
nature of content, pedagogy and research in initial teacher education (ACDE, 2005). Leon had
no access to pedagogical ideas from original educational research articles in mathematics education. Furthermore, he was not interested in getting such access. As a result, while Leon modified existing teaching strategies learned from other teachers, his modifications were not based on reading original educational research articles.

Without a balance of diversity and commonality in Leon and his associate teacher’s perspectives on teaching, conditions for collective learning about specific educational situations in classrooms during practicum were not favorable enough to avoid the theory-practice divide in Leon’s practice teaching. In revising and modifying instructional strategies, Leon’s goal was to make them more attractive and engaging for students in general rather than to achieve a specific learning outcome. Although his associate teacher did not actively collaborate with him in the process of these modifications, she respected his efforts in doing this because she learned something new from him. The associate teacher was very impressed by the clinometer activity lesson, as well as Leon’s practicum teaching in general. Leon believed she respected his efforts to use a wide variety of teaching methods in order to deliver the content in refreshing ways and to multiple types of learners. However, Leon’s selection of instructional strategies was based more on a trial and error approach rather than on the analysis of their contribution to attaining a desired educational goal.

Similarly, there was an imbalance of diversity and commonality in Leon and his students’ ideas about learning the lesson’s topic because he imposed his instructional ideas on them rather than to encourage students to express their own ideas. As a result, Leon’s approach did not form conditions for teacher-student collective learning despite a lot of engaging activities. He reported that students seemed to enjoy these activities. Leon noticed that most or all of the class was on-task and quite engaged while the activities were taking place. He also observed that some of the typically shy and less active students were much more engaged in their learning
while working in small groups on the tasks. Leon shared that these types of students also responded well to novelties such as being willing to come up and play around with the Smartboard technology. However, despite multiple hands-on activities, there was a lack of mathematical reasoning and students’ discussions about the mathematical concepts of the lesson.

Prioritizing secondary school mathematics content knowledge, all seven Case 2 interviewees, Megan, Stacey, Nicole, Sam, Kara, Sean and Tina, did not achieve a sufficient diversity of instructional ideas to form conditions for collective learning with their associate teachers and students during practicum. There was an average level of diversity between Case 2 participants and their associate teachers’ perspectives on teaching. While the participants took into account their associate teachers’ perspectives on teaching, they chose to preserve their prior disciplinary perspectives acquired in mathematically intensive professions. They tried to find a compromise between the two sets of perspectives in their instructional decisions rather than to passively accept their associate teachers’ perspectives. This finding provides empirical support for a trend in the literature on teacher education to view teacher candidates not as passive recipients of teaching skills but as active collaborators in the co-construction of knowledge (Bullock & Russell, 2010; Ewing & Smith, 2003; LeCornu & Ewing, 2008).

The average level of diversity in Case 2 participants’ perspectives on teaching was associated with the average awareness of research-based strategies in teaching mathematics. The average level of diversity was achieved due to partial overlap between the instructional perspectives of school teachers, professionals in mathematically intensive disciplines and educational researchers. The Case 2 participants’ perspectives on teaching were influenced in part by educational research findings that they learned from their foundation courses in the after-degree Bachelor of Education program. Similar to Case 1, the diversity of Case 2 participants’ instructional ideas was not sufficient to encourage them to synthesize all three types of
knowledge in his practice teaching according to the principle of the interconnected nature of content, pedagogy and research in initial teacher education (ACDE, 2005). While Case 2 participants had an opportunity to interact with educational researchers who taught foundation courses, they did not report such interactions. They did not report such interactions with mathematics education researchers.

The Case 2 participants did not report reading original educational research articles in their foundation courses. They had no access to pedagogical ideas from original educational research articles in mathematics education. Furthermore, they were not interested in getting such access. Without a balance of diversity and commonality in Case 2 participants and their associate teachers’ perspectives on teaching, conditions for collective learning about specific educational situations in classrooms during practicum were not favorable enough to support overcoming theory-practice divide in their practice teaching.

While they sometimes could disagree with the instructional strategies of their associate teachers, Case 2 participants avoided problematizing these differences because they deliberately chose to get along with their associate teachers. They identify themselves as teachers of their subject (Melville & Wallace, 2007). Their prior training in mathematically intensive professions gave them a sense of purpose as to what is important in their subject content, how it should be taught, and why it should be taught (Bass, 2005; Melville & Wallace, 2007). Teaching advanced mathematics courses during practicum was often a niche for them where they could experience success based on their prior knowledge of mathematics and instructional approaches in their disciplines without substantial knowledge of K-12 pedagogy and educational research.

In contrast to her claim that the extensive studies of pedagogy in Bachelor of Education program prepare teacher candidates for teaching, Megan emphasizes that pedagogical knowledge is mostly learned by trial and error while teaching or by professional intuition while only some of
pedagogy is learned from university coursework. Megan believes that the poor pedagogical knowledge of a mathematics teacher is not complete disaster because, in her opinion, this deficiency can be easily fixed by taking professional courses offered by school boards or by mentoring within the department. Megan believes that students would learn eventually mathematical concepts from a teacher with strong content knowledge but poor pedagogical content knowledge. These students, in her opinion, just struggle more than necessary to grasp these mathematical ideas.

Although Megan claimed that her university methods course instructor, an experienced classroom teacher whom she called the Mentor with the capital letter, had great professional and humanitarian influence on her learning to teach, Megan did not show much interest in utilizing his pedagogical ideas in her practice teaching. While she talks about his unparalleled enthusiasm, kindness, helpfulness and dedication to all teacher candidates in his methods course as well as many other wonderful things, Megan emphasizes that only some of pedagogy is learned from university coursework and the rest of pedagogical knowledge is mostly learned by professional intuition as well as by trial and error during practice teaching.

With more attention to content rather than to pedagogy, Megan experienced a lack of instructional tools for encouraging students to express their own views about learning mathematics. As a result, she was not able to achieve a balance of diversity and commonality between her and her students’ perspectives on teaching and learning secondary school mathematics, the balance that was necessary for her collective learning with students. Focusing on building good personal relations with her teacher educators and relying on her own professional intuition as well as trial and error approaches during practice teaching instead of consulting original educational research articles, Megan was not able to achieve a balance of diversity and commonality between her and her associate teacher’s perspectives on teaching and
learning as well, the balance that was necessary for her collective learning with her associate teacher.

Stacey tried to plan and prepare inquiry-oriented lessons that were different from the material in the textbook. However, students’ reactions to her inquiry-oriented lessons were mixed. While some students were excited about the opportunity to do creative group work or an ongoing project or question that they need to work on over time, other students found it hard to focus on a lesson that follows a different rhythm than their established template from the associate teacher, and became distracted or excluded in group work. Stacey believed that students must be inspired by the content more than anything else. She was disappointed when some students had a difficult time showing enthusiasm for the subject. Instead of encouraging students to express their own views about learning mathematics, Stacey tried to impose on them her beliefs about the value of mathematics. As a result, she was not able to achieve a balance of diversity and commonality in her and her students’ perspectives on teaching and learning secondary school mathematics.

Similarly, there was an average level of diversity in Stacey and her associate teacher’s instructional ideas because she deliberately chose not to mix her prior research perspectives on teaching and learning mathematics with school teachers’ perspectives learned from her associate teacher. Although she felt lucky to have a kind and enthusiastic associate teacher with 40 years of experience, Stacey was not sure that she was able to adopt her associate teacher’s teaching style to the full extent. Her associate teacher was full of great ideas, especially for incorporating kinesthetic activities into the class. Stacey was impressed with her associate teacher’s multiple engagements in her work as an educator: writing textbooks, creating volunteer opportunities for her students in the community, facilitating scholarships and more. However, Stacey had doubts that she could perform as well as her associate teacher when she observed that the associate
teacher really saw the potential and value in every student, whether they got great marks and came every day or if they were really struggling. Stacey believed that many teachers, including her, can only have a hope to be as good as this experienced associate teacher. As a result, she decided not to bring more diversity to instructional ideas in her practice teaching. In particular, Stacey did not base her teaching strategies on original educational research articles. She preferred to get along with her associate teacher.

Stacey’s husband, a research mathematician, advised her about different approaches to mathematical problems. She shared these different ways of solving problems with her students. However, the conversations of these two research mathematicians did not increase the diversity of perspectives much because they did not base their discussions on reading original educational research articles. Stacey’s husband was not an expert in pedagogy or educational research.

Impressed by the professional excellence of her associate teacher Stacey did not use enough of the available resources for diversifying instructional ideas. In particular, Stacey could have learned a lot about teaching from an existing mathematics education forum and its network and online resources, a forum comprised of researchers, instructors from universities, colleges and schools as well as administrators and policy makers. However, she attended only two of the forum meetings. Stacey learned something new about different approaches to group work in class from these meetings. She found the forum’s website useful as she found many creative problems posted. However, these creative problems did not prompt her to read original educational research articles.

Stacey studied disciplinary research methods and participated in disciplinary research prior to entering the after-degree Bachelor of Education program. Besides her own research for her honors and masters theses, she assisted the team of researchers in the department of physiology preparing the review of medical research literature for the project as well as
conducting 3D imaging and modeling involving matrix transformations. However, Stacey’s prior research experiences did not spark an interest in educational research. She believed that educational research is very much based on case studies and observation methods as well as longer term analysis of data and meta-analysis studies. Stacey felt that this is so different from a lot of what she did for research. Her research for her undergraduate and graduate degrees was a solitary activity with a very internal process, with limited tools and few real-world subjects to observe. In research that she conducted in the physiology department, she did not have contacts with the participants. Stacey dealt only with the data received from them. She shared that it was difficult for her to leave the logic and self-centeredness of mathematics when looking at research in other fields.

Stacey felt more comfortable borrowing ideas from mathematical books rather than from educational research literature. She picked up instructional ideas from mathematical books about problem solving, geometry, and graph and game theories. Stacey utilized pedagogical ideas from books about mathematics anxiety and ability as well as from books about the history of mathematics, child development and learning.

Nina stated that her teaching methods and strategies were continuously changing and shaping into what best suits the students’ needs. However, her change of strategies was based either on consulting with other teachers to learn their approaches in similar situations or on her own professional intuition. Nina preferred trial and error approaches. She reviewed the content of the mathematics by solving the problems herself first before offering these problems to her students. As a result, the diversity of Nina’s instructional strategies was limited. Similar to Stacey, she did not base her instructional decisions on reading original educational research articles. Relying mostly on other teachers’ instructional ideas, Nina had no resources to achieve more than an average level of diversity between her and her associate teacher’s instructional
ideas about teaching and learning. As a result, there were no conditions for creating a balance of
diversity and commonality between Nina and her associate teacher’s perspectives on learning
and teaching.

Sam believes that gaining pedagogical knowledge requires practice and reflection on the
part of the teacher. However, citing the lack of support from university teacher educators in
conducting such reflection during practicum, Sam based his instructional decisions on a
combination of his associate teacher’s pedagogical ideas and on educational perspectives learned
from his mathematically intensive profession. He did not critically analyze his pedagogical
methods based on reading original educational research articles. As a result, the diversity of
Sam’s teaching strategies was limited. Similar to Nina’s situation, there was no conditions for a
balance of diversity and commonality in Sam’s and his associate teacher’s perspectives on
learning and teaching.

Kara avoided increasing the diversity of instructional ideas in consultations with her
associate teacher. In particular, she was not comfortable to try research-based teaching strategies
that were different from her associate teacher’s instructional approaches. Although Kara was
aware of some teaching strategies based on educational psychology research findings, she did not
use these strategies often during practicum. For example, she learned from university
coursework cooperative learning activities such as jigsaw and round robin. Kara implemented
and molded these activities according to the needs of the students in her class. However, she did
not use differentiated instruction techniques at all. Kara explained that she did not try many
other teaching techniques during her practicum because her associate teacher was more of a
chalk and talk teacher and was uncomfortable with trying other ideas. Kara tried to match the
associate teacher’s teaching style to get along with her. As a result, there was a lack of diversity
in Kara’s instructional strategies during practicum. Her pedagogical ideas were limited to those
learned from her associate teacher, the practicum school mathematics department’s resources and other teachers in the department. As a result, there were no conditions for a balance of diversity and commonality in Kara’s and her associate teacher’s perspectives on learning and teaching.

Similar to Kara, Sean avoided increasing the diversity of instructional ideas in consultations with his associate teacher. He found a niche in teaching advanced mathematics courses during practicum where he could use his experience in teaching undergraduate mathematics. Sean explained that he gained all of his instructional ideas from his own previous teaching experience and from professional discussions with his associate teacher. He viewed his practicum as a success because the reaction of his students and the associate teacher to his lessons was usually overwhelmingly positive and was always better than he expected.

Sean did not see any reasons to consult educational research articles because his associate teacher was the mathematics department head. He believes that teacher candidates’ research knowledge is not actually important because they can learn more by collaborating with more experienced teachers. Sean admitted that teacher candidate’s pedagogical knowledge is important in teaching younger students such as Grade 9 students. He believed that mathematics lessons for younger students should not be purely academic but should be based on interactive learning activities. Similar to other Case 2 participants’ situations, there was no conditions for creating a balance of diversity and commonality in Sean’s and his associate teacher’s perspectives on learning and teaching.

Similar to other Case 2 participants, Tina did not read original educational research articles for supporting her instructional decision in practice teaching. Arguing that teacher candidates are not the primary consumers of research, Tina expressed an opinion that it would be better for teacher candidates to receive their certification in a school-based program rather than at the research university. She believes that having qualification received through research
universities creates nothing but overeducated unemployable teacher candidates who may understand the theory behind teaching but not its application. Tina shared that, from her experience, this theoretical over-education of teacher candidates at research universities contribute to the existence of a large pool of qualified but unemployed teachers.

While admitting that pedagogical knowledge provides the tools for teacher candidates to present the content knowledge in a more effective manner and that there is a significant interaction between these two types of knowledge, Tina emphasizes that educational research knowledge has a limited effect for teacher candidates especially when they are doing a short-term practicum. She argues that research knowledge can be used by curriculum leaders and administrators to help to implement policy. Tina point out that, for example, research showing that the new technology improves student learning can help to justify the purchase of the new technological equipment. She emphasizes that this way teacher candidates can benefit indirectly from these research findings without the need to read the original research articles. Similar to Sean’s situation, there was no conditions for creating a balance of diversity and commonality in Tina’s and her associate teacher’s perspectives on learning and teaching.

Both Case 3 interviewees, Susan and Tim, read original educational research articles to make instructional decisions in practice teaching. While prioritizing educational research knowledge as influencing content and pedagogy, they synthesized these three types of knowledge in their practice teaching and achieved a balance of diversity and commonality required for collective learning (McMurtry, 2010).

There was a higher level of diversity between Susan’s and Tim’s and their associate teachers’ perspectives on teaching and learning. Susan and Tim achieved a balance of diversity and similarity in these perspectives during practice teaching. This balance created conditions for Susan’s and Tim’s as well as their associate teachers’ and their students’ collective learning
about specific educational situations in classrooms during practicum, the conditions that were favorable enough to support overcoming theory-practice divide in Susan’s and Tim’s practice teaching. Their collective learning with their associate teachers during practicum can be viewed as a form of collaborative action research (McMurtry, 2010). This is an approach described in medical education research literature where the small (2-3 persons) groups of interprofessional students work on patient’s care as collaborative action researchers-practitioners based on the principles of collective learning (McMurtry, 2010).

Susan implemented research-based instructional strategies in her practice teaching such as real life connections to classroom mathematics and literacy in mathematics. Her associate teacher did not support her in utilizing the former strategy and disagreed with the latter one. However, Susan was able to gain at least her associate teacher’s neutrality toward her pedagogical innovations.

In the absence of support from associate teacher, Susan relied in part on her prior knowledge of scientific research that encouraged and supported her interest in reading original educational research articles. Susan valued her socializing into the methods of scientific research that occurred during her undergraduate studies. In her upper year courses, Susan’s readings were all based on original research articles and reviews. She learned from that how scientific research is conducted and what are its limitations. In particular, when media reported a particular study, Susan felt that she could critically evaluate the validity and reliability of the scientific results.

Susan applied educational psychology research findings about connecting classrooms to the outside world to her lesson planning and implementing during her practice teaching in a secondary school mathematics classroom. She showed students connections between mathematical concepts and the outside world. Susan tried to make connections between
secondary school mathematics and different professions such as engineering, architecture, construction.

Susan tried to apply research findings from the literature on literacy in mathematics in her practice teaching. The findings showed some connections between literacy abilities and success in mathematics. Taking in account these findings, Susan was always aware of her language and the literacy demands she was placing on her students when she was teaching a lesson, questioning students or assessing their performance. She always tried to use mathematics terminology and explanations in a simpler language to facilitate understanding for all students. In assessment, Susan always remembered about the proper use of terminology and students’ abilities to explain their thinking. As a result, Susan achieved a balance of diversity and commonality required for collective learning with her associate teacher and her students.

Tim was not happy with his mathematics methods course instructor’s approach. Tim’s disagreement with his university methods course instructor’s approaches encouraged him to look for alternatives. Although, before entering the initial teacher education program, Tim neither studied research methods in his discipline nor did he participate in conducting research, taking psychology courses with predominantly quantitative approaches to studying human behavior encouraged him to look for alternatives as well. He found an elective course in equitable mathematics, taught by an university professor who specialized in the studies of equity and social justice in mathematics education.

During both practica, Tim taught mathematics and implemented pedagogical ideas from his favorite elective course in equitable mathematics education that helped him to see the world of mathematics in a broader sense. He shared that this elective course gave him an opportunity to read many research papers and watch research videos. Tim pointed out that all of his pedagogical strategies during both practica were based on the ideas from this course. He
emphasized that the elective course in equitable mathematics education enriched his learning experience in the Bachelor of Education program. Similar to Susan, Tim achieved a balance of diversity and commonality required for collective learning with his associate teacher and his students.

Mutual interest in equitable mathematics allowed Tim and one of his associate teachers to work collaboratively. This associate teacher supported Tim’s innovative instructional approaches. Having the purely theoretical knowledge of equitable mathematics, Tim learned a lot from his associate teacher who had experience with applying this theory in practice. Tim shared that he used many of his associate teacher’s ideas because she helped him to see how equitable mathematics looked in a classroom on a practical level. All of these factors helped Tim to form a collective learner with his associate teacher who was impressed by his passion and commitment to equitable mathematics.

During the second practicum, Tim was not comfortable with the instructional approaches of his associate teacher. There was a higher level of diversity in their pedagogical ideas. Tim believed that this teacher gave students too much abstract and complex mathematics. His belief was supported by a student who felt that this type of mathematics was completely over his head. Tim was convinced that math became more fun when it was concrete and applicable, not abstract. Despite the differences in pedagogical views, he was able to maintain productive relations with his associate teacher. In particular, Tim was able to impress this associate teacher with his passion and commitment to equitable mathematics. While Tim believed that his associate teacher simply did not understand what Tim was trying to accomplish.

Paying attention to students’ interests and encouraging them to share their ideas, Tim was able to achieve a higher diversity of instructional approaches to practice teaching. His students appreciated his equitable approach to mathematics and liked him getting political in his teaching.
because it made mathematics more interesting. Tim was convinced that secondary school teachers need to make mathematics attainable for all students using a variety of strategies. He shared that he experimented with different faces of mathematics and its models to instill in his students a passion for exploration and learning. Tim believes that teaching mathematics is not only about mathematics itself. He thought about mathematics as his medium to teach his students how to become critical and engaged citizens.

In summary, this study found that the balance of diversity and commonality between participants and their associate teachers’ perspectives on learning and teaching became a factor contributing to teacher candidates’ RPACK perspectives and influencing conditions for overcoming theory-practice divide in their instructional decisions in various educational situations during practice teaching in secondary school mathematics classrooms. In turn, this balance of diversity and commonality was associated with a level of diversity between participants’ and their associate teachers’ perspectives on learning and teaching and with the level of the participants’ awareness of research-based teaching strategies.

In particular, a lower level of diversity between the Case 1 participant and his associate teacher’s perspectives on learning and teaching was associated with the domination of teachers’ culture on his instructional decisions in practice teaching. A lower level of diversity in these perspectives was associated with a lower level of his awareness of research-based strategies in teaching mathematics. With this lower level of diversity, there was no balance of diversity and commonality between the Case 1 participant and his associate teacher’s perspectives on learning and teaching. In turn, without this balance, conditions for collective learning about specific educational situations in classrooms during practicum were not favorable enough to support overcoming theory-practice divide in the Case 1 participant’s practice teaching.
Furthermore, an average level of diversity between Case 2 participants’ and their associate teachers’ perspectives on learning and teaching was associated with a compromise between perspectives on teaching and learning that they gained from their prior mathematically intensive disciplines on the one hand and from their associate teachers’ perspectives on the other hand. An average level of diversity between Case 2 participants and their associate teachers’ perspectives on learning and teaching was associated with an average level of their awareness of research-based strategies in teaching mathematics. With this average level of diversity, there was no balance of diversity and commonality between Case 2 participants’ and their associate teachers’ perspectives on learning and teaching. In turn, without this balance, conditions for collective learning about specific educational situations in classrooms during practicum were not favorable enough to support overcoming theory-practice divide in Case 2 participants’ practice teaching.

Finally, a higher level of diversity between Case 3 participants and their associate teachers’ perspectives on learning and teaching was associated with teacher candidates’ efforts to synthesize their content, pedagogical and educational research in practice teaching. A higher level of diversity between Case 3 participants and their associate teachers’ perspectives on learning and teaching was associated with a higher level of their awareness of research-based strategies in teaching mathematics. With this higher level of diversity, there was a balance of diversity and commonality between Case 3 participants and their associate teachers’ perspectives on learning and teaching. In turn, with this balance, conditions for collective learning about specific educational situations in classrooms during practicum were favorable enough to support overcoming theory-practice divide in Case 3 participants’ practice teaching.
5.2.1.4 Stages of Learning

In this section, I analyze participants’ stages of learning to teach secondary school mathematics. I use Nonaka, Toyama and Hirata’s (2008) 3-stage learning-breaking-creating theoretical model in their organizational knowledge creation theory. Similar to the collective learning concept (Davis & Simmt, 2006; McMurtry, 2010), this model assumes some balance of diversity and commonality between perspectives that each participant brings to the collective knowledge creating process within the organization.

This study found that teacher candidates’ stages of learning to teach secondary school mathematics were associated with the level of diversity between teacher candidates’ and their associate teachers’ perspectives on learning and teaching. In particular, a lower level of diversity between Leon’s and his associate teacher’s perspectives was associated with the first stage of learning in the 3-stage model. As was already discussed in the previous section, while some diversity of Leon’s and his teacher educators’ professional and personal knowledge provided an opportunity for Leon to revise and modify instructional strategies learned from them (McMurtry, 2010), this diversity was not sufficient to encourage him to synthesize all three types of knowledge in his practice teaching according to the principle of the interconnected nature of content, pedagogy and research in initial teacher education (ACDE, 2005). In revising and modifying instructional strategies, Leon’s goal was to make them more attractive and engaging for students in general rather than to achieve a specific learning outcome. As a result, he stayed at the first stage of the 3-stage model during his practice teaching.

As major resources of pedagogical and instructional knowledge for developing his revised and modified teaching strategies in the practicum lessons, Leon named ideas from his university mathematics methods course, taught by the experienced classroom teacher who demonstrated a variety of creative ways to deliver mathematics instruction, as well as face-to-
face discussions with instructors at university and colleagues at school. He placed pedagogical knowledge as the highest priority because he believed that pedagogical knowledge was needed for developing engaging lessons to inspire and motivate students to learn mathematics.

In Ontario, there are three levels of mathematics courses taught to Grade 9 and 10 students. The middle ability group of students focuses on mathematics for college or the workplace. During the practicum, Leon taught the middle level mathematics to Grade 9 students. His strategy of utilizing a lot of engaging activities worked well for this student population. Leon stated that his associate teacher was impressed by his engaging lessons in particular and his practicum teaching in general. He believed that his associate teacher respected his efforts to use a wide variety of teaching methods for delivering the content in refreshing ways for meeting educational needs of multiple types of learners. Leon pointed out that his students positively responded to his lessons by better engagement in learning activities. It can be interpreted in a way that Leon’s perception of success in utilizing revised and modified learning activities borrowed from other educators contributed to his decision to prioritize pedagogical knowledge.

Seeing limits in applying scientific quantitative research to education, he perceived qualitative educational research as having limitations in examining teaching practice as well. Leon points out that educational research may rely on teacher feedback in many situations because it is difficult to get quantitative data in education for some issues, and there is a very anecdotal and qualitative element to teaching. He argues that there is likely no practical way for outside observers to assess what is really going in a classroom without very detailed observation. Leon points out that it is difficult to decide whether a teacher or an outside observer is right in a specific teaching situation when education is partly an art form that has been practiced for thousands of years with no perfect solutions. He admits that educational research is definitely
valuable where there is a significant risk that, – due to a teacher’s specific flaws in the teaching style, biases, a lack of the objective perspective and unfamiliarity with research, – the teacher may mistakenly relate a positive learning outcome to one teaching strategy and negative to another.

However, Leon believes that the knowledge of educational research is not necessary in teaching mathematics. He views research knowledge as peripheral and the lowest in priority comparing to pedagogical and content knowledge. Instead, Leon argues that anecdotal evidence from a teacher's own experiences could yield such knowledge about the value of a teaching strategy and that collaboration with other teachers might provide such information as well. He believes that teachers can develop best practices based on a lot of individual observations.

An average level of diversity between Case 2 participants and their associate teachers’ perspectives on learning and teaching was associated with the second stage in Nonaka, Toyama and Hirata’s (2008) 3-stage learning-breaking-creating theoretical model. In contrast to Leon, all seven of the Case 2 interviewees, Megan, Stacey, Nicole, Sam, Kara, Sean and Tina, deliberately chose to avoid full immersion in secondary school instructional culture during their practice teaching. They preserved perspectives on learning and teaching that they developed during their prior studies of mathematically-intensive professions. They broke from their associate teachers’ perspectives back to their prior professions’ perspectives whenever it was possible. While Case 2 participants followed their associate teachers’ instructional advice to get along with them, they heavily relied on their prior training in mathematically intensive professions in making decisions about what is important in their subject content, how it should be taught, and why it should be taught (Bass, 2005; Melville & Wallace, 2007). As a result, the higher level of diversity in their educational perspectives than in Case 1 allowed them to move to the second stage in the 3-stage
model. However, without direct input from original educational research articles, the level of diversity was not high enough to move to the third stage in the 3-stage model.

A higher level of diversity between Case 3 participants’ and their associate teachers’ perspectives on learning and teaching was associated with the third stage in the 3-stage model. Prioritizing educational research knowledge as contributing to content and pedagogical knowledge, both Case 3 interviewees Tim and Susan progressed to this the most advanced stage of creating according to Nonaka, Toyama and Hirata’s (2008) 3-stage learning-breaking-creating theoretical model. In their practice teaching, they both used their own teaching strategies developed based on original educational research articles. Prioritising educational research knowledge, both Susan and Tim found inspiration in innovative research-based teaching methods and had courage to implement these methods during practicum.

Susan studied a number of original research articles on the role of literacy in teaching secondary school mathematics and developed her own teaching strategies based on this research literature. In planning her lessons, she used research findings about some connections between literacy abilities and success in mathematics. Susan shared that during practice teaching she was always aware of her language and the literacy demands that she was placing on her students in her lessons, especially when her students were answering questions or completing assessment tasks. Susan tried to use mathematics terminology and explanations in a simpler language to facilitate understanding to all students. In assessment, she was mindful of proper terminology use by her students and of their abilities to explain their thinking in any way they could.

In summary, this study found that participants’ stages of learning to teach secondary school mathematics became factors contributing to teacher candidates’ RPACK perspectives and influencing conditions for overcoming theory-practice divide in their instructional decisions in various educational situations during practice teaching. In turn, these stages of learning were
associated with a level of diversity between participants’ and their associate teachers’ perspectives on learning and teaching. These stages of learning were associated with the average level of participants’ awareness of research-based teaching strategies.

5.2.1.5 Values

In this section, I analyze participants’ perceptions about their ethical responsibility for student learning in their practice teaching secondary school mathematics. In particular, bringing up the issues of values and teachers’ responsibility for students’ learning triggered Leon’s (Case 1) theorizing about relations between educational research and practice teaching from a different point of view. Although Leon believed that anecdotal evidence from a teacher's own teaching experiences could yield knowledge about the value of a teaching strategy and its influence on student learning, he agreed there is a significant risk that, – due to a teacher’s specific flaws in the teaching style, biases, lack of the objective perspective, and unfamiliarity with research, the teacher may report negatively on one teaching strategy for not producing a successful outcome, and overlook the fact that the fault may lie with another factor entirely, such as classroom management. Similarly, in his opinion, the teacher may mistakenly relate a positive/successful learning outcome to some teaching strategy. The emergent finding here is that, admitting teachers’ ethical responsibility for students’ mathematics achievements, Leon recognizes the role of research in assessing the influence of a specific teaching strategy on student learning.

Although Leon gave the lowest priority to educational research knowledge, when he was encouraged to look at the same issue through the lens of values, ethics and moral responsibilities of teachers for student learning, he admitted that educational research could be helpful in deciding whether a specific teaching strategy produced a desired student learning outcome. However, admitting the helpfulness of educational research, Leon did not change his position about teachers’ ethical responsibility for student learning. He believes that anecdotal evidence
from a teacher's own experiences could yield the knowledge about the value of a teaching strategy. Leon added that collaboration with other teachers might provide more reliable information about the value of a specific teaching strategy rather than an opinion of one teacher. He believed that teachers, departments and schools could develop best teaching practices by synthetizing a lot of individual teachers’ observations. Leon reasoning can be interpreted in a way that, prioritizing pedagogical knowledge and full immersion into the practicum school’s teaching culture, fulfilled his ethical responsibility for student learning in his practice teaching.

By prioritizing content knowledge, Megan, Stacey, Nicole, Kara, Sam, Sean and Tina reveal an implicit belief that their strong knowledge of secondary school mathematics fulfills their ethical responsibility for student learning. This belief is in line with Dewey’s (1975) and Falkenberg and Noyes’ (2010) views of the development of intellectual ideas as a moral endeavour where these intellectual ideas become motivating and moving forces that guide students’ conduct. Case 2 participants’ experiences also support the research finding about a positive association between prospective secondary school mathematics teachers’ college study of mathematics and the mathematics learning of their secondary school students (Cochran-Smith & Zeichner, 2005).

For Megan, the core of teacher candidates’ ethical responsibility for student learning is in the solid knowledge of content. She believes that it is unfortunate and not fair for students to have a teacher with a limited understanding of math concepts. Megan argues that teaching incorrect math concepts could ruin the future of the students. She insists that only teachers who have a deep understanding of math should seek to teach it.

In contrast, Megan feels that a math teacher who is a poor pedagogue is not completely disastrous because, although students would struggle much more than necessary to grasp math concepts, they eventually would understand them. Despite her knowledge of and experience in
scientific research, Megan believes that intuitive and trial and error teaching strategies are more valuable rather than those based on the findings of educational research that she narrowly views as educational psychology research. Furthermore, she thinks that student learning occurs when students decode and absorb knowledge conveyed by the teacher using their individual skills.

Stacey believes that the use of any type of knowledge is directed by teacher candidates’ attitude and inner frame of mind. Although Stacey formally espouses a belief that teacher candidates should continue learning and reflecting on current research and pedagogy to increase student learning, she believes that the best teacher must have an expert, deep and broad knowledge of his or her subject area. She insists that students must be inspired by the content more than anything else. These views suggest that she believes in fulfilling her ethical responsibility for student learning through her strong knowledge of mathematics. Stacey shares that it is difficult for her to leave the logic and self-centeredness of mathematics and to accept educational research with its case study/observation methods because this is so different from her experience of research, which was a very internal process with limited tools.

Although Nina espouses a belief that all three factors (especially pedagogical and research knowledge) will forever be changing and adapting to the students best interests, she does not see herself as an active participant in this process preferring to take into account what strategies other teachers might have used. Similar to Stacey, Nina seems to believe that her strong knowledge of mathematics fulfills her ethical responsibility for student learning. Kara feels the same way as Stacey and Nina. Kara believes that her strong knowledge of secondary school mathematics fulfills her ethical responsibility for student learning. This belief was strengthened by her students’ feedback at the end of the practicum. This feedback indicated that her confidence in teaching an advanced mathematical course was important for her students. However, Kara admitted that she did not implement differentiated instruction strategies and
equitable mathematics ideas in her practice teaching to increase student learning because she wanted to get along with her associate teacher and tried to match her teaching style.

Sean was confident in student learning in his practicum classes because both the students and the associate teacher’s reactions to his practice teaching were overwhelmingly positive and always better than he expected. Similar to other Case 2 participants, Sean seems to believe that his strong knowledge of secondary school mathematics fulfilled his ethical responsibility for student learning.

Tina shares other Case 2 participants’ belief on the issue of ethical responsibility for student learning. Despite her knowledge of and experience in scientific research, Tina did not try to make connections between her prior research and educational research arguing that her teacher educators should decide what research to provide to help the teacher candidate become a better teacher and did not see herself among the primary consumers of research.

At first glance, Sam’s perspective on teacher candidate’s ethical responsibility for student learning is substantially different from the perspectives of the other six interviewees in Case 2. In contrast to those six participants, he espouses a belief that the issue of equity and social justice are the most important aspects of education. Although Sam prioritized content knowledge, our discussion about teachers’ ethical responsibility for student learning triggered his theorizing about relations between educational research and practice teaching from a different point of view. In his opinion, there is an ethical/moral argument to be made to the importance of the research-based teaching methods because those who may be deprived or oppressed are innocent children who end up falling victim to bad teaching. He is convinced that each researcher and educator should never forget that they are in the sacred business of helping empower the soul of a child or youth. However, Sam is not comfortable with the idea of reading original research articles as active consumer of research and applying the research findings.
It was difficult for Sam to think about teacher candidates as consumers of educational research because he believed that the term consumer assumed the power to choose. However, in his opinion, due to the existing dynamic of power relations between university researchers and teacher candidates, the latter do not really have the power to choose. Instead, Sam feels there is a lot of responsibility on researchers. He believes that there is the need to challenge the current paradigm of what research is and what the role of the research is.

For Sam, the way of representing the educational research findings to teacher candidates is really important. He explained that the way of presenting research finding to teacher candidates could trigger the issue of prejudice and paternalism for him. He needs to feel that researchers are motivated by desire to empower teacher candidates when they present research findings to them. It disturbs him when researchers are “dumbing down” research findings.

Sam felt that the lack of communication between graduate research students and teacher candidates is similar to tracking in schools and to relationship between early Africans and the European colonizers. In this disconnect, he saw the same patterns and the same social dynamics that existed in colonization. He brought up the issue of colonization because he has recently spent eight months in Zambia.

Being uncomfortable with the view of teacher candidates’ as consumers of research and constantly questioning the motivation of researchers for sharing their research findings, Sam joined the rest of Case 2 participants in the belief that their strong knowledge of secondary school mathematics fulfills their ethical responsibility for student learning. It can be interpreted in a way that, for him, the strong content knowledge of teacher candidates’ can be sufficient for empowering and not depriving students when this knowledge shared with the students without prejudice, racisms and paternalism no matter what teaching strategy, traditional or research-based, was implemented.
Taking their ethical responsibility for student learning seriously, both Susan and Tim (Case 3) used in their practice teaching pedagogical strategies that increase student achievement in secondary school mathematics according to the findings of empirical educational research. In particular, without any support from her associate teacher in applying educational psychology research findings about the importance of connecting real life and classroom mathematics, Susan tried to show these connections to her students in all her lessons. She spent plenty of time to research these connections before presenting them to the students and to finding out about the applications of mathematics beyond school.

Susan experienced even more difficulties in her efforts to apply in her practice teaching research findings about connections between literacy abilities and success in mathematics. She did it despite the disapproval of her associate teacher who dismissed literacy in mathematics concerns as unimportant. Susan based her applications both on original research articles and Ministry of Education documents. Despite the fact that non-traditional forms of assessment were not welcomed in the department of mathematics at the practicum school, she tried to use literacy-in-mathematics research findings in her assessment of students. She believed that heavily relied on reading and writing abilities tests and quizzes could be barriers to student learning. Susan always tried to use a simpler language in teaching. When assessing students’ learning, she took in account their abilities to explain their thinking.

Tim believes that it is the ethical responsibility of teachers to help their students to become critical and engaged citizens by making mathematics attainable for all their students. Tim’s belief is in line with a social turn in the mathematics education research community towards a greater interest in the values and broader educational purposes of mathematics education, including issues of social justice and citizenship education (Falkenberg & Noyes, 2010). Tim thinks that, instead of bragging about their knowledge of mathematics, teachers
should focus on facilitating student learning by approaching secondary school mathematics from the perspective of secondary school students. Viewing mathematics as socially constructed, Tim believes that there are many ways of doing secondary school mathematics to make it accessible to all students. He disagrees with the positivistic views of teachers and teacher candidates who see only one way of doing mathematics and who force their students to do it this way.

In summary, this study found that participants’ values became factors contributing to teacher candidates’ RPACK perspectives and influencing conditions for overcoming theory-practice divide in their instructional decisions in various educational situations during practice teaching. Specifically, participants’ perceptions of their ethical responsibility for student learning in practice teaching were associated with the levels of diversity between participants and their associate teachers’ perspectives on learning and teaching. This perception was associated with the level of the participants’ awareness of research-based teaching strategies.

5.2.1.6 Integration of Research

In this section, I analyze participants’ perspectives on the integration of educational research into their practice teaching secondary school mathematics. While Leon (Case 1) respects other teacher candidates’ perspectives on educational research integration, he believes that their educational research knowledge is peripheral to the other two types of knowledge and is not necessary in teaching mathematics. Although Leon likes to modify existing teaching strategies, his modifications are based on anecdotal evidence from his own teaching experience about the learning outcomes of these modified strategies. He never tried to modify existing teaching strategies based on reading original educational research articles. Leon is convinced that education involves uniquely personal and non-duplicable situations between specific students and specific teachers. He believes that there is a very anecdotal and qualitative element
in pedagogical issues that would be difficult to address relying only on data obtained by university researchers without consulting with practicing teachers about these data interpretation.

Leon recognizes that educational research findings possibly can be used to reform and modify pedagogical knowledge to improve existing practices and enhance the ability to reach out to all types of learners. However, this recognition does not have any influence on his opinion about the integration of educational research into practice teaching. This recognition simply shows Leon’s respect to other peoples’ views on the issue. For example, he respects an opinion that formative classroom assessment can be viewed as a type of mixed methods research where quizzes and tests can provide some quantitative data about student learning and questioning can be used to qualitatively assess student understanding. However, this opinion does not spark Leon’s interest in mixed methods research in education.

Moreover, he challenges some opinions. For example, while formally acknowledging that the process of socializing teacher candidates into educational research culture can make them better informed consumers of research, Leon insists that it would not be enough for researchers to merely visit as guest speakers or even teach mathematics methods courses for this to happen. He argues that, for teacher candidates to truly be immersed in and appreciate the inner workings of research, they need to be actively involved in research themselves. Leon suggests that, for this research immersion to happen, teacher candidates can assist a researcher for a month during the internship component of the Bachelor of Education program. Leon emphasizes that only by actively participating in an educational research project can teacher candidates better understand the value, limitations and pitfalls of educational research and its importance for educational practice. He agrees that, by socializing into research culture in this project, teacher candidates more likely would implement some newer research-based ideas and innovations in their classroom such as using social constructivist and student-centered learning...
environments or using guided inquiry labs. He admits that, without knowledge of educational research, teacher candidates may ignore much of the recent developments in education.

The Case 2 participants do not share Leon’s strong skepticism about the educational research findings of university researchers without direct involvement of practicing teachers. Although Megan, Stacey, Sam, Nicole, Kara, Sean and Tina did not use original research articles in their practice teaching, they expected that the integration of educational research into teaching practice should be done by intermediaries. Case 2 participants’ experiences are in line with research that shows that practitioners rarely come into contact with primary research directly from academic journals but engage with research indirectly through the professional development, the media and often through various third party organizations (Cooper, 2012).

Megan believes that teacher candidates should receive new pedagogical and educational psychology research knowledge from third parties: pre-service and in-service professional development programs as well as from mentors at schools. While expressing belief in ongoing reflecting on current research and pedagogy, Stacey thinks that it is good enough to know something about developed and researched best practices. She feels uncomfortable to leave the logic and self-centeredness of mathematics in order to read original educational research articles. Similarly, Nina prefers to reproduce teaching strategies shared by others. She does not see herself as an active participant in changing and adapting pedagogical and research knowledge to the students’ best interests.

Sam’s perspective on the integration of research into practice can be interpreted in a way that he expects the existence of intermediaries between educational researchers and teacher candidates. When asked to what extent the university community involved him and others in the events relevant to educational research, Sam replied that he viewed himself more informed than others about the life of the university community because of his active role in the Student
Teachers’ Union. However, he was never invited to the open workshop for teachers pursuing research degrees. Sam did not have any contacts with the graduate students involved in educational research.

Sam tried to make connections between knowledge translation in health care and knowledge mobilization in education. While acknowledging the importance of teacher candidates’ research knowledge, Sam argued that teacher candidates seem to turn away from it because of the cryptic nature of educational research articles and their overwhelmingly high volume that requires the involvement of the third party for proper translating research findings to teacher candidates. Sam believes that here is a need in systems/processes that educate teachers in the importance of applying research to their teaching methods.

Sam argues that a lot of the responsibility lies with researchers for helping teacher candidates to become consumers of educational research. He believes that there is the need to challenge the current paradigm of what research is and what the role of the research is. Sam thinks that socializing teacher candidates into educational research discourse can succeed only when it is done in a non-paternalistic way. He envisioned a dialog of equals between university researchers and teacher candidates as well as associate teachers and their colleagues where university researchers make an effort to immerse into school culture for better understanding the needs of teaching practice.

Sam suggested establishing research departments in schools to support teachers involved in researching their teaching practice and encouraged to conduct research with monetary compensation and lighter teaching load. He viewed these research departments as the agents of knowledge mobilization responsible for disseminating research findings. Sam shared that it is really important how educational research findings are presented to him and what is the motivation behind the form of presentation because the way of presenting may raise the
prejudice/paternalism issue for him. The educational research findings to him are really important. Sam insisted that research finding must be presented with the intention to empower teacher candidates and not in paternalistic and condescending manner.

Kara believes that teachers accumulate pedagogical and educational research along their teaching experience. However, she did not mention original research articles readings as her source for research findings. Instead, Kara named the mathematics department’s resources and discussions with other teachers about ideas as the ways to learn about pedagogy and research. Similarly, Sean gained his instructional ideas from his own previous teaching experience and from professional discussions with his associate teacher who was the head of mathematics department at practicum school. He emphasized that he never consulted any educational research articles during practice teaching.

Not viewing herself as a primary consumer of research, Tina believes that her teacher educators should decide whether she needs to know some research findings to become a better teacher. Instead, she sees curriculum leaders, administrators and policymakers as primary consumers of research who are responsible for implementing research-based policy. Tina emphasizes that this way teacher candidates can benefit from research without the need to read research articles.

In Case 3, both Susan and Tim chose active participation in the integration of educational research into teaching practice by reading original research articles and applying educational research findings in their practice teaching. The emergent finding here is that some teacher candidates prefer to use original research findings in their practice teaching. In her attempts to apply research findings from the literature on literacy in mathematics in her practice teaching, Susan read some original research articles about literacy in mathematics. In all her lessons, Susan tried to apply educational psychology research findings that a part of effective teaching is
connecting classrooms to the outside world. Responding to students’ inquiries, she searched for information about mathematics’ connections with different professions.

Prioritizing educational research knowledge, Susan believes that, to some extent, formative assessment of student learning can be viewed as a type of research that teachers routinely do. In particular, Susan thinks that teachers’ inquiries are similar to those of educational researchers in the way data is obtained. However, she acknowledges that the analysis of data is the key here and that educational research analysis of data is more rigorous and critical than simply forming an opinion.

Tim’s disagreement with the dominance of positivist approaches in his psychology courses, taking prior to the entering the Bachelor of Education program, encouraged him to look for alternatives in educational research studies. He believes that a lot of reliance on quantifying human behavior is not appropriate in education. Tim criticizes approaches to teaching secondary school mathematics that is not based on research. Tim argued that research is critical to both mathematics and to pedagogy. He clarifies that educational research is important because it informs pedagogy, helps to learn about new instructional strategies and allows to experiment with different faces of mathematics and its models to instill in students a passion for exploration and learning.

The examples of applying educational research content knowledge can be found in Susan’s and Tim’s practice teaching. Educational research content knowledge is the fusion of research and content knowledge that forms the new ways of teaching content based on the educational research findings as well as provides a new theoretical lens on the processes of teaching and learning in classroom. Inspired by the educational research literature on literacy in teaching mathematics, Susan tried to remove the barrier in student learning created by the dominance of the traditional methods of assessment in tests and quizzes heavily relied on
students’ reading and writing abilities rather than on their knowledge of mathematics. In her practice teaching, she focused on simpler language, the proper use of mathematical terminology, and students’ abilities to explain their thinking. Similarly, influenced by the research on equity and social justices, Tim focused in his practice teaching on making mathematical content attainable for all his students by constantly being aware of their perspectives on high school mathematics.

In summary, this study found that the participants’ views of the integration of educational research into practice teaching secondary school mathematics became factors contributing to teacher candidates’ RPACK perspectives and influencing conditions for overcoming theory-practice divide in their instructional decisions in various educational situations during practice teaching. Specifically, the participants’ views of the integration of educational research into practice teaching were associated with the levels of diversity between participants’ and their associate teachers’ perspectives on learning and teaching. Also, this view was associated with the level of the participants’ awareness of research-based teaching strategies.

In particular, a lower level of diversity between the Case 1 participant’s and his associate teacher’s perspectives on learning and teaching was associated with the view that there is a very anecdotal and qualitative element in pedagogical issues that would be difficult to address relying only on data obtained by university researchers without consulting with practicing teachers about these data interpretation. Out of respect for other people’s opinions, the Case 1 participant recognized possible benefits from integrating educational research into practice teaching secondary school mathematics. However, this recognition did not have any influence on his opinion about research integration. Moreover, the Case 1 participant challenged some opinions of others about research integration. Also, this view was associated with a lower level of his awareness of research-based teaching strategies.
Furthermore, an average level of diversity between Case 2 participants’ and their associate teachers’ perspectives on learning and teaching was associated with the expectation that the integration of educational research into teaching practice should be done by intermediaries. Case 2 participants do not share the Case 1 participant’s strong skepticism about the educational research findings of university researchers without direct involvement of practicing teachers. Also, this perception was associated with an average level of Case 2 participants’ awareness of research-based teaching strategies.

Finally, a higher level of diversity between Case 3 participants’ and their associate teachers’ perspectives on learning and teaching was associated with the view that teacher candidates should be actively involved in integrating educational research into practice teaching secondary school mathematics. Also, this perception was associated with a higher level of Case 3 participants’ awareness of research-based teaching strategies.

5.3 Major Findings

1. Participants’ different perspectives on their research pedagogical and content knowledge (RPACK) were associated with the different levels of their reform mindedness in mathematics education as measured by survey. The three sets of participants (low, medium and high reform minded teacher candidates) were identified.

2. The low reform minded participant placed pedagogical knowledge as the first priority. He placed content knowledge and educational research knowledge as the second and the third priorities, respectively.

3. The medium reform minded participants placed content knowledge as the first priority. The placed pedagogical knowledge and educational research knowledge as the second and the third priorities, respectively.
4. While the high reform minded participants placed educational research knowledge as the first priority, they emphasized the importance of synthesizing all three types of knowledge.

5.4 Suggestions and Considerations for After-Degree Bachelor of Education Programs

Based on the findings of this study, the following suggestions can be made for improving teacher candidates’ learning to teach secondary school mathematics:

1. Teaching methods courses should be taught by experienced teachers with an earned Ph. D. in Education.

2. Applicants’ prior disciplinary research knowledge and experiences should be taken in account for making enrollment decisions. This would increase the number of teacher candidates interested in becoming the informed consumers of educational research who regularly read original research articles.

3. Teacher educators should capitalize on teacher candidates’ prior disciplinary research knowledge and experiences to help them becoming the informed consumers of educational research and to spark their interest in reading original research articles.

4. Teacher candidates should be involved in discussing teacher ethical responsibility for student learning. This would motivate them to pay more attention to educational research on teaching strategies increasing student mathematics achievements.

5. More attention should be paid to the diversity of teacher candidates’ educational backgrounds and worldviews as well as to the contradictions and tensions surrounding the theory-practice divide in their practice teaching. This would help them to be better prepared for teaching in culturally and socially diverse secondary school classrooms.
6. The collective nature of learning to teach should be emphasized. This would encourage teacher candidates to look for opportunities to participate in professional conferences, workshops and networking.

7. Internationally trained teacher candidates should be encouraged to share their experiences and perspectives on teaching and learning with peers. This would help teacher candidates to be better prepared for teaching the student population of recent immigrants to Canada.

5.5 Implications for Future Research

This research can be viewed as a first step in a program of studying the research pedagogical and content knowledge (RPACK) of teacher candidates who are learning to teach mathematics to the school students of different ages in other types of initial teacher education programs.

It would be a valuable contribution to the research literature on pre-service teacher education to conduct research on teacher candidates’ learning experiences when they use their content, pedagogical and educational research knowledge in practice teaching in other types of initial teacher education programs.

This study was done for the Intermediate/Senior (grades 7 – 12) Consecutive Bachelor of Education Program. It would be a valuable contribution to the research literature on pre-service teacher education to compare, cross-analyze and synthesize the findings in the studies on learning experiences of teacher candidates in other types of initial teacher education programs.

Another valuable contribution to the literature on initial teacher education can be produced by a future study that focuses on the evolution of secondary school mathematics teacher candidates’ perspectives on their research pedagogical and content knowledge and factors influencing this evolution. Future participants should by surveyed and interviewed at least at
three points in time: at the beginning, at the end of the initial teacher education program and at
the end of the first year of participants’ teaching at schools.

It would be interesting to conduct similar studies with the focus in a number of other
areas of teacher certification and to compare findings of these studies.

5.6 Limitations of the Study

There is no research without limitations (Marshall & Rossman, 1999). Limitations of the study are listed below.

1. The findings of the study was based on the investigation of a consecutive teacher education program only in one university in Ontario.

2. I used purposeful sampling in the quantitative phase of the study. The sample was likely not representative of the population. I understand that findings cannot be generalized beyond very similar environments.

3. Only one out of the three types of teacher education programs at the university was studied. As a result, I missed an opportunity to compare data from consecutive program with data from concurrent and two-year programs that also provide teacher certification in two subject-matter areas.

4. Because of the nature of qualitative research, the data obtained in the qualitative phase of the study could be interpreted differently by different readers.

5. Complexities of the reform movement in mathematics. There is disagreement amongst teachers, teacher educators, parents and researchers about the effects and impact of mathematics reform.
References


culture, difference (pp. 207-221). London: Lawrence & Wishart.


both communities and organizations. *Teaching and Teacher Education, 23*(7), 1193-1205.


Appendix A

Survey

Part A:

1. Are you an internationally trained teacher candidate? NO  YES

2. Mark one of the 3 lines below, which is applicable to you and follow the instructions in the marked line:

   ____ I taught mathematics during my first practicum.

   ____ I taught mathematics during my second practicum

   ____ Other (Explain)________________________________________________________________________

Self-Report Questionnaire: Teacher Candidates’ Reform-Mindedness in Mathematics Education

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<tr>
<th>Statements</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Tend to Disagree</th>
<th>Tend to Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
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<tbody>
<tr>
<td>1. I like to use math problems that can be solved in many different ways.</td>
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<td>2. I regularly have my students work through real-life math problems that are of interest to them.</td>
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<td>3. When two students solve the same math problem correctly using two different strategies I have them share the steps they went through with each other.</td>
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<td>4. I tend to integrate multiple strands of mathematics within a single unit.</td>
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<td>5. I often learn from my students during math time</td>
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because my students come up with ingenious ways of solving problems that I have never thought of.

6. It is not very productive for students to work together during math time.

7. Every child in my room should feel that mathematics is something he or she can do.

8. I integrate math assessment into most math activities.

9. In my classes, students learn math best when they can work together to discover mathematical ideas.

10. I encourage students to use manipulatives to explain their mathematical ideas to other students.

11. When students are working on math problems, I put more emphasis on getting the correct answer than on the process followed.

12. Creating rubrics for math is a worthwhile assessment strategy.

13. In my class it is just as important for students to learn data management and probability as it is to learn multiplication facts.

14. I don't necessarily answer students' math questions but rather let them puzzle things out for themselves.

15. A lot of things in math must simply be accepted as true and remembered.
16. I like my students to master basic mathematical operations before they tackle complex problems.

17. I teach students how to explain their mathematical ideas.

18. Using computers to solve math problems distracts students from learning basic math skills.

19. If students use calculators they won't master the basic math skills they need to know.

20. If students use calculators they won't master the basic math skills they need to know.

Part B:

Demographic Questions

This next section contains seven questions. Provide your answers in the text boxes available.

1. What is your other Intermediate/Senior teaching subject that you are qualified to teach as of April 2011?
   Other teaching subject? ___________________________________________

2. What is your undergraduate ‘major’ (or equivalent)?
   Undergraduate ‘major’ or (equivalent)? _____________________________

3. What is your undergraduate ‘minor’ (or equivalent, if applicable)?
   Undergraduate ‘minor’ (or equivalent, if applicable) _____________________

4. What is your graduate ‘major’ (or equivalent, if applicable)?
   Graduate ‘major’ or (equivalent, if applicable)? __________________________

5. What is your graduate ‘minor’ (or equivalent, if applicable)?
   Graduate ‘minor’ (or equivalent, if applicable) ___________________________

6. Other educational background, if applicable (e.g., some jurisdiction view your foreign credentials as Ph.D. equivalent or you have more than one undergraduate/graduate degree or equivalent _________________________________________________________________

7. Did you take the elective course Science and Technology in Context EDU5517?
Yes_____  
No_____  

8. Prior to entering your Bachelor of Education, did you take any research methods course?  
Yes _____  
No _____  

9. Prior to entering B. Ed, did you participate in any empirical research at any level and in any capacity?  
Yes _____  
No _____  

**Part C: Contact Information.**  

This section is to be completed if you agree to be a possible candidate for a follow-up interview. The interview would last about 45 minutes.  

1. Please provide your contact information:  
   Name _________________________________________  
   Email address ___________________________________  
   Phone number (optional) ___________________________
Appendix B

Dimensions (D) of Reform-Minded Mathematics Teaching (Ross et al., 2003)

D1: Program scope
A broader scope (e.g., multiple mathematics strands with increased attention on those less commonly taught such as probability, rather than an exclusive focus on numeration and operations) with all students having access to all forms of mathematics.

D2: Student tasks
Student tasks are complex, open-ended problems embedded in real life contexts; many of these problems do not afford a single solution. In contrast, in traditional mathematics students work on routine applications of basic operations in decontextualized, single solution problems.

D3: Constructivist approach
Teaching in inquiry-oriented classes focuses on constructing mathematical ideas by students in contrast with the transmission of canonical knowledge through presentation, practice, feedback, and remediation in traditional programs.

D4: Teacher's role
The teacher's role in inquiry-oriented settings is that of co-learner and creator of a mathematical community rather than sole knowledge expert.

D5: Manipulatives and tools
Mathematical problems are undertaken in inquiry-oriented classes with the aid of manipulatives and with ready access to mathematical tools (i.e., calculators and computers). In traditional programs such tools are not available or their use is restricted to teacher presentations of new ideas.

D6: Student-student interaction
In inquiry-oriented teaching the classroom is organized to promotes student-student interaction, rather than to discourage it as an off task distraction.

D7: Student assessment
Assessment in the inquiry-oriented class is authentic (i.e., relevant to the lives of students), integrated with everyday instruction, and taps multiple-levels of performance. In contrast, assessment in traditional programs is characterized by near-transfer weekly and unit tests.

D8: Teacher's conceptions of math as a discipline
The teacher's conception of mathematics in the inquiry-oriented class is that of a dynamic subject rather than a fixed body of knowledge.

D9: Student confidence
Teachers in the inquiry-oriented setting strive to raise student self-confidence in mathematics rather than impede it.
## Appendix C

### Connections between the Questionnaire’s Items and Dimensions

Self-Report Questionnaire: Teacher Candidates’ Reform-Mindedness in Mathematics

**Education**

<table>
<thead>
<tr>
<th>Item number</th>
<th>Item</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I like to use math problems that can be solved in many different ways.</td>
<td>D2</td>
</tr>
<tr>
<td>2</td>
<td>I regularly have my students work through real-life math problems that are of interest to them.</td>
<td>D2</td>
</tr>
<tr>
<td>3</td>
<td>When two students solve the same math problem correctly using two different strategies I have them share the steps they went through with each other.</td>
<td>D6</td>
</tr>
<tr>
<td>4</td>
<td>I tend to integrate multiple strands of mathematics within a single unit.</td>
<td>D1</td>
</tr>
<tr>
<td>5</td>
<td>I often learn from my students during math time because my students come up with ingenious ways of solving problems that I have never thought of.</td>
<td>D4</td>
</tr>
<tr>
<td>6*</td>
<td>It is not very productive for students to work together during math time.</td>
<td>D6</td>
</tr>
<tr>
<td>7</td>
<td>Every child in my room should feel that mathematics is something he/she can do.</td>
<td>D9</td>
</tr>
<tr>
<td>8</td>
<td>I integrate math assessment into most math activities.</td>
<td>D7</td>
</tr>
<tr>
<td>9</td>
<td>In my classes, students learn math best when they can work together to discover mathematical ideas.</td>
<td>D6</td>
</tr>
<tr>
<td>10</td>
<td>I encourage students to use manipulatives to explain their mathematical ideas to other students.</td>
<td>D5</td>
</tr>
<tr>
<td>11*</td>
<td>When students are working on math problems, I put more emphasis on getting the correct answer than on the process followed.</td>
<td>D2</td>
</tr>
<tr>
<td>12</td>
<td>Creating rubrics for math is a worthwhile assessment strategy.</td>
<td>D7</td>
</tr>
<tr>
<td>13</td>
<td>In my class it is just as important for students to learn data management and probability as it is to learn multiplication facts.</td>
<td>D1</td>
</tr>
<tr>
<td>14</td>
<td>I don't necessarily answer students’ math questions but rather let them puzzle things out for themselves.</td>
<td>D3</td>
</tr>
<tr>
<td>15*</td>
<td>A lot of things in math must simply be accepted as true and remembered.</td>
<td>D8</td>
</tr>
<tr>
<td>16*</td>
<td>I like my students to master basic mathematical operations before they tackle complex problems.</td>
<td>D1</td>
</tr>
<tr>
<td>17</td>
<td>I teach students how to explain their mathematical ideas.</td>
<td>D4</td>
</tr>
<tr>
<td>18*</td>
<td>Using computers to solve math problems distracts students from learning basic math skills.</td>
<td>D5</td>
</tr>
<tr>
<td>19*</td>
<td>If students use calculators they won't master the basic math skills they need to know.</td>
<td>D5</td>
</tr>
<tr>
<td>20*</td>
<td>You have to study math for a long time before you see how useful it is.</td>
<td>D9</td>
</tr>
</tbody>
</table>

* Denotes negatively worded item.
Appendix D

Outline of Interview Questions

What is your perspective on the role of the listed below three factors in teaching secondary school mathematics? In your perspective, how these three factors interact with each other in teaching secondary school mathematics? The three factors are:

Factor 1: Teacher candidate's content knowledge (knowledge of secondary school mathematics).
Factor 2: Teacher candidate's pedagogical knowledge (knowledge of teaching methods).
Factor 3: Teacher candidate's research knowledge (knowledge of educational research on teaching and learning).

Please describe educational research finding(s) that you tried to apply to your lesson planning and implementing during your practice teaching secondary school mathematics. (Please specify the source of the educational research finding(s): reading original research paper, reference to research finding in your course work, internet search, etc.)

What supports and/or barriers did you experience in your attempts to apply these findings to lesson planning and implementing during your practice teaching secondary school mathematics?

What was the reaction of your students and/or associate teacher and/or university instructor/supervisor to your attempts to apply these findings to lesson planning and implementing during your practice teaching secondary school mathematics?

In your opinion, is there any resemblance between educational research and everyday consumer research as well as everyday problem solving?

In your opinion, can we view routine formative classroom assessment as a type of quantitative (quiz and test scores), qualitative (checking student understanding through
questioning/interviewing) or mixed methods (both quiz/test scores and questioning/interviewing) research?

In your opinion, would socializing teacher candidates into educational research make them informed consumers of research? Would aligning graduate research programs with B. Ed. program contribute to this socializing? By aligning graduate research programs with B. Ed. program I mean that research professors would teach math methods courses or at least often come to methods courses as guest speakers and invite teacher candidates to be their research assistants during internship.

Do you believe that teacher candidates should be socialized into research culture in the same way as they socialized into school culture?
Appendix E

Letter of Information

My name is Alexander Antropov, and I am a Ph.D. student at the Ontario Institute for Studies in Education, University of Toronto. I am currently conducting research about secondary school mathematics teacher candidates’ research pedagogical and content knowledge. I would like to invite you to participate in this research.

Data for this research will be collected via the survey with a 20-item questionnaire and demographic section. The estimated time for completing this survey is up to 20 minutes.

Also, if you are interested, I would like to invite you to participate in a 45-minute individual interview.

If you agree to participate in the interview, you will be asked to provide contact information at the end of the survey. If you only complete the survey, any identifying information will be modified with pseudonyms to ensure your anonymity.

If you elect to participate in the interview, any identifying information will be modified with pseudonyms once the interview is complete to ensure your anonymity.

After the analysis phase has begun, when not used for analysis purposes, all data collected will be kept locked in my office. As well, after the study, all data collected will remain locked in my office, and will be destroyed within 7 years of the completion of the study. All data collected will be used for research purposes only.

Your participation is voluntary. Should you consent to participate in this research, please be aware that you have the right to withdraw at any time, should you wish to do so, or to decline to answer any specific questions you would prefer not to answer. There are no known risks by participating in this study. The research findings will be provided upon request, when they are ready.

If you have any questions about this research, or any comments to make now or at a later date, please contact

Alexander Antropov at [email address] or
Dr. Douglas McDougall at [phone number], [email address].

If you wish to speak with someone aware of but not directly involved with the study, about your rights as a research participant, please contact the University of Toronto Ethics Review Office, 416-946-3273, ethics.review@utoronto.ca.