Describing the experiences of teachers undertaking Educational Design-Research (EDR) as a form of Teacher Professional Learning

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Abstract

Presently in Victoria there is a move to "introduce practitioner-led research, requiring teachers to undertake a new individual or team-based research project every two years" (Department of Education and Early Childhood Development [DEECD], 2012, p. 19). The justification for this is that high performing, or top-tier, systems in the Organization for Economic Co-operation and Development (OECD) "support research undertaken by teachers to drive innovation and school system improvement" (DEECD, 2012, p. 15). However, we are often provided with little or no information about the specific characteristics of the research experience and/or research context that are responsible for promoting this growth (Zeichner, 2003).

The purpose of this study is to examine the experiences of teachers participating in practitioner research, specifically Educational Design-Research (EDR), and its potential for teacher professional learning. EDR is the systematic study of designing, developing and evaluating educational programs, processes, and products (Plomp, 2007). The methodology is designed by and for educators seeking to increase the impact, transfer, and transitioning of education research into improved practice. In addition, EDR stresses the need for theory building and the development of design principles that guide, inform, and improve both practice and research in educational contexts (Anderson & Shattuck, 2012). A key aspect of this thesis is the examination of the claim made by McKenney and Reeves (2013) that one of the two main goals of EDR is to benefit practice. To date this claim has been underexplored in the literature.

In its simplest form, EDR is what educators (researchers and teachers) do when they pursue an instructional solution. A teacher and researcher collaborate to focus their thinking in order to satisfy wants and needs regarding a particular student, group of students or context. They recognize and define information relevant to their purpose, consider alternatives, decide what to do, do it,

determine if they are satisfied with the results, and if not, revise their approach until they are successful. All the while they are learning through the experience. EDR is a process of creative and critical thinking that allows information and ideas to be organized, decisions to be made, situations to be improved, and knowledge to be gained. While design is not widely considered to be the central or distinguishing activity of teaching, as educational systems increasingly incorporate teacher inquiry approaches, designing educational interventions to meet context specific situations is becoming more universally expected.

Data for this longitudinal study was collected from 352 teachers in an urban school district in California in the United States (US). The urban school district where this study took place serves 45,500 students over 80 campuses. The district caters for a diverse student group coming from both affluent neighborhoods around the capitol to low socio-economic areas that contain federal housing projects. Residents within the district speak more than 40 languages, with 24% of the population considered to be English Language Learners (ELLs).

The findings show that the EDR initiative enabled the majority of teachers to positively evolve their teaching practices. It also offers insights into the specific characteristics and dispositions of the participating teachers. Findings from this study indicate that teacher professional learning initiatives need to consider how to effectively cultivate a teacher's inquiry disposition, not just their skills and knowledge. In this respect, this study has important implications for the organization and conceptualization of teacher professional learning programs. First, the definition of 'inquiry disposition' can be used as a framework to determine what is required from teachers who aim to engage in classroom inquiry. Second, the inquiry disposition typology has the potential to be used as a self-assessment tool for teachers to evaluate their own professional learning needs as 'inquiring teachers'. Third, each type of teacher will have different

professional learning needs, implying that both the organization of these practitioner research initiatives and support within them (Lunenberg, Dengerink, & Korthagen, 2014) should be adapted to meet each type's specific needs.

Declaration

I certify that:

I. This thesis comprises only my original work towards the *Degree of Doctor of Philosophy,* except where indicated in the preface;
II. Due acknowledgement has been made in the text to all other material used;
III. The thesis is fewer than the maximum word limit in length, exclusive of tables, maps, bibliographies and appendices.

Signature of the candidate

Date

Preface and acknowledgements

I was drawn to this doctoral research topic after completing an action research project as part of my Masters in School Leadership at Monash University. It became apparent through this project that practitioner research had the potential to be not only an effective model for teacher professional learning, but also a powerful lever to drive school improvement. This thesis is an exercise in delving deeper into an area that genuinely piqued my curiosity and it has open up a world of experiences I never expected.

It was a pleasure and privilege to undertake my research at the University of Melbourne in the Melbourne Graduate School of Education. I am very fortunate to have had Professor John Hattie as a primary supervisor and am indebted to him for being so supportive when I was offered a position in New York in the early stages of my research. I am acutely aware that our monthly Skype meetings were just as much mentoring sessions as they were supervisory discussions. Your advice, guidance and knowledge of the US educational system provided fantastic support through this exciting and challenging period. As a supervisor, you were a true problem-solver and consistently challenged my thinking. Your contribution was also incredibly pragmatic: balancing critical feedback, encouragement, and perspective to keep me progressing towards completion.

I was lucky also to have Dr Terry Bowles' supervision over the last three years of my candidature. I am grateful for his thoughtful suggestions, incredible knowledge of statistical analysis, and generous encouragement during the final stages of my PhD. He was a great sounding board for ideas and I am deeply thankful for his critical eye, and willingness to catch up and work through aspects I was struggling with. I would also like to acknowledge the support of David Gurr, who co-supervised me in the first part of my candidature and was influential in the

conceptualization of this project. He offered critical feedback and his perspectives sharpened the focus of the project.

Researching and writing this PhD has been a stimulating and richly rewarding experience. It has also been hard work, especially when combined with full-time work, living overseas for a prolonged period and raising three energetic kids. Making it through the PhD wouldn't have been possible without the continued support of my family. A special mention must go to my wife Kate, I am truly grateful for her ongoing support and know she sacrificed many things along the journey to allow me to write. I look forward to spending a summer with my three kids, Leroy, Darcy and Mabel, without the need to slip away and write. I would not have achieved this without the support of my entire family and I am incredibly grateful for their generosity in allowing me to pursue this significant undertaking.

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Chapter 1: The nature of the investigation

1.1 Central theme

The modern teacher works within an educational setting that is constantly changing politically, technologically, and with an increasing diversity of learning and societal needs. To manage this increasingly complex environment, teachers need to become more sophisticated in their understandings of teaching (Wei, Darling-Hammond, Andree, Richardson, & Orphanos, 2009). A further pressure is economic, with nations aspiring to high-quality education systems that will teach their citizens the skills necessary to meet the challenges of an educated workforce. In a school setting, professional development or 'professional learning'[1] is often the mechanism used to build teacher capacity and push for higher levels of student achievement. The underlying premise is, "excellence in teaching is the single most powerful influence on achievement" (Hattie, 2003, p. 4), so providing support and resources for teachers to improve practice should positively impact student achievement. While logical, there is a still a paucity of definitive empirical research on what constitutes effective professional learning for teachers and what impact this learning has on the students they teach. As Yoon, Duncan, Lee, Scarloss and Shapley (2007, p. iii) articulated, "the connection seems intuitive. But demonstrating it is difficult."

Practitioner research is becoming more widely used as a form of teacher professional learning, yet its effectiveness is still underexplored in the literature. Such research is grounded on an inquiry process or improvement model that is aligned to teacher professional learning. That is, teachers undertaking practitioner research are usually focused on improving teaching and learning

[1] Defined as "a broad term to describe an internal process by which individuals create professional knowledge" (Timperley, Wilson, Barrar, & Fung, 2007, p. 284). Fishman, Marx, Best and Tal (2003) take the internal process to be, "teachers' knowledge, beliefs, and attitudes…aspects of teacher cognition that are affected by participation in professional development."

in their classroom or school. Noffke (1997) outlined three different motivations for teachers who conduct research about their own practices. First, there is the motivation to better understand and improve one's own teaching and/or the contexts in which that teaching is conducted. Second, there is the motivation to produce knowledge that will be useful to other educators where practitioners are interested in sharing their research with other educators through seminars, conference presentations and publications. Third, consistent with the democratic impulse that was originally associated with the use of action research in the United States (US) in the 1940s (Foshay, 1994), there is the motivation to contribute to greater equity and democracy in schooling and society.

Presently, there is a political push for the Victorian Education System to "introduce practitioner-led research, requiring teachers to undertake a new individual or team-based research project every two years" (Department of Education and Early Childhood Development [DEECD], 2012, p. 19). The justification is that high performing, or top tier, systems in the Organization for Economic Co-operation and Development (OECD) "support research undertaken by teachers to drive innovation and school system improvement" (DEECD, 2012, p. 15). Similarly, in Shanghai, teachers are "encouraged to identify a particular aspect of learning and examine the theory and evidence base, then trial different teaching practices drawing on their findings" (Jensen, Hunter, Sonnemann, & Burns, 2012, p. 23). In this context, practitioner research is closely focused on three aspects of student learning: what has worked in the past and has a research or theoretical focus that could inform teaching, how to best provide it to students and how to accurately measure it. However, further exploration into practitioner research as a form of professional learning, and how this can lead to a positive influence on student achievement is required. As Zeichner (2003) stated when discussing the impact of teacher research, "we are often provided with little or no information

about the specific characteristics of the research experience and/or research context that are responsible for promoting this growth" (p. 303).

There is little debate among educators concerning the need for effective teacher professional learning practices. Indeed, in the US, in the No Child Left Behind Blueprint for Reform (2010), teacher professional learning is a key aspect in the priority of educating college and career ready students. This emphasis on professional learning is not a new priority in the US; it was stated as one of the key national education goals twenty years ago (National Education Goals Panel, 1995). While extensive resources and research have been committed to developing effective professional learning practices to benefit teachers and students alike, there is little evidence of impact. However, the research also illustrates that the very idea of effective professional learning is contentious – with vigorous debate nationally and internationally over which particular strategies or practices should inform professional learning planning and policy making (Doecke, Parr, & North, 2008). Recently, in the US, the demand for professional learning has increased due to the national introduction of the Common Core State Standards (CCSS) and the reform agenda associated with this adoption. The standards have been adopted by "forty-two states, the District of Columbia, four territories, and the Department of Defense Education Activity" (Closing the Expectations Gap, 2013), which illustrates the significance and scale of this educational undertaking.

The adoption of a national curriculum in the US is heralded as bringing a consistency, not only to curriculum, but also pedagogy. The CCSS has accompanying "instructional shifts" associated with the implementation. With regards to mathematics, these shifts are: 1) A greater Focus on fewer topics; 2) Coherence - linking topics and thinking across grades; and 3) more Rigor - pursue conceptual understanding, procedural skills and fluency, and application with equal

intensity (Moschkovich, 2012). Added to this, the CCSS mathematics curriculum includes Standards of Mathematical Practices, which "describe varieties of expertise that mathematics educators at all levels should seek to develop in their students" (CCSS, 2010, p. 5). These practices are based on what are considered essential "processes and proficiencies" with longstanding importance in mathematics education. These are described as follows:

> The first of these are the NCTM [National Council of Teachers of Mathematics] process standards of problem solving, reasoning and proof, communication, representation, and connections. The second are the strands of mathematical proficiency specified in the National Research Council's report *Adding It Up*: adaptive reasoning, strategic competence, conceptual understanding (comprehension of mathematical concepts, operations and relations), procedural fluency (skill in carrying out procedures flexibly, accurately, efficiently and appropriately), and productive disposition (habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy) (CCSS, 2010, p. 5).

So, the mathematics CCSS is not intended simply to attach new names to old ways of doing things, it is intended to be a set of standards that not only outline a developmental and rigorous curriculum, but also provide specific guidance on the pedagogical approaches associated with the content area. While the curriculum outlines 'what' is to be covered, the Standards of Mathematical Practices outline 'how' students are expected to interact with this content; the instruction and pedagogy.

As the mathematics CCSS, and the associated instructional shifts, have the potential to create a radical departure from the current practices for many teachers, the professional learning must be more focused, coherent, and rigorous. There is evidence to suggest that some traditional professional learning practices are ineffective in the modern workplace, as they do not provide the depth of learning required to increase teachers' knowledge or foster meaningful changes in classroom practice (Loucks-Horsley, Hewson, Love, & Stiles, 1998). Educators historically tend to conduct 'conventional' professional development experiences such as workshops, presentations

or lectures that lack any genuine follow-up or feedback (Miller, 1995). The prevalence of one-off, single day workshops that often make teacher professional development "intellectually superficial, disconnected from deep issues of curriculum and learning, fragmented, and noncumulative" (Ball & Cohen, 1999, pp. 3-4) is consistently criticized in the literature. Corcoran (1999) suggested "workshops may be valuable for promoting awareness of new practices or curricula and provide opportunities for teachers to network and share but there is little evidence of outcomes of the process" (p. 4). Miller (1995) took this idea further when he stated, "the old model of staff development survives in a world where everything else has changed" (p. 96). Fullan, Hill and Crevola (2006) contended that, "in school education, there is no built-in mechanism that leads to ongoing improvement in classroom instruction" (p. 42).

Despite the increased focus on teacher professional learning over the past 20 years, and the increasing knowledge base about what constitutes effective professional learning or 'best practice', the education community is still grappling with what it takes for systems, districts and schools to learn and devise ongoing mechanisms for learning (Loucks-Horsley et al., 1998; Sparks, 2004. Central to broadening this understanding of effective teacher professional learning are empirical studies that explore the impact professional learning initiatives have on teachers and, in turn, the students they teach.

1.2 Statement of the problem

Professional learning opportunities are designed for a variety of purposes. The role of evaluation is to determine whether and in what ways the professional learning is successful, but fulfillment of this role is rarely easy. Regardless of the objectives of a given program, program administrators can often jump to measure what is easiest and most obvious: satisfaction of the participants with their immediate experience in the workshop, institute or other program (Reeves,

2012). What is overlooked in this approach is the extent to which the program's aims have been met, the extent to which the participants were impacted by the professional learning experience, how their teaching changed over time as a result of their experience, and how their students' learning was affected (Guskey, 2002 Loucks-Horsley et al., 1998).

In the US, schools have been implementing the CCSS for the past six years. Its introduction has led schools, districts and systems to intensify their focus on teacher professional learning to ensure the standards are implemented with rigor and fidelity. In 2013, an urban school district in California began to develop a professional learning initiative to support their teachers with the implementation of the mathematics CCSS. As a part of responding to the shift to the CCSS in mathematics, the urban school district in California developed strategies for high quality teacher professional learning based on current research and reform initiatives. The district established a framework for district action that would facilitate building teacher capacity through a collaborative Educational Design-Research (EDR) based methodology (Cobb, Confrey, diSessa, Lehrer, & Shauble, 2003; Design-Based Research Collective, 2003; Kelly, 2006; Reeves, Herrington, & Oliver, 2005; van den Akker, 1999; van den Akker, Gravemeijer, McKenney, & Nieveen, 2006). The professional learning model was conceptualized as an ongoing research project that continually measured the effectiveness of its impact. The rationale for more rigorous metrics for impact were partly based on the dangers of using a reduced range of evidence, such as students' test scores, to measure the outcomes of teachers' professional learning (Locke, 2004; Petrosky, 2003). The theory of action was designed to consider broader metrics than student achievement data and actively sought teacher perspectives on their experiences to inform the future direction of the implementation strategy (see Figure 1). EDR was selected by the district as an appropriate methodology, as McKenney and Reeves (2013) stated that one of the two main goals of EDR is to

benefit practice. As Guskey and Yoon (2009) pointed out, what is needed is sound, trustworthy, and scientifically valid evidence on the specific aspects of professional learning that contribute to improvement. In essence, the precise aim of design-research is to benefit teachers and advance theoretical understanding. The research framework and metrics of this study were designed to explore this assertion.

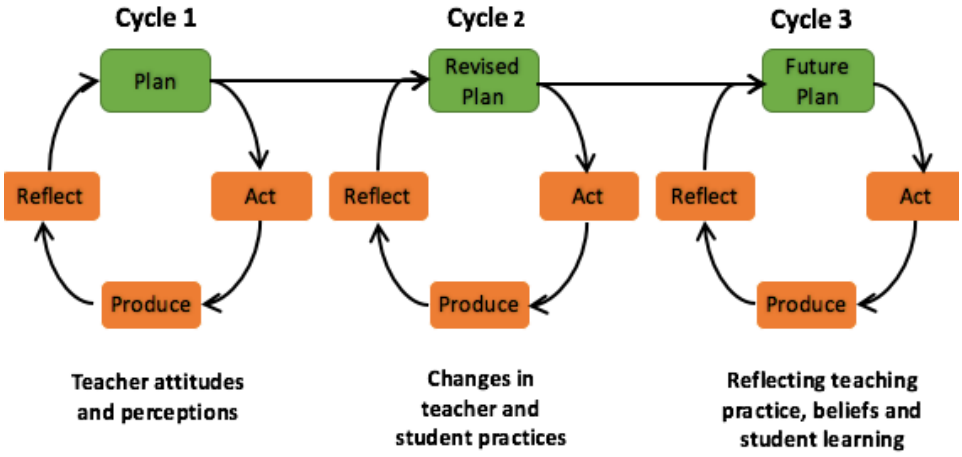

Figure 1: Theory of action inquiry model

1.3 Educational Design-Research (EDR)

EDR is the systematic study of designing, developing and evaluating educational programs, processes, and products (Plomp, 2007). EDR is a methodology designed by and for educators that seeks to increase the impact, transfer, and transitioning of education research into improved practice. In addition, it stresses the need for theory building and the development of design principles that guide, inform, and improve both practice and research in educational contexts (Anderson & Shattuck, 2012). Characteristics of an EDR approach can be listed as follows: situated in real educational contexts; focusing on the design and testing of interventions, using mixed-methods; involving multiple iterations, stemming from partnership between researchers and practitioners; yielding design principles; and concerned with an impact on practice (Anderson &

Shattuck, 2012). Added to this, while authors may vary in the details of how they picture EDR, there is general agreement that it comprises of a number of stages or phases. The phases are: "preliminary research, prototyping and an assessment phase" (Plomp, 2010, p. 15). These phases are discussed in more detail in Chapter 6 of this thesis.

The drive to expand the frequency and rigor of practitioner-led inquiry is becoming more prevalent across a range of educational systems. There have been increasing calls not only for teachers to base their practices on research but also for them to participate in inquiry and to act as researchers themselves (Barnatt, Cochran-Smith, Friedman, Pine, & Baroz, 2007; Cochran-Smith & Lytle, 1990, 1999; Darling-Hammond, 2006b; Henson, 2001; Hubbard & Power, 1999; Nelson & Slavit, 2008). For example, the Danielson Framework for Teaching (Danielson, 2011), a widely used teacher rubric in the US, includes an indicator that to be 'highly effective', "teachers [need to] seek out opportunities for professional development and make a systematic effort to conduct *action research*" (p. 451). Likewise, in Australia the Australian Professional Standards for Teachers (APST) explicitly states that at the Lead Teacher level teachers will, "initiate collaborative relationships to expand professional learning opportunities, [and] engage in research" (APST, 2014). Yet further exploration is required into the key determinants that influence teacher learning and how this can lead to a positive influence on student achievement.

1.4 Initial hypothesis and anticipated outcomes

The hypothesis to be tested was that teachers who participate in EDR in an intensive ongoing manner will display measurable improvement in their teaching beliefs, practice and subsequent impact on the students they teach. This is based on the notion that EDR meets the requirements outlined for effective teacher professional learning (Barab, Arici & Jackson, 2005; Cochran-Smith & Fries, 2001; Darling-Hammond, 2004; Desimone, 2009; Hall & Herrington,

2010; Hawley & Valli, 1999; Ingvarson, Meiers, & Beavis, 2005; Nelson, 2010; Timperley, Wilson, Barrar, & Fung, 2007), which is outlined in Chapter 2. As evidenced by Ormel, Roblin, McKenney, Voogt and Pieters, (2012) "practitioners have prominent roles in the projects". This led to the hypothesis that being actively involved in educational research will encourage teachers to think more deeply about how to best provide student learning, as well as how to accurately determine their impact on students. Anderson and Shattuck (2012) characterized EDR as: situated in real educational contexts, focusing on the design and testing of interventions, using mixed methods involving multiple iterations, stemming from partnership between researchers and practitioners, yielding design principles, and concerned with an impact on practice. McKenney and Reeves (2013) stated that the two main goals of EDR are advancing theoretical understanding and benefiting practice. It is timely to test these assertions.

This study explores the effectiveness of EDR in reaching one if its goals: benefiting practice. Does EDR impact on practice and is there evidence of this positively impacting student outcomes? The intention was to investigate teachers participating in EDR and to explore the conditions that affect teachers in changing or modifying their attitudes, beliefs and teaching practice. The knowledge generated from this study is intended to support systems, schools and private professional learning organizations to design and develop more effective opportunities for teacher professional learning.

1.5 The context and background

The US urban school district where this study took place serves 45,500 students on 80 campuses. The district caters for a diverse student group coming from affluent neighborhoods around the capitol as well as low socio-economic areas containing federal housing projects. The district reports that 72% of students qualify for a free or reduced-price lunch. At 36 of the schools

within the district, 100% of students meet this federal poverty threshold. This is partly due to the community having an unemployment rate of 9.2%, almost 1.6% higher than the national average. The student population is 36.8% Hispanic or Latino; 19.9% Asian; 16.2% African American; and 19.1% White. About 6% of students are of two or more races or ethnicities. Residents within the district speak more than 40 languages; 24% are considered to be English Language Learners (ELLs).

Outlined in the district's strategic plan is the core ethos to prepare students for college-career readiness. This required the district to closely examine their current status and practice. For this reason, the district adopted the mathematics CCSS, which was designed to prepare students for success beyond high school. Through a consultative process, it was agreed, at the district level, that a well-resourced, evidenced-based system be developed and implemented. The district leadership team sought to design a more systemic approach to their teacher professional learning, one that moved professional learning beyond one-off workshops to a more integrated, job-embedded, professional learning initiative.

The district leadership team began to implement the mathematics CCSS across the district in August 2012. To support the iterative and complex nature of this undertaking, the district utilized an inquiry-based collaborative design methodology (EDR) and methods that focused on learning in the three major components of the mathematics CCSS: standards for mathematical Practice, instructional shifts, and the content standards. The district leadership team believed that to truly develop students' conceptual understanding of mathematics, as outlined in the CCSS, and to also facilitate teachers' opportunities to learn deeply; a teacher inquiry-driven framework would need to be a key lever. Hence, the methodological decision to utilize EDR.

With the understanding that instructional leadership would be another key lever for transforming teaching and learning, the district convened monthly leadership meetings for principals to engage in professional learning and to develop strategic plans associated with the EDR initiative. These sessions focused on the enactment of the CCSS curriculum, with a particular emphasis on the the major implications for teaching and learning within this curriculum; the standards for mathematical practice and instructional shifts. This was a key mechanism to ensure the work teachers were undertaking was aligned and consistent with the work that principals undertook. Analyzing the experiences of principals who were involved in this study was outside the scope of this research project.

One of the espoused aims of the mathematics CCSS is that it provides a conceptual framework to support a change in content understanding, pedagogy, and assessment for all teachers. To that end, the district leadership team decided to utilize the EDR as an inquiry-based collaborative design methodology and the primary means for transforming teaching and learning.

The intention was to effectively change instructional practice and ensure quality implementation by providing support in the form of: ongoing professional learning opportunities for both teachers and principals utilizing the design methodology; job-embedded mathematics coaching; and teacher collaboration. To achieve this, the district highlighted that emphasis must be placed on understanding the depth rather than the breadth of the standards, practices, and instructional shifts. The content standards should also be connected to the essential understandings (topic-specific mathematical ideas and relationships) and related big ideas (statements that connect clusters of standards and essential understandings into a coherent whole) students must acquire. This knowledge will be used to create rigorous units of study with integrated assessments to determine students' proficiency of the standards and inform instruction.

As part of the EDR framework, the urban school district included teachers and leaders from within the K-8 band who would participate in learning as follows:

- To ensure all students are impacted, the professional learning design included an opportunity for all K-8 teachers (1,500), by grade level, to engage in six hours of professional learning in August (summer break) 2013.
- Teams of teachers (site leaders) from each school participated in a four-part series of district professional learning (October, December, February and May), which totaled 24 hours for the academic year. During this time, as a community of practice, they examined research and developed instructional modules, implemented them, examined student work, reflected on their own practice, and assisted in building capacity at their respective school sites. This constituted seven teachers per elementary school, nine teachers per K-8 school, four teachers per middle school, and four teachers per high school, totaling just under 400 teachers. To ensure coherence and create an opportunity for horizontal and vertical articulation, teachers were grouped by grade bands.
- Teachers collaborated with their colleagues onsite and further addressed local concerns twice in the 2013/2014 academic year (November and February), totaling 12 hours.
- Understanding that the most powerful professional learning is that which is directly linked to classroom practice, job-embedded classroom mathematics coaching was provided by the district's training specialists (instructional coaches) and technical support partners. This addressed instructional practice, the rigor and complexity of created tasks, and the use of data to make instructional changes.
- To continually deepen the knowledge-base and build the coaching capacity of the training specialists (11) and teacher leaders (15), both groups participated in a series of professional

learning coordinated and led by the technical support partners (external consultants). The main purpose of this professional learning was to provide a collaborative, supportive forum to explore and reflect on the deliberate use of mathematics content and practices as well as research-based questioning strategies as a means to encourage and deepen mathematical thinking of all students. This would form the basis for their instructional classroom coaching.

The mathematics CCSS required site leaders to think coherently across grades, not only about the specific learning at each grade level (horizontal alignment), but also the progression of mathematical understanding across grades (vertical alignment). Site leaders were the teachers from each school who attended the four day workshops during the 2013/2014 academic year. To ensure teachers were supported effectively, the EDR initiative included developing the leadership capacity of site leaders. This leadership development included closely examining: standards-based curricula, assessment frameworks, structures to promote professional learning, and developing strong home-to-school connections. As such, a three-phase model was utilized to provide ample time for learning and application. Described as follows:

Phase I – Exploring the Common Core State Standards

This focus began with leaders addressing the new instructional landscape, learning about the prescribed mathematical practices and shifts associated with the CCSS, as well as auditing their current reality in relation to the desired outcomes. This data analysis was used to guide the work and determine research-informed next steps. As the implementation progressed, site leaders continuously monitored the transition to the mathematics CCSS and fed back identified challenges to the district mathematics leader to inform what could be explored in future iterations of the EDR initiative. In addition, to deepen their content knowledge, site leaders studied the standards progressions, rigor and the CCSS instructional expectations,

beginning with lesson design and delivery.

Phase II - Aligning Assessments to the Core

To improve instruction, a strong emphasis was placed on the purpose of formative assessments, how to design them so that student understanding reflected the standards. Teachers provided information that could be used to identify learner-centered misconceptions and/or problems of instructional practice. Additionally, using the Smarter Balanced Assessment Consortium (SBAC) item specifications, sample items, claims, and achievement level descriptors as guideposts, site leaders examined their schools' assessment practices to determine warranted changes.

Phase III - Implementing Systemic Structures and Processes

The scale of change the CCSS proposed for teaching and learning required development and implementation of system-wide structures and processes. This included, but was not limited to, ongoing professional learning, observing student learning, and examining student work. As a consequence, site leaders collectively designed and/or modified site-based professional learning plans aligned to and supporting the demands of the CCSS. Plans included a focus on learning, methods for achieving that end, progress monitoring tools, as well as a dedicated time and structure for professional learning. Using an evidence-based framework with common tools, leaders observed classrooms, gathered data and analyzed findings, engaged in calibration conversations, and determined appropriate support for teachers and students. In addition, using the utility oriented EDR, leaders engaged in a deeper level of thinking by examining student data and work. They used the data to identify students' zone of actual development and/or misconceptions, addressed the implications for instruction, discussed ways of engaging teachers in instructional dialogue, and established strategies for continual

instructional improvement. The supports included an August leadership institute and monthly district-level convening's that were used to align the leadership work to the EDR teacher professional learning initiative.

1.6 The district theory of action

The purpose of this study was to explore the processes used by teachers to translate professional learning into classroom experiences for engaging students and improving learning. The teachers who participated in this process were part of a district-wide EDR project, used as a form of professional learning, during the 2014-2015 school year. The district historically collected satisfaction data from teacher participants at the end of workshops and had not conceptualized what impact data and ongoing in-classroom support would look like, but leaders were eager to transform and refine these practices to align with the explicit outcomes they sought. To support the conceptualization of the study, Figure 2 offers an early emerging theory of change developed by the school district. This theory outlines the hypothesis for framing a sequence of studies to support an increasingly rich understanding of teachers' experiences during the EDR initiative.

If:

- we clearly articulate the range of experiences of teachers who undertake EDR, and
- specify the characteristics, knowledge and skills that help them improve

then:

- we can more precisely specify the professional learning required to support teacher growth, and
- the kinds of experiences that are more likely to support teacher professional learning, and
- we can explicitly describe the range of practices and behaviors the district, school leaders and teachers need to apply to promote effective teacher professional learning, and
- we can clearly point to policy challenges and opportunities within teacher professional learning

so that:

- effective teacher professional learning becomes more widespread, and

- systems, school leaders and teachers value teacher professional learning and ensure it is applied systematically, and
- resources are directed to where they are needed most, and

so that:

- school systems embrace an ethic of effective teacher professional learning, and
- the experiences and learning of teachers is improved, and
- the learning of students is enhanced by quality teaching

Note: This was drawn on approaches to articulating theories of change in Davidoff F, Dixon-Woods M, Leviton L et al. Demystifying theory and its use in improvement. BMJ Qual Saf 2015;0:1–1.

Figure 2: Early emerging district theory of change

The aim of the research was to examine the impact of teacher professional learning, across a school district, with teachers who were engaging in an EDR project. To frame the conceptualization of instruments to examine this impact, the following questions were developed:

1. Do teachers report change in their behavior, attitudes and teaching repertoire?
2. Do teachers incorporate the CCSS and instructional shifts into their teaching practice?
3. Are the CCSS and instructional shifts embedded into classroom practice?
4. Is there evidence that student mathematics practices and knowledge are improving as a result of the changes in instruction?

This questions were designed to facilitate teachers' behavioral intentions to engage in the professional learning and employ the learning and knowledge gained as a result. Study 1 of this project sought to describe the behavioral intent of teachers to engage in the EDR initiative. That is: did they intend to use the ideas and practices explored as part of their classroom instruction? Study 2 explored the level of implementation and the changes that occurred over the course of one year while teachers were involved in the EDR project. It also sought to elucidate reasons for such incorporation or lack thereof. Study 3 explored teachers' reflections on changes in teaching beliefs, practice and student learning that could be attributed to their participation in the EDR initiative.

1.7 Theoretical framework

The theoretical framework for this research draws on socio-cultural and socio-cognitive perspectives; both conceptualize the relationship between social and individual factors in learners' development. Socio-cultural theory is central to this research as it examines the way the social world influences cognitive growth, and cognitive growth influences the social world (Tudge & Winterhoff, 1993). The culture of a social system shapes the prevailing thinking of those who are part of it and builds a specific system of behavior.

Schools and teams of teachers are unique cultural systems that influence what is learned through formal and informal conversations. That is, any change in behavior, in turn, impacts instruction at a school, thereby changing the behavior of not only teachers but also students. While culture influences learners, learners also influence culture. This research sought to understand this complex dynamic. To work within this paradigm, where both collective and individual intent to learning are analyzed, the Integrated Behavioral Model was applied. This model has been used primarily in the field of health promotion to establish the likelihood of individuals displaying a specific behavior – for instance would someone with back pain engage in remedial exercise to manage the pain. In the short term, the exercise might be painful, but in the long term it will lead to reduced pain. By applying this framework, health professionals have been able to establish the behavioral intent of individuals.

The picture of socio-cultural theory presented here is primarily one of collaboration, which inherently includes negotiation and adjustment. It focuses on the meaning people internalize as both members of a social group and as individuals. As Tudge and Winterhoff (1993) argued, "Individual development cannot be conceived outside a social world, and that social world is simultaneously interpersonal, cultural, and historical" (p. 75). According to socio-cognitive theory,

people are self-organizing, proactive, self-reflecting, and self-regulating rather than reactive organisms shaped and shepherded by environmental forces or driven by concealed inner impulses (Pajares, 2002). Socio-cognitive theory espouses people as active in their learning, transforming, classifying, and organizing concepts into easily remembered schemes rather than taking snapshots that simply store information (Tudge & Winterhoff, 1993).

Socio-cognitive theory goes beyond socio-cultural theory in positioning people as active decision-makers and agents. As Bandura (1986) put it,

> Social cognitive theory is rooted in a view of human agency in which individuals are agents proactively engaged in their own development and can make things happen by their actions. Key to this sense of agency is the fact that, among other personal factors, individuals possess self-beliefs that enable them to exercise a measure of control over their thoughts, feelings, and actions, that what people think, believe, and feel affects how they behave. (p. 361)

Socio-cognitive theory puts the idea of the individual thoughts, needs, and wants forward even though they are embedded within social groups. It stresses the role of people in assessing their accomplishments amid social groups' judgments. Personal decision-making is a key to learning and behaving as people learn what to engage in during group interactions. This picture of socio-cognitive theory is primarily one of individual decision-making. It is one of people deciding their thoughts and actions in light of group norms and feedback. It highlights self-determination amid cultural influences.

1.8 Theoretical rationale

This research utilized a mixed methods approach to collect quantitative and qualitative data. As indicated previously, the study had three distinct but overlapping phases (included in each of the overview of the phases are the specific methods employed to generate the data):

1. Exploring the salient beliefs, behavioral intent, and self-efficacy of participants to establish their attitudes and perceptions towards undertaking EDR. The establishment of Behavioral Intent was achieved by administering a Belief Survey that informed the development of self-report Behavioral Intention Questionnaire (BIQ);
2. Examining the perceived changes in teacher behavior (practice and planning) and the perceived changes in student mathematical practices that occurred as a result of the EDR project. To quantify this a 28-item Level of Implementation Questionnaire (LOIQ) was developed and administered four times throughout the academic year;
3. At the conclusion of the first year of the EDR project, extended response qualitative data was collected, via a four item open response questionnaire, to gain further insights into the actual perceptions and experiences of participants and evaluate the process.

The theory of planned behavior (TPB) was the foundation theoretical framework applied in Study 1 of this research project, as a means of measuring the impact of the EDR initiative on the implementation of instructional practices and planning associated with the CCSS. The TPB was developed by researchers in the 1980s (Ajzen & Fishbein, 1980). The theory claims that attitude toward behavior, subjective norms, and perceived behavioral control, together shape an individual's behavioral intentions and behaviors. It has been empirically tested and used to predict the behavioral intentions of students, pre-service teachers and in-service teachers in such areas as course choice, the use of hands-on activities, and participation in continuing education (Patterson, 2001). Few of these studies, however, closely examine the impact behavioral intention has on actual behavior.

The TPB uses a teacher's attitude toward behavior (*AB*), a measure of the social climate surrounding the teacher (subjective norm, *SN*), and the teacher's level of perceived control over

the ability to engage in the behavior (perceived behavioral control, *PBC*) to predict behavior. Developed by Ajzen and Fishbein (1980) and Ajzen and Madden (1986), the TPB provides a multi-faceted combination of factors and the circumstances that affect them. The power of the TPB in predicting behavior can be tied to its specificity, in which the variables are addressed at the same level of specificity in assessing attitude as they are in addressing behavior. Variables related to attitude and behavior, according to Ajzen and Fishbein (1980), must consist of four specific elements: the action, the target of the action, the context of the action, and the time in which the action occurs. In this study, the action was the teachers' implementation of the CCSS and the associated instructional shifts; the targets of the action were the mathematics teachers (kindergarten to grade 10); the context of the action was the mathematics CCSS curriculum; and the time frame was the 2014-2015 academic school year.

Through a self-report survey, administered four times throughout the year, Study 2 explored the perceived changes in teacher behavior (practice and planning) and the perceived changes in student mathematical practices as a consequence of the EDR project. The analytic approach employed to answer the research questions of study 2 were Structural Equation Modelling, more specifically Latent Growth Curvet Modelling. Latent Growth Curvet Modelling offered advantages over more traditional methods of assessing growth and change, such as allowing for the imputation of missing data points. It can also adequately represent non-normal data and allow for non-linear growth patterns to emerge (Curran, Obeidat, & Losardo, 2010). The theoretical framework for this phase of the study was informed by Timperley et al. (2007) who developed a theoretical framework comprising 84 different characteristics of the professional learning environment likely to impact on student outcomes. These characteristics were distilled

into seven elements considered to be effective for promoting professional learning opportunities that impacted on student outcomes:

1. *Extended time for opportunities to learn;*
2. *External expertise was typically necessary;*
3. *Teachers' engagement in learning at some point was more important than initial volunteering;*
4. *Prevailing discourses challenged;*
5. *Opportunities to participate in a professional community of practice were more important than place;*
6. *Consistency with wider trends in policy and research; and*
7. *Active school leadership:*

Study 3 (A) explored changes in teaching practice that could be attributed to participating in the EDR initiative by establishing the different trajectories of change teachers reported over the duration of the academic year. The aim of this study was to break the self-reported teacher data from Study 2 into four distinct groups that represented their learning trajectory throughout this longitudinal study. The intention was to strata the results into: large growth teachers; moderate growth teachers; small growth teachers; and finally, reverse growth teachers. More specifically, the aim was to assess whether or not teachers' magnitude of growth could be conceptualized as a typology, based on their effect size, and whether differences could be identified in their individual growth. In summary, the goal was to develop a typology that could be used to distinguish different types of teachers within the EDR initiative.

Study 3 (B) investigated the changes in teaching practice by analyzing the end of year teacher reflections. This qualitative analysis involved a process of immersion in data, to identify

and interpret the experiences of participants to better understand the depth and details of experiences (Denzin & Lincoln, 1998). Grounded theory was used for this study as it is a prominent approach to qualitative data collection and analysis in the social sciences. The initial development of grounded theory (Glaser & Strauss, 1967; Glaser, 1978) and its subsequent variations (Strauss & Corbin, 1990, 1998; Charmaz, 2014) have remained influential in guiding qualitative researchers throughout the world. By making the process of conducting qualitative research more explicit and transparent, proponents of grounded theory have demonstrated scientific rigor and "legitimized qualitative research as a credible methodological approach" (Charmaz, 2014, p. 6). Grounded theory is thus an approach to qualitative research that embraces both the rigor of 'science' and procedure, and the 'creative' elements of emergent discovery, remaining faithful to the interpretive nature of qualitative analysis. This was viewed as an appropriate methodology for the extended response reflections that were conducted with the teachers in the school district at the conclusion of the academic year (May 2014). The goal for this explorative study (3B) was to gain a deeper understanding of the specific characteristics of the research experience and/or research context responsible for promoting or inhibiting teacher professional learning growth. More specifically, the research endeavored to capture a deeper understanding of each teacher's experience with undertaking EDR as a form of professional learning by eliciting reflective responses to open-ended questions related to the impact of EDR on their teaching practice. The open-ended questionnaire was intended to draw out the perceptions of teachers in an attempt to highlight key aspects of the design framework, content explored, changes in teaching practice, and any observable changes in student mathematical behaviors. With their permission, each response was collected and analyzed. The analysis involved understanding and comparing the contextual

elements of the cases, which Pettigrew (1990) described as encompassing a 'vertical level', as well as the time dimension, labelled the 'horizontal level'.

1.9 Research questions

The specific purpose of this study was to explore the experiences of teachers who undertake practitioner research, specifically EDR, as a form of teacher professional learning and how this impacts on their practice and the students they teach. The intention was to investigate the conditions that affect teachers to change or modify their attitudes, beliefs and teaching practice, and monitor this change over time. The general question that guided this study was 'Does EDR impact the practice of teacher participants?'

This general question was then divided into the three phases outlined above, with each phase having a conceptual framework and set of questions to inform the broader research aim. Specifically, within Study 1, where the behavioral intent of participants was explored, the Theory of Planned Behavior study sought to answer the following research questions:

- Which of the three direct determinants of intention are statistically significant predictors of teachers' intentions to use the practices explored in the EDR initiative?
- What are the potential enablers and barriers to the subsequent use of the practices explored in the EDR initiative?
- Is the TPB an appropriate conceptual framework for evaluating the participants' intentions to use the practices explored in the EDR initiative?

In Study 2, where changes in teacher behavior (practice and planning) and in student mathematical practices were explored, the specific research questions were:

- How do the teachers perceive their own change as a consequence of the EDR project?

- How does teacher practice change as a consequence of their participation in the EDR project?
- How do the teachers perceive changes in student practices as a consequence of the EDR project?

Study 3 (A) analyzed the changes in teacher behavior (practice and planning) and changes in student mathematical practices data to answer the following research questions:

- What were the different learning trajectories for teacher's undertaking the EDR initiative?
- Can the sample be grouped as large, moderate, small or reverse growth teachers?

Study 3 (B) collected extended responses and qualitative data to gain further insights into the actual perceptions and experiences of participants. The specific research questions for this phase were:

- What did the teachers do and what distinctive dispositions did they characteristically display, particularly when most challenged?
- To what extent did teachers attribute any changes in teaching practice to their involvement in EDR?
- To what extent could they attribute changes in what their students know and are able to do to their involvement in EDR?

1.10 Thesis organization and chapter summary

This chapter has introduced the study. Chapter Two identifies and explores themes in the literature related to the research questions. Chapter Three introduces the thesis design, including the analytical framework employed. Chapters Four, Five and Six contain the findings and analysis of quantitative and qualitative data making up the respective interconnected studies of the thesis.

The three studies synthesized in an analysis in Chapter Seven, which also contains concluding statements relating to the teacher's experiences of the EDR initiative and future considerations.

This thesis outlines a brief socio-cultural and political framework for understanding the current context of teacher professional learning and practitioner research. A review of the literature explores the existing knowledge of how teachers negotiate and experience this increasingly important element of their professional lives. As outlined above the thesis is broken into three distinct, but overlapping phases. The study is designed to capture 'converging lines of inquiry' (Yin, 2009, p. 115), where participants can articulate their multiple subjectivities and the ways in which EDR connects with their ongoing teacher professional learning experiences. A discussion about the significance of the study and an explanation of the methodology and its applicability for this work is also explored. The current study is timely as it responds to recent social and political changes in the educational landscape in which practicing teachers are currently situated. The project sought to gather empirical data on a growing educational phenomenon.

Chapter 2: From professional development to professional learning

2.1 Introduction

Continuous improvement is a notion that is discussed at all levels of education, from a graduate teacher striving for continuous improvement from his/her students, to principals, regional staff and government education department employees all wanting their school/s and the system to evolve and elevate performance. Schools are predicated on a 'continuous improvement model'. In a school setting, professional development or 'professional learning' is often the mechanism used to push for higher levels of achievement. In Australia, for example, there have been significant investments in professional learning with little demonstrated impact. Base on the teaching and Learning International Survey (TALIS)), Freeman, O'Malley and Everleigh (2014) conclude that teachers report near-universal access to development opportunities (97% based on an OECD survey). Despite the access, however, teachers do not see a positive impact on their teaching (the share of Australian teachers reporting impact is lower than the OECD average in every category. Internationally, the OECD found that, on average, more than 40% of teachers reported that they had never taught a class jointly, observed classes or provided feedback (OECD, 2014).

Extensive resources and research have been committed to developing effective professional learning practices to benefit teachers and students alike. That said, the research also shows that the very idea of effective professional learning is contentious – with vigorous debate nationally and internationally over "which particular strategies or practices should inform professional learning planning and policy making" (Doecke et al., 2008, p.17). The crux of the debate often revolves around a 'top down' versus 'bottom up' approach to professional learning and the continuing uncertainty as to how to measure the impact of teacher professional learning

on student outcomes. It is no surprise then that the very idea of 'effective' professional learning can be elusive, even within an industry that has learning at is core. To complicate matters further, this all takes place against a backdrop of increasing diversity and complexity, which systems and school leadership teams must face. The end result is a realization that catering for individual teacher needs while also balancing the need for the collective group of teachers is not a simple process.

Recent initiatives from many ministries of education, among others, stress the need to teach more challenging multi-modal content that is differentiated for individual learners (e.g. the Melbourne Declaration on Educational Goals for Young Australian, 2008). The modern teacher works within an educational landscape that is constantly changing politically, technologically, and within an increasing diversity of learning needs and family structures. To cope with this increasingly complex environment, teachers need to become more sophisticated in their understandings of teaching. While analyzing US policies that support professional development, Darling-Hammond and McLaughlin (1995) wrote, "the vision of practice that underlies the nation's reform agenda requires most teachers to rethink their own practice, to construct new classroom roles and expectations about student outcomes, and to teach in ways they have never taught before" (p. 1).

This highlights the increasing duality of the modern teacher - that of both teacher and learner. It also suggests that 21st century teachers will be unable to navigate the modern educational workplace without the skills and dispositions that enable them to focus on their own learning needs. With this duality in mind, increasingly, learning scientists find themselves developing contexts, frameworks, tools and pedagogical models consistent with, and to better understand, emerging pedagogical theories or ontological commitments (diSessa & Cobb, 2004). In these contexts, the

research moves beyond simply observing and actually involves systematically engineering these contexts in ways that allow us to improve and generate evidence-based claims about learning. The commitment to examining learning in naturalistic contexts, many of which are designed and systematically changed by the researcher, necessitates the development of a methodological toolkit for deriving evidence-based claims from these contexts (Barab & Squire, 2004). Barab and Squire noted that one such methodology that has grown in application is that of design experimentation or EDR.

Chandler-Olcott described how in the US "the last 15 years have seen a groundswell of attention to teacher research – what Cochran-Smith & Lytle (1999) called 'systematic, intentional inquiry carried out by teachers'" (Chandler-Olcott, 2002, p. 23). Chandler-Olcott cited a number of school and university based scholars who argued that teacher research had the potential to prompt educational change, transform teachers' perceptions of themselves as professionals and contribute to the generation and critique of knowledge about teaching and learning. Her research also pointed out the growing number of professional organizations calling for teacher research to be a part of their frameworks for professional licensure and the increasing number of teacher training organizations incorporating research elements into their Initial Teacher Education (ITE) programs. While the requirements for these experiences differ across contexts, their primary purpose seems to be consistent: to introduce teachers to procedures for formal inquiry that can be used to improve and inform their work on an ongoing basis.

Generating and brokering 'relevant' or 'useful' research knowledge for practitioners to engage in and/or with to 'inform' their practice is now routinely discussed in national and international research forums. In 2003 an OECD report, New Challenges for Educational Research (OECD, 2003), claimed that:

> Major knowledge and cultural changes [are] needed in the practice of teachers, researchers and policy makers ... Teachers need to look beyond their schools for evidence and think rigorously about their practice. Policy makers need to 'value' and apply research evidence in the development of policy and implementation. Researchers must work more closely with teachers to improve the knowledge base on education practices. These changes are beginning to take place in a number of OECD countries. (p. 50)

2.2 Educational Design-Research (EDR)

While EDR is an emerging methodology, there is increasing agreement about a number of core elements that characterize EDR. Van den Akker et al. (2006, p. 5) built on previous work (Cobb et al., 2003; Kelly, 2003; Design-Based Research Collective, 2003; Reeves et al., 2005; van den Akker, 1999) in this area to characterize EDR as:

1. Interventionist: the research aims at designing an intervention in a real world setting;
2. Iterative: the research incorporates cycles of analysis, design and development, evaluation, and revision;
3. Involvement of practitioners: active participation of practitioners in the various stages and activities of the research;
4. Process oriented: the focus is on understanding and improving interventions;
5. Utility oriented: the merit of a design is measured, in part by its practicality for users in real contexts; and
6. Theory oriented: the design is (at least partly) based on a conceptual framework and upon theoretical propositions, whilst the systematic evaluation of consecutive prototypes of the intervention contributes to theory building. (p. 5)

Research projects that utilize these characteristics are inherently impact oriented. That is, evaluation is iterative and the *process orientation* characteristic ensures interventions strive for continual improvement where the merit of the design is continually measured and analyzed. For

EDR, the main foundation for improvement is grounded in student learning; how to best provide it and how to accurately measure it. This lens ensures it is more impact oriented than other forms of practitioner research.[2] Figure 3 outlines how Reeves (2006) conceptualized and operationalized the design-based research approach in educational technology research with consideration to the characteristics outlined by van den Akker et al. (2006).

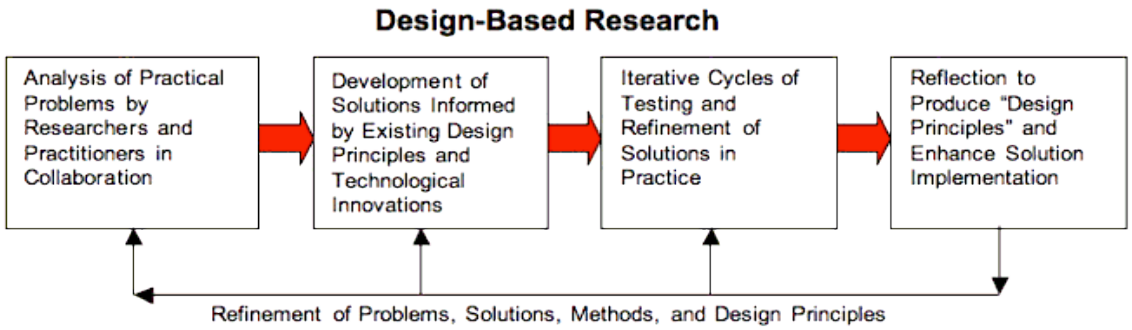

Figure 3: Design-based research (Reeves, 2006, p. 59)

For teachers, EDR usually begins with the assumption that existing practices are inadequate or can at least be improved. EDR seeks to develop practical and context specific interventions informed by current research. By carefully studying progressive approximations of ideal interventions in their target settings, researchers and practitioners construct increasingly workable and effective interventions, with improved articulations of principles that underpin their impact (Collins, Joseph, & Bielaczyc, 2004; van den Akker, 1999). These characteristics appear to complement its applicability as a methodology for teacher professional learning.

In EDR, researchers and participants seek to develop practical and context specific interventions informed by current research. While context specific in nature, if findings are considered relevant and generalizable, it is thought that this could also have implications for system

[2] An example is self-study that focuses on teacher growth without exploring the impact on students.

wide improvement. This idea can be linked to what Hargreaves and Fullan (2012) described as the 'moral imperative' where "people are motivated by good ideas tied to action; they are energized even more by pursuing action with others; they are spurred on still further by learning from their mistakes; and they are ultimately propelled by actions that make an impact" (p. 7).

So, while the contention is that EDR has the potential to offer a useful methodological toolkit to those researchers and practitioners committed to understanding variables within naturalistic contexts, there are many unresolved questions that we as a community must address if our assertions are going to be deemed credible and trustworthy to others (Barab & Squire, 2004). One issue is that despite the promise offered by advocates of EDR it is difficult to find empirical evidence to support its impact on practice. As Barab and Squire (2004) note in their review of the evolution of EDR as a methodology:

> It is our hope that we as a community can provide the important methodological grounding so that we can uncover useful constructs and advance new theory with respect to how people learn. At the same time, we must work to have an impact on those individuals directly engaged as participants/collaborators in our research partnerships. It is essential that we as a research community take on this challenge, grounding our specific work in credible, trustworthy, and useful studies while contributing more generally to the development of new methodological processes suited to meet the needs of learning scientists. It is only through the rigorous development of a new methodological toolkit that we as design scientists in the learning sciences will be able to put our stake in the ground, thereby gaining the supportive ear of others and contributing to a richer understanding of how people learn. (p. 13)

2.3 Design as a way of thinking

The term 'design thinking' has gained attention over the past decade in a wide range of contexts beyond the traditional preoccupations of designers. The main idea is that the ways professional designers problem-solve is of value to firms trying to innovate and to societies trying to make change happen. The term is often used to explain and advocate for design's unique approach to problems in innovative ways.

Before the term ‘design thinking’ became popular, these same words were used to refer to “design-specific cognitive activities that *designers* apply during the process of designing” (Lawson, 2006). These words referred to the way designers think and deal with problems. Now ‘design thinking’ has a different connotation: it denotes the problem-solving approach that equips *design* and *non-design* professionals with “a methodology for producing reliably innovative results in *any* field” (Miller, 2006). Designers’ skills, and ways of thinking and reasoning have been enlarged and adapted for solving problems beyond design, and are now applied in different contexts to address social, economic, health-related, and politically complex problems, among others.

With design thinking, the traditional way designers think has been enriched with a user-centered and empathic focus, a collaborative way of working, with a deliberate and self-conscious reflection on the design process. These characteristics actually levelled off the thinking part of the process (conceptual design) and the way the solution itself is developed (prototype design) (Miller, 2017).

Design thinking may employ such strategies as synthesis, divergent thinking, analysis, and convergent thinking in order to arrive at a solution. Divergent thinking is the process of brainstorming all possible solutions to a problem or all options in a given situation, while convergent thinking applies rules and logic to a limited set of options to determine which is best. With synthesis and divergent thinking, the designer may offer a number of ideas while considering a single aspect of the situation. After doing this, analysis and convergent thinking can be used to reach a decision about what should be done (Rholetter, 2016).

Design thinking is a thought process that depends on examining all sides of an issue from both practical and creative perspectives before deciding what course of action is most likely to

achieve the desired goal. Design thinking, within an education context, is a form of solution-focused thinking. Unlike the scientific method of thinking, which is based on a thorough analysis of a problem and involves both observation and experimentation, design thinking begins with a specific goal in mind and then investigates all possible paths that travel toward that goal. With design thinking, it is often necessary to redefine terms, repeat steps, and reexamine initial ideas before achieving the ultimate goal (Rholetter, 2016).

2.4 The increasing importance of professional learning

The research literature includes examples of large and small-scale studies, such as case studies, evaluations of programs designed to improve teaching and learning, observations of classroom teaching, and self-report studies where teachers reflect on professional learning activities (Garet, Birman, Porter, Desimone, Herman, & Suk Yoon, 1999). In addition, there is a large body of literature describing what constitutes best practices in professional development. Garet et al. (1999) stated that, "relatively little systematic research has been conducted on the effects of professional development on improvements in teaching or on student outcomes" (p. 917). While the literature is expanding, the same cannot be said for its empirical basis. While investigating the links between professional learning and student outcomes, Meiers and Ingvarson (2005) concluded that there are "difficulties in finding evidence about how teacher learning is linked to student learning" (p. 3). Meiers and Ingvarson's conclusion is consistent with a growing body of literature that discusses the need to consider a broad range of evidence of teachers' learning when evaluating the outcomes of that learning. Elmore (2000), Locke (2004) and Petrosky (2003) highlighted the dangers of using a smaller range of evidence, such as students' test scores, to measure the outcomes of teachers' professional learning. This current study is positioned to contribute to the field by using

a combination of research methods to analyze the experiences of teachers involved in EDR as well as the perceived impact it has on students they teach.

While exploring the complexity of teaching by comparing it with the field of medicine, Shulman (2004) noted that teaching "is perhaps the most complex, most challenging, and most demanding, subtle, nuanced, and frightening activity that our species has ever invented" (p. 504). The daily work of teaching is often pictured in the image of someone in the front of a classroom directing (and talking at) students. Teaching is often envisaged as an ongoing array of such scenes, lesson-by-lesson, day-by-day, across a school week. A fuller picture of teaching or the work of teachers, however, should also include the preparation involved in designing the lesson, thinking about and discussing instruction with colleagues, researching ideas and practices, testing them in a variety of contexts, and evaluating the impact. This (non-exhaustive) list will have aspects that teachers recognize as a part of their normal working lives. However, this is not what is commonly pictured when most people think about teaching. As a consequence, learning and thinking about teaching practices, the aspects that may occur externally to the classroom, is sometimes not given the priority and time necessary to bring about the changes in practice (and student outcomes) it aspires to achieve. So, until systems and policy makers truly value the time spent away from the classroom and acknowledge the impact the 'behind the scenes' work has on teaching practice, teachers and leaders will always view professional learning as an add on or extra; not something that is inherent and integral to their professional working lives.

Professional learning experiences for teachers have broadened from the more traditional structures, such as workshops, conferences or seminars where there was no real sense of follow up or feedback (Miller, 1995) and where professional development providers became increasingly focused on "audience appreciation … turning otherwise scholarly presenters into sycophantic

praise junkies" (Reeves, 2012). Currently, teachers are more likely to undertake development activities such as participating in collaborative teacher teams, mentoring, coaching, and observing peers teach. Many of these approaches to professional learning take place within the teacher's school, where the professional development is focused on the 'real' work happening in classrooms. This shift is supported by Cochran-Smith and Lytle (1999) who argued over a decade ago that "traditional professional development models" primarily focused on building teaching skills and knowledge, where the purpose of professional development was "to impart knowledge FOR practice" (p. 19). Cochran-Smith and Lytle (1999) recommended promoting active participation and ensuring learning is embedded as a part of the teacher's normal professional responsibilities. It should be recognized at this point there is an increasing ongoing emphasis in teacher professional learning research on the value of situated learning.

Increasingly, system leaders believe that "ambitious reforms cannot be developed at the drawing tables in government offices, but call for systematic research supporting the development and implementation processes in a variety of contexts" (Plomp, 2007, p. 9). The ability for reforms to adjust to various contextual aspects in a way that generates theory and practice in naturalistic contexts is an idea that presents an ongoing challenge for educational leaders. Interestingly, generating theory and practice in naturalistic contexts is espoused as a core characteristic of EDR. What this means is the current educational climate requires professional learning to nurture the middle ground in reform – somewhere between prescription and professional choice (Hargreaves & Fullan, 2012). Halsall (1998) also investigated this notion of the middle ground and concluded that "schools have found themselves subject to high levels of centralized policy making from central government, while simultaneously experiencing new levels of autonomy as a result of decentralization of certain aspects of policy and practice" (p. 20). In this context, the goal of

professional learning is to support reform by enabling teachers to "test their effectiveness and search for new practices wherever they could be found in research and innovation" (Hargreaves & Fullan, 2012, p. 50). Currently, professional learning initiatives are often discussed in dichotomous terms - 'top down' versus 'bottom up'. This dichotomy is too simplistic, modern teacher professional learning and current policy requires an approach that has the ability to nurture both top down and bottom up simultaneously. As outlined above, this is where advocates of EDR believe it can be positioned, as a method for practitioners to find the middle ground between system wide prescription and professional choice.

2.5 Current thinking: Key considerations in the teacher professional learning debate

Educational researchers have endeavored to identify the key characteristics of effective professional development. Traditionally, teachers attend courses, training, or conferences and read professional journals to refresh and update their knowledge and skills (Kwakman, 2003). However, a growing body of research suggests it is more important to identify the key principles that underpin learning (Cochran-Smith & Fries, 2001; Darling-Hammond, 2004; Hawley & Valli,1999; Opfer & Pedder, 2011). The premise is that through developing a deeper understanding about how we learn, we are better equipped to lead learning organizations. Just as education is becoming more individualized and student-centered, professional learning needs to shift from its reliance on traditional one-off workshops to an approach that focuses on more individualized and teacher-centered ongoing learning. By developing our understanding of theories of learning, we are better equipped to support the diverse needs of educators. Glickman, Gordan and Ross-Gordan (2004) believe that the nature of education demands teachers to be autonomous, and flexible thinkers. If we fall short in this area the alternative for teachers who are not supported to acquire the ability to "think abstractly and autonomously is to simplify and deaden the instructional

environment" (Glickman et al., 2004, p.69). This highlights the importance of continuing to research this vital area.

Much of the professional learning research has been derived in different ways ('bottom up' versus 'top down') based on vastly different criteria to determine 'effectiveness', and a variety of characteristics. At the core of the debate is how best to meet the professional learning needs of teachers and schools with limited resources in a complex workplace. Policy makers and academics are grappling with what strategies or practices of professional learning to use to meet future directions. One body of evidence advocates open-ended, flexible practices that give teachers increased autonomy. Cochran-Smith and Fries (2001), Darling-Hammond (2004), Petrosky (2004, 2006), and Goodson and Hargreaves (1996) wrote of the benefits of professional learning strategies and practices that are flexible and that build on teachers' existing professional knowledge. These researchers are critical of more highly structured strategies and practices that do not consider individual school contexts and advocate for practices that are based on the identified needs of teachers.

Contrary to this view, Hill and Crevola (1998) pointed out that governments have often invested considerable resources into highly structured top down professional learning activities with positive results. Can both of these propositions (flexible versus structured practices) hold simultaneously? The answer seems to lie in context and autonomy. Some schools are reluctant to relinquish their autonomy. They believe they are in the best situation to make informed strategic decisions about their future. The idea of being forced to implement top down professional development is met with resistance, essentially limiting the potential it has to be effective. Other schools may choose to embrace external intervention as a way of consolidating understanding – the contextual situation is vastly different. In this instance, the external professional development

may be supported, in turn leading to significant benefits for the organization and teachers involved. For both these scenarios, what is highlighted is the importance of the role context plays in the behavioral intent of participants. As outlined in the TPB, it also highlights the importance of explicitly gathering data on teachers' intent to engage in the behavior, as the success (or failure) of the professional learning initiative hinges on whether teachers plan to engage (or not) in the work. If the teachers' intent to engage in the professional learning is weak, then it has serious implications for the initiative's ability to have the desired impact.

Strong behavioral intent does not necessarily mean that teachers have volunteered to participate, nor does it mean the professional learning initiative is associated with more flexible practices where teachers have more autonomy. As Earl (2007) suggested:

> professional learning is a powerful lever for getting the kinds of change that can enhance student learning. But this may not happen if the process is purely voluntary, left to teachers to take (or not take) up. The kind of professional learning that makes a difference for students is hard work and demands strong policy support and professional determination. (as cited in Timperley, et al. p. ix)

With a finite amount of time to devote to professional learning, it is essential that teachers undertake work that has the potential to significantly impact on student learning. Systems aspire for teaching to have a significant positive impact on student outcomes. Professional learning should be held to the same high standard.

2.6 Professional learning that cultivates evidence-informed practice

The term 'evidence-informed practice' is used to define educational initiatives and activities that utilize information about what works. It means using evidence to identify the potential benefits, harms and costs of any intervention as well as acknowledging that what works in one context may not be appropriate or feasible in another. Comparisons around evidence–informed practice in education, criminal justice and social care inevitably turn to medicine and

engineering, with good reason. Although not perfect, these fields have developed systems by which they are able to capture and build on the knowledge held within research and practice, so that innovation can stand on the shoulders of previous progress (Shepherd, 2003). It should be noted that these developments in medicine and engineering have taken a long time, they have required considerable investment, and, of course, the systems continue to be refined (Sharples, 2013).

Evidence–based practice is not prescriptive and is focused on integrating professional expertise with evidence from research to improve the quality of practice. It is important to remember that there is a huge amount of experiential knowledge that is not captured by research, and, therefore, that an absence of evidence certainly does not mean absence of effectiveness (Sharples, 2013). In education, research is too often seen as outside of professional practice; something that is done to practice, where practice serves research, but rarely the other way around. However, writes Sharples (2013), if we "compare this to medicine we see that the communities involved in delivering frontline services are much more infused with a research–facing outlook, so that the people involved in training, research and practice are able to move more fluidly between these different roles" (p. 7).

The overall process of knowledge mobilization is a relatively complex chain of activities, requiring distinct processes of research production, synthesis, distribution, transformation and implementation all working together. Therefore, if we are to create effective evidence ecosystems in social practice it is crucial we consider these elements as a whole (Shepherd, 2007). It is, after all, no use producing world–class research if that research is not accessible to the profession.

2.7 Characteristics of effective professional learning

As established, there is a growing body of research focusing on identifying the key characteristics of effective professional learning for teachers. It is also important to analyze these characteristics to establish how EDR is positioned within the espoused professional learning theory. It is generally agreed, a 'one-size fits all' professional learning approach is no longer considered appropriate or capable of delivering the desired impact. It is claimed (Glickman et al., 2003) that by developing our understanding of theories of learning, teachers are better equipped to support the diverse needs of learners. Glickman et al. (2003) believe that the nature of education demands teachers to be autonomous and flexible thinkers yet at the same time we need teachers to work within systemic structures with common goals and norms. Finding the right balance between guidance and professional choice is essential for effective EDR.

Another body of literature focuses on how professional learning impacts the teachers involved. Desimone (2009) argued there is clear empirical evidence to support the identification of a core set of features and a conceptual framework for studying the effects of professional learning. The five core features identified were: content focus, active learning, coherence, time span, and collective participation. Desimone (2009), Hawley and Valli (1999), and Ingvarson et al. (2005) all emphasized enhancing teacher content and pedagogical knowledge. Helping teachers to understand more deeply the content they teach and the best strategies for students to learn that content is a vital dimension of effective professional learning. The evidence for this claim, however, is wanting. Darling-Hammond and Sykes (1999) added the importance of professional learning that aligns with "school improvement priorities and goals" (p.10) as another key characteristic.

In the aforementioned studies examining the core features for teacher professional learning, what is conspicuous by its absence is a focus on students and student achievement. If the aim of

major reform efforts is to improve student achievement and professional learning is seen as the primary mechanism for achieving this, it is perplexing that student achievement is not a key consideration. As Fishman, Marx, Best and Tal (2003) contended "the most important measure of whether professional development is 'working' is whether teacher enactment yields evidence of improved student learning and performance" (p. 655). This view is supported by Jensen, Sonnemann, Roberts-Hull and Hunter (2016) who explored four educational systems that were all high performing in the OECD Program for International Student Assessments (PISA) and have implemented reforms to teacher development and professional learning to lift student learning on all points of the performance spectrum. Jensen et al. (2016) outlined the strategic approach adopted in these systems, arguing that it requires all professional learning to be developed around an improvement cycle in schools that is always tied to student learning. The cycle orients professional learning around the following steps:

1. Assess students' learning to identify their next stage of learning (at either an individual or school level).
2. Develop the teaching practices that provide for the next stage of student learning (and being clear what evidence supports this).
3. Evaluate the impact of new practices on student learning and refine practice. (Jensen et al. 2016, p. 6)

Hawley and Valli (1999) espoused nine key principles to foster effective professional learning, including a focus on student learning and their associated outcomes. The nine principles support the premise of EDR as an effective form of teacher professional learning and recognized examples of quality design-research display clear evidence of these components (Barab, Arici, &

Jackson, 2005; Hall & Herrington, 2010; Nelson, Ketelhut, Clarke, Bowman, & Dede, 2005). Hawley and Valli (1999) believe professional learning should:

- Focus on what students are to learn and how to address the different problems students may face in learning the material.
- Be based on analysis of the differences between (a) actual student performance and (b) goals and standards for student learning.
- Involve teachers identifying what they need to learn and developing the learning experiences in which they will be involved.
- Be primarily school-based and built into the day-to-day work of teaching.
- Be organized around collaborative problem solving.
- Be continuous and ongoing, involving follow-up and support for further learning. This should include support from sources external to the school that can provide the necessary resources and new perspectives.
- Incorporate evaluation of multiple sources of information on (a) outcomes for students and (b) the instruction and other processes that are involved in implementing the lessons learned through professional development.
- Provide opportunities to gain an understanding of the theory underlying the knowledge and skills being learned.
- Be connected to a comprehensive change process focused on improving student learning. (p. 138)

Gordon (2004) discussed the balance that is required to successfully implement individualized professional learning. He stated, "school improvement calls for collegial dialogue, shared vision, re-culturing, and collaboration. Yet, experts on change processes remind us that

change within an organization takes place at an individual level" (Gordon, 2004, p. 201). There appears to be a fundamental paradox here. For schools to effectively align and work towards a shared vision, the school needs to cater for individual needs. The key element appears to be catering for individual teacher needs in a collaborative framework. Whilst these appear to be opposing ideas, Gordon's (2004) research on individual teacher development focused on the five key features of "developing the whole teacher, adult learning styles, assisting beginning teachers, individualized professional development and finally teacher portfolios" (p. 200). The key message here is that while we can develop an organizational framework, we must not lose sight of how to best cater for the individual. Advocates of EDR suggest it has the capacity to addresses this dichotomy. It cultivates the collective vision of participants while building individual teacher capacity.

As Opfer and Pedder (2011) observed "the importance of improving schools, increasing teacher quality, and improving the quality of student learning has led to a concentrated concern with professional development of teachers as one important way of achieving these goals" (p. 376). A review of current research in this area highlights the notion that EDR, when undertaken in a rigorous manner, should meet the aforementioned requirements, while also focusing on key outcomes of interest, such as student achievement and the active participation of practitioners.

2.8 Professional learning autonomy and life-long learning

Loucks-Horsley, Hewson, Love and Stiles (1998) drew attention to the need to match the professional learning model to the purpose of the professional learning. They contended that the appropriateness of any particular model varies depending on the goals, the content and the context of implementation.

The process of change is not as simple as imposing a new professional development framework onto a school or system. It is important to firstly consider the current school or system

culture to establish teacher readiness for such an undertaking. Contextual features need to be carefully considered and catered for to ensure that any change is not seen as a prescribed intervention program, with limited autonomy for individual teachers. Where this occurs, "teachers feel like pawns rather than players who can control their own behavior, they are likely to respond with reduced commitment, mechanical behavior, indifference, and even dissatisfaction and alienation" (Sergiovanni, 2005, p. 129). As Fullan (1993) stated "you can't mandate what matters" (p. 20). This means that teachers need to have input (real input) throughout the entire process. It is clear that any professional learning initiative needs to be an ongoing, evolving process with the teachers firmly positioned at the center of the change.

As Mabey, Mayon-White and Mayon-White (1993) pointed out, "while the primary stimulus for change remains those forces in the external environment, the primary motivator for how change is accomplished resides with the people within the organisation" (p. 7). In these terms, change can be described as technically simple, but socially complex. This is a very complicated issue to work around. If teachers are overloaded with departmental and district initiatives, there is little time, energy or impetus to continue their own professional learning journey. Goodson (2003) noted, "when educators think about educational change, the first thing that comes to mind is usually external rather than internal change … rather than self-generated or professionally initiated innovation" (p. 12).

In the current educational landscape, schools are granted much greater freedom to pursue their own approaches, something that has generally been welcomed across the sector (Sharples, 2013). Yet with this freedom has come increased responsibility to make informed choices, as teachers and commissioners are faced with a myriad of different strategies and interventions to choose from, each with varying levels of effectiveness. In this context, how are school leaders

expected to know if the claims made by publishers, colleagues or advocates for a given approach are true? What, or who, can they rely on to give them accurate and tested information about what has been proven to work? The need for reliable and accessible evidence to inform decision-making becomes ever more acute.

An additional challenge posed by decentralization is how to bring research to bear on practice at scale. In the United Kingdom (UK), decentralization has, inevitably, led to a range of different networks and affiliations forming in education, including academy chains, teaching schools, free schools and local authority networks. As a result, there is a profusion of individual, small-scale approaches to finding and using evidence emerging, and without a coherent overall infrastructure there is a real danger of duplication and confusion for practitioners (Sharples, 2013). As Campbell and Levin (2012) argue, "mobilizing knowledge for 20,000 individual schools is not an easy task" (p. 9)

An examination of the research on teacher professional development also reveals the importance of teacher autonomy as advocated by Knowles (1978). As Colbert, Brown, Choi and Thomas (2008) stated, "when teachers are empowered to create their own professional growth plan, their passion for teaching and for improving the lives of their students is greatly enhanced" (p. 148). Colbert et al.'s (2008) small study observed three major occurrences where teachers were allowed to develop their own professional development plans. These were:

1. Teachers embraced and quickly took steps to address their needs. The alternative - a prescribed professional development program - may stifle a teacher's ability to take proactive steps toward improving their instruction.
2. Teachers pursued authentic professional development experiences to increase academic content knowledge.

3. Teachers quickly developed into the role of teacher-leader. Implementing their classroom and school plans required teachers to take on leadership roles in their schools. (p. 148)

There are no simple solutions, just as there is no one single approach or practice that should be implemented. It is clear, however, that any future professional learning needs to be underpinned by well thought out definitions and rationales for teachers' learning (Doecke et al., 2008). Servage (2008) found that while studying best practice has merit, it is an incomplete representation of the crucial role of collaboration. A fundamental tenet for professional learning is that it needs to be transformative (Brookfield, 2003). Unlike learning that targets building skills or knowledge,

> transformative learning causes an individual to come to a new understanding of something that causes a fundamental reordering of the paradigmatic assumptions she holds and leads her to live in a fundamentally different way. (Brookfield, 2003, p. 142)

This suggests that it is no longer acceptable for teachers to strive to solely acquire knowledge and skills. Professional learning must be more long term and strategic as we strive for transformation of the educational system and teaching practice. Transformative experiences force us to confront the possibility that our assumptions may not actually fit. In this way, teachers will voluntarily, albeit sometimes reluctantly, critically evaluate their pre-conceived notions and practice. Transformative experiences challenge teachers to think about their role and the impact they have on the students they teach. Added to this, school leaders must also acknowledge that they do not have control over the process. In fact, to be truly teacher centered, it might be essential that they do not. With this in mind, school leadership may need to conceptualize its purpose as striving for significant cultural change, rather than easy tokenistic change that has no lasting impact on teachers or the students they teach.

2.9 Deepening practice through teacher inquiry

As outlined, there is evidence to suggest that some traditional professional learning practices are ineffective in the modern workplace, as they do not provide the depth of learning required to increase teacher's knowledge or foster meaningful changes in classroom practice (Loucks-Horsley, et al., 1998). As stated earlier, the prevalence of one-off, single day workshops that often make teacher professional development "intellectually superficial, disconnected from deep issues of curriculum and learning, fragmented, and noncumulative" (Ball & Cohen, 1999, pp. 3-4) is consistently criticized in the literature.

Fullan et al. (2006) contended that, "in school education, there is no built-in mechanism that leads to ongoing improvement in classroom instruction" (p. 42). To illustrate this point, Fullan et al. (2006) cited some of the recent institutionalized approaches that attempt to redesign the process. These are: lesson study in Japan, lighter teaching loads in China, and classroom coaching in many English-speaking countries. The authors stated, however, that "none of these possess the rigour or power to bring about sustained and systematic improvement" (Fullan et al., 2006, p. 42). Their rationale was that these efforts were too small in scale, too limited in scope, under-conceptualized, too fragmented, under resourced, and without a rigorous research foundation (Fullan et al. 2006, pp. 42-43). The alternative they offer is EDR, believing that "instructional systems need to be conceptualized as ongoing research and development projects concerned with constant refinement and improvement" (p. 43).

Singapore sets a deliberate policy for ensuring teachers have adequate time for inquiry in everyday practice. While this is an expensive policy, requiring concessions in other areas, it is nonetheless an effective one. Schools receive additional funds so that teachers can collaborate throughout the working week. This strategy targets the continual development of learning

communities as the primary platform for professional learning in Singapore's schools, with teachers heavily involved in setting the framework for how these operate. Learning communities are shaped by four critical development questions that reflect the improvement cycle: What is it we expect students to learn? How will we know when they have learned it? How will we respond when they do not learn? How will we respond when they already know it? (Jensen et al., 2016, p. 9). These inquiry questions guide data collection and evaluation with a view to developing teaching practice to improve student outcomes. It is worth noting that part of Singapore's rise in OECD PISA rankings has been attributed to the shared responsibility for professional learning in schools. This is regularly reinforced by teacher evaluation and school accountability policies that place a greater focus on the quality of collaborative inquiry professional learning in schools (Jensen et al., 2016).

The concept of practitioner research is part of a larger international discussion too. Johnson (1993) is often acknowledged as introducing the concept of teacher-as-researcher when she wrote: "The concept of teacher-as-researcher is included in recent literature on educational reform, which encourages teachers to be collaborators in revising curriculum, improving their work environment, professionalizing teaching, and developing policy. Teacher research has its roots in action research" (p. 1).

In the US, Zeichner and Klehr (1999) conducted a national review of teacher research activities and found that teacher research can be a major strategy for teacher professional learning, with the potential for significant effects on teaching and learning. They also found that teacher researchers gained confidence from conducting research, and developed closer relationships with their students and colleagues. The types of teacher research investigated by Zeichner and Klehr (1999) varied from data analysis of observations, interviews and document collection, to interpretative dissertations. They acknowledged that some teacher research involves posing and

investigating a specific question, while other projects focus simultaneously on several questions; some projects primarily attempt to develop a better understanding of practice, others also aim to improve it. They also found that the degree to which external research is incorporated into the teachers' studies varied widely. For example, some teacher researchers used concepts, questions and ideas from external research as the starting point for their own research; others used external research as a resource later on in the research process; and some chose not to use external research at all. The authors went on to describe the range of motivations behind teacher engagement in research and cautioned about the anecdotal nature of much of the evidence about impact and the lack of information about how the research was conducted or supported. The latter are two issues at the core of the research questions for this study.

2.10 Teachers' experiences with practitioner research

It is timely at this juncture to examine the experiences of teachers undertaking practitioner research as a form of professional learning. The term 'practitioner research' has become increasingly broad, and increasingly difficult to define. Zeichner and Noffke (2001) described it as a form of educational inquiry that covers action research, self-study, and teacher research. Saunders (2004) posed the questions:

> who 'owns' the professional culture of research? How and by whom is the creation and take-up of knowledge in education safeguarded, monitored and 'policed'? How do teachers, and other educationists critically engage with the range of claims to legitimacy of educational (particularly pedagogical) knowledge? (p. 119)

Shulman (2004) highlighted the importance of teachers as researchers and bringing together the cognitive learning aspect with the teacher research tradition. While EDR does not advocate that teachers necessarily lead the research, it does advocate that teachers are active participants in the research process. As Shulman (2004) stated: "Teacher learning becomes more active through

experimentation and inquiry, as well as through writing, dialogue, and questioning" (p. 514). Here is where a clear distinction between EDR and other forms of teacher research can be made. An often cited shortcoming of teacher research is the ability of teachers to navigate the dual role of teacher and researcher. Issues can arise, as research requires a set of skills, dispositions and way of thinking that may be unfamiliar to a classroom practitioner. This is often an unfamiliar paradigm for teachers.

A distinction can be made in this context between the 'knowledge agenda' of academics and the 'knowledge agenda' of teachers (Eraut, 1994; Fenstermacher, 1994; Hoyle & John, 1995; Sachs, 2003). Ponte, Ax, Beijaard and Wubbels (2004) contended, "academics attempt to develop general knowledge about certain aspects of reality, whereas teachers aim to develop knowledge about how to act in specific, complex and unpredictable situations" (p. 572). While the two are inherently intertwined, they do however each serve different purposes and seek different outcomes. Sachs (2003) similarly argued that teacher research should not be confused with academic research, as the two serve different purposes and have different tests of validity and reliability. For her, teacher research enables teachers to understand and improve their practice. Its main contribution to the individual teacher is to make their knowledge explicit and to help them explore and understand their epistemology.

The underlying assumption for practitioner research is that creating knowledge closer to the local practice of education is more meaningful than the knowledge created by external institutions (Gibbons, Limoges, Nowotny, Schwartzman, Scott, & Trow, 1994; Hargreaves 1996; de Bruijn & Westerhuis 2004). As Reeves (2006) stated, "educational research is usually published in refereed journals that are unread by the vast majority of practitioners … reading research papers and translating the findings into practical solutions is a formidable task for educational practitioners"

(pp. 58-59). It should be pointed out, however, that EDR is not completely autonomous and like other forms of educational research, theory needs to support the intervention. In EDR, theory informs design, and design then adds to or supports the theory (Plomp & Nieveen, 2007). Advocates (van den Akker, Gravemeijer, McKenney, and Nieveen, 2006; Barab & Squire, 2004; Plomp & Nievenn, 2007) of EDR would argue it has the potential to meet the criteria (or middle ground) for reform initiatives as outlined by Hargreaves and Fullan (2012). That is, design research should be theory oriented and the design should be based on a conceptual framework and upon theoretical propositions. Likewise, it should also incorporate professional choice as it is interventionist and the research aims at designing an intervention in a real world setting where contextual considerations are built into the iterative process. Nevertheless, further exploration to establish its actual impact on teachers, and subsequently students, is needed to determine if the reality in fact matches the espoused purpose.

Added to this, in a recent comprehensive international study, the 2009 OECD Teaching and Learning International Survey (TALIS) report (Freeman, O'Malley, & Eveleigh, 2014) found that individual and collaborative research has the highest impact rate in terms of teachers' perceptions of their professional learning. Yet, despite increased participation in recent years, research engagement as a form of professional learning has one of the lowest teacher participation rates (Bell, Cordingley, Isham, & Davis, 2010).

Saunders (2007) posed the question: "what are teachers doing when they engage with and in research?" She suggested that practitioners may be doing some or all of the following:

- directly accessing research intelligence, for example, through websites, reading groups, researcher-in-school schemes, as well as journals and other print media;
- participating in externally generated research studies;

- undertaking research as part of their accredited professional studies;
- undertaking specific teacher researcher activities outside accredited study;
- actively experimenting in their own classrooms using a reflective-evaluative enquiry approach; and
- working in pairs or groups to read, analyse and discuss research relevant to professional and school development, and to design collaborative studies within or even across schools (p. 45).

In support of her contention that increasing numbers of teachers are research active and research literate, Saunders (2007) cited: a growing base of evidence and theory to support the development of teaching expertise. This included: school curricular and pedagogical development that is teacher led; rigorous and relevant professional learning and development for teachers; a range of rich data for accountability purposes; a culture of self and collective scrutiny and evaluation; and [opportunities] to question one's assumptions, to think and look beyond one's own horizons and to work in communities of other professionals.

2.11 Issues to consider with practitioner research

As discussed earlier, the role of researcher is often unfamiliar to classroom practitioners. One fundamental issue that is often associated with practitioner research, is that the principal researcher can be the primary data source, yet the associated bias is not fully understood or explored (Stringer, 2008). An important aspect of teacher inquiry that needs to be considered to temper this is teacher support throughout the research process. That is, someone is needed to actively support and guide the research design and development. The mechanism EDR includes in this respect, and

that sets it apart from other forms of practitioner research, is an experienced principal researcher who actively guides the research design and seeks input from teachers in the design process.

In the UK, the Department for Education and Skills (DfES) commissioned a review of the developments relating to practitioner engagement in and/or with research (Bell, Cordingley, Isham & Davis, 2010). This review highlighted some issues relating to practitioner research, such as:

- it is frequently small scale and incapable of generating findings that are reliable and generalizable;
- it is insufficiently based on existing knowledge and therefore incapable of advancing understanding;
- it is presented in a form or medium that is largely inaccessible to a non-academic audience; and
- it does not offer interpretation for a policy making or practitioner audience (p. 11).

Having said that, it should also be acknowledged that the Bell et al, (2010) review noted an increase in research outputs, with a greater focus on teaching and learning, as well as in the number and range of resources designed to support practitioner engagement in and/or with the research outputs (Bell et al, 2007).

While the issue of the relationship between research and practice generally, and teacher engagement in and/or with research more specifically, continues to spark debate (Vanderlinde, van Braak, & Hermans, 2009), a number of studies are beginning to yield an empirical evidence base around the processes and outcomes of teacher engagement with research and evidence (Figgis, Zubrick, Butorac, & Alderson, 2000; Morris, Percy-Smith, & Rickinson, 2007). Figgis et al. (2000) explored what research made it through to practice, and the nature of the 'connecting web' between practitioners and researchers. Morris et al. (2007) brought together evidence from a range of

sources to provide guidance on the design of practitioner research and development programs. However, much less is known about the ways in which practitioner engagement in and/or with research and evidence impacts on learner outcomes. There are numerous empirical studies of teacher professional learning that investigate and report on the links between a professional learning intervention and the outcomes for the learners involved (e.g. Timperley et al., 2007; Cordingley et al., 2003). But evidence about such links in relation to practitioner engagement in and/or with research has been less extensively identified, analyzed and synthesized (Bell et al, 2010).

Time is an important consideration. For teachers to effectively self-monitor and undertake practitioner research they need sufficient time allocation to do so. As Timperley et al. (2007) concluded, "extended timeframes and frequent contact were probably necessary because … the process of changing teaching practice involved substantive new learning that, at times, challenged existing beliefs, values, and/or the understandings that underpinned that practice" (p. xxviii). While allocating extra time to teachers through lighter teaching loads does not necessarily mean improvements in practice will follow (see Fullan et al., 2006), what we do know is that if teachers are not given adequate time, they may feel pressured to pursue short-term goals that revolve around finding what Appleton (2006) described as activities that work. This is where teachers are given activities to undertake in their classrooms without exploring or understanding the pedagogy and content that underpins the learning experience. There is a difference between thinking about and reconsidering practice as opposed to actively researching that practice. As Stenhouse (1975) explained:

> It is difficult to see how teaching can be improved or how curricula proposals can be evaluated without self-monitoring on the part of teachers. A research tradition, which is accessible to teachers, and which feeds teaching, must be created if education is to be significantly improved. (p. 165)

Teacher inquiry can be collaborative and should be aimed at explicating locally existing knowledge and creating new, relevant, practical knowledge (Enthoven & de Bruijn, 2010). Mertens (2010) described this as "cooperative inquiry, where the focus is on the group setting the agenda, participating in the data collection and analysis, and controlling the use of results" (p. 238). The research should be highly practical with the intentions of having immediate benefits to teaching and learning. However, there is tension between the desire for locally usable knowledge on the one hand and scientifically sound, generalizable knowledge on the other. One of the criticisms of practitioner research is that while it does create local context-specific knowledge, the results are often not generalizable to other contexts and the methodology can be based on participant researchers' perceptions (research bias), with biases not explored thoroughly or fully understood (Cochran-Smith & Lytle, 1999).

According to Schön (1983, 1987), teachers develop professional knowledge through a process of defining and solving problems. Goodson (1997) viewed the best way of improving the practice of teachers as researching and reflecting upon their own practice. Thus, agreed Maaranen (2009), 'great teachers' all "constantly reflect upon and refine their practice, try new things, work at what is not working well and think through the problems that face them" (p. 220). These are all essential components of effective EDR. While not directly stated by Goodson (2007), students' needs should be considered at the forefront of the reflective process. Here teachers reflect on the impact they are having on their students and use this in a continuous cycle of practice improvement. The inherent risk is that teachers who miss this key factor may move towards what works better for them (even on a subconscious level), rather than the students they teach. This could be considered teacher centered in terms of what is easiest for the teacher rather than student-centered learning.

2.12 Leading practitioner research: The importance of support

While practitioner research is becoming more widely practiced, it is worth noting that teachers may not have the required skills and dispositions to undertake it rigorously. This is not a criticism of teachers, or to say that they are not capable of learning these capabilities, it is more an observation that many teachers have not been trained in research practices or do not have support for research at a school level. Bell et al. (2010) highlighted how practitioners drew support from external assistance, peer collaboration, or both. Peer collaboration includes teachers jointly practicing the new teaching strategies, jointly planning and reflecting together and talking to others about the project. It also includes institutional resources and supports, and joint workshop and feedback sessions. Bell et al. (2010) discusses interventions focused on teacher learning found that institutional support was critical to the success of their interventions. The interventions pointed to the need for schools/leaders to:

- be knowledgeable about the professional development opportunity that action research offers;
- realize that support during the implementation steps of an action research study, specifically during the data analysis phase, is essential to the teacher's and school's success; and
- provide a supportive culture that enables teachers to learn new practices (such as assessment for learning strategies), feel safe about taking risks and have opportunities to learn from mistakes.

Bell et al. (2010) also identified the importance of external critical friends to support the practitioner research process. Good facilitators offered feedback, guidance, resources and tenacity.

Effective support from researchers in studies where teachers were part of an externally facilitated research project included modeling and training. For example, one of the studies Bell et al. (2010) explored referred to the researchers as 'mentors' who modeled the intervention strategies and provided technical support. Another study described how the researchers provided teachers with initial training in the intervention strategy and a manual that outlined specific learning goals and strategies that they then used collaboratively. For the EDR initiative to be effective, it is clear that research support for classroom teachers will need to be considered. The EDR initiative has considered peer support by ensuring the site leaders work in collaborative teams, while also incorporating external critical friends (technical support partners/consultants) to offer guidance and feedback throughout the research process.

2.13 Leading practitioner research: Leading inquiry

Coherence across professional learning environments is not achieved through the completion of checklists and scripted lessons, but rather through creating learning situations that promote inquiry habits of mind throughout the school (Timperley, 2011). Indeed, engaging in inquiry and knowledge building cycles is increasingly seen as core to professionalism, where leaders and teachers become deeply knowledgeable about both the content of what is taught and how to teach it.

With an inquiry stance on leadership, teachers challenge the purposes and underlying assumptions behind educational change, rather than simply helping to specify or carry out the most effective methods for predetermined ends (Cochran-Smith & Lytle, 2001). As teachers investigate their practice more deeply, they adopt a scholarship of teaching. They are doing more than transmitting information to students, they investigate, transform and extend knowledge, using the

same habits of mind that characterize the scholarly work found in the field of medicine or law, the type of practice that is the hallmark of discipline-based inquiry (Hutchings & Shulman, 1999).

Just like teachers, school leaders need to engage in ongoing inquiry into the impact of their policies and practices. They need to identify personal learning goals and seek the appropriate response to achieving them. When it comes to the issue of teacher learning and improvement, an important question to ask is this: is the rhetoric around developing motivated professionals who can make informed decisions about their practice based on deep knowledge, but then contradicted by approaches to professional learning that involve brief workshops about how to teach something? (Timperley, 2011). Teachers need learning leaders who can provide the right support for teachers to learn, so that they, in turn, promote their students' learning. They need to work in a system that learns. And a system lift requires a systemic response. The way schools are organized and run needs to be consistent with the broadening outcomes and the balance of, or selection between, the forces on them. Schools and their leaders will need to move from the bureaucratic and mechanistic to organic living systems, from thin to deep democracy, from mass education to personalization through participation, and from hierarchies to networks (Mulford, 2008).

Improving learning for students over an entire district is a complex task. Mourshed, Chijioke and Barber (2011) identified a small number of critical factors that complement each other to create the chemistry of widespread improvement. A school system can develop and implement a journey to improvement, but to achieve success, these four points must be in place (Mourshed et al., 2011):

1. The status quo, or performance stage, which identifies an awareness of where the system currently stands, while having an appreciation for the ongoing journey towards school and student improvement.

2. It is a snapshot of a moment in time. Student outcomes determine where a school system stands in relation to others.
3. The intervention cluster**,** which is all about what is needed to make the desired improvement in student outcomes.
4. Leaders must take into account the performance of the system currently, while deciding on interventions to improve performance with consideration of the socio-economic, political and cultural context in which they operate.

School based collaborative practitioner research is one intervention that has the potential to drive improved teacher practices. To be able to accomplish this, an educational system needs to be able to adapt to the interventions, taking into account the history, culture, politics and structure of the school system and community context. To be able to sustain this, school systems need to focus on improvement over the long term**.** So, for systems and schools, it is important to consider the conditions that need to be in place for a learning focused education system. How do we create or cultivate an environment in which teachers and school leaders work together to embed routines that nurture instructional and leadership excellence? This should include aspects such as making classroom practice public, and developing teachers into coaches of their peers. These practices are supported by an infrastructure of professional career paths that not only enable teachers to chart their individual development, but also make them responsible for sharing their skills across the system. Because these collaborative practices shift the drive for change to the front lines of schools, they have the potential to create self-sustaining system improvement.

Effective leadership practices are also an important sustaining factor for any professional learning framework. Robinson, Hohepa, and Lloyd (2009) noted that recent reviews of the impact of leadership on student outcomes have led to disparate conclusions (see also Robinson, Lloyd, &

Rowe, 2008). For example, Witziers, Bosker and Krüger (2003) concluded that the impact is minimal; Hallinger and Heck (1998) and Leithwood, Seashore, Anderson and Wahlstrom (2004) concluded that it is modest but important; and Marzano, Waters and McNulty (2005) concluded that it is quite substantial. A major problem with such reviews, claimed Robinson et al. (2009), is that they do not distinguish between two major forms of leadership: transformational and instructional.

Transformational leaders aim to inspire their people with a vision that energizes and encourages others to work collaboratively towards a common good. They specify what is expected and provide consequences for meeting or not meeting those expectations, they set direction (vision, expectations), redesign the organization (building collaborative cultures), provide transactional and managerial conditions (contingent rewards, monitoring school activity), and buffer staff from external demands (Leithwood, Tomlinson, & Genge, 1996). Instructional or pedagogical leaders are involved in classroom observations, review and interpret test information with staff, have a clear mission about learning gains, have high expectations about achievement, and attend to opportunities to learn. Instructional leaders have a more direct involvement in learning whereas transformational leaders are more indirect in their involvement towards enhanced learning outcomes. From their meta-analysis of 12 studies (188 effects), Robinson et al. (2009) calculated an overall effect size from transformational leadership of 0.11 and from Instructional leadership of 0.42. These conclusions are also supported by Elmore (2004), as well as Marks and Printy (2003).

In their report 'How the world's most improved systems keep getting better', Mourshed et al. (2011) noted that as the performance of the school system rises as a whole, professional development shifts away from a focus on technical training delivered by central coaches to a greater reliance on teacher-peer collaboration and development. This leads to further innovations in

teaching and learning, and more of a feeling of professional fulfillment among educators. Added to this, accountability for student learning also expands and improves, from the sole indicator of assessment being standardized tests, to the inclusion of school and teacher self-evaluation.

2.14 A gap in the literature

Despite the increasing importance being placed on professional learning, there is still a paucity of definitive research about the impact EDR has on teaching practice. A recent report from the Committee on the Study of Teacher Preparation Programs in the US reached similar conclusions (National Research Council, 2010). They pointed to the methodological and conceptual difficulties in establishing causal links between teacher preparation and pupil outcomes. The report stated:

- There are no well-formed theories that link teacher preparation to student outcomes.
- The complex nature of schooling children makes it difficult to identify empirically the role of teacher preparation among the many intertwined influences on student outcomes.
- The use of strict experimental design principles can be problematic in some educational settings … it is difficult to control for all the important factors that are likely to influence student outcomes. (p. 22)

Timperley et al. (2007) also highlighted the paucity of definitive empirical studies on professional learning. In their Best Evidence Synthesis on professional learning and development, Timperley et al. (2007) highlighted specific shortcomings in educational research, such as "the weak theory base for professional learning; limited information concerning the qualities of effective providers … [and conclude that] the empirical evidence relating to the professional learning of teachers is sparse" (p. 228). It is therefore important to develop this body of research further to

ensure the needs of practitioners and students are being met. In order for education to attract, develop and, crucially, retain the best practitioners for the demands of 21st century teaching, it is increasing important to explore opportunities to link quality research with classroom practice. As Dinham (2012) pointed out, what is needed is a strong evidence base, where teachers are informed users of research and data, and where practices are constantly put to the evidence test.

While it is acknowledged that many factors influence student achievement, it is also acknowledged that teachers are a significant factor (Hattie, 2003). As such, we need to continue to strive for advances in determining teachers' impact. It is important to acknowledge, "there is extensive empirical evidence and theoretical development relating to children's learning, what promotes it, and what limits it" (Timperley, 2007, p. 228). This theoretical base led researchers to identify the role that teachers play in influencing student outcomes. As a consequence, educators now agree that many aspects support student learning. The next imperative is "understanding the ways in which teacher education influences student outcomes" (National Research Council, 2010, p. 22). The function of research, and the aim of this study, is therefore to tackle difficult questions and to attempt to make what is complex understandable. This will add to discourse in this area.

2.15 Educational Design-Research (EDR) as teacher professional learning

It is also important to ground thinking and solutions in theory and evidence. That is, decisions and interventions are based on research and the impact on teachers and student is continually evaluated and analyzed to inform the future direction of the professional learning initiative. Since EDR is exploratory by nature, it also has the potential to be perceived as inherently risky. Developing new interventions and searching for new practices may lead to alternatives with unsatisfactory outcomes for students or teachers. The opportunity for EDR to nurture innovation is one that carries inherent risk. However, claimed Edelson (2006, p. 104), the "criterion that design

research should be research-driven helps mitigate that risk … if the proposed design is grounded in existing research or sound theory, then it can be innovative without being overly risky". In EDR, this is one of the key roles of the lead researcher; ensuring the project is grounded in theory to minimize and mitigate the risk of unsatisfactory outcomes.

Timperley et al. (2007) found 72 studies that assessed the effects of professional development on student outcomes: the overall effect on student academic outcomes was an effect size of 0.66. Hattie (2008) synthesized five meta-analyses on professional development that included 537 studies and found an effect size of 0.62. He concluded that professional learning falls within the high category in his "zone of desired effects" (p. 19) on student achievement. In other words, 'effective' professional learning is a key mechanism for improving outcomes and is well worth pursuing to attain higher levels of student achievement. Timperley et al. (2007) developed a theoretical framework comprising 84 different characteristics of the professional learning environment likely to impact on student outcomes. They used this to analyze studies in their literature review. These categories included the social context in which teachers work—the wider policy and school environments—together with the specifics of the professional learning context. These characteristics and how they relate to EDR are explored below. Timperley et al. (2007) concluded that effective contexts for promoting professional learning opportunities that impact student outcomes, how the seven elements relate to EDR is briefly explained below:

- *Extended time for opportunities to learn:* EDR is an iterative process that utilizes a cycle of analysis, design and development, evaluation and refinement.
- *External expertise was typically necessary:* EDR advocates external expertise to work in collaboration with practitioners to analyze practical teaching and learning problems, develop solutions using research design principles, then test and refine the solutions.

- *Teachers' engagement in learning at some point was more important than initial volunteering:* EDR encourages active participation of practitioners in the various cycles and activities of the research.
- *Prevailing discourses challenged:* EDR is process oriented, where the focus is on understanding and improving interventions in a process of iterative cycles of thinking and alternatives.
- *Opportunities to participate in a professional community of practice were more important than place:* EDR is collaborative and participative.
- *Consistency with wider trends in policy and research:* EDR is theory oriented where the design is based on a theoretical framework that should mean interventions are consistent with current research and/or current policy.
- *Active school leadership:* EDR in a school setting requires school leaders to actively organize a supportive environment to promote professional learning opportunities and the implementation of new practices in the classroom. It may also include school leaders developing a learning culture within the school, were they are also seen as learners.

As stated in earlier, EDR and participation in learning communities is aimed at explicating locally existing knowledge and creating new relevant, practical knowledge (Enthoven & de Bruijn, 2010). Mertens (2010) described this as "cooperative inquiry, where the focus is on the group setting the agenda, participating in the data collection and analysis, and controlling the use of results" (p. 238). However, as highlighted previously there is tension between the desire for locally usable knowledge on the one hand and scientifically sound, generalizable knowledge on the other. To mitigate this issue EDR espouses active participation by practitioners, where teachers take on many of the roles of a practitioner-researcher, however the research is still guided by an experienced

researcher. This component, in theory, ensures that some of the aforementioned shortcomings are tempered, as the practitioners are not working in isolation within this unfamiliar research paradigm.

2.16 Quality assurance in Educational Design-Research (EDR)

As with all forms of research, there needs to be a method to "assure the quality of data collected and the correctness of the interpretation … just as importantly it must demonstrate the conclusions to be more likely than other alternative interpretations" (Dick, 2012). This needed to be closely scrutinized to ensure the EDR project examined in this study was based on valid and reliable data sources. Identifying specific inclusion criteria for the EDR projects considered in this study was therefore a necessary prerequisite to ensure the integrity and rigor of the project data.

It was also important to establish the quality of EDR projects with recognized scientific research standards. Incorporating a research informed inclusion criteria was essential to ensure the impact attributed to participating in this project was accurate. If the EDR projects are considered scientifically sound, then the findings will, in turn, be defendable. This ensured the integrity of the research process and the subsequent findings and conclusions. Shavelson and Towne (2002) described the scientific process in terms of six interrelated principles of inquiry:

- Pose significant questions that can be investigated;
- Link research to relevant theory;
- Use methods that permit direct investigation of the question;
- Provide a coherent and explicit chain of reasoning;
- Replicate and generalize across studies; and
- Disclose research to encourage professional scrutiny and critique. (p. 54)

These principles offer a set of standards that could be used as a set of norms for EDR. Shavelson and Towne (2002) viewed the "guiding principles as constituting a code of conduct that

includes notions of ethical behavior" (p. 52). However, these principles are not specific to this project and it was important that specific criteria be established to determine the type of EDR project that would be examined in this study. This is supported by Cobb et al. (2003) and Kelly and Lesh (2000), who argued that design research does not describe a single methodology, since within this field exists differences in goals, methods and measures. Brown (1992) and Collins (1992) noted the complexity of this research, arguing that the design researcher:

- conducts research in a messy (not lab) setting;
- involves many dependent variables;
- characterizes, but does not control, variables;
- flexibly refines design rather than following a set of fixed procedures;
- values social interaction over isolated learning;
- generates profiles; does not test hypotheses; and
- values participant input to researcher judgments.

Establishing criteria for a research method that works with procedural ambiguity, ill-defined problems, and open systems that are socially multi-level, and multi-timescale (Lemke, 2001) is problematic. Cobb et al. (2003) observed that, in many cases, EDR uses the structure of a domain (for example, mathematics or science) as a theoretical guide for designing solutions. While discussing quality criteria for design research, Kelly (2006) stated, "a simple or single codification of criteria for judging the quality of *design research* studies or proposals is not plausible or even desirable" (p. 108). So, for the purpose of this study, the focus was on inclusion criteria as a mechanism to ensure a high quality of empirical evidence was used. Ormel, Roblin, McKenney, Voogt and Pieters (2012) identified the following inclusion criteria to exemplify research-practice interactions evident during design research:

- Educational orientation: The project described was developed either within a formal educational setting (i.e. primary, secondary or tertiary education) and/or as part of a teacher professional development program.
- Researcher-practitioner participants: Besides the researchers, the project involved (student) teachers, and/or intermediaries (e.g. teacher educators, content experts, etc.).
- Research contributes to a practical output: The intervention has an explicit emphasis on the ways in which (design) research informed the design of instructional solutions (i.e. lesson plans, pedagogical strategies, etc.).
- Empiricism: The intervention is based on the collection and analysis of empirical data. (pp. 5-6)

While reviewing the evidence on how professional development affects student achievement, Yoon et al. (2007) discussed the importance of ensuring the empirical evidence is of high quality to successfully establish this affect. They points to three essential steps to successfully measure the effect professional learning has on student achievement;

1. The professional learning must be high quality in its theory of action, planning, design, and implementation.
2. The teachers must have the motivation, belief, and skills to apply the professional development to classroom teaching.
3. Teaching—improved by professional learning—raises student achievement. (p. 4)

Illustrating that professional learning translates into gains in student achievement poses tremendous challenges, despite an intuitive and logical connection (Borko, 2004; Supovitz, 2001; Loucks-Horsley & Matsumoto, 1999;). Yoon et al. (2007) noted that, “even if professional development

enhances teacher knowledge and skills and improves classroom instruction, a poorly designed evaluation or inadequate implementation would make it difficult to detect any effects from the professional development" (p. 4). Yoon et al. (2007, p. 3) argued that to substantiate the empirical link between professional development and student achievement, studies should ensure the empirical evidence is of high quality. Yoon et al. (2007) content that high quality evidence can be established by:

- A rigorous research design must ensure the internal validity of causal inferences about the effectiveness of professional development. Using a study design with strong internal validity can rule out competing explanations for gains in student academic achievement. The research design should be able to measure the value that professional learning adds to student learning separately from the value added by innovative curricula, instruction, or materials. A rigorous research design must also have externally valid findings, adequate statistical power to detect true effects, and sufficient time between the professional learning and the measurement of teacher and student outcomes.
- The study design must be executed with high fidelity and sufficient implementation of professional development. This will be established through classroom semi-structured interview's.
- Psychometric properties of measures must be adequate (measures of classroom teaching practices, of student achievement, and of teacher knowledge, beliefs, and behaviours). Measures should be valid, reliable, age-appropriate, and sensitive to and aligned with the intervention.
- Analytic models must be well specified and statistical methods must be appropriate (pp. 4 & 5).

2.17 Summary

A significant shift over the last ten years in relation to teacher professional learning and use of research has been the realization that passively disseminating research – 'packaging and posting' – is unlikely to have a significant impact on people's behaviors (Nutley, Walter & Davies, 2007, Levin, 2011). Like so many aspects of work, research use is emerging as a largely social process, with interaction and relationships being key factors in determining how evidence gets used and applied in practical settings. Having the opportunity to discuss research helps practitioners gain a deeper understanding and sense of ownership of the findings and, in doing so, enables evidence to be integrated more relevantly and sensitively in professional settings (Cooper, 2010). In this respect, it is unsurprising that collaborative–based approaches, such as EDR, which support direct engagement and dialogue between researchers and users, are proving to be particularly effective (Nutley et al., 2007). As such, our notion of knowledge mobilization in education requires extending beyond just communicating research, to looking at how it is effectively engaged and applied to practice.

Chapter 3: Thesis design

3.1 Introduction

The specific purpose of this thesis is to explore the experiences of teachers who undertake practitioner research, specifically EDR, as a form of teacher professional learning and how this impacts on their practice and the students they teach. The intention was to investigate the conditions that affect teachers in changing or modifying their attitudes, beliefs and teaching practice, and monitor these changes over time. This chapter begins with an explanation and defense of the research design, including the conceptual framework underpinning this project. Three interrelated studies were undertaken to explore the impact EDR has on teachers. The core questions and general overview of the three studies are outlined below. The general question that guided this study, however, was 'Does EDR impact the practice of teacher participants?'

This general question was then divided into the three phases, as outlined in the previous chapter, with each phase having a conceptual framework and set of questions to inform the broader research aim. Specifically, within Study 1, where the behavioral intent of participants was explored, the TPB study sought to answer the following research questions:

- Which of the three direct determinants of intention are statistically significant predictors of teachers' intentions to use the practices explored in the EDR initiative?
- What are the potential enablers and barriers to the subsequent use of the practices explored in the EDR initiative?
- Is the TPB an appropriate conceptual framework for evaluating the participants' intentions to use the practices explored in the EDR initiative?

For Study 2, where changes in teacher behavior (practice and planning) and changes in student mathematical practices were explored, the specific research questions were:

- How do the teachers perceive their own change as a consequence of the EDR project?
- How does teacher practice change as a consequence of their participation in the EDR project?

Study 3 (A) involved breaking down the matched level of implementation questionnaire (LOIQ) teacher data into four distinct groups according to their learning trajectory throughout this longitudinal study (large, medium, small or reverse growth). Data were analyzed to answer the following research question:

- What were the different learning trajectories for teachers undertaking the EDR initiative?
- Can the sample be grouped as large, moderate, small or reverse growth teachers?

Study 3 (B) collected extended response, qualitative data to gain further insights into the actual perceptions and experiences of participants. The specific research questions were:

- What did the teachers do and what distinctive dispositions did they characteristically display, particularly when most challenged?
- To what extent did teachers attribute any changes in teaching practice to their involvement in EDR?
- To what extent could they attribute changes in what their students know and are able to do to their involvement in EDR?

This study utilized a mixed methods approach, combining qualitative research (the generation of data in non-numerical form) and quantitative research (the generation of data in the form of numbers) (Punch, 2013) to triangulate and synthesize the findings from each of the three studies.

3.2 Multiple methods approach

According to Creswell and Garrett (2008) using a mixed methods approach has gained increased interest and momentum worldwide over the last two decades. This is likely to continue (Denscombe, 2008). Similarly, Doyle, Brady and Byrne (2009) contended that:

> Mixed methods research is viewed as the third methodological movement and as an approach it has much to offer health and social science research. Its emergence was in response to the limitations of the sole use of quantitative or qualitative methods and is now considered by many a legitimate alternative to these two traditions (p. 175).

Utilizing a mixed method, pragmatic framework approach allows the researcher to collect and analyze the data and integrate findings by drawing inferences between both the qualitative and quantitative findings within the same study (Tashakkori & Creswell, 2007). In turn, this provides the researcher with the opportunity to gain a deeper and more in-depth understanding of the research problems (Creswell & Plano Clark, 2007). Using multiple approaches when answering research questions provides the researcher with more choice, and this is viewed as a less restricting and more expansive form of conducting research (Johnson & Onwuegbuzie, 2004).

Greene, Caracelli and Graham (1989) suggested five purposes for using a mixed methods approach. First, the research can be triangulated, which seeks convergence and corroboration of results from different methods and designs while studying the same phenomenon. Second is the notion of complementarity, which aims to elaborate, enhance, illustrate and clarify the results from one method to the results from the other method. Third, is initiation, in which the researcher discovers paradoxes and contradictions that lead to a re-framing of the research question(s). Fourth is the idea of development, when the findings from one method can be used to help inform the other method. Finally, the mixed methods approach enables an expansion of the breadth and range of research by using different methods for different inquiry components.

In this research, Studies 1 and 2 utilized a quantitative approach and the findings from the qualitative results in Study 3 were used to validate and triangulate the findings from the first two studies. In turn, the qualitative results from Study 3 were used to clarify and enhance the findings from the first two studies. In other words, the qualitative component from Study 3 helped inform and enhance the findings from the quantitative research undertaken in Studies 1 and 2. Therefore, the use of a mixed methods approach enabled a more complete understanding of the phenomenon. Using a mixed methods approach aligns with the work of Locke (2004) and Petrosky (2003), who highlighted the dangers of using a smaller range of evidence, such as students' test scores, to measure the outcomes of teachers' professional learning. Any single methodological approach is unlikely to capture the complexity associated with teacher professional learning.

The specific quantitative approaches used in Studies 1 and 2 are explained in Chapters 4 and 5 respectively and the specific qualitative approach is explained in Chapter 6. Figure 4 presents an outline of the broad research design.

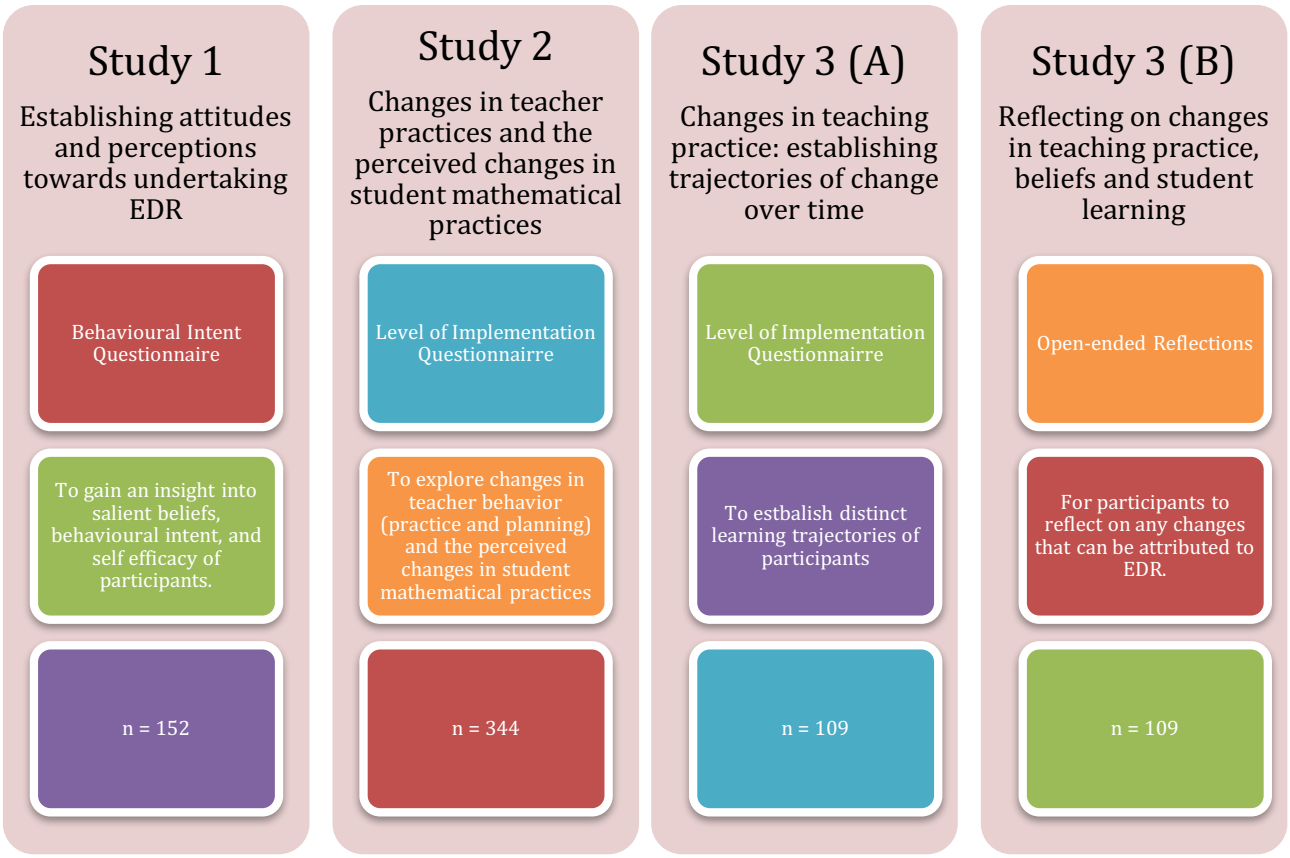

Figure 4: Research design

The three studies were designed to produce an integrated understanding of the experiences of practitioners who participated in EDR as a form of teacher professional learning. How does EDR impact on their practice and the students they teach? The intention was to move beyond a simple description of professional learning from the teacher's perspective, to explore these perspectives more deeply through the development of instruments and analysis of quantitative and qualitative data.

In Study 1, the TPB was used to gain an insight into the behavioral intentions of participants and to explain specific behaviors linked to the EDR initiative. It sought to build a portrait of teacher professional behaviors linked to the EDR as professional learning. The TPB (Ajzen & Fishbein, 1980; Ajzen & Madden, 1986) was used to predict the intentions of teachers to actively engage in

ongoing professional learning and modify teaching practices as a result of this process. Based on the work of Francis, Eccles, Johnston, Walker, Grimshaw, Foy, Kaner, Smith and Bonetti (2004) the Behavioral Intent Questionnaire (BIQ) targeted the population to elicit the actual beliefs of teachers (the target population) regarding their intention to participate in professional learning and to assess the strengths of these beliefs (Study 1).

Through a self-report survey, Study 2 explored the perceived changes in teacher behavior (practice and planning) and the perceived changes in student mathematical practices as a consequence of the EDR initiative. Study 2 built on the understandings and profiles developed by the TPB phase (Study 1). The self-report survey was administered four times over the 2013/2014 academic year to establish the impact the EDR initiative had on teachers over time.

The qualitative open-ended reflections in Study 3 (B), took place at the conclusion of the 2013/2014 academic year. This ensured insights represented teachers who had participated in the EDR for a sustained period of time. Study 3 sought to gain a deeper understanding of teacher perceptions on the content of the EDR, changes in teaching practice, observable changes in students and the teachers' reactions (affective domain) to participating in EDR. To understand and provide an in-depth and critical exploration of the experiences of each participant, it was essential to consider changes in teaching practice over time with the target population. The intention of Study 3 was to consider and establish key themes that emerged from the data generated from participants. The purpose here was to identify and explain important factors influencing participants and what changes in practice (if any) are embedded in the classroom. The open-ended reflections coupled with the quantitative studies (Studies 1 and 2) enabled "converging lines of inquiry" (Yin, 2009, p. 115) and the scope for participants to articulate their multiple subjectivities and the ways in which they connect with their teacher professional learning in a classroom context.

Thus, because the study involved a variety of inter-related data collection tools, collecting data from groups of individuals at different points before and during the EDR projects, it was expected that an accurate description of teacher experiences and the impact on the students they teach would be established. The following paragraphs outline the planned methodology and justification for the tools employed, as shown in Figure 4.

3.3 Study 1 data analysis framework

3.3.1 Background of attitudinal research on professional learning

Over the past thirty years, an increasing amount of literature has focused on the attitude-behavior relationship in teacher professional learning. When exploring science education, Shrigley (1990) declared that attitude scales must have a higher degree of validity and the search must continue for better measurement schemes. Testing the social situation and additive testing should be explored more fully. It is over twenty-five years since Shrigley (1990) suggested that educators pay close attention to the theories proposed by social psychologists Ajzen and Fishbein (1980), particularly the Theory of Reasoned Action (TRA), and the more recent TPB, yet despite some small scale studies the literature suggest very little has occurred during this period.

The relationship between attitude and behavior is complicated and factors other than attitude are at play in the implementation of a behavior (Kennedy & Kennedy, 1996). The TPB is a framework designed to predict and explain human behavior in specific contexts (Conner, Povey, Sparks, James, & Shepherd, 2003; Shin, 2004; Cheng, Lam, and Hsu 2005). TPB (Ajzen, 1985, 1991) is a theoretical framework formed as an extension of the TRA (Ajzen & Fishbein, 1975; 1980). The theory assumes that human beings make rational decisions based on the information available to them. Both theories (TPB and TRA) are meant to "demonstrate that general attitudes and personality traits are implicated in human behavior, but that their influence can be discerned

only by looking at broad, aggregated, valid samples of behavior" (Ajzen, 1991, p. 181). A central notion of the TPB model is that an individual's *intention* to perform a given behavior is a strong indication of how willing the individual is to perform the *actual* behavior (Ajzen, 1991, 1985). Intention is a causal mediator among the psychosocial variables of the three constructs of the model (Ajzen, 1991). The theory postulates that four factors influence behaviors: (a) intention; (b) beliefs about the likely consequences of the behavior (attitudes); (c) beliefs about the expectation of others (subjective norm); and (d) beliefs about internal and external barriers that may hinder the behavior to be performed (perceived behavioral control) (Ajzen, 1985, 1991).

The TRA posits that behavior is best predicted by intentions, and "intentions are jointly determined by the person's attitude and subjective norm concerning the behavior" (Leong, 2003, p. 8). The TPB specifies the two original determinants of intention of the TRA – attitude and subjective norm – as well as a third determinant of intention, namely perceived behavioral control (Proctor, 2004). Demir (2010) pointed out that attitude toward the behavior refers to the degree to which a person has a favorable or unfavorable evaluation or appraisal of the behavior in question. Subjective norm refers to the perceived social pressure to perform or not to perform the behavior. The degree of perceived behavioral control refers to the perceived ease or difficulty of performing the behavior, assumed to reflect past experience as well as anticipating impediments and obstacles. As a general rule, the more favorable the attitude and subjective norm with respect to behavior, and the greater the perceived behavioral control, the stronger an individual's intention should be to perform the behavior under consideration (Ajzen, 1991). Figure 5 illustrates this relationship. The inclusion of perceived behavioral control is what distinguishes the TPB from the TRA.

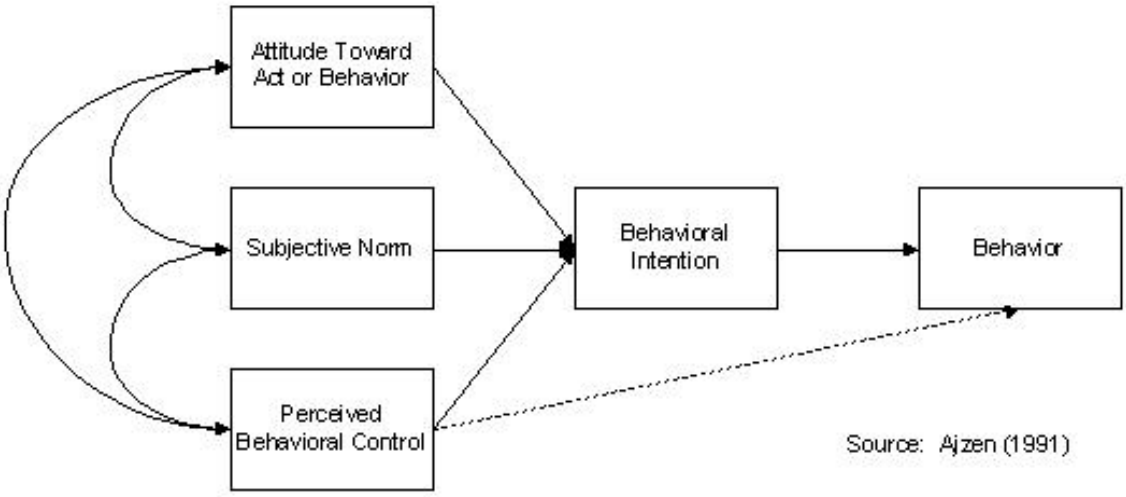

Figure 5: The Theory of Planned Behavior, Ajzen (1991)

The pioneering research conducted by social psychologists Fishbein and Ajzen (1975), Fishbein (1980), and Petty and Cacioppo (1981) provided the conceptual foundation and empirical evidence necessary to understand the relationship between attitude and behavior. Their theories have encouraged investigations in the prediction of behavior, development of measurement instruments, and creation of belief-based intervention strategies. The usefulness of the attitude/behavior theories is based on three considerations: (a) they aid the understanding and prediction of behavior; (b) they direct the creation of instruments to measure the variables that determine behavior; and (c) they guide the development of belief-based intervention techniques.

3.3.2 Theory of reasoned action (TRA)

Fishbein and Ajzen (1975, 1981) proposed the TRA to mathematically relate beliefs, attitudes, and behaviors. They argued that most human behaviors can be predicted and explained almost exclusively in terms of individual beliefs and attitudes. This argument is based on the assumption that "humans are rational animals that systematically utilize or process the information available to them" and that "the information is used in a reasonable way to arrive at a behavioral

decision" (Fishbein, 1980, p. 111). The theory has been used to understand and predict a variety of behaviors, including family planning, consumer behavior, voting, weight loss, the intent to enroll in a science course and intent to use investigative teaching methods (Crawley & Coe, 1990).

According to the TRA, the primary determinant of a person's observable behavior is the person's intention to perform (or not to perform) the behavior. Behavior is defined as an overt action under an individual's volitional control and within the individual's capability. Since people usually do what they intend to do, behavioral intention is the variable that predicts a person's behavior. However, this is contingent upon consistency between the level of specificity of the behavior and the behavioral intention (Crawley & Coe, 1990). Intention can be predicted if two antecedents are known: (a) the person's attitude toward the behavior and (b) the person's subjective norm. Attitude toward the behavior in this case is solely evaluative; a readiness to respond behaviorally is not included in the equation and thus intention is considered the immediate precursor to behavior (Shrigley, 1990).

According to the TRA, attitudes are a direct result of the information the person has about the attitude object, so one could measure the salient beliefs the person has about the object. Personal beliefs are linked with outcome evaluations and normative beliefs with motivation to comply through the expectancy-value theorem that is rooted in Edwards' (1954, cited in Crawley & Koballa, 1994) subjective-expected-utility (SEU) theory. The SEU theory predicts that a person making a behavioral choice will select the alternative that will lead to the most favorable outcome. The TRA links beliefs with attitude toward the behavior (*AB*), beliefs with the subjective norm (*SN*), attitude and subjective norm with behavioral intention (*BI*), attitude and subjective norm with behavioral intention, and behavioral intention with behavior *(B)* through the following equation (Crawley & Coe, 1990):

$$B \sim BI \sim AB + SN$$

Accumulated research has provided support for the notion that behavioral intentions can be predicted from attitudes and subjective norm (Petty & Cacioppo, 1996). Fishbein (1980) noted that, although a person's intention to perform a given behavior is the best single predictor of whether or not the person will act, predictions may be statistically improved by measuring intentions with respect to all of the person's alternative courses of action.

3.3.3 Theory of planned behavior (TPB)

The TRA has met with criticism due to its limited applicability. Liska (1984) emphasized that most behavior is neither volitional nor non-volitional, but ranges from that which requires a degree of skill, a degree of social cooperation, or both. The TRA was found to be insufficient in explaining behavioral intention when subjects perceived that control over the behavior was incomplete. When subjects did not possess the requisite personal attributes, resources, or opportunities to engage in the behavior, the theory proved to be an unacceptable model for understanding and predicting behavior. Ajzen (1985), therefore, proposed the TPB as an extension to the TRA to account for the performance of behaviors that are not completely under volitional control.

In addition to attitude toward the behavior and subjective norm, a third construct, perceived behavioral control was added to the model. Perceived behavioral control is "the person's belief as to how easy or difficult performance of the behavior is likely to be" (Ajzen & Madden, 1986, p. 457) and represents the extent to which the individual believes that performance of the behavior is affected by internal and external factors. This has relevance for teacher professional learning. Internal factors may include inadequate skill, talent or ability, and external factors may include

lack of resources (time, supplies, funds, etc.) opportunity, or the cooperation of others. As in the TRA, intentions occupy a central role in the prediction of behavior.

Perceived behavioral control is rooted in belief-based antecedents; a subject will associate a limited number of controls with performance of a behavior (termed control beliefs, *cb*), weight each by the likelihood it will occur (likelihood of occurrence, *lo*) and combine each control-action association to form a generalized self-efficacy judgment (Ajzen & Madden, 1986). At least two rationales are offered for the hypothesis that perceived behavioral control, along with behavioral intention, can be used to predict behavioral achievement. First, holding intention constant, the effort expended to successfully complete a behavior is likely to increase with perceived behavioral control. Second is that perceived behavioral control may be used as a substitute for a measure of actual control. This, however, depends on the accuracy of the individual's perceptions. Perceived behavioral control may not be realistic if the person has little information about the behavior, when requirements or available resources have changed, or when new and unfamiliar elements influence the behavior. Under these conditions, the addition of a measure of perceived behavioral control to the TRA may add little accuracy to the prediction of behavioral intention (Ajzen, 1985).

Ajzen and his colleagues asserted that perceived behavioral control *(PBC)* will influence both behavioral intention and behavior. They argued that behavior is influenced directly to the extent that perceived behavioral control will have a motivating or demotivating influence based upon the individual's assessment of their likelihood of success (Ajzen & Madden, 1985). Madden, Ellen, and Ajzen (1992) reported that perceived behavioral control has the greatest influence on both behavioral intention and behavior when perceived control over the behavior is low. Under these conditions, attitude toward the behavior and subjective norm would not be expected to explain behavioral intention and behavior accurately.

The TPB has been broadly supported in empirical literature in different fields (Chiou, 2000; King & Dennis, 2003; Cheng et al., 2005; Fusilier & Durlabhji, 2005; Francis et al., 2004). Meta-analyses also indicate that the TPB provides an explanation for a wide range of behaviors (Ajzen, 1991; Armitage & Conner, 2001; Cooke & Sheeran, 2004; Godin & Kok, 1996; Sheeran & Taylor, 1999). Applying the TPB to this research context suggests that a teacher's behavior (modifying practice as a result of EDR) is jointly determined by his/her: (a) attitudes to undertaking EDR for professional learning; (b) perception of relevant others' opinions on whether he/she should undertake EDR for professional learning; and (c) perception of the availability of skills, resources or opportunities necessary for using EDR for professional learning. Validated scales from previous research (Demir, 2010; Francis et al., 2004; Patterson, 2001; Venkatesh & Davis, 2000) were used to develop a questionnaire to measure the variables of interest.

It is proposed that the TPB in education permits the identification of salient beliefs underlying personal action and demonstrates the crucial role they play when an individual constructs a model of reality. It is this model that an individual consults when facing the need to make a personal decision. Once determined, salient beliefs can be reinforced, downplayed, or supplemented with additional information relevant to decision-making (Simpson, Koballa, Oliver, & Crawley, 1994). This is a worthwhile insight for further exploration.

3.3.4 Identifying teacher learning needs and behavioral intent

Most professional learning evaluations are administered after the professional learning has occurred. However, the use of formative data to support the design of the professional learning experiences has the potential to increase teacher engagement, when the professional learning framework considers the specific local context needs of participants. Guskey (2002) developed a framework that explored five levels of professional learning evaluation (shown in Table 1), stating

that, “with each succeeding level, the process of gathering evaluation information gets a bit more complex” (p. 46).

Table **1**:Guskey's five critical levels for evaluating professional development

Level	Implication
Level 1: Participants' reaction	Helps improve the design and delivery of programs
Level 2: Participants' learning	Validates the relationship between what is intended and what was achieved
Level 3: Organizational support and change	Some of the best and most promising improvement strategies have been seriously stifled or halted completely because of seemingly immutable factors in the organization's culture (Fullan, 1993)
Level 4: Participants' use of new knowledge and skills	Are participants using the knowledge and skills to implement practice as it was intended to be implemented?
Level 5: Student learning outcomes	Changes in teacher practices are sustained only when professional development and implementation is combined with evidence of improved student learning (Guskey, 1982, 1984)

Yet the first level of evaluation begins by eliciting the ‘participants’ reaction’ after the initial professional learning experience. It would possibly be more relevant to explore the participants’ intent to engage prior to the learning experience. By eliciting intention and analyzing the factors that influence intention, there is an opportunity to design the professional learning experience based on the needs and attitudes of participants. To investigate how teacher practices builds teacher capacity, this study presents research that develops and applies measures based on the TPB (Ajzen, 1985).

Applying the TPB offers an insight into the behavioral intention of participants undertaking EDR. A key aspect of this theory is to explore the salient beliefs of participants, specifically: their attitude toward behavior, subjective norm, and perceived behavioral control. Rust and Meyers (2006) offered insight into specific examples that may affect attitude toward behavior and perceived behavioral control. They identified key issues in the work done with school professionals beginning research. Problems reported included: time constraints; difficulties of sustaining research under the pressure of normal routines of work; the absence of an audience for the research being undertaken; the difficulty of framing research questions; under-confidence regarding the reliability of findings; conducting research work; and the interpretation of data. Added to this, Mourshed et al. (2011) analyzed high performing school systems and observed that in these contexts teachers are regularly given "the time, resources and flexibility … to try out new ideas to better support student learning" (p. 42). That is, time for practitioner inquiry is built into the everyday work of teachers, it is not seen as an add-on. Timperley et al. (2007) identified active school leadership as a characteristic that promotes effective professional learning. This requires school leaders to actively organize a supportive environment to promote professional learning opportunities and the implementation of new practices in the classroom. In essence, Timperley et al. (2007) advocated that school leaders need to ensure contextual factors such as time, resources, learning culture and goals are considered.

EDR is about changing practice as a result of study and clearer understandings. Through this change, teachers becoming producers as well as mediators and consumers of knowledge (Zeichner & Noffke 2001). When investigating the research practice gap in education, Aubusson, Steele, Dinham and Brady (2007) contended, "one possible approach is stimulation of teacher research as a way of promoting teacher learning" (p. 134). They suggested three conditions that

needed to be present for teacher research to be transforming: a culture of inquiry that respected the teacher voice; collaboration over a sustained period of time; and intellectual challenge and stimulation. Teachers can produce knowledge, which is useful for their context and practice, and may also provide information about their own profession. By gaining deeper knowledge of the profession, teachers are able to learn from their work, and make changes within it. The result is professional learning that may find an appropriate balance between centralization and decentralization of policy and reform.

3.3.5 Definition of terms in the theory of planned behavior (TPB)

Attitude: A person's evaluation of any psychological object (Fishbein & Ajzen, 1975).

Behavioral Intention: A measure of the likelihood that an individual will engage in a given behavior (Fishbein & Ajzen, 1980).

Belief: A cognition that associates an object with an attribute. In the case of behavioral beliefs, the object is the behavior under investigation and the attribute is usually a consequence or outcome of the behavior (Ajzen & Fishbein, 1980).

Direct measure of predictor variables: Data collected during the behavioral intention stage of the study for each of the predictor variables using broad, encompassing items. The measure targets a response to the predictor variable viewed as a whole.

Indirect measure of predictor variables: Data collected during the behavioral intention stage of the study for each of the predictor variables using specific belief items. The measure targets a specific belief within a predictor variable.

Perceived behavioral control: A person's belief as to how easy or difficult performance of a behavior will be (Ajzen & Madden, 1986).

Salient beliefs: The number of beliefs that a person may hold about any given object at any given time. The number is considered to be small, perhaps five to nine (Fishbein & Ajzen, 1980).

Subjective norm: A person's perception of the social pressures that influence his or her decision to engage in a behavior (Fishbein & Ajzen, 1980).

3.3.6 Application of social cognitive theory in the prediction of behavior

Like Ajzen and Fishbein's theories, social cognitive theories assume that goal-directed behavior is a purposive action rooted in cognitive activity. The hypothesis central to these theories is that humans systematically utilize and process information and thereby self-regulate their behavior. Bandura's (1986) social cognitive theory is a framework intent upon explaining self-regulation of action. This theory suggests that behavior is influenced by three self-regulatory mechanisms operating in concert: (a) perceived efficacy expectations; (b) outcome expectations; and (c) personal goal setting.

Perceived efficacy expectations are defined as a person's judgments of their capability to organize and execute their skills and resources to perform an action that will lead to a given outcome (Bandura 1977, 1986). Outcome expectations are beliefs regarding the relationship between specific levels of task performance and experienced outcome (Bandura, 1986). Bandura (1997) contended there are three major classes of outcome expectations: physical, social, and self-evaluative. Within each form, the positive expectations serve as incentives; the negative expectations serve as disincentives. For example, physical effects such as sensory experiences and physical experiences may result from engaging in a particular behavior. These effects may be positive (e.g. pleasure) or negative (e.g. pain).

Behavior is partly regulated by the social reactions it evokes and can also be positive or negative. On the positive side are social reactions such as approval of others, monetary

compensation, conferral of power or status, or social recognition. On the negative side are social rejection, deprivation of privileges, and imposed penalties. It should be noted that social cognitive theory rejects the view that behavior is solely regulated by rewards and punishments (Bandura, 1997).

The third major class of outcomes is self-evaluation, and, like the other two classes, this includes both positive and negative reactions to one's behavior. After people adopt personal standards, they regulate their behavior by their self-sanctions. Conditional relationships exist between efficacy beliefs and these three outcome expectancies. In given domains of functioning, efficacy beliefs will vary in level, strength, and generality. The outcomes that flow from engaging in the behavior will take the form of positive or negative physical, social, and self-evaluation effects.

3.4 Study 2 data analysis framework

3.4.1 Representing the shape of growth over time

Over the past three decades we have witnessed an increase in the complexity of theoretical models that attempt to explain development in a number of behavioral domains (Duncan & Duncan, 2004). The representation and measurement of change is an increasingly fundamental element to educational research. As Hattie (2009) noted, "in the field of education, one of the most enduring messages is that 'everything seems to work'" (p. 1), so establishing the degree to which specific interventions or innovations have worked is increasingly important for schools, systems and policy makers. Internationally there is continuing debate about what truly matters: whether this be a discussion about the key instructional strategies that have the greatest impact on students learning, investigating professional learning characteristics that impact teaching, or focusing on collaboration between teachers and researchers to cultivate excellence in our schools. Regardless

of the focus, there is general agreement that impact is an important aspect to consider. In essence, this debate is centered on the idea that progress (student, teacher or system) is a far more powerful measure than proficiency. The difference an intervention/innovation has made provides a richer picture than simply looking at proficiency without any sense of the starting point.

Historically, the most prevalent type of longitudinal data in the behavioral and social sciences has been longitudinal panel data consisting of observations made on many individuals across pre-test and post-test occasions (Duncan & Duncan, 2004). In the analysis of longitudinal data, of primary interest is the nature of change over time. An appropriate developmental model is one that not only describes a single individual's development trajectory, but also captures individual differences in these trajectories over time. Another critical attribute of the developmental model is that it reflects individual differences in the slopes and intercepts of the lines created.

There has been a recent resurgence of interest in statistical models for time-ordered data utilizing a structural equation methodology. Interest in models with the ability to incorporate information concerning the group or population, as well as changes in the individual, has led to the reintroduction of the formative work of Rao (1958) and Tucker (1958) (as cited in Duncan & Duncan, 2004). The basic notion that Rao and Tucker promoted was that while everyone develops in a similar way, individual differences are both meaningful and important. These researchers proposed a partial solution to this problem by constructing a procedure that included unspecified longitudinal growth curves or functions. One methodology that provides a means of modeling individual differences in growth curves has been termed a latent growth curve (LGC) model.

3.4.2 Latent growth curve modeling (LGC)

LGC modeling was conducted to establish any change in teaching practices and student mathematical behaviors that occurred during the course of the 2013/2014 academic school year. Latent growth models represent the pattern of growth over time of a selected construct (e.g. teaching practices and student mathematical behaviors) and are considered a special type of structure equation modeling (SEM). Similar to an analysis of variance (ANOVA) or multiple regression models, there is an intercept, which represents the initial level of the outcome measure and a slope. In turn, this represents the rate of change in the outcome measure (Preacher, Wichman, MacCallum, & Briggs, 2008). More specifically, the intercept and slopes are latent factors that indicate the pattern of growth, whether linear or quadratic (Hox, Moerbeek, & van de Schoot, 2010). So, by focusing on the collection of data that enabled insights into the impact on teaching and student practices, it was hoped that insights into change over time (or not) would be highlighted.

Although closely resembling the classic confirmatory factor analysis (CFA), the latent growth factors are actually interpreted as individual differences in attributes of growth trajectories over time (McArdle, 1988). For example, two attributes of growth trajectories may be rates of change and initial status. For simple straight-line growth models, these are the slope and intercept respectively. Meredith and Tisak (1990) noted that repeated measure polynomial ANOVA models are actually special cases of latent growth models in which only the factor means are of interest. In contrast, a fully expanded latent growth analysis takes into account both factor means, corresponding to group level information, and variances, which then correspond to individual differences. This combination of the individual and group levels of analysis is unique to the procedure (Duncan & Duncan, 2004).

In addition, a fundamental assumption of growth curve methodology is that change is systematically related to the passage of time, at least over the time interval of interest (Burchinal & Appelbaum, 1991). Evaluating the extent to which a particular growth model is capable of describing the observed pattern of change with respect to time is an important part of growth model testing. The application of LGC modeling within the SEM framework depends, at least ideally, on data that are collected when subjects are observed at about the same time, and the spacing of assessments are the same for all individuals. Longitudinal panel data is typical of this design.

3.4.3 Specifications of latent growth curve (LGC) models

The most basic LGC model involves one variable measured the same way at two points in time. However, argue Rogosa and Willett (1985), two points in time are not ideal for studying development or for using growth curve methodology, as the collection of individual trajectories are limited to a collection of straight-lines. So, while two observations provide information about change, due to its linear nature it may poorly address some research questions (Rogosa, Brandt, & Zimowski, 1982). Multi-wave data offer important advantages over two-wave data. With more than two observations the validity of the straight-line growth model for the trajectory can be evaluated (e.g. tests for non-linearity can be performed). In addition, the precision of parameter estimates will tend to increase along with the number of observations for each individual (Duncan & Duncan, 2004). To introduce the LGC, a model with four time-points is presented in Figure 6.

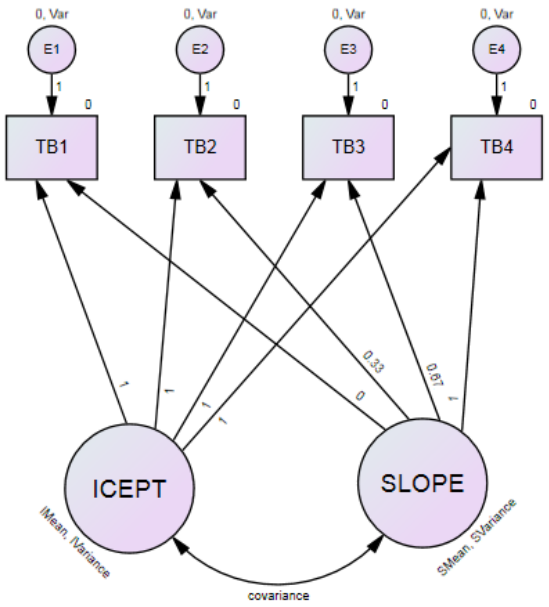

Figure 6: Latent growth curve (LGC) model for four points in time, Duncan & Duncan, 2004

Intercept: As seen from Figure 6, the first factor *(F1)* is labeled *Icept* to represent the intercept. The intercept is a constant for any given individual across time, hence the fixed values of 1 for factor loadings on the repeated measures. The intercept in this model for a given individual has the same meaning as the intercept of a straight-line on a two-dimensional coordinate system. It is the point where the line 'intercepts' the vertical axis. The intercept factor presents information in the sample about the mean *(Mi)* and variance *(Di)* of the collection of intercepts that characterize each individual's professional growth curve (Duncan and Duncan, 2004) related to the EDR initiative.

Slope: The second factor *(F2)*, labeled *Slope* represents the slope of an individual's professional learning trajectory. In this case, it is the slope of the straight-line determined by the four repeated measures. The slope factor has a mean *(Ms)* and variance *(Ds)* across the whole sample which, like the intercept mean and variance, can be estimated from the data. The two

factors, *Slope* and *Icept*, are allowed to covary, which is represented by the double-headed arrow between the factors. The error variance terms *(El, E2)* (Duncan and Duncan, 2004) are shown in Figure 6. To identify this model, four slope loadings must be fixed to four different values. Although the choice of loadings is somewhat arbitrary, the intercept factor is bound to the time scale (Duncan and Duncan, 2004).

3.4.4 Teachers' use of new knowledge and skills

Utilizing Guskey's (2002) five critical levels for evaluating professional development as a framework (refer to Table 1 in Section 3.3.4), it was decided to focus the LGC data collection on Level 4: Participants' use of new knowledge and skills. Added to this, some items of the LOIQ would ask teachers to report on observed changes in student mathematical practices and behaviors. It is important to note that for the vast majority of teachers, becoming a better teacher means enhancing student learning outcomes. In an early study of teachers' perceptions of success, for example, Harootunian and Yargar (1981) found that, "regardless of teaching level, most teachers define their success in terms of their pupils' behaviors and activities, rather than in terms of themselves or other criteria" (p. 4). What attracts teachers to professional development, therefore, is their belief that it will expand their knowledge and skills, contribute to their growth, and enhance their effectiveness with students (Guskey, 1999).

When considering Guskey's critical levels for evaluating professional development, Level 4: Participants' use of their knowledge and skills focuses on the what has been implemented in classrooms. That is, what did the teachers learn through the professional learning experience, in this case EDR, that affected their classroom practice? Unlike Levels 1 and 2 in Guskey's framework, data for Level 4 cannot be collected at the completion of a professional learning session. Instead, measures of the use of newly acquired knowledge and skills must be made after

participants have had sufficient time to reflect on what they learned and to adapt the new ideas to their particular setting (Guskey, 1999). Furthermore, Guskey (1999) stated "because implementing new practices is usually a progressive and ongoing process, measures of use may need to be gathered at several points in time" (p. 178). Due to this, LGC modeling, with four waves of data collection, was seen as a complementary statistical analysis technique.

Guskey (1999) highlighted four challenges that need to be met for successful evaluation of teachers' use of knowledge and skills. The first challenge is to identify accurate, appropriate, and sufficient indicators of use. This challenge requires the evaluation to be clear in terms of the actions and behaviors that should and should not take place in relation to the newly acquired knowledge and skills. Second, in identifying these indicators, dimensions of both quantity (frequency and regularity of use) and quality (appropriateness and adequacy of use) must be specified. Third, consideration should be given to whether enough time has been allowed for relevant use to occur. And finally, sufficient flexibility must be allowed for contextual adaptations; use does not equate to prescription.

3.5 Study 3 (A) data analysis framework

3.5.1 Paired-sample *t* test

Zimmerman (1997) acknowledged that "many experimental designs in education, psychology, and social science employ paired or matched observations" (p. 379). Researchers typically analyze paired data using the paired-samples *t* test, which essentially is a one-sample student *t* test performed on difference scores. Applied statisticians generally are aware of the advantages and disadvantages of this test. First, the correlation associated with pairing or matching of observations reduces the standard error of the difference between means, so the error term differs from that of the independent-sample (Zimmerman, 1997). Essentially, the common use

definition or description of *t* tests is simply comparing two means to see if they are significantly different from each other (Urdan, 2011).

A dependent sample *t* test can be used to compare two means on a single dependent variable. Unlike the independent samples test, however, a dependent sample *t* test is used to compare the means of two matched or paired samples (Urdan, 2011). For this study, the matched pair refers to comparing Wave 1 and Wave 4 data of the LOIQ. That is, teachers completed the same questionnaire in October 2013 and then again in May 2014 and the individual teacher scores were matched, or paired. Due to the pairing, the scores are dependent upon each other, and a paired sample *t* test is warranted. The results for the paired sample *t* test are displayed in Table 13 in Chapter 5. While significance in the paired sample *t* test explains that the result is not a random error, which is necessary, Cohen's *d* enabled insight into the magnitude of change between Wave 1 and Wave 4.

3.5.2 Results: Calculating and grouping change over time trajectories

An effect size is a useful method for comparing results on different measures over time (Hattie, 2012). Effect size refers to the size between two points that you want your statistical test to detect (Shavelson, 1988). To calculate Cohen's *d*, the standard error must be converted into a standard deviation, thereby eliminating the effect of the sample size that is built into the standard error formula and creating a measure of the standardized difference between the means (Urdan, 2006). The standard deviation is then divided by the sample size to find the standard error. Once this has been completed the standard error can be multiplied by the square root of the sample size to find the standard deviation. Once the standard deviation is calculated, it is simple to calculate a Cohen's *d* effect size. With regards to the LOIQ, effect size was calculated for every teacher (n=109) for all three factors that focused on teaching practice (student mathematical behaviors,

teacher behaviors and planning for ELLs). It was decided not to calculate effect size for textbook use as it would be nothing more than an assumption to conclude that a change in textbook use translated into improved or declining practices. A teacher may use a textbook as an instructional tool effectively, so could be improving practice while simultaneously increasing their use of the prescribed mathematics textbook.

There are no definitive rules regarding the interpretation of Cohen's *d* effect sizes. A common rule-of-thumb is that effect sizes smaller than 0.20 are small, those between 0.20 and 0.75 are moderate, and those over 0.75 are large (Urdan, 2006).

3.5.3 Effect size: Representing the magnitude of change

It is also important not to assume that an overall effect size represents the lived experiences of the entire sample. That is, we cannot assume that the aggregated magnitude of change from the Wave 1 data collection to Wave 4 accurately represents the lived experiences of individual teachers participating in the EDR initiative. As with all summaries in the research literature, caution should be the byword when interpreting overall effects. The nuances and details of each influence are important. By using Urdan's (2006) rule for interpreting effect sizes (an effect size less than 0 is reverse, 0 to less than 0.20 are small, those between 0.20 and 0.75 are moderate, and those over 0.75 are large), teachers could be grouped as a way of gaining further insights into their experiences.

3.5.2 Systematic stratified sampling

Stratified systematic sampling is a method of sampling that involves the division of a population into smaller groups known as strata. There are two different aspects of the stratified sampling representative method: random or purposive sampling. Purposive sampling techniques are primarily used in qualitative studies and may be defined as selecting units (e.g. individuals,

groups of individuals, institutions) based on specific purposes associated with answering a research study's questions. Maxwell (2008) further defined purposive sampling as a method in which, ''particular settings, persons, or events are deliberately selected for the important information they can provide that cannot be gotten as well from other choices'' (p. 87). Purposive sampling techniques have also been referred to as non-probability sampling or purposeful sampling. Techniques involve selecting certain units or cases ''based on a specific purpose rather than randomly'' (Tashakkori & Teddlie, 2003, p. 713). Although some purposive sampling techniques are aimed at generating representative cases, most are aimed at producing contrasting cases. Comparisons or contrasts are at the very core of data analysis strategies (Glaser & Strauss, 1967; Mason, 2002; Spradley, 1979), including the contrast principle and the constant comparative technique. Based on the effect size for student practices and teacher practices, teachers can be categorized as large, moderate, small or reverse growth teachers. This allowed individual teachers to be presented in a typology according to the magnitude of teacher professional learning growth they attributed to the EDR initiative. The individual quantitative data was matched to the qualitative open-ended reflections in Study 3 (B), which explored insights into the specific characteristics of the research experience that enabled or inhibited teacher professional learning.

3.6 Study 3 (B) data analysis framework

An open-ended questionnaire was used to ascertain how the EDR initiative impacted teachers' daily practices. As such, the majority of questions in the protocol were based on the 'behavioral dimension'. Other questions attempted to reconstruct the teachers' beliefs, motives and attitudes towards using the ideas and practices explored, as well as how this impacted the students they teach (affective dimension).

The data analysis framework was developed using Grounded Theory with reference to the strategy outlined by Miles and Huberman (1994). First, a 'vertical analysis' of the data was undertaken in order to fully 'understand' the data provided by each respondent. After reading the self-report responses several times, all reports were segmented and coded. The text was labelled with descriptive and interpretative codes based on the theoretical framework outlined above. The analysis was carried out in two phases. The vertical analysis was conducted (Miles & Huberman, 1994) and each teacher's responses were analyzed at an individual level. The individual, vertical analysis, was completed to gain insight into the teacher's perceptions of their professional learning as a result of the EDR initiative. This data was coded and displayed in matrices (Miles & Huberman, 1994) so it could be compared systematically.

The second step of the analysis, the 'horizontal' analysis, allowed for a comparison among the teachers. The typical patterns found in the vertical analysis were compared with one another to "discover whether a pattern in one … plays out in others as well, suggesting a common scenario" (Huberman & Miles, 1994, p. 64). By adopting a constant comparative analysis (Glaser & Strauss, 1967), the goal of this phase was to explore for similarities and differences between the teachers.

3.7 Recruitment of participants

The population for this study consisted of 344 teachers who completed the Behavioral Intention Questionnaire (BIQ), Level of Implementation Questionnaire (LOIQ), and the open-ended reflection completed at conclusion of the academic year. The teachers were from an urban school district in California in the US. The researcher gathered data from the participating teachers employed during the 2013-2014 school year. The data was gathered during professional learning sessions in October and December 2013 and then in February and May 2014. The participating teachers were given a two-week window after the October professional learning workshop to

complete the BIQ. The four-wave data collection for the changes in teaching practices survey was completed (n=344) at the conclusion of each of the four workshops for the 2013/2014 academic school year (October, December, February and May). The Level of Implementation Questionnaire (LOIQ) was completed as part of the May 2014 workshop. Extensive research and planning was done before implementing the survey, with consideration given to the following: (a) the research population; (b) the scope of the survey instruments and demographics; (c) the timeframe to complete the surveys; (d) giving teachers ample time to participate; and (e) how the data would be analyzed. Through voluntary participation, teachers participated by completing the BIQ, LOIQ and open-ended reflection. Participating teachers took the survey during their professional learning session or at a time convenient to them. The survey was administered either online or in hard copy and all participants received the same instructions through an email sent prior to their participation.

3.8 Summary

This study used the TPB as a theoretical framework to explore the experience of teachers undertaking EDR. By investigating the experiences of these teachers in this way, it was hoped that a contribution could be made to further understand the linkages between behavioral intention and actual behavior. Furthermore, teachers completed a self-report questionnaire four times during the year (LOIQ), as well as one short open response questionnaire, to provide an in-depth and critical exploration of their experiences in establishing changes in teaching practice over time that could be attributed to undertaking EDR.

Exploring the impact of teacher professional learning is complex. This project has endeavored to better understand the lived experiences of participants through the use of multiple data sources. As Clarke and Holllingworth (2002) stated:

> Change can occur in one area of influence but may not lead to change in another. That is, teachers may change their beliefs but not their practices, may change their practices but not their beliefs, and ultimately may change their practice but not the learning outcomes of their students. For teacher learning or growth to occur, change must occur in multiple areas of influence (p. 961).

As already outlined, the aim of this study was to understand the experiences of teachers participating in EDR by examining those participants, their behavioral intentions, any changes in attitudes, beliefs and practice and, ultimately, any student learning behaviors that could be attributed to their teacher's involvement in EDR. It was hoped that by examining these elements closely we could begin to gain a deeper understanding of these multiple areas of influence.

Chapter 4: Study 1 - Exploring behavioral intent

Section one: Research aim, strategy and methods

4.1 Methodology

4.1.1 Introduction

The professional learning evaluation procedure the school district had been using was based on participant satisfaction. End-of-workshop evaluations of the learning experiences and staff satisfaction had been collected in the past but there was little emphasis on establishing implementation of the learning and instructional strategies into the participants' classrooms. This study applied the tenets of the TPB to assess the initial effectiveness of the EDR initiative, as well inform the next iteration. That is, focus was given to the collection of data that would enable insights into the impact on teaching practices, rather than simply establishing if teachers were satisfied with the professional learning.

The TPB has been reviewed in the literature as a viable means to predict behavior and thus was considered a valid model to directly assess the implementation of instructional practices explored throughout the EDR initiative. Intention to engage in a behavior has been demonstrated to correlate highly with subsequent behavior of birth control users, cigarette smokers, and dieters (Ajzen & Fishbein, 1980). This study extended and further validated the transfer of the TPB from social psychology to science education in the tradition of research supervised by Crawley and Koballa (1994).

The methodology used in this study was based on more than twenty years of research by Ajzen and Fishbein, who proposed and validated the TRA, the antecedent to the TPB of Ajzen and Madden (1986). The process by which the TPB is implemented is hierarchical and specific parameters and procedures are to be followed. Data on three variables, attitude toward behavior,

subjective norm, and perceived behavioral control, were collected via an online questionnaire administered to the subjects of the study at the beginning of the EDR initiative. Figure 7 depicts an overview of the stages of the process that were used.

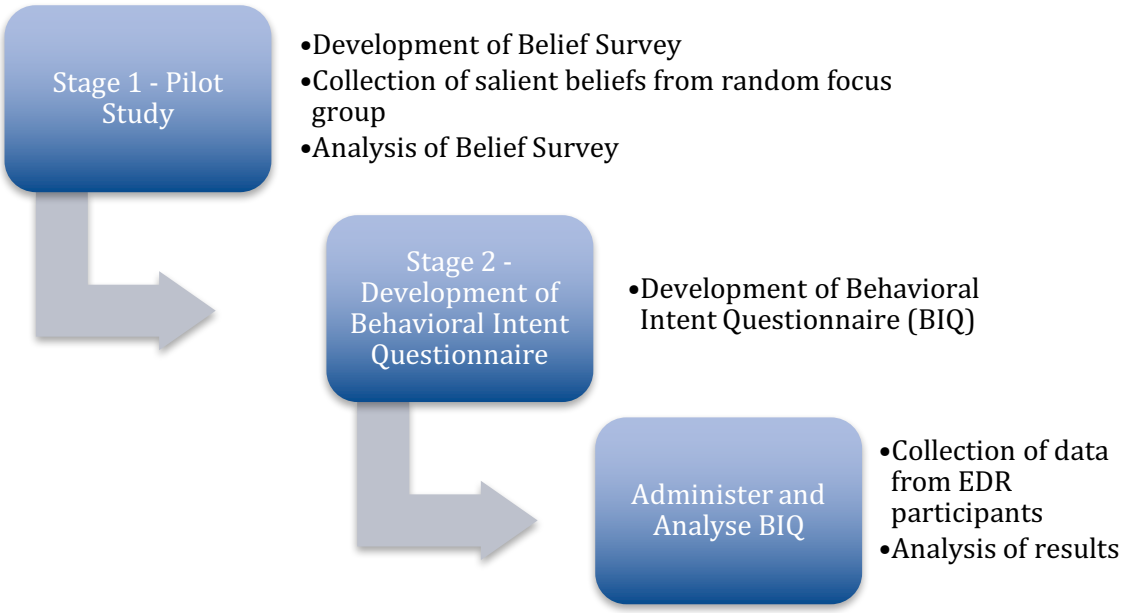

Figure 7: Overview of instrument development process

Motivated by research failing to demonstrate predictions of behavior from attitudes, Fishbein and Ajzen (1975, 1980) explored variables related to attitude and behavior and concluded that they must consist of four specific elements: the action, the target of the action, the context of the action, and the time the action occurs. According to the TPB, when these specific elements are addressed at the same level of specificity in assessing attitude and predicting behavior, the correlation between the two will be significant and meaningful.

Data were collected and analyzed at several stages in order to answer the following three research questions:

- Which of the three direct determinants of intention are statistically significant predictors of teachers' intentions to use the professional learning in their classrooms?
- What are the potential enablers and barriers to the subsequent use of the professional learning?
- Is the TPB an appropriate conceptual framework for evaluating the participants' intentions to use the professional learning?

This study examined the relationship between the variables in a sequential manner, with emphasis on understanding the enablers and/or inhibitors for the behavioral intent of teachers. The role of the three-predictor variables - attitude toward the behavior, subjective norm, and perceived behavioral control - on this relationship was examined to determine which combination of these variables contributes to behavioral intention. For each of the predictor variables deemed significant in the prediction of behavioral intention, a correlation analysis was conducted between the direct and the indirect measure scores for that variable to deduce the extent to which beliefs within each variable predict that variable. Finally, at the most specific level, the salient beliefs of the participants in this study were analyzed in order to determine which beliefs are most influential in determining attitude toward the behavior, subjective norm, and perceived behavioral control.

To collect the data required, the questionnaire was developed based on the frameworks of Demir (2010), Patterson (2001), Venkatesh, Morris, Davis, Davis (2003) and Francis et al. (2004). Demir (2010) used the TPB to predict teacher's internet use for their professional development. The scales developed by Demir (2010) have been validated and high reliability was reported for each, he reported an average reliability for all constructs at 0.87 using Cronbach's alpha. An α-value greater than 0.7 is a common threshold for exploratory research (Nunnally &

Bernstein, 1994). In the following paragraphs, the methodological details of the current work are discussed.

Following the method described by Ajzen and Fishbein (1980), Ajzen and Madden (1986), and Crawley and Koballa (1994), an open-ended survey was designed to collect salient belief data from a random group of teachers involved in the project. The purpose of the Belief Survey (BS) was to collect pertinent belief information from a representative group of the sample teacher's regarding their willingness to engage in the EDR and to use the instructional practices explored through this initiative (target behavior). The survey used to collect these preliminary data is included in Appendix A. The letter that accompanied this belief survey (BS) is shown in Appendix B.

The BS consisted of three sections with three open-ended questions per section. The first section questioned attitude toward behavior by asking teachers one question each on the advantages and disadvantages of being involved in an EDR initiative that focuses on mathematics teaching and learning. An additional question asked for other outcomes associated with the target behavior. Each question was developed to elicit a level of specificity, indicating the action, the target of the action, the context of the action, and the time the action is to occur.

Section two of the BS investigated subjective norm by asking teachers to identify those groups or individuals who would approve (one question) or disapprove (one question) of using the instructional strategies explored in the EDR project with their students. A third question asked for any other persons who might influence their actions. The results from the BS were analysed and used to inform the development of the Behavioral Intention Questionnaire (BIQ). The instrument development process is explored in more detail in the succeeding sections.

4.2 Method

4.2.1 Participants

The participants for this study included 152 teachers involved in the mathematics CCSS professional learning initiative and who had completed the online self-report Behavioral Intention Questionnaire (BIQ). As indicated previously, data was collected during professional learning sessions in October 2013 and May 2014. Of the respondents, 32% were males and 68% were females. Of these participants, 41% were high school teachers, 22% taught grade 8, 19% taught grade 6 and 7, 17% taught grade 4 and 5, 27% taught grade 2 and 3 and 25% taught kindergarten and grade 1. Further demographic information is presented in Table 2.

Table 2: Combined and recorded demographic table

Variable	N	%
Gender		
Female	103	67.8
Male	49	32.2
Education Level		
Associate Degree	1	0.7
Bachelor's Degree	82	53.9
Master's Degree	64	42.1
Doctoral Degree	5	3.3
Number of Years Teaching		
1-2 Years	4	2.6
3-6 Years	24	15.8
7-10 Years	23	15.1
11-20 Years	64	42.1
Over 20 Years	37	24.3
Grade Level Currently Teaching		
Kindergarten and Grade 1	25	16.5
Grade 2 and 3	27	17.8
Grade 4 and 5	17	11.2
Grade 6 and 7	19	12.5
Grade 8	22	14.5
High School	41	27.0
Other	1	0.7

Section three of the BS was designed to ascertain perceived behavioral control by seeking information from teachers concerning factors that might help (one question) or hinder (one question) them to participate and embed the learning associated with EDR initiative. The final question in the section asked for any additional factors that might influence the use of the activities. Each question in each section was presented in an open-ended format with no prompts. For example, the first question asked: "What do you perceive the advantages of using the ideas and practices explored during the EDR initiative with your students will be?"

4.2.2 Administration of the belief survey (BS)

A random sample of teachers was selected and notified of the study via email through a listserv moderated by the investigator. Teachers were told they would be receiving a survey in a subsequent email. They also received a plain speak statement outlining the broader research agenda. The questionnaire was completed online using the survey platform, SurveyMonkey (www.surveymonkey.com), allowing the number of completed responses to be determined in real time. A reminder to complete the questionnaire was sent via e-mail two weeks after the initial email. The random sample of teachers notified was 60 and the returned BS questionnaires analyzed was 27 (n=27).

4.2.3 Analysis of the belief survey (BS) and development of the behavioral intention questionnaire (BIQ)

Responses to the open-ended survey items were collected, counted, and content analyzed as per the method described by Ajzen and Fishbein (1980, pp. 70-71 & 261-263). The unedited responses were categorized by the investigator and a single belief statement was derived from the category. The number of times the belief was reported was tabulated and a frequency distribution was established. To select the most salient beliefs, Fishbein and Ajzen recommended that the 75%

most frequently voiced responses be retained to compose the BIQ. The raw data and frequency distributions can be found in Appendix D.

The BIQ was developed according to the guidelines that evolved from the work of Fishbein and Ajzen (1975), Ajzen and Madden (1986), and Crawley and Koballa (1992), using the results of the BS. Once the salient beliefs were ascertained from the BS, two questionnaire items were written for each belief: one linking the outcome to the behavior, called the behavioral belief (b_i); and the other an evaluation of the outcome (e_i). For example, if a salient belief derived from the first open-ended question on the BS was determined to be "Using ideas explored in the EDR will be beneficial for my students", the behavioral belief statement would be written as: "My students will benefit from the ideas generated from the CCSS mathematics EDR project." The statement is then evaluated by the participants using a 7-point scale ranging from extremely likely to extremely unlikely. The evaluation (e_i) of the outcome statement would be written as: "Using the ideas generated from the CCSS mathematics workshops with students will be …" and would be evaluated on a 7-point scale from extremely good to extremely bad.

Similarly, referents associated with the subjective norm were derived from the BS and for each referent a pair of statements was written. For example, since students were determined to be influential in the decision to use ideas explored in the EDR project, the subjective norm paired statements read:

1. My students think that I should use instructional practices explored as part of my mathematics teaching.
2. I want to do what my students think I should do concerning my teaching decisions in mathematics.

Statement 1 is termed the normative belief (*nb*) and Statement 2 measures motivation to comply (*mc*). Each statement was evaluated on a 5-point bi-polar scale. The combination of the normative belief pairs ($nb_j mc_j$) served as an indirect, belief-based estimate of subjective norm. Likewise, each event associated with perceived behavioral control resulted in an item pair on the BIQ. One item linked the event to the behavior (called the control belief, cb_k) and the other assessed the likelihood of occurrence of the event (lo_k). As an example, a perceived behavioral control pair appeared as such on the BIQ:

1. Additional time and resources would make it easier for me to use the instructional practices.
2. Having additional time and resources available to me during the school year is … likely to unlikely.

Thus, the BIQ consisted of paired statements, each derived from the BS in three areas: attitude toward behavior, subjective norm and perceived behavioral control. The salient beliefs derived from the BS that was used to create the BIQ are shown in Appendix E.

4.2.4 Measurement model for behavioral intent

Constructs from previous relevant studies were investigated and used to inform and operationalize the BIQ (Demir, 2010; Francis et al. 2004; Patterson, 2001; Venkatesh et al. 2003). The questionnaire comprised of 12 items based on four constructs: attitude toward behavior, subjective norm, perceived behavioral control, and behavioral intention. Each construct was measured using a five-point Likert scale. Three items were used to measure behavioral intentions, for example: "I intend to use CCSS mathematics workshops for professional learning". Subjective norms were measured with three items (e.g. "People who influence my behavior think I should engage in CCSS mathematics workshops"). Attitudes were assessed through three bi-polar

adjectives. One adjective reflected moral evaluations (very poor/very good), and two adjectives reflected instrumental evaluations (extremely useless/extremely useful and very inappropriate/very appropriate). All adjectives were measured on five-point semantic differential scales. The measurement of perceived behavioral control consisted of three items, for example: "I have the resources and time necessary to use the CCSS mathematics workshops for my professional learning".

The Behavioral Intention Questionnaire (BIQ) was used to ascertain the participants' intentions to use the teaching practices and ideas explored during the mathematics professional learning, their attitudes toward using them, the degree of influence significant others had in their decision to use them, the control they perceived they had in performing them, and the confidence they had concerning implementation of the teaching practices in their classroom.

The data analysis procedure for the TPB was adapted from Demir (2010). The procedure required a CFA to assess the construct validity of the four scales (attitude toward behavior, subjective norm, perceived behavioral control and behavioral intention). Reliability was analyzed using Cronbach's alpha. A discriminant validity of the resulting scales was assessed using the guidelines suggested by Fornell and Larcker (1981): the square root of the average variance extracted (AVE) from the construct should be greater than the squared correlation shared between the construct and other constructs in the model. The hypothesized structural model was tested using AMOS with maximum likelihood estimation.

4.3 Administration of the behavioral intent questionnaire (BIQ)

The BIQ was administered to the 152 teachers participating in the mathematics CCSS professional learning initiative. An explanation of the study was provided to the participants by the researcher in accordance with the consent parameters approved by the Human Ethics Advisory

Group at the University of Melbourne. The participants were asked to respond to each of the questionnaire items by clicking a dot along the five-point continuum characteristic of a semantic differential scale. The BIQ is shown in Appendix F.

4.4 Analysis of theory of planned behavior (TPB) constructs and behavioral intent questionnaire (BIQ)

The analysis of data in this study progressed in a sequence of steps moving from analysis of the broad categories to more specific categories. The study began with the collection of salient beliefs and progressed sequentially through to the collection of behavioral intent data. This enabled analysis of the specific beliefs of teachers participating in the EDR professional learning initiative.

4.4.1 Descriptive statistics

As already indicated, the BIQ was used to ascertain the participants' intent to use the teaching practices and ideas explored during the EDR initiative, their attitude toward using them, the degree of influence significant others had in their decision to use them, the control they perceived they had in performing them, and the confidence they had concerning implementation of the teaching practices in their classroom.

Responses to the survey were assigned a value on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). As shown in Table 3, the questionnaire was divided into sections for analysis according to the method described by Ajzen and Fishbein (1980) and subsequently used by other educational researchers (Crawley, 1999; Demir, 2010; Haney, Czerniak, & Lumpe, 1996; Smith, 1993). Prior to determination of inferential statistics, descriptive statistics were calculated from the data. These data are presented in Table 4.

Table 3: Computation scheme for variable scales on the behavioral intent questionnaire

Survey	Measurement	Computation

Question (Q)		Procedure
4, 5 and 6	The intent to use the teaching practices and ideas explored during the EDR (behavioral intention *BI*).	*BI* = (Q4)(Q5)(Q6)
3, 7 and 9	Direct measure of influence of others on the participants' decision-making (subjective norm *SN*).	*SN* = (Q3)(Q7)(Q9)
1, 2 and 8	Direct measure of participants' perceived control over performing the behavior (perceived behavioral control *PBC*)	*PBC* = (Q1)(Q2)(Q8)
10, 11 and 12	Attitude toward using the ideas and practices explored during the EDR (attitude toward the behavior *AB*).	*AB*= (Q10)(Q11)(Q12)

Table 4: Statistics for behavioral intent questionnaire (BIQ)Figure

Item No.	N	M	SD	SE
Item 1 (PBC)	152	3.75	0.85	0.07
Item 2 (PBC)	152	3.73	0.79	0.06
Item 3 (SN)	152	3.59	0.96	0.08
Item 4 (BI)	152	4.01	0.79	0.06
Item 5 (BI)	152	4.05	0.84	0.07
Item 6 (BI)	152	3.90	0.80	0.06
Item 7 (SN)	152	3.63	0.96	0.08
Item 8 (PBC)	152	3.07	0.98	0.08
Item 9 (SN)	152	3.49	0.98	0.08
Item 10 (AB)	152	3.94	0.74	0.06
Item 11 (AB)	152	3.69	0.79	0.06
Item 12 (AB)	152	3.91	0.76	0.06

The means and standard deviations for each of the 12 items in the BIQ are shown in Table 4. The highest mean for any one item was 4.05 for Item 5, "I intend to use EDR". In Item 4 teachers were asked whether they intended to use the EDR for their professional learning needs and 80.9% (123/152) of participants indicated they agreed or strongly agreed with this statement. The lowest mean was 3.07 for Item 8, "I have the resources and time necessary to use the CCSS mathematics workshops for my professional learning". This indicates that teachers' lack of perceived behavioral control over resources and time could negatively impact their professional learning. Each teacher's responses to the BIQ were averaged and used in the correlational analysis. The highest means (4.01 to 3.94), scored on Items 4, 5, and 10, would indicate these teachers believed they had a strong intention to embed the professional learning into their regular teaching practice and they believed

using the ideas generated from the EDR was a good idea.

Frequency distributions for the direct measure TPB variables are presented in Figures 8 through 11. These tables provide information regarding the way in which each factor was perceived by the sample. While the mean gives evidence regarding the overall perception of each item and how each item compared to one another, the frequency distribution gives a deeper sense of the occurrences of responses within a particular group. As evident in the figures, the frequency distributions are positively skewed with 4 on the Likert scale being the most selected response in every factor.

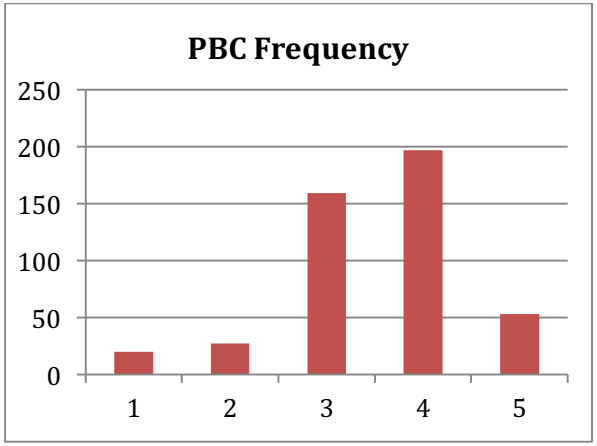

Figure 8: Frequency distribution of perceived behavioral control

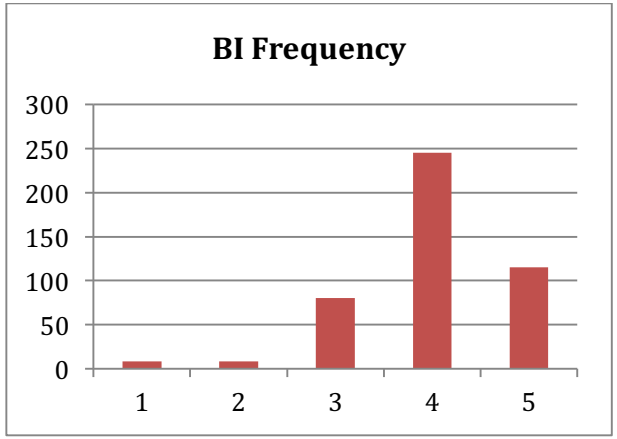

Figure 10: Frequency distribution for behavioral intent

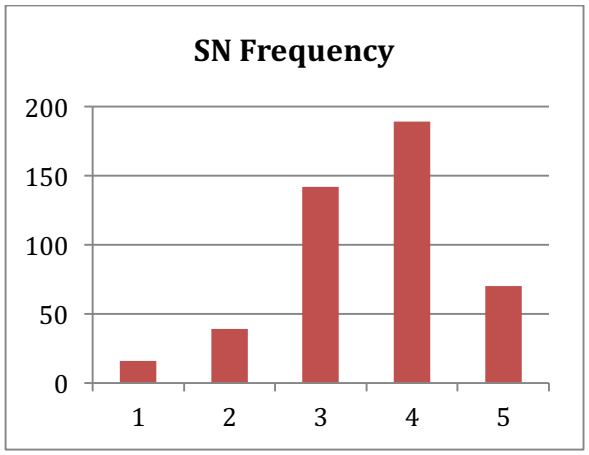

Figure 9: Frequency distribution for subjective norm

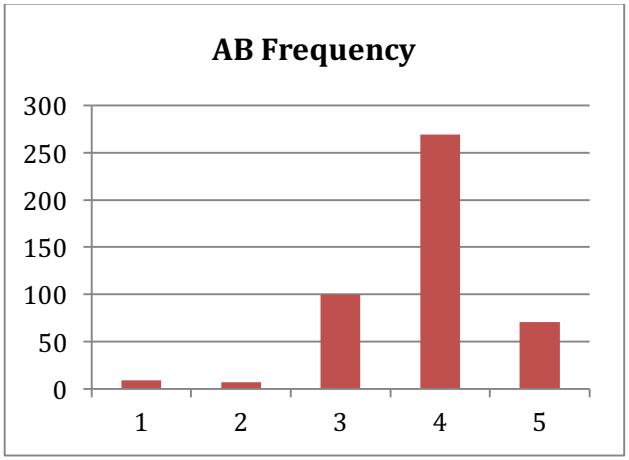

Figure 11: Frequency distribution for attitude toward behavior

The means, standard deviation, and minimum and maximum scores were computed for each of the TPB constructs and corresponding measures. Adding up all the expectancy and value item scores and then averaging the summed score derived the composite scores for the means of each construct. Likewise, adding up the expectancy and value item scores of each individual measure derived the composite score for the means of each measure. The average score for each construct, and each measure, was then described in terms of means and standard deviation. These scores are presented in Table 5. Higher scores indicate increased importance of an item towards intentions to comply, whereas lower scores indicate the importance of an item towards intentions not to comply.

Table 5: Descriptive statistics for behavioral intent and direct measures of predictor variables

Variable	N	Mean	SD	SE
PBC	152	3.52	0.73	0.06
SN	152	3.57	0.76	0.06
BI	152	3.99	0.68	0.06
AB	152	3.85	0.66	0.05

Note. BI = behavioral intent; PBC = perceived behavioral control; SN = subjective norm; AB = attitudes.

4.4.2 Reliability, validity and correlations

A CFA was conducted to determine whether the designed item-factor structure (i.e. the proposed grouping of items to measure 12 underlying factors: attitudes, subjective norms, perceived behavioral control and behavioral intentions) did indeed comprise an adequate measurement model for the items. The model fit indices indicated a reasonably good fit of item responses to the designed measurement model: specifically, $X^2(48) = 113.71$. As the chi-square statistic is affected by the sample size, the relative fit of a proposed model can be assessed by using the ratio of chi-square to degrees of freedom (Demir, 2010). The model was assessed using other common fit indexes: normed fit index (NFI), root mean square error of approximation (RMSEA), and the goodness of fit index (GFI). For measurement models to have sufficiently good model fit,

the X^2 value normalized by degrees of freedom (X^2/df) should not exceed 3 (Kline, 1998), GFI should exceed 0.8 (Doll, Xia, & Torkzadeh, 1994), NFI should exceed 0.9 (Hu & Bentler, 1999), and RMSEA should not exceed 0.08 (Browne & Cudeck, 1993). The fit indices for the measurement model indicated a reasonably good fit between the model and the data (X^2/df = 2.37; NFI = 0.90; RMSEA = 0.09; GFI = 0.90).

To establish reliability of the four factors, Cronbach's alpha was used. As shown in Table 6, based on the data collected, all constructs exhibited an α-value greater than 0.7, a common threshold for exploratory research, as noted earlier (Nunnally & Bernstein 1994).

Table 6: Reliability, validity and correlations

Variables	BI	PBC	SN	AB
BI	(0.78)			
PBC	0.64**	0(.80)		
SN	0.57**	0.55**	(0.71)	
ATT	0.47**	0.51**	0.42**	(0.85)

Note. BI = behavioral intent; PBC = perceived behavioral control; SN = subjective norm; AB = attitudes. Numbers in parentheses indicate Cronbach's alpha reliabilities of the constructs. Correlation is significant at the 0.01 level (2-tailed)

4.4.3 Statistical analysis

To test the hypothesis that the TPB constructs and antecedent beliefs would impact upon behaviors, AMOS was used to examine the direction and significance of the path coefficients. Figure 12 depicts the path analysis model, including the overall explanatory power and the estimated standardized path coefficients. It was found that perceived behavioral control had a significant direct effect on the intention of participants (β = 0.54, p < 0.001), the standardized regression coefficient indicated that perceived behavioral control explained 27% of the variance in intention. Subjective norm was found to have a significant effect on intention (β = 0.26, p < 0.05), which explained 23% of the variance in intention. Attitude was also found to have a significant effect on intention (β = 0.19, p < 0.05), which explained 9% of the variance in intention.

Perceived behavioral control, subjective norm and attitude together explained 60% of the total variance in intention. The antecedent beliefs with the strongest indirect effects on intention were control beliefs. The model was specified and tested using SEM and was found to fit the data well. Overall, the results of the study provide partial support for the adequacy of the TPB as an appropriate conceptual framework for evaluating the participants' intentions to use the professional learning.

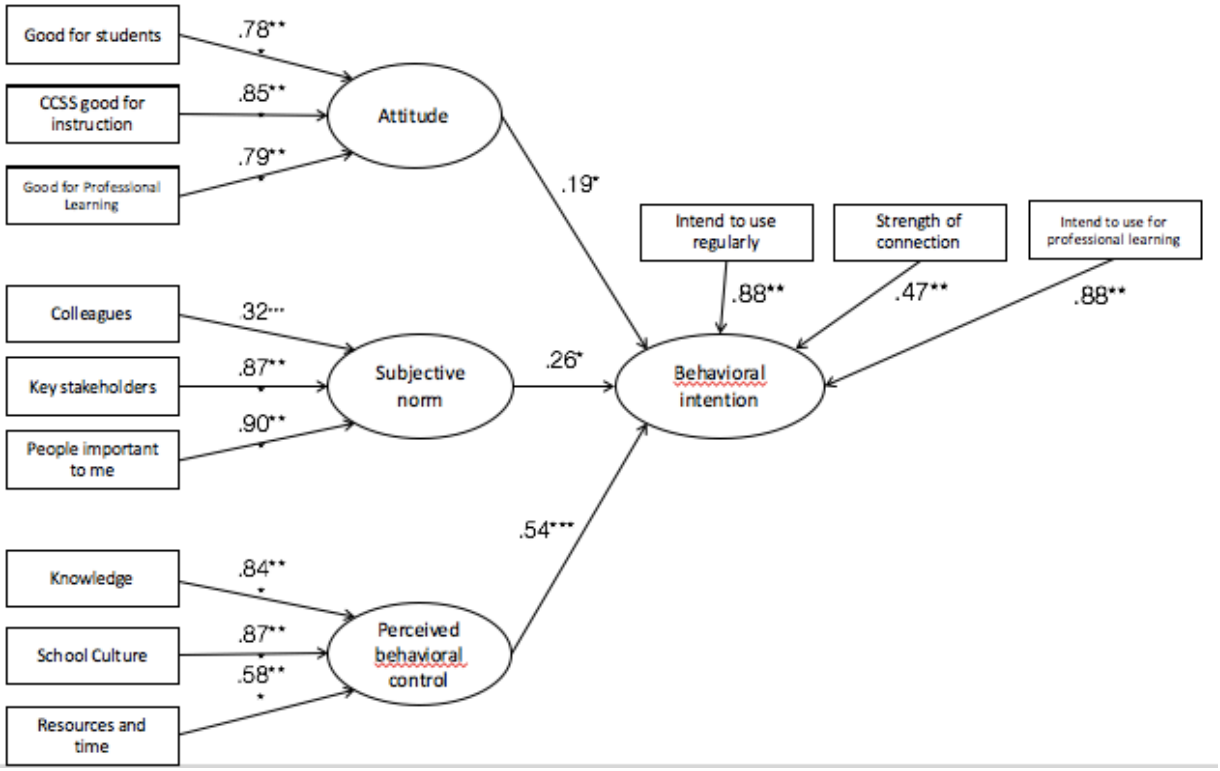

Figure 12: Path analysis for the theory of planned behavior, Ajzen and Fishbein (1980).

4.5 Ethical considerations

Approval for the study was granted by the University of Melbourne Human Ethics Committee (Ethics ID: 1339296.1), ensuring the research complied with the Committee's code of ethics pertaining to the conduct of research involving human participants.

All teacher data collected for the purpose of this study was provided anonymously and therefore the researcher had no way of identifying the teachers. Each teacher was given a plain speak statement outlining the research and time to consider if they were willing to be involved. The online behavioral intent questionnaire began with the consent form and the survey would not activate until participants had agreed to participate in the study. It should be noted that the researcher had no direct contact with any of the teachers during the recruitment and completion of the online questionnaire. Participation in this study was completely voluntary and participants were free to withdraw at any time. For the purpose of anonymity and confidentiality, the participating school district has not been named or identified in any way, other than being referred to as an urban school district in California.

4.6 Summary

The study design was based on the sequential process outlined by the authors of the TPB, Ajzen and Fishbein (1980). The research began with collection of salient beliefs from teachers who were participating in the EDR initiative, followed by the development of the BIQ, and culminating in the calculation of behavioral intent scores.

The salient beliefs of teachers were collected at the beginning of the initiative using an open-ended questionnaire, the BS. These beliefs were centered in three areas: (a) attitude toward the behavior; (b) subjective norm; and (c) perceived behavioral control. As indicated above, once grouped and categorized, the beliefs were used to construct the BIQ. The BIQ was used to measure attitude toward behavior, subjective norm, and perceived behavioral control directly through a series of questions prescribed by the tenets of the TPB; the indirect measures were developed directly from the BS. The BIQ was administered to the teachers participating in the professional learning during the 2013/2014 academic year.

Section two: Findings

4.7 Which salient beliefs within each predictor variable contribute most to the direct measure variables?

In a critical examination of the causal structure of the TPB, Liska (1984) questioned whether beliefs affect behavioral intentions and behavior independently of the effect of attitude. He argued the effect of attitude on behavior may be contingent on attitude-belief consistency and that attitudes not supported by beliefs are ill-formed and susceptible to change, making them poor predictors of behavior. Fishbein and Ajzen (1975) reported beliefs and attitudes as highly correlated, but Liska (1984) argued that because similar measurement techniques were used to measure both beliefs and attitudes (namely the semantic differential scales), some unknown part of the observed correlation was probably generated by systematic measurement error. The underlying correlation may thus be lower than observed. He suggested that both attitudes and beliefs be measured by more than one method. This has been done by several researchers (Bagozzi, 1978; Bagozzi & Burnkrandt, 1979; as cited in Liska, 1984), who found considerable independent variation between attitudes and beliefs.

Liska (1984) also argued that the TRA ignores the causal relationship between attitudes and social norms. He viewed their joint effects on behavior as entirely independent, leading to an over-simplification of the causal structure. He further argued that, while the beliefs that underlie the attitude toward the behavior and the subjective norms may be independent by definition, they are not necessarily causally independent. They may affect each other, and a substantial portion of the effects may be statistically interactive.

To understand why the predictor variables contribute to the behavioral intention, it is beneficial to connect the predictor variables to the salient beliefs. To achieve this, a stepwise multiple regression analyses was conducted, as follows.

Attitude toward the behavior: the analysis revealed that, within the construct of attitude toward behavior, all three antecedent beliefs were significantly correlated with the direct measure. These belief were: that EDR would be good for students, good for instruction and good for professional learning.

The findings in this study only partially supported the hypothesis that salient beliefs that pertain to enhancement of student learning would be the most significant predictors of attitude toward behavior. The salient attitude toward behavior beliefs fell into two categories: those that supported student learning, and those that supported ease of preparation or adaptability to current situations. This study hypothesized based on assumptions outlined by Loucks-Horsley at al. (1998), who reported that "all teachers want to teach well and can do so … all teachers want students to achieve" (p. 33). It was assumed that teachers would be more concerned with student learning than the ease by which they could incorporate acceptable methods of learning.

Although not directly supporting the hypothesis, the second significant salient belief was corroborated by another finding in the study. The salient belief that the activities align well with the curriculum was supported by the finding that most of the activities used by the participants were inquiry-adaptations of activities already in use in microbiology or biology curriculums. Thus, the ideas and activities aligned well with what the teachers were looking to do as part of their classroom practice.

Subjective norm: The relationship between the direct measure of subjective norm and the salient beliefs was examined. The analysis revealed that 'people important to me professionally'

was the most powerful predictor within the subjective norm variable as measured indirectly. Having said that, 'key stakeholders' was also very highly correlated to the subjective norm. Surprisingly, 'colleague approval', while statistically significant, was not as powerful a predictor within the subjective norm variable. The overall predictive power of subjective norm is not surprising considering the research indicating that professional communities thrive where collaboration, experimentation, and challenging discourse are possible and encouraged (Hord & Boyd, 1995; Little, 1993; Norris & Barnett, 1994). The EDR initiative attempted to explicitly cultivate such collaboration by virtue of its process; participating teachers worked in teams.

Perceived behavioral control: The relationship between the direct measure of perceived behavioral control and the salient beliefs was also examined and illustrated 'knowledge' and 'school culture' had the most powerful relationship in the perceived behavioral control variable. 'Resources and time', while also statistically significant, was not as powerful a predictor. The hypothesis that salient beliefs involving time constraints would have the most predictive power was confirmed. The hypothesis was based on several observations including those made by Haney et al. (1996). In their study of teacher implementation of the four strands of Ohio's Competency-Based Science Model, they found that having available resources, including time, made a significant contribution to the perceived behavioral control variable. Additional research has shown that preparation time is necessary for effective change (Timperley et al., 2007). For professional development to occur, ample time for in-depth investigation and reflection must be made available (Loucks-Horsley et al., 1998). In fact, time emerged as the key issue in every analysis of school change published in the 1980s (Fullan & Miles, 1992).

4.7.1 The effects of combining attitude toward the behavior, subjective norm and perceived behavioral control scores on the prediction of behavioral intention

As previously discussed, within the tenets of the TPB, three predictors were investigated: (a) the attitude toward the behavior; (b) the subjective norm; and (c) perceived behavioral control. The third research question linked the three variables, asking, "Is the TPB an appropriate conceptual framework for evaluating the participants' intentions to use the practices explored in the EDR initiative?"

A regression analysis demonstrated that the combination of the three variables was a significant predictor of behavioral intention. The establishment of the combined predictor variable scores as a significant predictor of behavioral intention supported further analyses of the individual predictor variables and provided further support for the TPB as a viable conceptual framework for assessing behavioral intention of teachers participating in the EDR initiative. Support for the hypothesis that the combined predictor scores would predict behavioral intention was obtained, which also supports the findings of others who have applied the TPB to the prediction of behavioral intention (Crawley & Koballa, 1992; Myeong & Crawley, 1993; Smith, 1990).

4.7.2 The relative contributions of the predictor variables to the prediction of behavioral intention

The first research question explored each of the predicator variables individually by asking, "Which of the three direct determinants of intention are statistically significant predictors of teachers' intentions to use the practices explored in the EDR initiative?" Analysis revealed the importance of each directly measured variable to the prediction of intention to use the ideas and activities.

It was shown that within the direct measures of the three predictor variables, all three (attitude toward behavior, subjective norm and perceived behavioral control) were significantly correlated with behavioral intention. By undertaking a stepwise multiple regression analysis, it was revealed that all three predictor variables have a statistically significant influence in the prediction of behavioral intention. These results give support to the TPB (and possibly the TRA) as a preferred model to evaluate the behavioral intention of teachers in engaging in professional learning. It was determined that the addition of subjective norm and perceived behavioral control did improve the predictive capacity of the model when compared to an attitude-only model, highlighted by the fact that perceived behavioral control was most highly correlated with behavioral intention. This suggests that in terms of teacher professional learning, the person's belief as to how easy or difficult performance of the behavior is likely to be and the extent to which the individual believes that performance of the behavior is affected by internal and external factors, is an important factor influencing teacher's intent to engage in the behavior (i.e. professional learning). The perceived behavioral control variable includes aspects such as inadequate skill, talent, or ability and external factors may include lack of resources (time, supplies, funds, etc.), opportunity, or the cooperation of others.

The finding that all three predictor variables were significantly correlated to behavioral intention is a proposition that has been contested in the literature. Crawley (1990), who examined science teachers' intentions to use investigative teaching methods after attending a five-week activity, found that attitude toward behavior was the only variable predictive of behavioral intention. In Crawley's study, regardless of the availability of resources and time, intention to perform the behavior appeared to be totally under the control of the participants, with little need for social support or validation from those important to the participant in teaching decisions.

However, in the context of this study, where teacher collaborative inquiry was a core element of design research, it appears aspects such as skills, resources and the social element of learning *do* impact the behavioral intention of teachers.

While the descriptive statistical analysis revealed the mean for attitude toward behavior to be higher than the means for subjective norm and perceived behavioral control (see Table 5), the difference was significantly higher. Broadly, the participating teachers could be described as having very positive attitudes towards the EDR initiative, yet they were also motivated to fulfill the wishes of others, and were likely to attempt to change things that may appear out of their control (e.g. advocating to principals for more time to work in collaborative inquiry groups).

The results of Study 1 indicated there was a strong link between the antecedent beliefs and behavioral intention. Intention was predicted significantly by perceived behavioral control, subjective norm and attitude. The statistical analysis identified perceived behavioral control as the most powerful predictor of behavioral intention. Ajzen (1991) argued the magnitude of the perceived behavioral control-intention relationship is dependent upon the type of behavior and the nature of the situation. Demir (2010) suggested the increased importance perceived behavioral control may have with behaviors that require skills and resources. This is consistent with the findings of this study, where the nature of the teacher professional learning was focused on the required instructional shifts (the skill of teaching) and operationalizing the CCSS mathematics curriculum (resources, materials, time to collaborate, etc.). Hence, the perceived behavioral control factors were the most significant predictor of intention. The control factors suggest the importance of resources and time for teachers when implementing the CCSS. This is consistent with Timperley et al. (2007), as they highlighted "an extended timeframe is needed for substantive learning to occur" (p. xxviii).

In the current study, perceived expectations of principals, colleagues, and students were used to establish the subjective norm. While other teacher professional learning studies (Demir, 2010; Patterson, 2001) have found subjective norm to be less important than attitude to predict behavioral intention, the results of this study indicate subjective norm was *more* important in this context. Taylor and Todd (1995) argued that innovation can create uncertainty, so the relative influence of subjective norm on intentions is expected to be stronger for people with no prior experience as they rely on the reactions of others in forming their opinions. With over 40 states in the US adopting the CCSS, as well as the innovative instructional shifts associated the new standards, teachers are engaging in professional discourse about the merits and implications of the standards. The results for subjective norm highlight the importance that people who are professionally significant to teachers play in the initial stages of implementation and the influence they have over teachers' normative beliefs. It would seem logical that teachers refer to significant others to help shape their understanding and opinions. While not in the scope of this study, it also highlights the need for future explanatory research exploring the influence that professional bodies, such as teacher unions, state departments, universities and school districts, play in shaping teachers' subjective norms and behavioral intent. Their influence on large scale system innovation may be significant.

Attitude toward the behavior, while significant, was the least powerful predictor of the three direct measures. This measure refers to the degree to which a person has a favorable or unfavorable evaluation or appraisal of the behavior in question. The descriptive statistics (Table 4 and 5) indicate that while teachers have a generally favorable evaluation of the behavior, their attitude is not the most powerful predictor in their decision to engage in the professional learning.

4.8 Summary

The teachers involved in the EDR initiative during the 2013/2014 academic year provided the data for analysis through the BS (to ascertain the salient beliefs of teachers) and subsequently the online self-report BIQ. Twenty-seven of the 60 participants replied to the BS and there were 152 respondents for the BIQ.

The analysis of data was done sequentially, beginning with the beliefs to behavioral intention relationship, then progressing through each of the direct and indirect measures of predictor variables to, finally, analyses of individual beliefs. Each successive step was based upon the findings of the previous step. When relationships of variables were found to be significant, the next, more specific data analysis step, was instituted. If the relationships between the variables were found not to be significant, data analysis along that line was discontinued.

The relationship between behavioral intention scores and the antecedent beliefs (perceived behavioral control, subjective norm and attitude toward the behavior) was found to be significant. Previous research (see Ajzen & Fishbein, 1980; Demir, 2010; Patterson, 2001) has illustrated that behavioral intention scores are significant predictors of behavior. Analysis focused on the direct measures of the predictor variables: attitude toward the behavior, subjective norm and perceived behavioral control in order to answer the first research question. When used in combination, the variables had greater predictability than with use of each variable alone, providing support for the second hypothesis. The next step involved analysis of the variables as separate predictors. Regression analyses identified perceived behavioral control perceived behavioral control, subjective norm subjective norm, and attitude toward the behavior as significant predictors of behavioral intention.

As highlighted earlier, a regression analysis demonstrated that the combination of the three variables was a significant predictor of behavioral intention. The establishment of the combined predictor variable scores as a significant predictor of behavioral intention supported further analyses of the individual predictor variables and provided further support for the TPB as a viable conceptual framework for assessing behavioral intention of the teachers undertaking EDR. An in-depth discussion of the findings is presented in Chapter 7 of this thesis.

Chapter 5: Study 2 – Changes in teaching practice

Section one: Research objective

The objective of this study was to conduct an analysis of the perceived changes in teacher's practices as a result of the EDR project. This is important to explore, as Zeichner (2003) pointed out, we are often provided with little or no information about the specific characteristics of the research experience that is responsible for promoting teacher growth". While self-reported data from this study may not give us insights into the specific characteristics of the research, it enabled conclusions to be drawn about the impact (over time) the EDR project had on teaching practices.

5.1 Methodology

5.1.1 Introduction

Study 2 examined the perceived changes in teacher behavior (practice and planning) and in student mathematical practices that could be attributed to the EDR initiative. All teachers participating in this study received mathematics professional learning throughout the 2013/2014 academic school year. This involved the following:

1. An opportunity for all teachers (1,500), by grade level, to engage in six hours of learning in August (summer break) 2013.
2. Teams of teachers from each school participated in a four-part series of district professional learning (October, December, February and May), which totaled 24 hours. During this time, as a community of practice, they examined research and developed instructional modules, implemented them, examined student work, reflected on their own practice, and assisted in building capacity at their respective school sites.
3. Teachers collaborated with their colleagues (and a training specialist) onsite and further

addressed local concerns twice in the 2013/2014 academic year (November and February), totaling 12 hours.

4. Job-embedded classroom mathematics coaching was provided by the district's training specialists (instructional coaches) and technical support partners (external mathematics and leadership consultants). This provided an opportunity for teachers to receive individual feedback and coaching on their current classroom practice.

Up to this point, the district had collected teacher satisfaction data when evaluating district professional learning initiatives. In the past, end-of-workshop evaluations of the learning experiences and staff satisfaction had been collected, but there was little emphasis on establishing the impact or level of implementation in classrooms that could be attributed to the professional learning experiences. This study recognized that contemporary theories of human development acknowledge that growth and change of any cognitive function is a dynamic, constructive process that occurs between an individual and his or her cultural context (Fischer & Bidell, 2006). As such, a LGC analysis was conducted to establish any change that occurred during the course of the 2013/2014 academic school year.

Data was collected and analyzed in order to answer the following three research questions:

- How do the teachers perceive their own change as a consequence of the EDR project?
- How does teacher practice change as a consequence of their participation in the EDR project?
- How do the teachers perceive changes in student practices as a consequence of the EDR project?

5.2 Method

As previously discussed, teachers' professional learning activities took place over the 2013-2014 school year, and data collection occurred in four waves through a self-report questionnaire. Wave 1 occurred during the October 2013; Wave 2 during December 2013; Wave 3 during February 2014; Wave 4 during May 2014.

Building on the work of Smith (1993), this research sought to measure the actual behavior of teachers, rather than just their behavioral intent. Behavior, in this study, was viewed as implementing evolved teaching practices. The EDR professional learning followed a chain of logic: where the professional learning is designed for teachers to develop and evolve their teaching practice, so, in turn it will lead to changes that impact on students. The self-report questionnaire was designed to capture the changes in teacher behavior that could be attributed to this professional learning initiative. As such, teachers also reported on observed changes in student practices they could attribute to their evolving teaching practice. The premise was to explore the degree and quality of transfer of the learning associated with the EDR initiative. As Hall, Loucks, Rutherford and Newlove (1975) argued, change in instructional method is rarely an all or nothing phenomenon; it usually is a case of adoption and implementation to a degree. Hence, the development of a LOIQ.

5.2.1 Development of the level of implementation questionnaire(LOIQ)

Since this study sought to determine if the teachers' intentions to use the skills and knowledge in their instructional repertoire transferred to actual use, a measure of teacher behavior, the LOIQ was developed. The purpose of the LOIQ was to identify where, along a continuum from non-use to fully-integrated use, each teacher's behavior might fall. The psychometric quality of this tool is an important consideration given its centrality to this study with respect to reliability of

implementation. A list of key aspects that were explored over the course of the 2013/2014 academic school year professional learning workshops was compiled and a continuum was developed to score the participants' practices in utilizing the ideas explored. The LOIQ is presented in Appendix G. The content validity of the LOIQ is derived from the fact that it assessed participants' transfer of ideas explored during the EDR initiative. This was cross-referenced at the end of the academic year to ensure the content explored was the same as the content that was intended (planned) for the 2013/2014 academic year. As a result of mapping the annual action plan to the delivered content, it was concluded that the plan and the content were closely aligned, ensuring the validity of the LOIQ as a way to measure implementation of the professional learning associated with the EDR initiative.

5.2.2 Administration of the level of implementation questionnaire (LOIQ)

Teachers completed the Level of Implementation Questionnaire (LOIQ) during each of the four workshops in the 2013-2014 academic year. The LOIQ was offered to all teachers attending the workshops, as a result; 344 teachers completed it in October (Wave 1); 264 completed it teachers in December (Wave 2); 232 teachers completed it in February (Wave 3); and 227 teachers completed it in May (Wave 4). An explanation of the study was provided to the participants by the researcher in accordance with the consent parameters approved by the Human Ethics Advisory Group at the University of Melbourne. The participants were asked to respond to each of the questionnaire items by coloring a dot along a four-point Likert scale (see Appendix G).

5.2.4 Study attrition

Attrition is generally understood as the loss of follow-up of a respondent, causing all further information on this respondent to be missing (Deeg, 2002). Although the attrition rate in the EDR initiative appeared to be gradual over the course of the year, attrition was more about the

availability of teachers would could attend all four workshops (where data was collected), rather than due to withdrawals from the EDR initiative. It is also worth noting that due to a severe storm, the December workshop for the grade 4 and 5 teachers was cancelled, meaning there was very little data collected for this session. Table 7 shows that the original cohort is represented by the retained sample. In short, although the study contained fewer teachers than the original Wave 1 (n=344) data, it continued to include teachers from a wide range of schools, year levels and teaching experience.

Table 7: Number of participants in each wave of data collection

	October		December		February		May	
Variable	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Grade Level Currently Teaching								
Kindergarten	30	8.7	33	12.5	32	13.8	18	8.0
Grade 1	31	9.0	30	11.4	21	9.1	30	13.3
Grade 2	30	8.7	36	13.7	28	12.1	18	8.0
Grade 3	37	10.7	33	12.5	22	9.5	26	11.5
Grade 4	45	13.0	-	-	18	7.8	16	7.1
Grade 5	36	10.4	1	0.4	16	6.9	24	10.6
Grade 6	34	9.9	30	11.4	14	6.0	19	8.4
Grade 7	21	6.1	25	9.5	10	4.3	15	6.6
Grade 8	21	6.1	18	6.8	12	5.2	21	9.3
High School	58	16.8	57	21.7	59	25.4	39	17.3
Missing Data	1	0.3						
Total	344		263		232		226	

5.3 Analysis of the Level of Implementation Questionnaire (LOIQ)

This section reports on the analyses performed to examine the statistical assumptions required for the current sample. This is followed by a description of the analytic approach employed to answer the current study's research questions. In selecting the most appropriate statistical approach to answer the research questions, the techniques of multiple regression and SEM were considered; with SEM judged to be a clearer way of representing change over time. This is because SEM enables the testing of a network of several developmental relationships, simultaneously. SEM also provides model fit indices, which encourage researchers to think more critically about the conceptual and empirical quality of their measurable variables (Byrne, 2010).

The LGC model offered advantages over more traditional methods of assessing growth and change, allowing for the imputation of missing data points. It can also adequately represent non-normal data and allow for non-linear growth patterns to emerge (Curran, Obeidat, & Losardo, 2010). Each participant's LOIQ results was utilized for the analysis, using the maximum likelihood estimation procedure in AMOS v19 (Arbuckle, 2008).

Missing data (discussed in more detail in sections 5.3.2 and 5.3.3) can be adequately modeled with the use of multiple imputation or maximum likelihood methods, assuming the data is missing completely at random (MCAR) or missing at random (MAR). MCAR can be assumed if the missing data is not related to the variable under examination. MAR has a slightly less strict definition that states the probability of the data missing may be related to the variable under investigation but the value of that variable does not affect the probability of missingness (Allison, 2003).

5.3.1 Statistical assumptions

Within the data set used for this study, missing data averaged 17.3% and appeared to be MAR. Those cases missing data from two or more of the four waves were removed from the sample. Cases that had data on three or more of the four waves were retained. The expectation-maximization (EM) algorithm has been identified as an effective method for imputing missing data (Enders, 2006; Kline, 1998; McDonald & Ho, 2002; Raghunatan, 2004), and was employed in the current study. The justification for this technique to manage missing data is explained below. Once the data had been managed in this way, all analyses were conducted with the same sample of 109 participating teachers.

5.3.2 Missing data mechanisms

Prior to examining missing data handling options, it is important to have an understanding of so-called 'missing data mechanisms'. Rubin (1976) and colleagues (Little & Rubin, 2002) came up with the classification system of MCAR, MAR, and missing not at random (MNAR). These mechanisms describe relationships between measured variables and the probability of missing data. While these terms have a precise probabilistic and mathematical meaning, they are essentially

three different explanations for why data are missing. From a practical perspective, the mechanisms are assumptions that dictate the performance of different missing data techniques.

Data are MCAR when the probability of missing data on a variable X is unrelated to other measured variables and to the values of X itself. In other words, missingness is completely unsystematic and the observed data can be thought of as a random sub-sample of the hypothetically complete data. Because MCAR requires missingness to be unrelated to study variables, methodologists often argue that it is a very strict assumption that is unlikely to be satisfied in practice (Muthen, Kaplan, & Hollis, 1987; Raghunatan, 2004). The MAR mechanism requires a less stringent assumption about the reason for missing data compared to MCAR. Data are MAR if missingness is related to other measured variables in the analysis model, but not to the underlying values of the incomplete variable (i.e. the hypothetical values that would have resulted had the data been complete). Finally, data are MNAR if the probability of missing data is systematically related to the hypothetical values that are missing. In other words, the MNAR mechanism describes data that are missing based on the would-be values of the missing scores. By undertaking this process, it was established that the data for this study could be described as MCAR.

5.3.3 Missing data techniques

As mentioned, recognizing which missing data mechanism is occurring in a dataset is important as this dictates the performance of different missing data techniques. Deletion techniques, such as listwise deletion, are perhaps the most basic of the traditional missing data techniques. With listwise deletion (also called complete-case analysis or casewise deletion), cases with any missing values are discarded, so the analyses are restricted to cases that have complete data. Excluding cases with missing data is a strategy that is firmly entrenched in statistical software packages and is exceedingly common in disciplines such as psychology and education (Peugh &

Enders, 2004). However, this practice is at odds with a report by the American Psychological Association Task Force on Statistical Inference, which stated that deletion methods "are among the worst methods available for practical applications" (Wilkinson & The Task Force on Statistical Inference, 1999, p. 598). Added to this, deleting missing data was not a good option in this case, as the small number of participants would not produce robust parameter estimates.

The disadvantages of using listwise deletion are numerous. Deleting incomplete records can dramatically reduce the total sample size, particularly for data sets that include a large proportion of missing data or many variables. As a result, significance tests will lack power. More importantly, listwise deletion assumes that the data are MCAR (i.e. missingness is unrelated to all measured variables) (Baraldi & Enders, 2010). When the MCAR assumption is violated, as it often is in real life research settings, the analyses will produce biased estimates, incorrect standard errors, or both (Little & Rubin, 2002). Thus, deleting cases with any missing data has been amply shown to be inadequate at best and misleading at worst (Allison, 2003; Peugh & Enders, 2004; Schafer & Graham, 2002; Wothke, 2000).

5.3.4 Maximum likelihood

Maximum likelihood is a theoretically appealing technique because it requires a weaker, and probably more realistic, assumption about the missing data relative to traditional missing data techniques. In practice, this means that maximum likelihood should produce unbiased and efficient parameter estimates in situations where traditional methods (such as deletion techniques) will not (Enders, 2006). Indeed, a growing body of empirical studies has demonstrated that maximum likelihood is generally superior to the traditional missing data techniques that are still prevalent in the applied literature (Arbuckle, 1996; Enders, 2001, 2003; Enders & Bandalos, 2001; Gold & Bentler, 2000; Graham, Hofer, & MacKinnon, 1996; Graham & Schafer, 1999; Kaplan, 1995;

Muthen et al., 1987; Wothke, 2000). Briefly, the basic goal of maximum likelihood estimation is to identify the population parameter values that are most likely to have produced a particular sample of data (Enders, 2006). Although maximum likelihood techniques such as direct maximum likelihood and multiple imputation are not without their own potentially tenuous assumptions (i.e. MAR and multi-variate normality), these techniques are currently considered to be amongst the best procedures available (Enders, 2006). Some researchers appear dubious about maximum likelihood because they hold the misperception that such procedures involve 'making up data'. However, maximum likelihood does not impute missing values at all but estimates parameters directly from the observed data (Enders, 2006).

5.3.5 Statistical Method for Handling Missing Data: Multiple Imputation

According to Graham (2009), missing data can be safely estimated in longitudinal models using multiple imputation. Multiple imputation is a general approach to the problem of missing data that is available in several commonly used statistical packages. It aims to allow for the uncertainty about the missing data by creating several different plausible imputed data sets and appropriately combining results obtained from each of them. The first stage is to create multiple copies of the dataset, with the missing values replaced by imputed values. These are sampled from their predictive distribution based on the observed data—thus multiple imputation is based on a Bayesian approach. The imputation procedure must fully account for all uncertainty in predicting the missing values by injecting appropriate variability into the multiple imputed values.

The second stage is to use standard statistical methods to fit the model of interest to each of the imputed datasets. Estimated associations in each of the imputed datasets will differ because of the variation introduced in the imputation of the missing values, and they are only useful when averaged together to give overall estimated associations. Standard errors are calculated using

Rubin's rules (Rubin, 1987), which take account of the variability in results between the imputed datasets, reflecting the uncertainty associated with the missing values. Valid inferences are obtained because we are averaging over the distribution of the missing data given the observed data. The data imputation procedure was carried out in AMOS v19 (Arbuckle, 2008), and estimated data sets were examined to ensure error variances were still in the acceptable range (Graham, 2009).

5.3.6 Analytic approach

All analyses described in this thesis were conducted using the IBM SPSS 19 statistical package and IBM SPSS AMOS v19 (Arbuckle, 2010; SPSS, 2010). The analytic approach comprises three steps. First, CFA was used to further validate and form the latent constructs of the LOIQ at each time point. Second, using these structural equation models, latent factor scores were generated for the level of implementation questionnaire. Finally, LGC analysis was performed to establish change over time. The objective of LGC models is to capture information about inter-individual differences in intra-individual change (Nesselroade, 1991). In their simplest forms, LGC models establish change over time. Unlike ANOVA or regression models, a non-linear growth pattern can be modeled and tested for adequacy of fit (in other words how well the model reproduces the data). As the data is longitudinal, it violates the independence of observation requirement of ANOVA, and so a different analysis is desirable. Using the dynamic analysis framework, the model is fit to allow for quadratic growth, and then the parameter estimates are obtained to ascertain if the quadratic model is a good fit to the data (Byrne & Crombie, 2003).

5.3.7 Confirmatory factor analysis (CFA)

In order to remove error variance and extract the strongest possible level of implementation scores for subsequent analyses with SEM models of level of implementation as an overall

construct, five levels of implementation dimensions were used. These were: student practices; teacher practices; planning for ELLs, gifted and students with additional needs (SWANS); textbook use; and finally curriculum map use, which were constructed and tested using CFA in AMOS v19 (Arbuckle, 2010). Model estimations were based on a covariance matrix and used maximum likelihood estimates (Tabachnick & Fidell, 2001). All models presented were identified and the estimation process converged in each analysis. All parameter estimates were within the range of permissible values. The final model figures show standardized parameter estimates.

CFA for the overall level of implementation dimensions was performed in a two-stage procedure (Hair, Anderson, Tatham, & Black, 1995), ensuring that each first-order measurement model was psychometrically sound before making any attempt to evaluate the second-order structural model. This maximized the interpretability of the final structure (Byrne, 2010).

A large number of measures are available to assess the fit between the SEM models and data, and there is a lack of consensus in the literature regarding which of these fit statistics should be examined. Hence, it is generally accepted that multiple fit statistics should be consulted (Hu & Bentler, 1999; Schermelleh-Engel, Moosbrugger, & Muller, 2003). The current study employed the set of fit measures suggested by Byrne (2010), including chi-square (χ^2), standard root mean square residual (SRMR), adjusted goodness-of-fit index (AGFI), comparative fit index (CFI), and RMSEA with an associated 90% confidence interval. When assessing relative model fit, the chi-square difference test was also examined.

Chi-square is the most commonly reported fit statistic and is a 'badness of fit' measure, as a significant chi-square value suggests that the sample correlation matrix and the model correlated matrix are significantly different (Schermelleh-Engel et al., 2003). However, large sample sizes (over 200) tend to increase chi-square (Hair et al., 1995) so that significant differences become

very common. Thus it is reported only as a matter of convention in the current study. The SRMR measures the average of the fitted residuals, and provides the proportion of variance in the data accounted for by the model. SRMR values below 0.05 indicate a very good fit (Hair et al., 1995) while values up to 0.08 fall into the category of acceptable fit (Hu & Bentler, 1999). The AGFI is a measure of overall model fit, and provides the proportion of variance that is explained by the model, adjusted for the degrees of freedom. AGFI values greater than 0.80 are taken to reflect acceptable fit (Hair et al., 5; Schermelleh-Engel et al., 2003). The CFI is derived from comparison of a hypothesized model with the independence (or null) model. As such, it provides a measure of complete covariation in the data. Hu & Bentler (1999) advise a CFI cut-off value of close to 0.95 as being representative of a well-fitting model, while 0.90 indicates adequate model fit (Bentler, 1990). The RMSEA with an associated 90% confidence interval is based on the non-centrality parameter, and takes particular account of the error of approximation (Zubrick & Lawrence, 2006). Browne and Cudeck (1993) suggested that a RMSEA value below 0.05 indicates a very good fit, and values up to 0.08 indicate acceptable fit. It is important to note that RMSEA is sensitive to the number of estimated parameters in a model (i.e. the complexity of the model) (Byrne, 2010). These measures are summarized in Table 8.

Table 8: Acceptable Fit Statistics

Fit statistic	Acceptable fit	Source
Chi-square	p<.01	Schermelleh-Engel, et al. (2003); Byrne (2010)
SRMR	< .08	Hu and Bentler (1998); Byrne (2010)
AGFI	> .80	Hair et al. (1995)
CFI	> .90	Hu and Bentler (1998); Byrne (2010)
RMSEA	< .08	Browne & Cudeck (1993); Byrne (2010)

A final but nevertheless crucial issue to consider when examining SEM model fit is to balance the model's fit to the data with its theoretical underpinning. Hayduk, Cummings, Boadu, Pazderka-Robinson, and Boulianne (2007) caution against strict reliance on fit statistic cut-offs:

> A statistician who focuses on fit is merely sticking to what they are supposed to know about (statistics and data) and avoiding what they are not required to know (substantive theoretical matters). *Researchers* ought to be extremely interested in the relevant substantive theory. (p. 842)

5.3.8 Generating latent factor scores

Once the SEM models were estimated and acceptable fit was achieved, latent factor scores for each dimension were calculated using model-based imputation in AMOS v19 (Arbuckle, 2010) for follow-up analysis. A latent factor score is a linear composite of the optimally-weighted observed variables and is therefore a more valid representation of the underlying latent construct than a factor-based score, which is merely a linear composite (e.g. mean or sum) of the variables that demonstrated meaningful factor loadings (Hatcher, 1994).

Using the SEM models, a latent factor level of implementation score was imputed for all participants for each of the four separate time-points throughout the 2013/2014 academic year. Higher values reflect high levels of implementation. A latent factor score reflecting each of the

five dimensions was also imputed for all participants. Higher values reflect higher or stronger levels of the implementation. An overall level of implementation latent factor score was imputed from the second-order level of implementation model using the same process. Higher values reflect higher levels of overall implementation. These latent factor scores were used in subsequent analyses to represent level of implementation for the five dimensions.

5.4 Descriptive statistics

Figures 13 through 17 depict the average growth for each item of the LOIQ throughout the course of the 2013/2014 academic year. This data is for all participants (October n= 344, December n=263, February n=232 and May n=226).

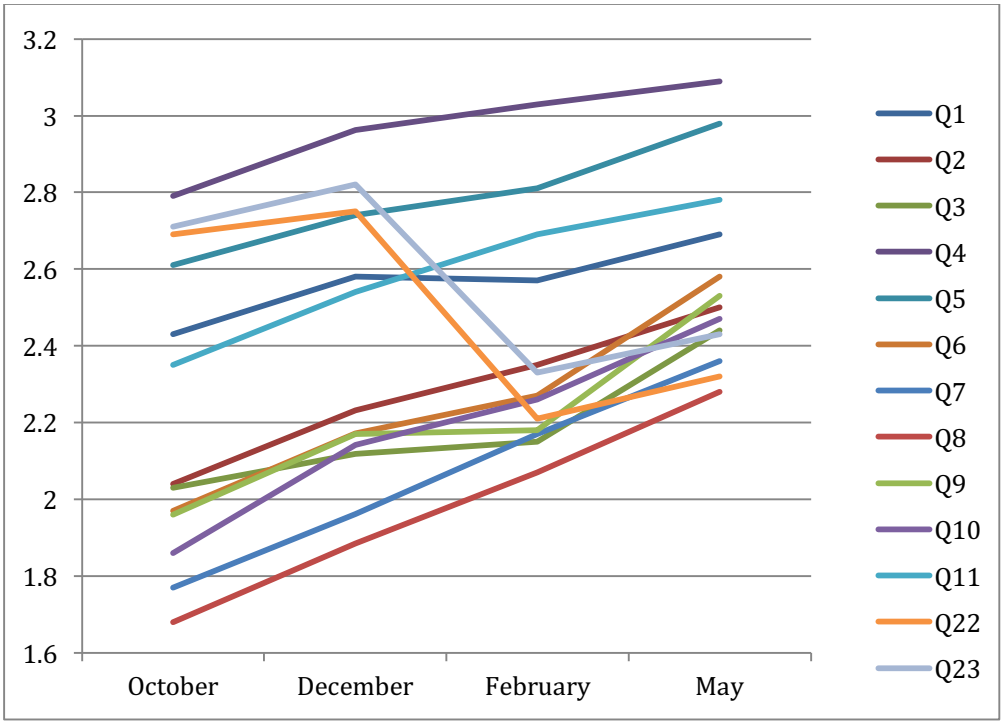

Figure 13: Student practices

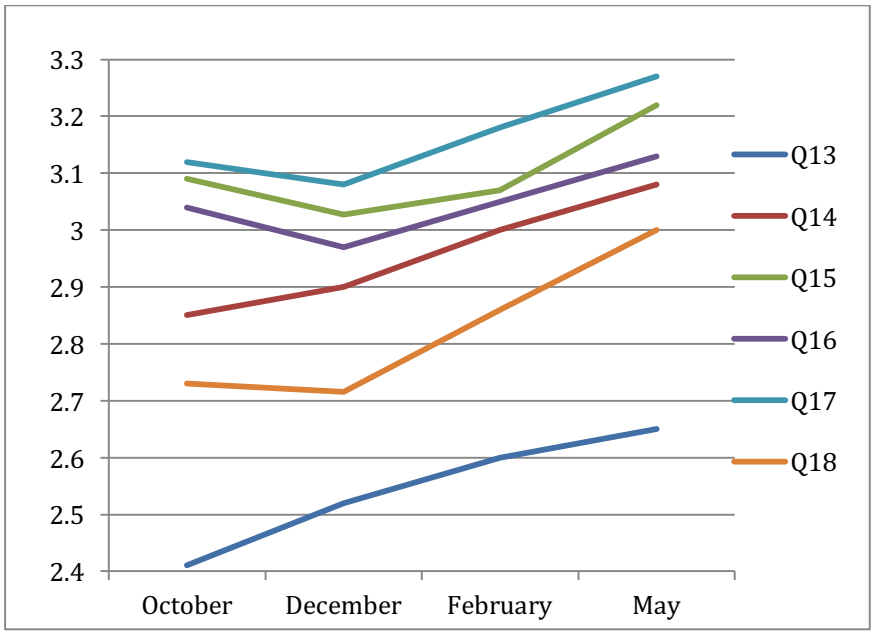

Figure 14: Teacher practices

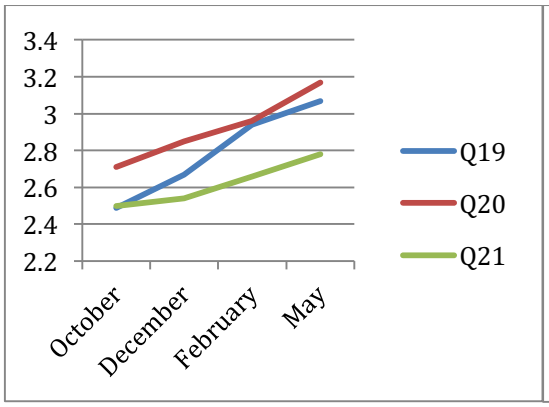

Figure 15: Planning for ELLs, SWANs and gifted

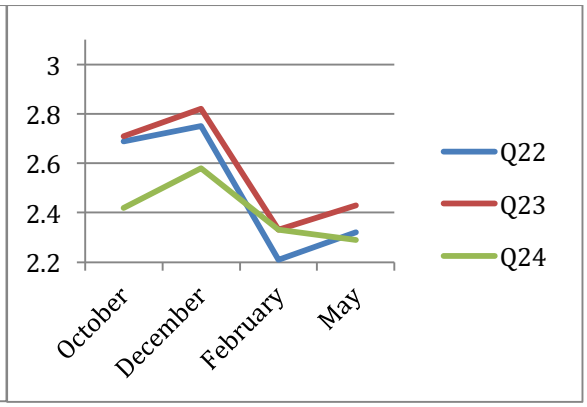

Figure 16: Textbook use

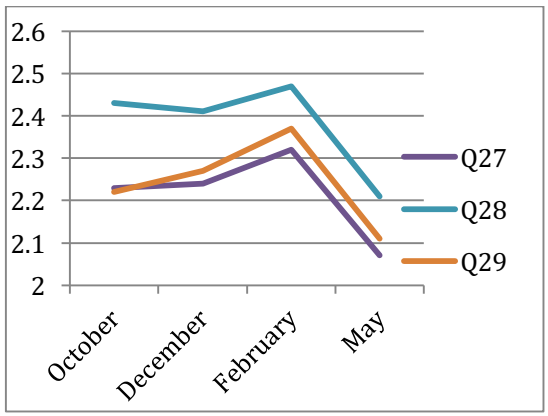

Figure 17: Curriculum map use

Table 9 reports the observed means and standard deviations for each item of the LOIQ at each time point (wave). With the exception of items 22 and 23, these scores indicate that teachers perceived a steady increase in student mathematical behaviors (see Figure 13). Items 22 and 23 were focused on planning for the Standards of Mathematical Practices and posing rigorous questions. These two questions displayed a significant dip between December and February before moving up again between February and May. The teacher practices items (questions 13-18) displayed a slight dip between October and December before moving up between December and May. Two teacher practices items maintained a consistent growth over the course of the year, these items focused on incorporating the CCSS in lessons with the use of formative assessment to drive instruction. Planning for ELLs, SWANs and gifted learners all show an upward trend. Planning for gifted learners was not a major focus and this is reflected in its lower growth than the other two areas. At the beginning of the academic year, the school district offered textbooks to schools to use as a supplementary resource. Use of these textbook was quite high at the beginning of the year before dropping sharply between December and February. Use of the district curriculum maps was quite consistent throughout the year, before falling between February and May. As Table 9 outlines, there was consistency with the standard deviations, indicating general low variability in the scores.

Table 9: Means and standard deviations for LOIQ

	October	December	February	May
Student Practices Mean	2.11	2.37	2.54	2.70
Student Practices SD	0.57	0.52	0.53	0.52
Teacher Practices Mean	2.83	2.80	2.81	2.89
Teacher Practices SD	0.63	0.53	0.45	0.41
Planning for ELLs, SWANS & Gifted Mean	2.38	2.72	2.91	2.97
Planning for ELLs, SWANS & Gifted SD	0.92	0.79	0.79	0.79

Textbook Use Mean	2.49	2.69	2.47	2.29
Textbook Use SD	0.76	0.76	0.65	0.50
Curriculum Map Use Mean	2.18	2.21	2.37	2.11
Curriculum Map Use SD	0.78	0.81	0.87	0.59

5.5 Latent growth curve (LGC) analysis

The standardized scores of the teachers were modeled in a LGC model. Figure 6 displays the schematic of the base model, where the intercept represents the initial level of performance on the LOIQ, and the slope represents the change of factors over time (student practices, teacher practices, textbook use, curriculum map use, and planning for ELLs, SWANS, and gifted). For the intercept factor, loadings of observed variables were constrained to 1. For the slope factor, loadings were constrained to 0 and 0.33 for observed Wave 1 and Wave 2, 0.33 and 0.67 for Wave 2 and 3 and 0.67 and 1 for Wave 3 and Wave 4. This parameterization (a) centered the analysis at Wave 1 and (b) estimated the metric of time (i.e. the slope). The intercept is thus interpreted as the mean frequency of LOIQ at the beginning of the year, and the slope between any two time-points is interpreted relative to the amount of change between the first two time-points (i.e. Wave 1 and Wave 2). The five factors were modeled as separate processes. The errors in this model represent individual variation.

Figure 6 displays the LGC model estimated with maximum likelihood parameter estimates. The residual variances (E1-E4) indicate the amount of individual variance in the observed scores of the LOIQ. Squares indicate observed scores of the LOIQ at each wave of data collection (October, December, February and May). Circles indicate latent intercept and latent growth slope, and the double-headed arrow indicates these latent factors are allowed to co-vary.

5.6 Model fit

Assessing model fit in a LGC is complex and must be based on a priori theory (Curran et al., 2010). The method of assessing model fit is to determine how well the sample data fits into the proposed model. Several factors must be assessed to determine if the proposed model is a good fitting model or not (Beecher, 2011). The fit indices, the parameter estimates and residual variances are all examined. The base model was fit to allow for linear growth, and then a quadratic term was fit to the model in order to compare the shape of developmental trajectories over time. A comparison of the fit indices for the linear and quadratic model is presented in Table 10. Based on the model fit data, the linear model appears to be the better fitting model.

Table 10: Model fit indices for linear and quadratic model

Variable	x^2	**SRMR** ***(<.08)***	**CFI** ***(>.90)***	**RMSEA (<.08)**	***df***
	Linear Model				
Student Practices	1.74	0.06	0.93	0.08	8
Teacher Practices	2.36	0.08	0.84	0.11	8
Planning	1.81	0.06	0.86	0.09	8
Textbook Use	3.70	0.12	0.00	0.16	8
Curriculum Map Use	5.31	0.11	0.16	0.20	8
	Quadratic Model				
Student Practices	30.21	0.40	0.00	0.52	8
Teacher Practices	29.13	0.40	0.00	0.51	8
Planning	7.17	0.40	0.00	0.24	8
Textbook Use	9.51	0.18	0.00	0.28	8
Curriculum Map Use	9.88	0.19	0.00	0.29	8

Note: x^2 = chi squared, SRMR = Standardized root mean square residual, CFI = Confirmatory fit index, RMSEA = Root mean square error of approximation

Although the significant x^2 indicates a less-than-perfect model fit (for textbook use and curriculum map use), the other fit indices indicate the linear model is better fitting than the quadratic model, and has an acceptable overall fit. A positive relationship between intercept and

slope means indicates teachers whose intercept was lower initially attained more growth than those who were higher initially. This is a common psychological phenomenon called 'law of initial values', which states that higher values in starting levels will show less growth than lower initial values (Jamieson, 1995). The positive values of the linear term indicate there is a downward concavity or an overall propensity for individuals' change to increase over time (Hancock & Lawrence, 2006). Conversely, a negative relationship between intercept and slope indicates the teachers whose intercept was higher initially made less gain (or went backwards) than those who were lower.

Table 11: Mean intercept, slope and AIC

Variable	Mean Intercept	Mean Slope	AIC	
Student Practices	2.14	0.58	25.94	
Teacher Practices	2.80	0.06	30.87	
Planning	2.45	0.57	26.50	
Textbook Use	2.61	-2.45	41.62	
Curriculum Map Use	2.23	-0.02	54.47	

Note: AIC = Akaike Information Criterion

The hypothesized linear model of LOIQ was estimated (see Table 10) and found to be a good fit for the data. Thus, no model building was necessary.

5.7 Results

This section presents descriptive information about the sample involved in this study. SEMs of level of implementation measures are also be presented, as well as descriptive statistics and intercorrelations of the latent factor scores of these constructs.

5.7.1 Reliability, validity, correlations and multiple regression analysis

To establish reliability of the five factors Cronbach's alpha was used. As shown in Table 13, based on the data collected, all constructs, except for textbook use, exhibited an α-value greater

than 0.7, which, as noted previously, is a common threshold for exploratory research (Nunnally & Bernstein, 1994).

Table 12: Reliability, validity and correlations

Variables	SP	TP	P	TBU	CMU
SP	(0.92)				
TP	0.33**	(0.87)			
P	0.15	0.52**	(0.77)		
TBU	0.16	0.51**	0.39**	(0.57)	
CMU	0.12	0.17	0.13	0.41**	(0.79)

Note: SP = Student Practices; TP = Teacher Practices; P = Planning; TBU = Textbook Use; CMU = Curriculum Map Use. Numbers in parentheses indicate Cronbach's alpha reliabilities of the constructs. Correlation is significant at the 0.01 level (2-tailed)

The results contained in Table 13 indicate that each of the predictor variables had differing levels of influence on the criterion. The Beta scores indicated that an individual's level of Teacher Practices had a larger impact on their engagement in the EDR initiative compared to their use of Textbooks. Indeed, the relationship between engagement in the EDR initiative was considered to be statistically significant ($p < .05$).

Table 13: Summary of regression statistics

	B	Std. Error	Beta	*t*	Sig
Student Practices Total Score	.429	.099	.388	4.35	.000
Teacher Practices Total Score	.612	.126	.425	4.857	.000
Textbook Use Total Score	.220	.095	.219	2.317	.022
EAL Total Score	.374	.107	.321	3.505	.001

5.8 Statistical analysis

The standardized scores for the matched teacher data (n=109) were calculated and modeled in a parallel LGC model. To be included in the LGC, there needed to be data for three of the four

waves of data collection. That is, there was individual teacher data for at least three of the four LOIQ data collections throughout the academic year. This was to ensure statistical validity for the Structural Equation Modelling. Figure 6 displays the schematic of the base model, where the intercept represents the initial level of performance reported on the LOIQ, and the slope represents the growth factor for teachers over time.

The base or unconditional model was fit to allow for linear growth, and then a quadratic term was fit to the model in order to compare the shape of developmental trajectories over time. Table 11 presents the estimated means of the latent intercept and slopes, along with the model fit indices of the base model with linear growth compared to the quadratic model. The linear model appears to be the better fitting model. Figure 19 presents the aggregated linear model for each of the four factors, at four different time-points during the academic year.

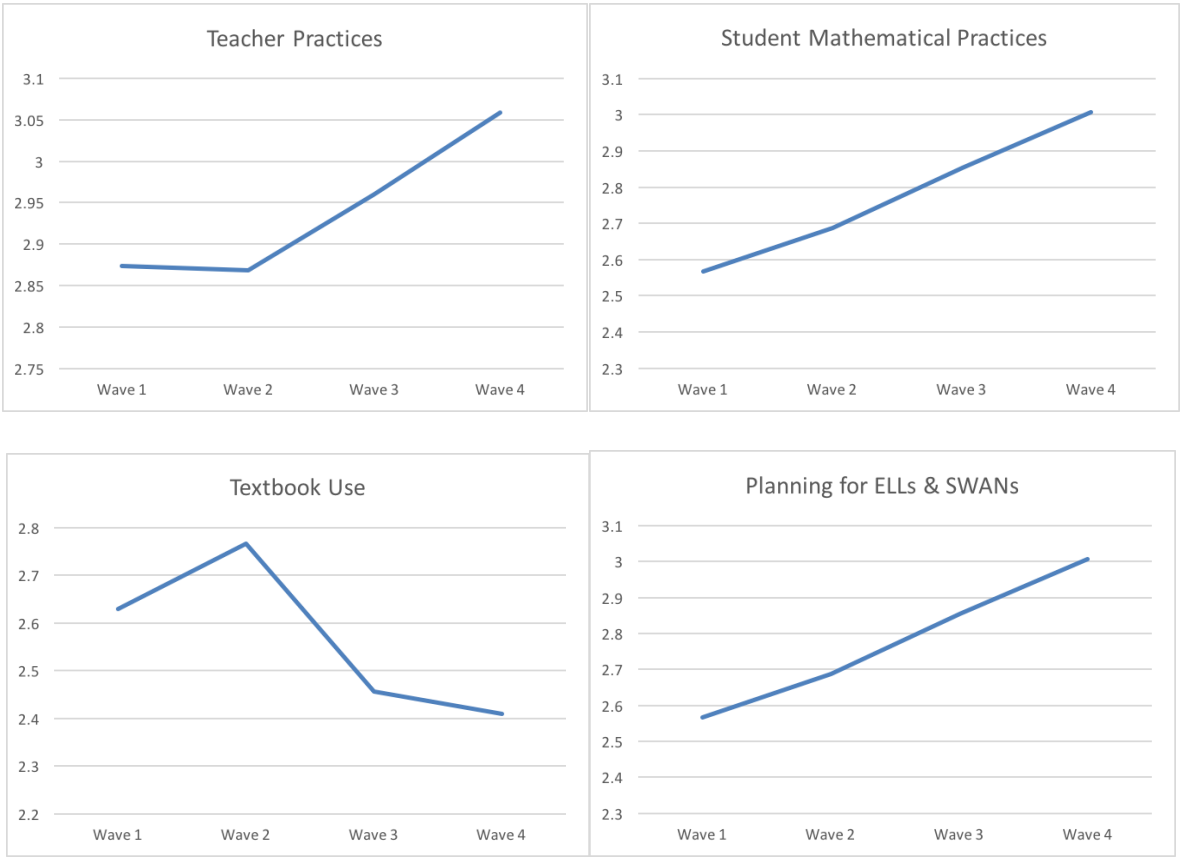

Figure 18: Latent growth data from Wave 1 through to Wave 4

5.9 Summary

The LGC modeling, as well as the descriptive statistics, outline an interesting proposition: teachers between Waves 1 and 2 reported gains in student mathematical practices while simultaneously reporting a slight decline in teaching practices. This raises the question of how teaching can reportedly be declining, yet at the same time student practices improving. Added to this, teaching practices rose dramatically from Wave 2 through to Wave 4, which corresponded with a dramatic decline in textbook use from Wave 2 through to Wave 4 (quite a rapid decline from Wave 2 to 3). That is, teachers' practice improvements coincided with a rapid decline in textbook use. Students mathematical practices and planning for ELLs was reported to improve consistently throughout the year.

Overall teachers perceived the EDR project to have a positive impact on instruction and the students they teach. Added to this, collaborative teacher teams that are instructionally focused, emerged as a cornerstone for effective professional learning within the district

Section two: Discussion

This section provides a brief review of the research rationale and the research questions that the study aimed to address. Of particular importance is that the current study has addressed a question that has previously been ignored in the literature: 'Does EDR impact the practice of teacher participants?' The results of the analyses examining the teachers perceived changes in practice as a consequence of the EDR project are explored. Consideration is given to the findings from the LOIQ.

5.10 How does teacher practice change as a consequence of their participation in the Educational Design-Research (EDR) project?

One of the persistent questions in teacher professional learning is how we make sustainable improvements in teacher practice. By acknowledging the premise that excellence in teaching is the most powerful influence on achievement (Hattie, 2003), then providing support and resources to improve teaching practice should be an effective and efficient mechanism to positively impact student achievement. While theory of action is logical, there is a still a paucity of definitive empirical research on what constitutes effective professional learning for teachers.

5.10.1 Perceived changes in teacher practices

The first major finding of Study 2 concerns the effectiveness of EDR in promoting changes in teacher practices. The study results illustrated the intended effect, with the EDR project benefiting teacher practice. Teachers who were involved in the project reported improvements in their practices as well as in the mathematics practices of their students.

Of importance, was a clear growth over time in teacher practices, student practices and planning, with the teachers reporting higher rates at the end of the 2013/2014 academic year. It is also worth noting that all 11 items related to student practices displayed a consistent upward trajectory through the year. The teachers observed a consistent improvement in students' mathematical practices over the course of the year, yet with teacher practices they reported a drop in five of the six items from October to December before all items displayed an upward trend from December to May. This created an interesting scenario in which the teachers reported improving student practices, while at the same time reporting that their practices had gone backwards.

5.10.2 Perceived changes in planning

An area of focus the teachers identified for exploration during the year was planning for ELLs, SWANs and gifted leaners. While it was anticipated that all three of these areas would be explored during the year, planning for gifted students was not undertaken in the same depth as the work on planning for ELLs and SWANs. This is also evidenced by the data, with growth in planning for ELLs and SWANs far higher than planning for gifted students.

As outlined in Chapter 1, the urban school district where this study took place is culturally diverse. The student population is 36.8% Hispanic or Latino; 19.9% Asian; 16.2% African American; and 19.1% White. Around 6% of students identify as two or more races or ethnicities. Residents within the school district speak more than 40 languages; 24% are considered to be ELLs. With this in mind, the teachers identified planning for ELLs as a key priority in the EDR project. The district supported this direction as a review of the literature clearly outlines issues with achievement in mathematics for ELLs.

Statistics on mathematics achievement show that Latinos are significantly under-represented in all scientific and engineering careers in direct proportion to the amount of mathematics required for a particular job (Secada, 1992; National Research Council, 2010). A factor in the low levels of achievement among Latino students may be the misconception among educators that since mathematics uses symbols, it is therefore 'culture free' and ideal for instructing students who are still learning the English language (California Department of Education, 1990). This misconception ignores the vital role of language in the development of mathematical concepts. Mathematics power is rooted in a strong conceptual understanding of mathematics, and this conceptual base is best developed through concrete experiences and language (National Council of Teachers of Mathematics [NCTM], 1989).

The relationship between language proficiency and mathematics achievement has been documented by researchers such as De Avila and Duncan (1982), who found that the low achievement in mathematics of Latino ELLs could be attributed to low levels of English proficiency. A lack of understanding about the role of language in mathematics instruction has led either to unreasonably high expectations for ELL achievements in situations in which they receive no linguistic support or to lowered expectations that deny equal access to mathematical skills and reasoning (Secada, 1992). The dilemma faced by the mathematics teacher of ELLs is this: How should mathematics be taught to make a meaningful and powerful curriculum accessible to ELLs?

The NCTM advocates an incremental developmental process in mathematics instruction in Curriculum and Evaluation Standards for School Mathematics (1989). These standards offer guidance on how to construct a conceptual understanding of mathematics by urging teachers to begin each new concept with concrete examples and experiences. The curriculum should then provide opportunities for students to make connections among concrete experiences, semi-concrete graphical depiction, abstract symbolic representations, verbal language, and written expression to develop a thorough understanding of the new concept (Garrison & Kerper Mora, 1999).

Concept development can be the primary goal in mathematics classrooms where all students are proficient in the language of instruction (Garrison & Kerper Mora, 1999). However, in linguistically diverse classrooms, teachers must also consider the linguistic complexity of the language used in instruction and the language proficiency of the students in order to provide comprehensible input. If new concepts are introduced in an unfamiliar language, students must struggle with two unknowns: the language and the concept. This dual challenge of unknowns makes learning formidable (De Avila, 1988).

With regards to the EDR initiative, the direction set by the teachers, and supported by the district and the research literature, meant that in addition to focusing on the instructional shifts and Standards of Mathematical Practices associated with the CCSS, the district also had a strong focus on planning for ELLs. The planning for ELLs focus centered specifically on language development in the domain of mathematics. The research literature relating to ELLs and mathematics was operationalized by teachers within the EDR project in many different ways, to ensure interventions suited individual student needs and school contexts. Some examples of planning for ELLs that took place were:

- Investigating effective strategies for development of tier three domain specific vocabulary using tools such as a Frayer Model.
- Exploring the use of sentence frames as a way of scaffolding students' use tier three domain specific language (Fisher, Rothenberg, & Frey, 2008).
- Examining the use of writing genres in mathematics; what are the structure and language features for a prompt such as 'explain your reasoning'? (Cope & Kalantzis, 2014).

5.10.3 Perceived changes in textbook use

The district recommended a mathematics textbook for schools to use at the beginning of the 2013/2014 academic year. In many ways, the use of textbooks and worksheet driven instruction did not match the ideas explored in the EDR project. The EDR project focused on operationalizing the Standards of Mathematical Practices outlined in the CCSS. Practices include "construct viable arguments and critique the reasoning of others" (2011), where mathematically proficient students will conjecture, analyze, justify and communicate plausible arguments. These mathematical practices are not intentionally cultivated in most textbooks, and while referenced, are generally not explicitly unpacked with any depth. While teachers initially used the textbook, with a slight

increase from October to December, the inadequacy of the textbook in developing the necessary mathematical practices and dispositions is illustrated by the dramatic drop in use between December and February (see Figure 19). The use of the textbook to support differentiated instruction continued to decline from December through to the end of the year, suggesting that as teachers became more adept at differentiating instruction, the more they recognized the learning experiences in the textbook were not an appropriate resource.

The results of this model show that the general trend was a curvi-linear upward slope for student practices, teacher practices and planning (for Ells, SWANs and gifted learners). For textbook use, there was a negative trend over the course of the year. Within the context of this study, the downward trend in textbook use is not considered a negative, as it indicated an evolution in practice beyond the low cognitive demand tasks associated with mathematics textbooks. The data indicates a sharp decline in teachers relying on the textbook to enact the curriculum. It is contended that through the supportive structure and collegiate learning experiences associated with the EDR project, teachers were able to develop the instructional skills and knowledge to operationalize the CCSS curriculum, which led to them no longer depending heavily on textbooks.

The importance and prevalence of textbooks in the mathematics classroom has been recognized for a long time. Recent research has acknowledged the complexity of the issues that determine the actual content taught and that the pedagogical approaches used by teachers are quite often heavily influenced by the textbook recommended or mandated by a school district. The irony is that:

> before the CCSS came along, America long resisted the idea of commonality of standards and curriculum …[yet] there has been a de facto national mathematics curriculum for decades: the curriculum defined by the school mathematics textbooks. There are several widely used textbooks, but mathematically they are very much alike. Let's call this de facto mathematics curriculum Textbook School Mathematics (TSM). (Wu, 2011, p. 3)

So, if classrooms were to be truly grounded in the CCSS and the instructional shifts associated with the CCSS, then the heavy reliance on textbooks (and the de facto curriculum within these) needed to be overcome. Fuller (1928) stated it clearly:

> The textbook is the most important of the teacher's tools. In determining the subject matter of the child's experience, it is more decisive in day-to-day affairs than is the course of study outlined by the school system. In determining teaching procedure, the text is more influential from hour to hour than a manual of methods. In fact, the total series of textbooks in use by students and teachers are the real course of study and manual of teaching. This is not the usual theory, but it is the actual fact. (p. 52)

Interestingly, Fuller's (1928) sentiment is still relevant almost ninety years later and the importance of textbooks cannot be overstated. Tyson-Bernstein and Woodward (1991) described the role of textbooks in American schools as ubiquitous and a prominent, if not dominant, part of teaching and learning. This happens in other education systems as well, as Robitaille and Travers (1992) noted:

> Teachers of mathematics in all countries rely very heavily on textbooks in their day-to-day teaching, and this is perhaps more characteristic of the teaching of mathematics than of any other subject in the curriculum. Teachers decide what to teach, how to teach it, and what sorts of exercises to assign to their students largely on the basis of what is contained in the textbook authorized for their course. (p. 706)

Grouws and Smith (2000) concluded that, in the US, the textbook continues to be the base of instruction at grade 8, although the daily use of textbooks has decreased from 1992. Seventy-two percent of the students in grade 8 in the 1996 National Assessment of Education Progression (NAEP) study did problems from textbooks almost every day, as was reported by their teachers, compared with 83% in 1992. In contrast, 16% of the students in 1996 did problems on worksheets almost every day, compared with 12% in 1992. These data suggest that for the majority of mathematics teachers, the textbook determines not only the content, but also how it is taught.

Ultimately, it is the teacher who determines how the curriculum is enacted in the classroom by making decisions that affect classroom practices directly (Clandinin & Connelly, 1992; Drake & Sherin, 2002; Love & Pimm, 1996; Remillard, 1999). By shifting the focus to the CCSS and equipping teachers with the skills to effectively and efficiently interpret and operationalize the CCSS, the teacher acts as a mediator between their students and the CCSS, rather than simply following a predetermined script outlined in a textbook.

Porter (2006) noted that curriculum can be divided into the intended, enacted, assessed, and learned curricula. For K-12 education, the intended curriculum is captured most explicitly in state standards (the CCSS); statements of what every student must know and be able to do by some specified point in time. The enacted curriculum refers to instruction (e.g. what happens in classrooms). So, when planning the enacted curriculum, it is essential to focus and operationalize the intended curriculum (the CCSS) and not rely on a de facto curriculum, such as a text book. Having said that, the role of the textbook as a de facto curriculum was still predominant in many of the classrooms at the commencement of this study. Teachers used textbooks to develop the enacted curriculum and the introduction of the CCSS was identified by the district as an opportunity to move beyond this practice. The results indicate the reliance on a textbook significantly reduced over the course of the 2013/2014 academic year. The minimal amount of use illustrates that teachers evolved their practices and used the textbook when they saw learning experiences that matched what was espoused in the CCSS (the intended curriculum). Together, these results suggest the EDR is a successful framework for promoting sustained and meaningful changes in mathematics teaching and learning.

5.10.4 Perceived changes in student practices

The self-reported results for perceived changes in student practices illustrate teachers attributed a consistent positive upward trend for their students based on the ideas and experiences explored as part of the EDR initiative. This result illustrates the intended effect in which the EDR initiative benefiting teacher practice with the intention of positively impacting student outcomes (students' skills, knowledge and mathematics dispositions). The results indicate that teachers who were involved in the initiative reported growth in their students' mathematical practices. As already indicated, teachers reported growth in student practices while simultaneously reporting a decline in teaching practice between Waves 1 and 2. The most obvious explanation for this paradox is that the teachers recalibrated their own level of expertise between Waves 1 and 2 through deeper exploration of the CCSS and accompanying instructional shifts; they realized they may have been generous in their initial appraisal of their current level of skill and understanding. So, while they were implementing, reflecting and improving practice between Waves 1 and 2, this was not readily observable until the entire academic year data was explored.

5.11 Summary: Main findings and quality of evidence

Overall, the balance of evidence appears to suggest that participating in EDR in a rigorous and ongoing manner may play a role in improving teachers' instructional practice. An important finding of the literature review was the lack of research on the specific characteristics of the research experience and/or research context that are responsible for promoting this improvement (Zeichner, 2003). Rather, the research studies tended to examine teacher inquiry as a process or model to be implemented. The risk is that any process can be undertaken with varying degrees of rigor, so it is essential to dig further into the specific characteristics and contexts that enable (or inhibit) growth. One of the important distinctions between EDR and other forms of teacher inquiry

is the engagement of learners (in this case teachers) permeating each phase of the process. This shift, while subtle, is quite significant as it requires academics to move beyond seeking learner voice to a space that is focused on developing learner agency. This is achieved by the learners collaborating to identify and address problems of practice in their learning environment. The proposition is that through a disciplined approach to collaborative inquiry, resulting in new learning and new action, academics, school leaders and teachers will gain the confidence, the insights, and the mindsets required to design new and powerful learning systems (Timperley, Kaser, & Halbert, 2014).

Chapter 6: Changes in teaching practice

Study 3 (A) – Changes in teaching practice: Establishing trajectories of change over time

6.1 Study aims

While the LGC model illustrates the improvement of participants over time, it is important to understand the specific characteristics of the research experience and the research context responsible for promoting or hindering teacher growth. By researching and analyzing this further it may be possible to establish some generalizable principles for engagement in EDR as a form of teacher professional learning. From a practical point of view, by acknowledging the experiences of sub-groups within the district initiative, this should also highlight the varied experiences of teachers while seeking some common ground between those experiences.

The aim of Study 3 (A) was to break the matched teacher data (n=109) into four distinct groups representing their learning trajectories throughout this longitudinal study. The intention, as discussed previously, was to strata the results into: large, moderate, small, and finally reverse growth teachers. More specifically, the aim was to assess whether or not the magnitude of growth can be conceptualized as a typology, based on their effect size over time, and whether differences can be identified within their individual growth groups. In summary, the goal was to develop a typology that could be used to distinguish different types of teachers with the EDR initiative. As indicated earlier, data were analyzed to answer the following research questions:

- What were the different learning trajectories for teachers undertaking the EDR initiative?
- Can the sample be grouped as large, moderate, small or reverse growth teachers?

6.2 Paired-sample *t* test

For this study, the matched pair was calculated by comparing Wave 1 and Wave 4 data of the LOIQ. That is, teachers completed the same questionnaire in October 2013 and then again in May 2014. A dependent sample *t* test was used to compare these two means and Cohen's *d* effect size was also calculated (see Table 13).

Table 14**: Paired sample t test results and effect sizes**

Factor (Wave 1 to Wave 4)	Effect Size (*d*)	se	***t***	***df***	**Sig. (2-tailed)**
Student practices	0.91	0.06	-9.57	108	<0.01*
Teacher practices	0.40	0.06	-3.45	108	<0.01*
Planning	0.59	0.10	-6.13	108	<0.01*

* Significance at the 0.01 level (2-tailed)

6.3 Results: Calculating and grouping change over time trajectories

With regards to the LOIQ, effect size was calculated for every teacher (n=109) for all the three factors that focused on teaching practice (student mathematical behaviors, teacher behaviors and planning for ELLs). As explained in Chapter 3, it was decided not to calculate the effect size for textbook use as it would be an assumption to conclude a change in textbook use translated into improved or declining practices. A teacher may use the textbook as an instructional tool effectively, so could be improving practice while simultaneously increasing their use of the prescribed mathematics textbook.

As also noted in Chapter 3, caution should be taken when interpreting overall effects, with consideration of the influencing nuances. The overall hinge point of 0.40 was suggested by Hattie (2012) as starting point for discussion. So, while a there is a strong and clear indication of the perceived magnitude of change to teachers that resulted from this EDR initiative, it is prudent to

explore the experiences of individual teachers and identify the specific characteristics of the research experience and/or research context responsible for promoting or inhibiting growth.

6.3.1 Magnitude of change: Effect size for individuals and sub-groups within the sample

There are many different ways to use an effect size, the section above explained how it was used to confirm the LGC model, by clearly illustrating the magnitude of change for participating teachers. However, it is also possible to calculate effect sizes for individual teachers to begin to get a sense of the individual teacher experience. By using Urdan's (2006) rule for interpreting effect sizes (those less than 0 is reverse, 0 to less than 0.20 are small, those between 0.20 and 0.75 are moderate, and those over 0.75 are large) to group teachers, we were able to gain insights into their experience. Effect size frequency distributions for the latent factors are depicted in Figures 20 through to 22.

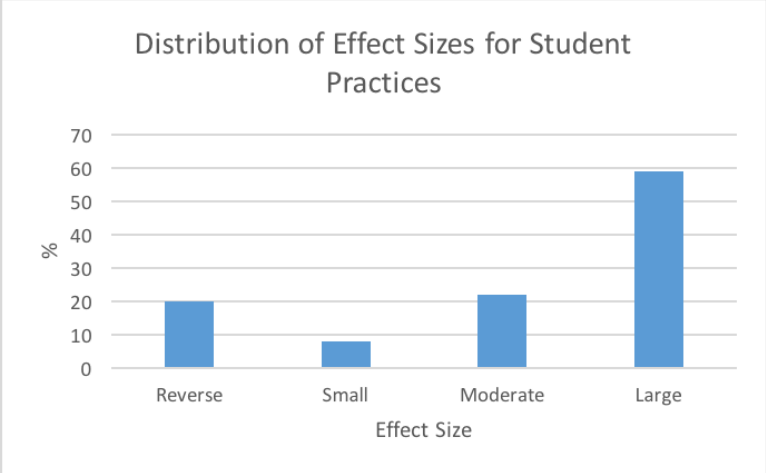

Figure 20: Teacher practices effect size distribution

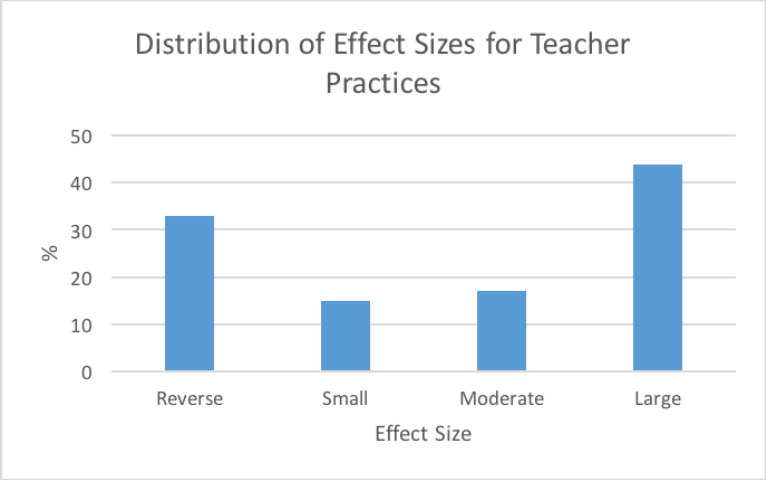

Figure 21: Teacher practices effect size distribution

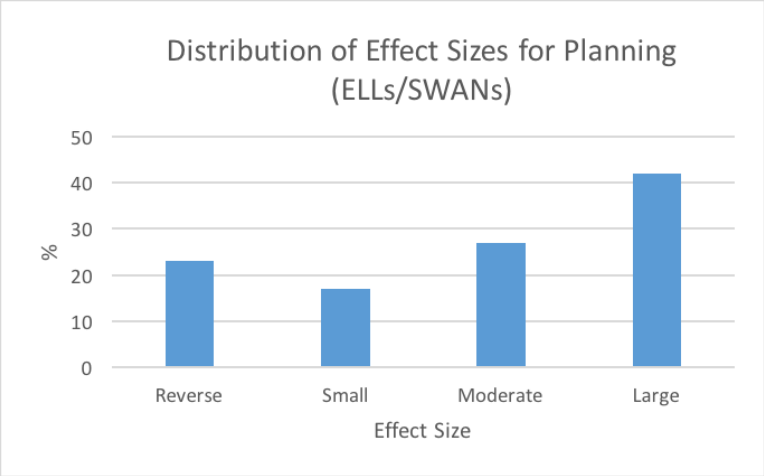

Figure 22: Planning effect size distribution

* Less than 0 is *reverse*, 0 to less than 0.20 are *small*, those between 0.20 and 0.75 are *moderate*, and those over 0.75 are *large*

Figure 20 illustrates that 74% (n=81) of the teachers displayed an effect size in the moderate to large growth category for student practices that teachers attributed to the EDR initiative. Likewise, 56% (n=61) and 63% (n=69) of teachers had an effect size in the moderate to large growth for teacher practices and planning for ELLs/SWANs respectively. These figures illustrate that just under two-thirds of the teachers (64%) or 70 of the 109 participants, were represented in

the moderate to large growth categories. However, 18% of teachers reported student practices stayed the same or declined during the EDR initiative. This was also the case for 30% of the group for teacher practices and 21% in planning for ELLs and SWANs. So, in total, 23% of the participating teachers reported a negative aspect associated with the EDR initiative.

6.3.2 Systematic stratified sampling

Table 15 presents the number of teachers who, based on the mean of their effect size for student practices and teacher practices, could be categorized as large, moderate, small or reverse growth teachers. To be included in the systematic stratified sampling, teachers needed to have reported a consistent level for all three factors. That is, they reported large, moderate, small or reverse growth in all three factors. This enabled individual teachers to be presented in a typology, represented by the magnitude of teacher professional learning growth they attributed to the EDR initiative. The individual quantitative data would be matched to the qualitative open-ended reflections in Study 3 (B) (discussed in second part of this chapter).

It is worth noting that 46% (n=50) of teachers reported large growth (d=0.76 or >), 26% reported moderate growth (d was between 0.2 and 0.75), 10% reported small growth (d was between 0 and 0.19), and finally 18% of teachers reported reverse growth (d = < 0) as a result of the EDR initiative.

Table 12: Magnitude of growth

Magnitude of growth	n
Large	50
Moderate	28
Small	11
Reverse	20

Note: Using Urdan (2006) rule for interpreting effect sizes less than 0 is reverse, 0 to less than 0.20 are small, those between 0.20 and 0.75 are moderate, and those over 0.75 are large

6.3.3 Demographic information for stratified groups

The participants for this study were the 109 teachers who completed the online self-report BIQ a minimum of three times throughout the academic year. While we are able to stratify the sample into four distinct groups, by using effect sizes, it was important to also explore the demographics of the teachers who made up each of these groups. Tables 15 to 18 present the demographic information for each of the stratified samples (large, moderate, small and reverse growth). As evidenced by these tables, each group had a broad representation of participating teachers. For example, each group had a broad range of teaching experiences, grade levels they taught, education levels achieved and, in relation to the sample, an even distribution of gender. While the large growth group had greater representation of teachers with over 11 years teaching experience, this is in proportion to the entire sample of participating teachers, with senior teachers more likely to participate in the EDR initiative. As such, the EDR initiative does not appear to advantage (or disadvantage) one particular group based on their demographic information.

Table 13: Large growth teacher demographics

Variable	N (50)	%
Gender		
Female	30	60.0
Male	20	40.0
Education Level		
Bachelor's Degree	27	54.0
Master's Degree	20	40.0
Doctoral Degree	3	6.0
Number of Years Teaching		
1-2 Years	4	8.0
3-6 Years	5	10.0
7-10 Years	8	16.0
11-20 Years	18	36.0
Over 20 Years	15	30.0

Grade Level Currently Teaching		
Kindergarten and Grade 1	10	20.0
Grade 2 and 3	14	28.0
Grade 4 and 5	8	16.0
Grade 6 and 7	6	12.0
Grade 8	4	8.0
High School	8	16.0

Table 14: Moderate growth teacher demographics

Variable	N (17)	%
Gender		
Female	16	57.1
Male	12	42.9
Education Level		
Bachelor's Degree	11	39.3
Master's Degree	17	60.7
Number of Years Teaching		
1-2 Years	2	7.1
3-6 Years	5	17.9
7-10 Years	9	32.1
11-20 Years	8	28.6
Over 20 Years	4	14.3
Grade Level Currently Teaching		
Kindergarten and Grade 1	4	14.3
Grade 2 and 3	7	25.0
Grade 4 and 5	4	14.3
Grade 6 and 7	6	21.4
Grade 8	3	10.7
High School	4	14.3

Table 15: Small growth teacher demographics

Variable	N (11)	%
Gender		
Female	6	54.5
Male	5	45.5
Education Level		
Bachelor's Degree	4	36.4
Master's Degree	7	63.6
Number of Years Teaching		
1-2 Years	2	18.2
3-6 Years	1	9.1
7-10 Years	2	18.2
11-20 Years	4	36.4
Over 20 Years	2	18.2
Grade Level Currently Teaching		
Kindergarten and Grade 1	2	18.2
Grade 2 and 3	2	18.2
Grade 4 and 5	3	27.3
Grade 6 and 7	2	18.2
Grade 8	1	9.1
High School	1	9.1

Table 16: Reverse growth teacher demographics

Variable	N (11)	%
Gender		
Female	12	60.0
Male	8	40.0
Education Level		
Bachelor's Degree	13	65.0
Master's Degree	7	35.0
Number of Years Teaching		
1-2 Years	3	15.0
3-6 Years	3	15.0
7-10 Years	4	20.0
11-20 Years	4	20.0
Over 20 Years	6	30.0
Grade Level Currently Teaching		
Kindergarten and Grade 1	3	15.0
Grade 2 and 3	2	10.0
Grade 4 and 5	3	15.0
Grade 6 and 7	4	20.0
Grade 8	3	15.0
High School	5	25.0

6.4 Summary

Individuals differ in their capacity to function, adapt, and change (Bowles & Hattie, 2013) and, as such, it is essential to get insights into the lived experiences of the teachers who participated in the EDR experiences. This aim Study 3 (A) was to establish whether the teachers could be classified into four change typologies. The pair sample *t* test and Cohen's *d* calculations both supported the generation of four clear typologies within this cohort, which were explored in more detail in Study 3 (B). These typologies can be summarized as follows:

- Large impact: the EDR initiative has impacted significantly (d>0.75) on student practices, teacher practices and planning for ELLs and SWANs.
- Moderate impact: the EDR initiative has impacted moderately (d is 2.0-0.74) on student practices, teacher practices and planning for ELLs and SWANs.

- Small impact: the EDR initiative had a small impact (*d* is 0-1.99) on student practices, teacher practices and planning for ELLs and SWANs.
- Reverse impact: the EDR initiative has impacted negatively (*d*<0) on student practices, teacher practices and planning for ELLs and SWANs.

One implication of these findings is that it is important to strata data to identify the nuances of experience for sub-groups of teachers involved in teacher professional learning, in this case the EDR initiative. This is preferable to simply representing the individual's experience by assigning them to, and reporting on, aggregated data. Establishing typologies of teachers within the entire cohort should enable further insights into the experiences of teachers undertaking EDR. This will help elicit the enablers and barriers that may be associated with this experience. Importantly, the utility of these typologies requires further analysis if we are to gain a deeper understanding.

Study 3 (B) - Qualitative analysis of the end of year teacher reflections

Section one: Methodology

6.5 Context and aim

Extended response reflections were conducted with the teachers from the school district at the conclusion of the academic year (May 2014). The teacher written reflections were matched to their longitudinal quantitative LOIQ data (n=109). The goal of the research for this explorative study was to gain a deeper understanding of the specific characteristics of the research experience and/or research context that teachers attributed to promoting or inhibiting teacher professional learning. More specifically, the sought a deeper understanding of teachers' experiences when undertaking EDR as a form of professional learning. This was achieved by eliciting reflective responses to open-ended questions related to the impact of EDR on their teaching practice. The

open-ended questionnaire was intended to highlight the learning dispositions teachers displayed that may have enhanced or inhibited their learning when undertaking EDR.

While the thesis to this point has focused on the intent of teachers to engage in the EDR initiative, and whether the EDR enhanced their mathematical instruction skills and/or knowledge, Study 3 (B) offers insights into the habits and dispositions individuals display as part of the inquiry EDR cycle. Continuous improvement is a key tenet in education, for both teachers and students, yet currently the conversation for both is dominated by improvement in skills and knowledge. However, there is an emerging focus on learning dispositions, habits and capabilities (Australian Curriculum, Assessment and Reporting Authority [ACARA], 2014; Lucas & Nacer, 2015; OECD, 2012; Tack & Vanderlinde, 2014). While currently the focus tends to be on developing students' dispositions, habits and capabilities, it would be logical to assume that effective learning for adults (teachers) would also require these dispositions to be cultivated. With teachers increasingly being required to undertake practitioner research, whether that be EDR, action research, or other inquiry models, it is prudent that future teacher professional learning approaches consider how to work within these models of learning. The premise of Study 3 (B) was to explore the dispositions displayed by the large, medium, small and reverse growth teachers identified in Study 3 (A).

The emerging focus on learning dispositions, habits and capabilities is not an alternative to content pedagogical knowledge and skills that classroom teachers require (Lucas & Nacer, 2015). Rather, it is complementary, where the focus is on developing the attributes of teachers to critically engage with subject content and knowledge effectively, efficiently and rigorously. As Lucas and Nacer (2015) pointed out when justifying the use of the term 'habit':

> Knowing something or even being skilled at doing something does not itself lead to improvement. Only when people habitually and reliably use their knowledge and skills in real-world contexts … will behaviors change. (p. 5)

So, the hypothesis is for teacher professional learning to be considered effective it may require teachers to change their habits. If teachers are to change habits, then the habits (or dispositions) that lead to improvement need to be clearly identified and explicitly developed and cultivated. And so, starting with the habits we desire as outcomes of teacher learners is a critical undertaking. Using the stratified data from Study 3 (A), the intention was to explore dispositions that are conducive (or common) to improvement (among large and moderate growth teachers), while also exploring dispositions that may be inhibiting to improvement (among small and reverse growth teachers).

6.6 A background on learning dispositions

There is a growing agreement that 'learning to learn' is, as Burgogne (1998) put it, the "ultimate life skill for the 21st century" (p. 28). A recent "focus of education is shifting to a concern with the development of aptitudes and attitudes that will equip young people to function well under conditions of complexity, uncertainty and individual responsibility: to help them become, in other words, good real-life learners" (Carr & Claxton, 2002, p. 9). Yet, scanning the teacher professional learning literature it does not seem to have the same imperative. It is predominantly concerned with characteristics and principles that underpin and cultivate effective professional learning (Cochran-Smith & Fries, 2001; Darling-Hammond, 2004; Hawley & Valli,1999; Kwakman, 2003 Opfer & Pedder, 2011). As Carr and Claxton (2002) state:

> capabilities are the skills, strategies and abilities which learning requires: what you might think of as the 'toolkit' for learning. To be a good learner you have to be able. But if such capabilities are necessary, they are not themselves sufficient. One has to be disposed to learn, ready and willing to take learning opportunities. (p. 10)

Of course, the two aspects (being 'able' and being 'disposed') interact. It would be reasonable to assume that developing ability breeds success and success may tend to make a person more

inclined to engage in the successful activity. Equally, the disposition to learn about something tends to lead to greater engagement and thus to the development of ability. But the relationship is an uncertain one: capability does not always produce disposition, nor vice versa. Education for lifelong learning has, therefore, to attend to the cultivation of positive learning dispositions, as well as effective learning skills (Carr & Claxton, 2002). This highlights the point that skills and knowledge are still, and will remain, vitally important for teachers (and students), yet we now also need to consider the learning dispositions that promote the meaningful interactions with the content, knowledge and development of skills.

This study explores the idea that a better understanding of teachers learning dispositions connected to EDR could in turn lead to more precise specifications of the kinds of learning environments or methods that may best cultivate the desired habits or dispositions. As stated earlier in the thesis, EDR is the systematic study of designing, developing and evaluating educational programs, processes, and products (Plomp, 2007). So, what are the dispositions that are particularly crucial for learning when undertaking inquiry, such as EDR? While researchers may vary in the details of how they picture EDR, there is general agreement that EDR comprises a number of stages or phases. These phases give insights into the type of habits that teachers may utilize when undertaking EDR. They are:

- *preliminary research:* needs and context analysis, review of literature, development of a conceptual or theoretical framework for the study
- *prototyping phase:* iterative design phase consisting of iterations, each being a micro-cycle of research with formative evaluation as the most important research activity aimed at improving and refining the intervention

- *assessment phase:* (semi-) summative evaluation to conclude whether the solution or intervention meets the predetermined specifications. As this phase often also results in recommendations for improvement of the intervention, we call this phase semi- summative (Plomp, 2010, p. 15).

Professions that use design thinking processes similar to that outlined above, such as engineering, require the workforce to move from problem to prototype to testing and back to a more refined understanding of the problem as they ply their profession (Lucas, Hanson, & Claxton, 2013). This iterative cycle has many similarities with EDR. One point of difference is that engineering, quite recently, has also articulated 'habits of mind' (dispositions) that complement the design cycle. This is quite distinct from teacher professional learning, where most teacher inquiry or practitioner research models are conceptualized as a process, with little or no reference to the habits of mind, or dispositions, required to engage and undertake the process with rigor and fidelity. This study will offer insights into the habits of mind (dispositions) that teachers display as part of EDR, or more broadly, teacher inquiry.

6.7 What are dispositions?

Though the word 'disposition' is necessarily imprecise, it points very usefully at a domain of human attributes that are clearly different from 'knowledge, skill and understanding' (Carr & Claxton, 2002). Katz (1993), for example, states that "dispositions are a very different type of learning from skills and knowledge [which were explored in Study 2]. They can be thought of as habits of mind, tendencies to respond to situations in certain ways" (p. 30). Perkins, Jay and Tishman (1993) argue that a disposition has three aspects: skill, inclination and sensitivity to occasion. For them, to be disposed to act in a certain way involves being competent to do so and

aware of when it is appropriate to do so. So, it is more than just being able to possess these dispositions, it is also about knowing when and where it is appropriate to act. Lucas and Nacer (2015) used the example of health professionals washing hands in hospitals to illustrate the inter-relationship between knowledge, skills and dispositions. In terms of knowledge, most hospital professionals understand the basic science of sanitizing hands to reduce the spread of infection. This knowledge has been commonplace for the past 100 years. In terms of skill, cleaning hands effectively is a relatively simple one to acquire; using enough soap, drying hands and turning off taps while ensuring hands remain sanitized. Yet while we have the possession of knowledge and skill in and of itself, this has not led to any change in behavior. To achieve change, knowledge and skills need to become routine habits of action (Lucas & Nacer, 2015).

This kind of real-world learning is not unlike Aristotle's notion of phronesis (Lucas & Nacer, 2015). Phronesis is a kind of practical wisdom and situational awareness – knowledge, skills and habits 'working together' in practice. As Perkins (1993) noted, such phronesis is not achieved unless there is 'sensitivity to occasion'. That is, it is only useful if, when you are faced with a situation, your mind and body routinely 'prompt' you to do whatever is the right thing to do (Lucas & Nacer, 2015). That is, you act on the disposition when opportunity arises by being sensitive to opportunities, being able to engage in opportunities and displaying an inclination towards opportunities.

6.8 What key learning dispositions might teachers utilize when undertaking EDR?

Bronfenbrenner (1979) described 'educational competence', or the disposition to learn, in terms of dispositions to think, to persist in tasks, to give opinions and contribute ideas, and to work collaboratively. Goleman's (1996) list, or what he describes as the seven key ingredients for the capacity to know "how to learn" (p. 193), comprises disposition-like terms: confidence, curiosity,

intentionality, self-control, relatedness, communication and cooperation. Lucas et al. (2014), however, who researched the habits of mind related to the profession of engineering with engineers and engineer educators, identified six habits of mind (related to engineering): systems thinking, problem-finding, visualizing, improving, creative problem-solving and adaptability. All of these offer insights into the type of dispositions that might be present with the teachers undertaking EDR. While focused on primary and high school students' dispositions, Claxton (2002) identified four dispositions to support learning. He referred to these dispositions as 'building learning power': resilience, resourcefulness, reflectiveness and reciprocity.

With regards to EDR, Study 3 (B) was concerned with exploring the habits of mind that each of the different sub-groups of teachers (large, moderate, small and reverse growth) displayed. This was with the intent of discovering learning dispositions teachers utilize when working within an EDR framework. While it is assumed there will be specific habits of mind associated with practitioner research, the literature has not explored this aspect with specificity.

6.9 Research questions

As previously discussed, Study 3 (B) collected extended response, qualitative data, to gain further insights into the actual perceptions and experiences of participants. The specific research questions were:

- What did the teachers do and what distinctive dispositions did they characteristically display, particularly when most challenged?
- To what extent did teachers attribute any changes in teaching practice to their involvement in EDR?
- To what extent could they attribute changes in what their students know and are able to do to their involvement in EDR?

6.10 Theoretical framework: Grounded theory

Although there are different approaches to analyzing qualitative data (discourse analysis, content analysis, thematic analysis, biographical or narrative analysis), the approach in this thesis was built on the broad principles of grounded theory (Hennink, Hutter, & Bailey, 2010). Grounded theory provides a set of flexible guidelines and a process for textual data analysis that is well suited to understanding human behavior, and identifying social processes and cultural norms. The process of grounded theory also provides analytic rigor in interpreting qualitative data and developing empirical theory. Although grounded theory offers an implicitly inductive approach, what is not made explicit are the deductive strategies that researchers also use in qualitative data analysis. Hennink et al. (2010) acknowledge the use of deductive strategies in this approach to data analysis and believe that qualitative data analysis involves the interplay between induction and deduction.

Grounded theory provides a set of guidelines for data analysis. However, as Charmaz (2014) pointed out, "how researchers use these guidelines is not neutral: nor are the assumptions that they bring to their research and enact during the process" (p. 9). In the approach outlined by Hennink, et al. (2010) they reflect on the circular nature of qualitative data analysis in their analytic cycle, whereby core analytic tasks are inductive and repeated in a circular manner throughout the analysis process. However, they add deductive strategies to their approach, such as deductive code development, deductive comparison, and the influence of deductive reasoning on inductive conceptualizing and theory building. These strategies were added to the data analysis plan for this study.

6.10.1 Principles of grounded theory

Grounded theory is a prominent approach to qualitative data collection and analysis in the social sciences. It was developed by two American sociologists, Barney Glaser and Anselm

Strauss, in the mid-1960s. The initial development of grounded theory (Glaser & Strauss, 1967; Glaser, 1978) and its subsequent variations (Strauss & Corbin, 1994, 1998; Charmaz, 2014) have remained influential in guiding qualitative researchers throughout the world. By making the process of conducting qualitative research more explicit and transparent, proponents of grounded theory have demonstrated scientific rigor and "legitimised qualitative research as a credible methodological approach" (Charmaz, 2014, p. 6). Grounded theory is thus an approach to qualitative research that embraces both the rigor of 'science' and procedure, and the 'creative' elements of emergent discovery, remaining faithful to the interpretive nature of qualitative analysis.

Grounded theory is not a theory itself: it is a process for developing empirical theory from qualitative research that consists of a set of tasks and underlying principles. Grounded theory therefore provides an approach through which "theory can be built up through careful observation of the social world" (Liamputtong & Ezzy, 2007, p. 265). The underlying principles of grounded theory that influence the analysis of qualitative data include the following:

- Data analysis is a circular process, not a linear sequence. Analytic activities are conducted in a circular way, whereby tasks may be repeated, overlap or conducted simultaneously (Dey, 2003; Rubin & Rubin, 2011), which enables researchers to go deeper into the data.
- Verbatim transcripts are used in analysis. This enables researchers to understand the views of study participants in their own words (the emic perspective), interpret their meanings and form conclusions that are well rooted in the data.
- Data collection and analysis are interlinked. Some analytic tasks begin during data collection.

- Analytic concepts are constructed inductively from data, not from deductive theories (Charmaz, 2014).
- Constant comparison is used throughout the analysis to define and refine concepts.
- Analytic and reflexive memo writing is used. Memo writing throughout the study provides transparency in the research process and a trail of analytic decisions.
- Analysis goes beyond description. Data analysis includes description but goes further to develop explanatory frameworks and theory (Hennink et al., 2010).

Section two: Methods

6.11 Data collection

An open-ended questionnaire was used and the majority of questions in the protocol were based on the 'behavioral dimension', with teachers asked to provide examples of how the EDR initiative impacted their daily practices. Other questions attempted to reconstruct the teacher's beliefs, motives and attitudes towards using the ideas and practices explored and how this impacted the students they teach (affective dimension). The inclusion of this qualitative data enabled converging lines of inquiry, as discussed in Chapter 3, as well as the scope for participating teachers to articulate their multiple subjectivities and the ways in which they connected their teacher professional learning from the EDR initiative with the classroom context.

The open-ended questionnaire was piloted with five teachers in order to determine limitations within the questionnaire before the data collection process began (Miles & Huberman, 1994). The pilot respondents were asked to answer each question and to give feedback on the question formulation. Afterwards, the initial protocol was slightly modified to ensure the validity and reliability of responses.

The focus of qualitative research tends to be on understanding the meaning imbedded in participant experiences through an open-ended, unstructured and subjective approach (Lincoln & Guba, 1985). Essentially qualitative data analysis involves a process of immersion in data, through which you can identify and interpret the experiences of your study participants (Hutter et al., 2010). The research is most often conducted in a naturalistic setting with a purposive sample (Patton, 2002). The research tends to be holistic, descriptive and focuses on the depth and details of experiences (Denzin & Lincoln, 1998). Data collection methods include interviews, observations, field notes and documents, to name a few (Wolcott, 1994). Data tend to be analyzed through an inductive, ongoing and evolving process of identifying themes within a particular context (Miles & Huberman, 1994). As Creswell (1998) indicated:

> Qualitative research is an inquiry process of understanding based on distinct methodological traditions of inquiry that explore a social or human problem. The researcher builds a complex, holistic picture, analyzes words, reports detailed views of informants and conducts the study in a natural setting. (p.15)

An iterative, cyclical process characterizes the interaction between data collection and the three components of data analysis: data reduction, data display and conclusion drawing (Miles & Huberman, 1994). Data reduction refers to the process of selecting, focusing, simplifying, abstracting, and transforming the qualitative data. The intention of this analysis is to sharpen and organize the data in preparation for conclusion drawing and verification (Kotzab, Seuring, Müller, & Reiner, 2006). Data displays enable concentration on a reduced set of data as a basis for thinking about its meaning and seeing patterns. The process of writing conclusions calls for further analytic techniques in data displays, which in turn drive further conclusions verification (Kotzab et al., 2006).

The aim of comparative qualitative research is to understand, explain and interpret the phenomenon of interest by identifying similarities and differences across cases. Indeed, wrote

Ragin (1987), "it is not difficult to make sense of an individual case … the challenge comes in trying to make sense of the diversity across cases in a way that unites similarities and differences in a single, coherent framework" (p. 17).

One characteristic of comparative research is that cases need to be viewed as 'combinations of characteristics' and investigated as whole (Ragin, 1987). As discussed in Chapter 1, this involves understanding and comparing the contextual elements of the cases, which Pettigrew (1990) described as encompassing a 'vertical level' as well as the time dimension, labelled the 'horizontal level'.

6.12 Researcher's role

The researcher endeavored to capture a deeper understanding of each teacher's experience with the EDR initiative. Each open-ended reflection was anonymously completed. Teachers included the same unique identifier they used in Study 2, this ensured the qualitative reflections could be matched to the individual's quantitative data while remaining anonymous. The reflection took between 10 and 15 minutes to complete and data were collected at the end of the morning professional learning session in May 2014.

6.13 Data analysis

6.13.1 Vertical and horizontal analysis

As outlined in detail in Chapter 3, the data analysis framework was developed with reference to the strategy outlined by Miles and Huberman (1994). First, a vertical analysis of the data was made in order to fully 'understand' the data provided by each respondent. The analysis was carried out in two phases. The vertical analysis was conducted (Miles & Huberman, 1994) and each teacher was analyzed at an individual level. The individual, vertical analysis, was

completed to gain insight into the teacher's perceptions of their professional learning as a result of the EDR initiative. This data was coded and displayed in matrices (Miles & Huberman, 1994) so it could be compared systematically.

The second step of the analysis, the horizontal analysis, explored the comparison among the teachers. The typical patterns found in the vertical analysis were compared with one another to "discover whether a pattern in one…plays out in others as well, suggesting a common scenario" This is an iterative and recursive process, where interpretations are developed, reconsidered and modified if necessary (Tack & Vanderlinde, 2014). The approach for the analysis of the teacher reflection data is outlined in Figure 22.

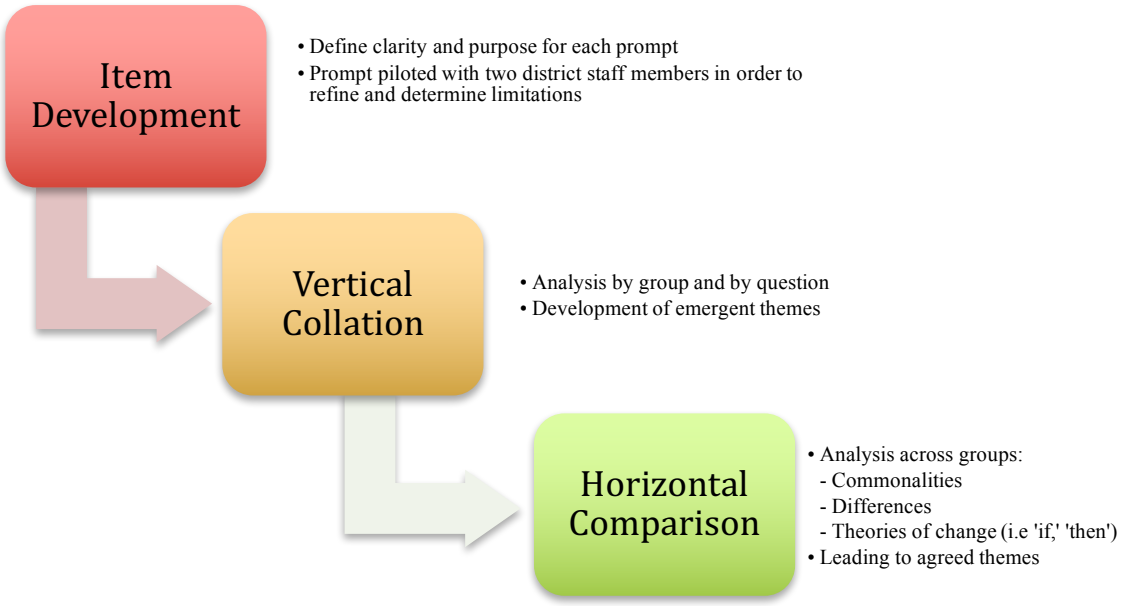

Figure 19: Data analysis approach

6.13.2 Validity

To ensure internal validity each analysis was conducted by two researchers independently (Creswell & Miller, 2000). The assistance of an independent research assistant was employed to

undertake this phase of the research process. After the initial independent analysis, the interpretations were examined and refined until agreement was reached. By carefully describing the theoretical framework, the research procedure, the data collection, the analysis and the quality of the research process can be critically judged by others.

Section two: Findings

Each teacher reported explicitly on the specific characteristics of the research experience and/or research context that were responsible for promoting or inhibiting teacher professional learning. The open-ended questionnaire was intended to highlight the learning dispositions teachers displayed that may have enhanced or inhibited their learning when undertaking EDR. The intention was to explore the commonalities and differences that existed between individuals and groups of teachers that reported similar magnitudes of growth (Study 3(A)). All the names used in this study are pseudonyms.

6.14 Learning disposition one: Innovates – takes calculated risks

Based on the analysis of the qualitative reflections, a consistent theme for large growth teachers was displaying an inclination to take calculated risks. They understood that if anything is to be improved or changed, it will inherently have a degree of risk. Hattie (2009) emphasized that "innovation occurs when a teacher makes a deliberate action to introduce a different (not necessarily new) method of teaching, curriculum, or strategy that is different from what he or she is currently using" (p. 251). Julie, a first grade teacher, highlighted this when she stated:

> *This year has made me let loose and be a little more adventurous in teaching math. If it doesn't work – so what? Re-teach or try it a different way.*

This is not to say that large growth teachers are reckless and take unnecessary risks with student learning. Risks to students are mitigated by basing instructional decisions on research

informed practices, even if teachers are not certain these will result in immediate success. Implementing innovative approaches (different teaching methods, curriculum and/or strategies) appeared to be viewed as an iterative process of constant refinement, evaluation and prototyping. Trent, a kindergarten teacher, explained:

> *Sometimes, when we explored new math practices I thought to myself kindergarten students can't do that, but then I tried it and the result proved me wrong. I really tried to be open minded and give it a go, and then after trying it I am able to make a judgement on how it can be used or changed to suit my context and classroom.*

Lucas and Nacer (2015) discussed the idea that improvers are adept at taking reasonable risks – playing with possibilities and daring to be different. Improvers will want to ensure that value and safety are carefully weighed against any possible risks. They have the mindset that not taking action can be a greater risk than taking one.

There was also evidence the EDR initiative emboldened teachers to embrace a calculated risk-taking mindset. Jody, a fourth grade teacher, highlighted this when she said:

> *I felt that as a math representative for my school I was empowered to explore different ideas and try different things in my classroom that took us into a more vocal whole class discussion.*

Hattie (2009) outlined various stages of innovation, such as initiation, implementation and evaluation, emphasizing that the most critical attribute when undertaking innovation is heightened attention to its effects. That is, innovators (in this case teachers) seek feedback about the impact of the innovation. The innovation brings increased attention to evaluating the worth and/or merit of the intervention. So, the definition of innovation must also include an evaluative aspect; it is more than just trying new (or different) instructional practices.

The moderate growth teacher, while also displaying an innovative disposition, tended to focus their efforts on existing practices that are widely agreed to be effective. For example, they focused on practices such as formative assessment, feedback, learning intentions and dialogic

teaching. While these practices are worthwhile, Hargreaves and Fullan (2012) would describe those who employed them as 'best practice teachers', whereas large growth teachers would be seen as 'next practice teachers', who focus on innovative approaches. They argued: "Best practice without next practice just drives teachers through implementing and fine-tuning what already exists ... next practice without best practice has no way of sorting out the strong emerging ideas from the weak ones" (Hargreaves & Fullan, 2012, p. 51).

As already indicated, innovation occurs when a teacher makes a deliberate action to introduce a different, not necessarily new, practice. In the case of the moderate growth teachers, the focus tended to be on the refinement of practice, rather than the introduction of new practices. Teachers reflected this in the following comments:

> *I need to continue to focus on better formative assessments that incorporate multiple steps and show what students know and where they need to go next.* (Mario, second grade teacher)

> *My procedural delivery has changed. I'm more understanding of what needs to be in place for my 2nd graders before learning takes place. My new learning has made me aware of my daily practice – I know what works and what needs to be worked on. I learn best by watching others teaching.* (Alison, first grade teacher)

Based on these reflections, the most common innovation for the moderate growth teacher was to focus on student-centered practices. In essence, student-centered practices in this context are focused on constructivist and socio-cultural theories of learning. Although one theory focuses on the individual learner and the other emphasizes the social and cultural aspects of the classroom, these theories are not competing; they are actually compatible (Norton & D'Ambrosio, 2008). Some of the comments that exemplify the focus on student-centered practices include:

> *I am more willing to have students direct learning and work together*. (John eighth grade teacher)

> *Student interactions are important.* (Kim, first grade teacher)

> *I've learned to give my students more independence and be more flexible in my lessons. I've learned that the answer isn't always so black and white and that talking about the process students used to arrive at answers is an essential part of good math teaching.* (Belinda, sixth grade teacher)

Small growth teachers, while still focused on 'best practice', found the new learning challenging. They tended to focus on implementing specific activities from the professional learning sessions as an introduction to the practice, but were not competent to alter or refine the practice to suit their classroom or context. Examples of this were evident in the following:

> *As I learned new activities, I tried to incorporate those into my classroom.* (Mary, fourth grade teacher)

> *I wanted to focus on formative assessment, but it is hard to get an assessment that is aligned to the new Common Core Standards.* (Vinnie, third grade teacher)

Small growth teachers tended to implement activities, rather than consider the research basis and adapt practices to suit their context. Having said that, there was evidence in this group that some teachers, after experiencing success implementing activities, were motivated to explore practices at a deeper level. Rob and Mario, both second grade teachers, highlight this progression:

> *I don't think you will see a whole lot of impact on my students as a result of the EDR initiative until next year. I have implemented activities that were presented at the professional learning session, but then quickly returned to the textbook. It wasn't until the end of the year that I tossed the textbook to the side and explored other possibilities.* (Rob, second grade teacher)

> *I think the biggest impact will be next year when I can better refine and apply the strategies in my classroom.* (Mario, second grade teacher)

While the reverse growth teachers were inclined to attempt implementation of new practices, they appeared to find it difficult to make any adaptions to suit their classroom needs. It was also evident that they viewed the four professional learning sessions as a learning experience, rather than using the ideas explored in these sessions as a stimulus to delve deeper, as kindergarten teacher Anne stated:

We have been given a few good ideas to use, but I think we should be given more grade level ideas.

6.15 Learning disposition two: Collaborates – valuing others while taking individual responsibility

Large growth teachers were collaborators who recognized the value of other people's ideas and perspectives. They referenced a collaborative mindset, with the sharing of ideas and working closely with other colleagues seen as positive aspect of the EDR initiative. Examples of this are presented below:

A big factor in my learning was the ability to be able to collaborate and share with each other. (Anna, third grade teacher)

I enjoyed collaborating with other sites [schools] that have similar contexts and circumstances as mine. The use of new math instructional techniques we shared pushed me (and the students) to think more deeply about math. (Jim, eighth grade teacher)

Just as we [the teachers] have focused on students being able to share and learn from one another on a daily basis, I have been energized by the new ideas that have come about through collaborating with colleagues from different schools. (Kate, fifth grade teacher)

Collegiality is notion that has purported to support school improvement (Marzano, 2003). Villani (1996) defined teacher collegiality as follows: "Collegial behaviour is demonstrated by teachers who are supportive of one another. They openly enjoy professional interactions, are respectful and courteous of each other's needs" (p. 44).

Fullan and Hargreaves (1996) cautioned that genuine collegiality cannot be contrived. Collegiality should be characterized by authentic interactions that are professional in nature (Marzano, 2003). These behaviors include: openly sharing failures and mistakes, demonstrating respect for each other, and constructively analyzing and criticizing practices and procedures.

One of Marzano's (2003) action steps to enhance collegiality is for schools to engage teachers in meaningful professional learning. This is an aspect that was highlighted by the large

growth teachers:

> *District collaboration helped me to see the larger picture. For example, what other teachers were doing, different grade levels, and how they were operationalizing the Common Core. This gave me great ideas to use back in my school*. (Sylvia, third grade teacher)

> *Just as the district enabled us to do, I need to create an atmosphere of collaboration, acceptance and perseverance*. (Sonia, eighth grade teacher)

The moderate growth teacher also saw the importance of working collaboratively. However, evidence suggested this to be an emerging aspect of their work rather than an ingrained practice:

> *I learned that teacher collaboration is just as important as student collaboration.* (Belinda, sixth grade teacher)

> *It helped to talk to other teachers about what their students were doing and compare success and ideas for improvement.* (Sandra, third grade teacher)

Small growth and reverse growth teachers discussed their learning in individualistic terms. Learning, planning, and developing implementation strategies were seen as activities undertaken by the individual, with little or no reference to utilizing the support network from their colleagues. This is evident in the following:

> *I did not implement as much as I wished. But hopefully will be able to do more next year. I didn't have the time to develop consistently good lessons and was in survival mode all year.* (Mario, second grade teacher, small growth)

> *It was very difficult what was being explored during the professional learning. It was more a matter of keeping my head above water with the depth of standards I had to learn, interpret and deliver.* (Johanna, fifth grade teacher, reverse growth)

6.16 Learning disposition three: Resilient – learning was challenging

Large growth teachers articulated that they found learning challenging. Lucas and Nacer (2015) discussed adaptation and the ability to bounce back from adverse events as core to improvement. This claim was supported by large growth teachers in that learning deeply was also

linked to challenge, rather than ease. They displayed the ability to keep going despite the challenges, which could be attributed to a belief they could work through it. When teachers remain positive and optimistic about their work they have the capability to improve, as highlighted in the following comments:

> *It [implementing new learning] is hard for the students and me. It was rough, but it does get easier.* (Tracie, second grade teacher)

> *There was a lot of challenge. It has been a hard year implementing the new math standards. But it will be smoother next year!* (Geoff, sixth grade teacher)

The notion of resilience as a learning disposition is supported by Carr and Claxton (2002), who stated:

> one of the key learning dispositions must surely be the inclination to take on (at least some) learning challenges where the outcome is uncertain, to persist with learning despite temporary confusion or frustration and to recover from setbacks or failures and rededicate oneself to the learning task. (p. 14)

Likewise, Dweck (1991) and others have identified resilience as a central characteristic of those with 'learning' (Dweck, 1991), 'mastery' (Ames, 1992) or 'task-involvement' (Nicholls, 1984) goals.

The key indicators of resilience might be taken to be: "sticking with a difficult learning task; having a relatively high tolerance for frustration without getting upset; being able to recover from setback or disappointment relatively quickly" (Claxton & Carr, 2004, p. 14). These aspects were evident in large growth teacher responses:

> *This has been a transitional year. It has been frustrating for teachers and students, however, I know that change is difficult* ☺ (Hannah, kindergarten teacher)

> *I have very much learned from my mistakes this year – in ways too numerous to list. I will teach many concepts differently next year. (Rob, fifth grade teacher)*

Interestingly, when analyzing resilience, moderate and small growth teachers appeared to display similar characteristics to large growth teachers. That is, while frustration was evident

during the learning process, the frustration was matched by a positive outlook. This outlook seemed to mitigate the frustration, with teachers believing they could work their way through it. Struggle was seen as an inherent part of the learning process, as evident in the following:

> *I still have a long way to go.* (Valentina, kindergarten teacher, moderate growth)
>
> *It hasn't impacted my current students as much as it will next year.* (Carlos, sixth grade teacher, moderate growth)
>
> *I'm still practicing this type of math – looking forward to next school year!* (Sofia, third grade teacher, small growth)
>
> *Still a work in progress.* (Isabella, fourth grade teacher, small growth)

However, if we contrast the above responses with those of the reverse growth teachers, for the latter, frustration continues to be evident without a positive outlook to offset it, apparent in these two comments:

> *It has been a difficult year in math and I'm not sure what to do next.* (Lucas, second grade teacher)
>
> *My students are not ready for the Common Core, so math is very frustrating.* (Mia, sixth grade teacher)

6.17 Learning disposition four: Curious – open to new experiences

A curiosity towards learning and continual improvement in teaching practice was a common hallmark of the large growth teacher group. This seems logical, as curiosity is often seen as central to improvement. Beswick (2000) highlighted that curiosity does more than spur interest, it also linked to perseverance:

> Highly curious people will remain longer than others in situations of uncertainty … they will have developed a range of investigative skills to help resolve conceptual conflicts by gathering additional information … they will have a sense of security in their world to put their cognitive map in jeopardy without debilitating anxiety, to run the risk of creating a new and better order, and they have the capacity to carry out the integration required to … create, maintain, and resolve conceptual conflicts. (p. 151)

Claxton, Lucas, Byron and Black (2015) claimed "curiosity is at the heart of all learning" (p. 157). Curious learners tend to have an inclination to know or learn, especially about novel or strange things (Beswick, 2000). An example of this came from Pedro, a fourth grade teacher:

> *It is a completely new and exciting experience for learning. The attitude in which my students come into my classroom is completely opposite to what it was at the beginning of the year. I come to work and enjoy the challenge of what is new and still unknown and leave each day with a smile.*

This insight from Pedro could be characterized by what Malone (1981) describes as 'cognitive curiosity'; a desire to bring better form to one's knowledge structures. There is an orientation to delve into the experience of learning new skills and knowledge. As EDR usually begins with the assumption that existing practices are inadequate or can at least be improved, the curiosity and desire to seek alternative practices appears to be an aspect that enhances the impact of EDR. By carefully exploring progressive approximations of ideal interventions in their classrooms, EDR encourages practitioners to construct increasingly workable and effective interventions, with improved articulations of principles that underpin their impact (Collins et al., 2004; van den Akker, 1999). With this in mind, it may be more accurate to categorize large growth teachers as 'critically curious', as there is a sense of reasoning to complement the curiosity. Eighth grade teacher, Kevin, exemplified this:

> *This year I was really interested in (and focused closely on) why and how I was teaching the concept and to give myself (and the students) time to take it in. By slowing down and spending more time to deeply explore math, I can better understand how to move forward.*

Moderate growth and small growth teachers also displayed a desire to be curious and gain a deeper understanding of effective mathematics instruction. This curiosity was centered on the more practical aspects of teaching, particularly an interest in what was occurring when

implementing ideas and practices in the classroom. The following comments highlight this observation:

> *I'm still learning how to put this all into practice. It has really got me thinking.* (Christie, second grade teacher, moderate growth)

> *I learned so much this year. Different classes respond to the Common Core very differently. I learned that there is still a lot I don't know yet … darn! The students felt like they were getting state of the art math. They wanted to know what I learned as soon as I got back to school.* (Steve, eighth grade teacher, moderate growth)

Reverse growth teachers appeared to be more passive in their learning, in contrast to the 'critically curious' large growth teachers. They displayed an inclination to see learning as being told how to do things and were not active agents in the learning process. This is evident in the following comments from members of the reverse growth group:

> *I enjoy the new math curriculum. But we didn't learn much about multiplication and I wish we had more time to focus on this.* (Frank, fourth grade teacher)

> *What I did not learn was classroom management for the Common Core, I wanted to be shown how to do this. Going from the textbook to this is a challenge.* (Gary, seventh grade teacher)

6.18 Towards a typology of teacher inquiry dispositions

Although each teacher reported explicitly on the specific characteristics of the research experience and/or research context that were responsible for promoting or inhibiting teacher professional learning, important differences exist between the individual teachers who participated in the study. More specifically, the comparative analysis reveals a typology with four types of teachers who participated in the EDR initiative: 'the inquisitive teacher' or large growth (Type 1), 'the best practice teacher' or moderate impact (Type 2), 'the technical teacher' or small impact (Type 3) and 'the transmissive learner' or reverse impact (Type 4).

6.18.1 Type 1. Large growth: The inquisitive teacher

The majority of participants (50 out of 109) were considered to be inquisitive teachers.

These teachers displayed an effect size of 0.75 or greater for teacher practices, student practices and planning for ELLs/SWANs. The inquisitive teacher is most closely matched to Perkins et al.'s (1993) analytical lens of 'disposition': the teacher has developed an inquiry disposition by having a sensitivity to inquiry opportunities, the actual ability to engage in inquiry and an inclination towards inquiry.

The inquisitive teacher has an orientation to get beneath the surface, they are the opposite of passive. They are interested in questioning, critically thinking, developing social resources, as well as making connections between research and practice. The inquisitive teacher is less likely to accept information uncritically without the reasoning behind it. Typical characteristics of the inquisitive teacher are:

- Displays an innovative mindset that commits to continually stretching their teaching practice.
- Appreciates challenge and confronting complexity.
- Utilizes research to support trialing innovative teaching practices.
- Seeks to make connections and integrate ideas.
- Builds strong social resources. Collaborates with colleagues within and outside of their school.
- Willing to wrestle with difficult concepts.
- Exhibits agency and takes responsibility for their professional learning.

6.18.2 Type 2. Moderate growth: The best practices teacher

The second largest group of teachers were classified as moderate growth, incorporating 26% (28 out of 109) of participants. These best practices teachers displayed an effect size of

between 0.4 and 0.75 for teacher practices, student practices and planning for ELLs/SWANs. While the best practices teachers displayed similar characteristics to the inquisitive teachers, they were focused on embedding effective teaching practices explored during the EDR initiative and did not appear to critically examine these practices (objectively evaluating them and considering alternatives and multiple perspectives) as their inquisitive counterparts had done. Typical characteristics of the best practices teacher are:

- Displays a curiosity to explore new teaching practices.
- Utilizes collaborative structures to support learning.
- Focuses on developing effective content pedagogical practices.
- Explores new ideas and concepts.
- Persists in pursuing professional goals related to classroom practice.
- Seeks to develop their understanding of student-centered instructional practices.
- Reflects on the impact new practices are having on the students they teach.

6.18.3 Type 3. Small growth: The technical teacher

The smallest group of teachers were those classified as small growth (11 out of 109), representing 10% of participants. These technical teachers displayed an effect size of between 0.0 and 0.39 for teacher practices, student practices and planning for ELLs/SWANs. Technical teachers were beginning to recognize the shortcomings of textbooks or worksheet driven teaching. They implemented activities presented during the EDR workshops and acknowledged their learning as a work in progress, believing that greater learning would occur with further professional development. Typical characteristics of the technical teacher are:

- Implements ideas with minimal critical evaluation.
- Seeks activities to implement rather than the research basis for activities.

- Undertakes learning in an individualistic manner.
- Recognizes existing teaching practices are inadequate or can at least be improved.

6.18.4 Type 4. Reverse growth: The transmissive learner

The reverse growth teacher group represented 18% of teachers in the EDR initiative (20 out of 109). These transmissive teachers displayed a negative effect size for teacher practices, student practices and planning for ELLs/SWANs. Transmissive teachers attempted to implement ideas and practices explored during the EDR initiative. However, they found it difficult to adapt these practices to suit their classroom context and to connect these activities to the broader classroom curriculum. These teachers displayed feelings of professional isolation and discussed a lack of support from school leadership to implement collaborative teacher learning structures at their school. Transmissive teachers were also inclined to view learning as a passive activity; they want to be told what to do and how to do it. Typical characteristics of the transmissive teacher are:

- Inclined to passivity and more likely to accept what they are told uncritically.
- Approaches learning situations with fragmentation, where connections and meaning-making between ideas and concepts is not sought.
- Propensity towards learning in isolation.[3]
- Tendency to be frustrated, with a pessimistic outlook on future professional learning growth.
- Proneness to low self-efficacy, which leads to being risk averse and to seek less challenging situations.

[3] Some reverse growth teachers highlighted school culture and teacher professional learning structures as an inhibitor to working collaboratively, so it was not necessarily a choice or preference to work in isolation.

6.19 Summary

This study used grounded theory as a theoretical framework to explore the experience of teachers undertaking EDR. By investigating these experiences, through end of year teacher self reflections, it was hoped that a deeper understanding would be gained of the specific characteristics of the research experience and/or research context responsible for promoting or inhibiting teacher professional learning. The thesis has focused on the intent of teachers to engage in the EDR initiative, and whether the EDR enhanced their mathematical instruction skills and/or knowledge, as well as offering insights into the habits and dispositions individuals display as part of the inquiry EDR cycle.

This study presents significant guidance for those considering undertaking not only EDR, but a range of practitioner research or teacher inquiry. By exploring the type of learning dispositions or habits that enhance (and inhibit) the impact of teacher inquiry models, such as EDR, we are better placed to make informed decisions about how to explicitly cultivate them. As the empirical work on this topic is still emerging, this exploratory study adds to the body of literature in several ways. Firstly, Perkins et al.'s (1993) analytical lens has been used to explain teacher inquiry dispositions through: an affective aspect referring to an inclination or a felt tendency towards research; a cognitive aspect concerning the actual ability to engage in research; and a behavioral aspect involving a sensitivity to research opportunities. This triad enables insights into the dispositions that teachers display while undertaking EDR. Secondly, based on the theoretical framework of an inquiry disposition, a typology with four different types of teachers has been identified: 'the inquisitive teacher' large impact (Type 1), 'the best practice teacher' moderate impact (Type 2), *'the technical teacher' small impact* (Type 3) and 'the transmissive learner' reverse impact (Type 4).

This study argues that teachers who displayed an inquiry disposition exhibited a deep engagement with the professional learning experience on a cognitive, affective and behavioral level. EDR had the capacity to enable teachers to be innovative, resilient, curious and to collaborate. An inquiry disposition involves teachers continually critically evaluating and refining their practice. With this in mind, explicitly developing a teacher's inquiry disposition would appear to be a powerful lever to support the continued enhancement of an individual's professional skills and knowledge about their own teaching practice.

Chapter 7: Discussion and conclusions

This research has addressed a question that has been previously underexplored in the literature: 'Does EDR impact the practice of teacher participants?' The results of the three studies within this research (Studies 1, 2 and 3 (A and B)), examining the impact of EDR as form of teacher professional learning are explored in this final chapter. Consideration is given to the findings of each of the studies, identifying the major themes elicited from this thesis. Finally, the strengths and limitations of the current study and possibilities for future research are presented. This chapter provides a brief overview of the rationale of the current research and the research questions the study aimed to address.

7.1 Study rationale

As outlined in Chapter 1, the modern teacher works within an educational setting that is constantly changing politically, technologically, and with an increasing diversity of learning and societal needs. Within this rapidly changing environment, there is an increased emphasis on the learning needs of teachers. While teacher professional learning opportunities are designed for a variety of purposes, regardless of the objectives of a given program, evaluators often jump to measure what is easiest and most obvious: the satisfaction of participants with their immediate experience in the workshop, institute or program (Reeves, 2012). What is often overlooked in this approach is the extent to which the program's aims have been met, the extent to which the participants were impacted by the professional learning experience, how their teaching changed over time as a result of their experience, and how their students' learning was affected (Guskey, 2000; Loucks-Horsley et al., 1998). With an increased emphasis on teacher professional learning, inevitably there is an increased emphasis to better understand the impact of teacher professional learning initiatives, such as the EDR initiative undertaken by this urban Californian school district.

In its simplest form, EDR is what educators (researchers and teachers) do when they pursue an instructional solution. A teacher and researcher collaborates to focus their thinking in order to satisfy wants and needs regarding a particular student, group of students or context. They recognize and define information relevant to their purpose, consider alternatives, decide what to do, do it, determine if they are satisfied with the results, and if not, revise their approach until they are successful. All the while they are learning through the experience. EDR is a process of creative and critical thinking that allows information and ideas to be organized, decisions to be made, situations to be improved, and knowledge to be gained. While design is not widely considered to be the central or a distinguishing activity of teaching, as educational systems increasingly incorporate teacher inquiry approaches, designing educational interventions to meet context specific situations is becoming more universally expected.

As indicated at the outset, the specific purpose of this study was to explore the experiences of teachers who undertake practitioner research, specifically EDR, as a form of teacher professional learning and how this impacts on their practice and the students they teach. The intention was to investigate the conditions that affect teachers to change or modify their attitudes, beliefs and teaching practice, and monitor this change over time. The general question that guided this study was 'Does EDR impact the practice of teacher participants?'

This general question was then divided into the three interconnected phases outlined below. With each phase having a conceptual framework and set of questions to inform the broader research aim. Specifically, within Study 1, where the behavioral intent of participants is explored, the TPB study sought to answer the following research questions:

- Which of the three direct determinants of intention are statistically significant predictors of teachers' intentions to use the practices explored in the EDR initiative?

- What are the potential enablers and barriers to the subsequent use of the practices explored in the EDR initiative?
- Is the TPB an appropriate conceptual framework for evaluating the participants' intents to use the practices explored in the EDR initiative?

Study 2, where changes in teacher behavior (practice and planning) and changes in student mathematical practices were explored the specific research questions were:

- How do the teachers perceive their own change as a consequence of the EDR project?
- How does teacher practice change as a consequence of their participation in the EDR project?

Study 3 (A) where the aim of this study was to break the matched LOIQ teacher data (n=109) into four distinct groups that represent their learning trajectory throughout this longitudinal study. Data were analyzed to answer the following research questions:

- What were the different learning trajectories for teacher's undertaking the EDR initiative?
- Can the sample be grouped as large, moderate, small or reverse growth teachers?

Study 3 (B) where extended response, qualitative data, was collected to gain further insights into the actual perceptions and experiences of participants. The specific research questions were:

- What did the teachers do and what distinctive dispositions did they characteristically display, particularly when most challenged?
- To what extent did teachers attribute any changes in teaching practice to their involvement in EDR?
- To what extent could they attribute changes in what their students know and are able to do to their involvement in EDR?

This research was designed to examine the impact EDR had on the participating teachers by eliciting their behavioral intent, exploring the impact on classroom practice, and examining teacher reflections on the professional learning as a result of the EDR initiative. Study 1 of this project focused on describing the behavioral intent of teachers to engage in the EDR initiative - did they intend to use the ideas and practices explored as part of their classroom instruction? Study 2 explored the level of implementation and the changes in practice that occurred over the course of one year while they were involved in the EDR initiative. Study 3 (A) separated the level of implementation data into four distinct groups representing the teachers' learning trajectories throughout this longitudinal study (large, moderate, small and reverse growth). Study 3 (B) explored teachers' reflections on changes in teaching beliefs, practice and student learning that could be attributed to their participation in the EDR initiative and to elucidate reasons for changing (or not) teaching practices.

The research utilized a mixed methods approach to collect quantitative and qualitative data. The following instruments were conceptualized, designed, tested, and administered:

1. A nine-item, open-ended BS to elicit teachers' salient beliefs that would influence their decisions to implement ideas and activities in their teaching repertoire.
2. A 12-item Likert scale BIQ generated from the analysis of the BS and administered to the teachers to assess behavioral intention, attitude toward the behavior, subjective norm, and perceived behavioral control. This survey was administered near the beginning of the 2013 academic school year.
3. A 29-item LOIQ to ascertain the extent to which the teachers implemented the ideas and activities explored during the design research initiative. Part of this questionnaire focused on the perceived changes in students' mathematical behaviors and skills. To

establish change over time, the LOIQ was administered four times during the 2013/2014 academic year.

4. End of academic year open-ended reflections to enable converging lines of inquiry (Yin, 2009). Teachers could articulate their multiple subjectivities and the ways in which they connected (or not) their learning from the EDR initiative to their classroom context and classroom practice.

7.2 Research objectives

The first objective of this research was to undertake a systematic review of the relationship between teacher professional learning and improved teaching practices. This would identify if there was a connection between professional learning research and the espoused characteristics of EDR. The balance of evidence from this review suggested that teacher professional learning and teacher inquiry does have the potential to positively impact teacher practice.

As noted earlier, there is limited empirical evidence relating to the professional learning of teachers (Timperley et al., 2007). Added to this, while the literature broadly supports teacher inquiry as a form of teacher professional learning, there is a lack of research on the specific characteristics of the research experience and/or research context responsible for promoting teacher improvement (Zeichner, 2003). The current research aimed to address these identified gaps in the literature by examining the claim that EDR benefits teaching practice (McKenney & Reeves, 2013). Based on the findings of the systematic literature review, it appears the current study may be the first one of its kind to do undertake this task.

7.2.1 Study 1 research objectives

Study 1 applied the tenets of the TPB in order to establish the behavioral intent of the teachers participating in the EDR initiative. Added to this, conclusions from the TPB study were

also used to inform the next iteration of the EDR initiative. That is, by focusing on the collection and analysis of data that enabled insights into the intent of teachers to engage in the learning at the initial stages of the project, it assisted the school district to consider enablers and inhibitors to the teacher's intent to engage in the EDR initiative from the outset, as opposed to the usual practice of establishing teacher satisfaction (or not) at the conclusion professional learning initiative.

The process by which the TPB is implemented is hierarchical and specific parameters and procedures are to be followed. Data on three variables, attitude toward behavior, subjective norm, and perceived behavioral control, were collected via an online questionnaire administered to the teachers at the beginning of the EDR initiative (see Figure 7 in Chapter 4).

To collect the data necessary to answer the research questions, the questionnaire was developed based on Demir (2010), Patterson (2001), Venkatesh et al. (2003) and Francis et al. (2004) frameworks. Demir (2010) used the TPB to predict teacher's internet use for their professional development. The purpose of the Behavioral Intention Questionnaire (BIQ) was to collect pertinent belief information from the teacher's regarding their willingness to engage in the EDR initiative and to use the instructional practices explored through this initiative (target behavior).

7.2.2 Study 2 research objectives

Study 2 examined the perceived changes in teacher behavior (practice and planning) and the perceived changes in student mathematical practices that could be attributed to the EDR initiative. Teacher professional learning activities took place over an entire school year, and data collection occurred in four waves. Wave 1 occurred during the October; Wave 2 during December; Wave 3 during February; and Wave 4 during May.

As discussed in Chapter 5, the LOIQ was developed to capture changes in teacher behavior, specifically the degree and quality of change that is occurring (or not) that could be attributed to the EDR initiative. Building on the work of Smith (1993), this research sought to measure the actual behavior of teachers, rather than just the behavioral intent. Behavior, in this study, was viewed as implementing evolved teaching practices the teachers attributed to being involved in the EDR initiative. The professional learning in the EDR initiative follows a chain of logic; where the professional learning is designed for teachers to develop and evolve their teaching practice, so, in turn it will lead to changes which impacts upon students. The self-report questionnaire was designed to capture the changes in teacher behavior that could be attributed to this professional learning initiative. As such, teachers also reported on observed changes in student practices they could attribute to their evolving teaching practice.

As Study 2 sought to determine if the teacher's intention to use the skills and knowledge in their instructional repertoire transferred to actual use, the measure of teacher behavior, the LOIQ was developed. The purpose of the LOIQ was to identify where, along a continuum from non-use to fully-integrated use, each teacher would position their behavior as a result of the EDR initiative. The LOIQ was analyzed at the conclusion of the academic year to ensure the content explored was the same as the content that was intended (planned) to be explored for the academic year. As a result, it was concluded the annual action plan and the delivered content were closely aligned, ensuring the content validity of the LOIQ as a way to measure implementation of the professional learning associated with the EDR initiative. Teachers completed the LOIQ as part of the four workshops they participated, with a view to assessing any changes in practice over the course of a full academic year.

7.2.3 Study 3 (A) research objectives

The aim of Study 3 (A) was to classify the matched teacher LOIQ data from Study 2 (n=109) into four distinct groups representing teachers' learning trajectories throughout this longitudinal study (large growth, moderate growth, small growth, and finally reverse growth teachers). More specifically, the aim was to assess whether or not the magnitude of growth could be conceptualized as a typology to distinguish different types of teachers within the EDR initiative, based on the teacher's individual effect sizes over time.

7.2.4 Study 3 (B) research objectives

Study 3 (B) explored teachers' reflections on changes in teaching beliefs, practice and student learning that could be attributed to their participation in the EDR initiative. By utilizing the stratified data from Study 3 (A), this study sought to elucidate reasons incorporating changes in teacher practice or lack thereof as a way of gaining a deeper understanding of the learning habits and dispositions associated with each learning trajectory (large growth, moderate growth, small growth, and finally reverse growth teachers).

To capture the required data, extended response reflections were conducted with the teachers from the school district at the conclusion of the academic year. The teacher reflections were matched to the quantitative LOIQ data. This was undertaken to gain a deeper understanding of the specific characteristics of the EDR experience and/or EDR context teachers claimed were responsible for promoting or inhibiting their professional learning. More specifically, the research endeavored to capture a deeper understanding of each teacher's experience with EDR as a form of professional learning by eliciting reflective responses to open-ended questions related to the impact of the learning on their teaching practice.

The open-ended questionnaire was used to highlight the learning dispositions teachers displayed that may have enhanced or inhibited their professional learning in the EDR. Using the stratified data from Study 3 (A), Study 3 (B) examined the dispositions that were conducive (or common) to improvement (large and moderate growth teachers) and those that may inhibit improvement (small and reverse growth teachers).

7.3 Overview of the findings for the individual studies

7.3.1 Study 1: Exploring behavioral intent

Study 1 applied the tenets of the TPB to establish the behavioral intent of the teachers participating in the EDR initiative. The 12-item Likert scale BIQ was used to assess behavioral intention, attitude toward the behavior, subjective norm, and perceived behavioral control. The results highlighted the statistically significant relationship between behavioral intention scores and the antecedent beliefs (attitude toward the behavior, subjective norm, and perceived behavioral control). Perceived behavioral control, subjective norm, and attitude towards the behavior were identified as significant predictors of behavioral intention.

As concluded in Chapter 4, the establishment of the combined predictor variable scores as a significant predictor of behavioral intention supported further analyses of the individual predictor variables. It also confirmed the use of the TPB as a viable conceptual framework for assessing the behavioral intention of teachers in the EDR initiative. The BIQ was a reliable and valid measure of teachers' behavioral intent, supporting the hypothesis that the combined predictor scores would predict behavioral intention. This corroborates the findings of others who have applied the TPB to predict behavioral intention (Crawley & Koballa, 1992; Myeong & Crawley, 1993; Smith & Lazarus, 1990).

7.3.2 Study 2: Changes in teaching practice

Study 2 examined the perceived changes in teacher behavior and the perceived changes in student mathematical practices attributed to the EDR initiative. Overall, the evidence suggests that participating in EDR may play a role improving teachers' instructional practice. One of the persistent questions in teacher professional learning is how do we make sustainable improvements in teacher practice? The results of this longitudinal study provide insight into the trajectories of teacher learning when participating in EDR. The study results illustrated the intended effect, with the EDR initiative benefiting teacher (and student) practices. Of importance is the clear growth over time in teacher practices, student practices and teacher planning, with teachers reporting improved practices at the end of the academic year as a result of participating in the EDR initiative. It is also worth noting that all 11 items related to student practices displayed a consistent upward trajectory throughout the year. The participating teachers observed a consistent improvement in students' mathematical practices, although they reported a drop in 5 of the 6 items from October to December before all items displayed an upward trend for the rest of the academic year (December to May). Interestingly, teachers reported improvements in student practices while viewing their own practices as going backwards.

7.3.3 Study 3 (A): Changes in teaching practice - establishing trajectories of change over time

Study 3 (A) sought to establish whether teachers could be classified into four change typologies (large growth, moderate growth, small growth, and finally reverse growth teachers). The paired sample *t* test and Cohen's *d* calculations both supported the generation of four clear typologies within this cohort. The findings suggest that it is important to strata data to identify the nuances of experiences for sub-groups of teachers involved in teacher professional learning, in this

case the EDR initiative. Notably, Study 3 (A) established that the EDR initiative did not appear to advantage (or disadvantage) one particular group of teachers based on their demographic information. That is, experienced teachers and inexperienced teachers were represented in each level of the typology in proportion to the entire sample.

7.3.4 Study 3 (B): Qualitative analysis of the end of year teacher reflections

Study 3 (B) explored teacher's reflections on changes in teaching beliefs, practice and student learning attributed to their participation in the EDR initiative. This study (3B) offers insights into the habits and dispositions individuals display as part of the inquiry EDR cycle. The findings established that, based on the theoretical framework of an inquiry disposition, a typology with four different types of teachers could be identified: 'the inquisitive teacher' large impact (Type 1), 'the best practice teacher' moderate impact (Type 2), 'the technical teacher' small impact (Type 3) and the transmissive learner' reverse impact (Type 4).

The findings of this study illustrated that teachers who displayed an inquiry disposition exhibited a deep engagement with the professional learning experience on a cognitive, affective and behavioral level. It also highlighted that EDR has the capacity to enable teachers to be innovative, resilient, curious and to collaborate to continually refine and improve their instructional practice. An inquiry disposition involves teachers continually critically evaluating and refining their practice. Explicitly developing a teacher's inquiry disposition appears is a powerful means of supporting the continued enhancement of individual professional skills and knowledge about their own teaching practice.

Major themes

Five major themes emerged from the findings of this study. These are discussed in the following sections.

7.4 Major theme 1: Educational Design-Research (EDR) is more than a process, it is a way of thinking

As stated earlier, design is not widely considered to be a central or distinguishing activity of teaching. Yet as educational systems increasingly incorporate teacher inquiry approaches, designing educational interventions to meet context specific situations is becoming more universally expected. The term design thinking is increasingly used to mean the human-centered 'open' problem-solving process decision-makers use to solve real world 'wicked' problems (Mellesa, Howard, & Thompson-Whiteside, 2012). Claims have been made that design thinking in this sense can radically improve decision-making in fields such as health care and other service related professions (Mellesa et al., 2012), such as education. In these other fields, the employment of designerly strategies (e.g. designing with and for stakeholders), through the decision-making process, creates a better environment, it is argued, for quality outcomes.

As previously stated, design thinking in education is what people do when they pursue an instructional solution. A teacher focuses their thinking in order to satisfy wants and needs regarding a particular student, group of students or context. They recognize and define information relevant to their purpose, consider alternatives, decide what to do, do it, determine if they are satisfied with the results, and if not, revise their approach until they are successful. All the while learning through the experience. Design thinking is a process of creative and critical thinking that allows information and ideas to be organized, decisions to be made, situations to be improved, knowledge to be gained, and importantly action to be taken.

EDR is not only a process, but it is also a way of thinking and acting. Dispositions, as an active and executive component of cognitive processes, are an important explanatory basis in shaping how individuals think and act, and also play a key role in how individuals tackle problem-

solving activities in their vocational practice (Billett, 2008). A disposition is broadly defined in cognitive psychology as a tendency or habit of mind towards particular behavior (Katz & Raths, 1985). When it concerns teacher professional learning and transforming a teacher's frame of references in new vocational practices, several authors have emphasized the central role dispositions play (Perkins et al., 1993; Billett, 2008).

Design thinking comprises of a set methods that can be utilized to approach an identified problem, in this case the instructional shifts associated with the CCSS curriculum were perceived as a dramatic shift in teaching practice. EDR is an approach to generate new ideas (using design thinking techniques). One of the requirements is that teachers and researchers work in partnerships to use their domain and professional knowledge to help bring out more diverse solutions and draw in different perspectives.

As highlighted in the results of Study 3 (B), continuous improvement is a key tenet in education, yet currently the debate is centered on how to enhance skills and knowledge, of both teachers and students. However, as discussed in Chapter 6, there is an emerging emphasis to focus more on the learning dispositions, habits and capabilities that are needed to compliment the necessary skills and knowledge (ACARA, 2014; Lucas & Nacer, 2015; OECD, 2012; Tack & Vanderlinde, 2014). With teachers increasingly being expected to undertake practitioner research, such as EDR, it is prudent that future teacher professional learning approaches consider how to cultivate the types of thinking and capabilities that are required to undertake these inquiry processes in a meaningful way. That is, how can a teacher's dispositions, habits and capabilities be cultivated effectively to support a teacher's professional learning throughout their career?

7.4.1 The importance of learning to learn

As explored earlier there is a growing agreement that 'learning to learn' is, as Burgogne

(1998) put it, the ultimate life skill for the 21st century. Yet, scanning the teacher professional learning literature capability and dispositional development does not seem to have the same imperative or emphasis that is currently taking place with for student learning (see the Capabilities Curriculum within the Australian Curriculum, 2014). As such, teacher professional learning literature is predominantly concerned with principles that underpin and cultivate effective professional learning (Cochran-Smith & Fries, 2001; Darling-Hammond, 2004; Hawley & Valli,1999; Kwakman, 2002; Opfer & Pedder, 2011). As Carr and Claxton (2002) state:

> capabilities are the skills, strategies and abilities which learning requires: what you might think of as the 'toolkit' for learning. To be a good learner you have to be able. But if such capabilities are necessary, they are not themselves sufficient. One has to be disposed to learn, ready and willing to take learning opportunities. (p. 10)

Of course, the two aspects (being 'able' and being 'disposed') interact. It would be reasonable to assume that developing ability breeds success and success may tend to make a person more inclined to engage in the successful activity. Equally, the disposition to learn about something tends to lead to greater engagement and thus to the development of ability. But the relationship is an uncertain one: capability does not always produce disposition, nor vice versa. Education for lifelong learning has, therefore, to attend to the cultivation of positive learning dispositions, as well as of effective learning skills (Carr & Claxton, 2002). Which highlights the point that skills and knowledge are still, and will remain, vitally important for teachers (and students), yet we also need to carefully consider the learning dispositions that promote the meaningful interactions with the content, knowledge and development of skills.

This thesis offers insights into teachers' learning dispositions associated within an EDR framework. For the purpose of this study, a disposition was defined as a prevailing cognitive and emotional state towards the content being learned and toward the learning process. It assumed that a disposition is not a fixed trait. Rather, a disposition could be learned or acquired and was dynamic

and flexible. Through developing a deeper understanding of the dispositions inherently linked to EDR and teacher inquiry, it is hoped that this could in turn lead to more precise specifications of the kinds of learning environments and methods that might best cultivate the desired habits or dispositions of teachers. Teachers develop an 'inquisitive disposition' as they learn to generate and evaluate knowledge, ideas and possibilities, and use them in combination when seeking new pathways or solutions in their teaching practice. An inquisitive disposition enables teachers to pursue deep learning about teaching practices.

Dispositions are always grounded in personal histories and affected by both earlier and current socially-derived experiences (Billett, 2008). For this research, this means that previous experiences and work contexts affect the development of an individual's dispositions, clearly linked to perceived behavioral control as explored in Study 1. In this respect, professional learning within a new context, such as teacher inquiry or EDR, is in the first place not solely about changing the acquired knowledge and concepts itself, but rather about transforming their underpinning dispositions (Billett, 2008). Inquiry dispositions are explicitly linked to working within and EDR framework, one that is: action oriented, includes continuous experimentation cycles (prototyping), and seeks timely feedback to guide new iterations of the practice. In this study, significant growth in teacher practices was evident when the EDR framework was matched with the 'inquisitive teacher' dispositions through such factors as: displaying an orientation to get beneath the surface, being interested in questioning, critically thinking, developing social resources, as well as making connections between research and practice.

Study 3 (A) highlighted typical characteristics of an inquisitive teacher, these characteristics enable insights into the precise specifications and kinds of learning environments that may best cultivate the desired dispositions. That is, the research engaged with the question: 'What did the

teachers do and what distinctive dispositions did they characteristically display, particularly when most challenged?' By analyzing the insights from participating teachers, typical characteristics of the inquisitive teacher could be identified, as presented in Chapter 6. These characteristics are represented as outer ring in Figure 24, which that complements the design research process outlined by Reeves (2006). The results of this study suggest that the outer ring is just as integral as the inner, process oriented ring.

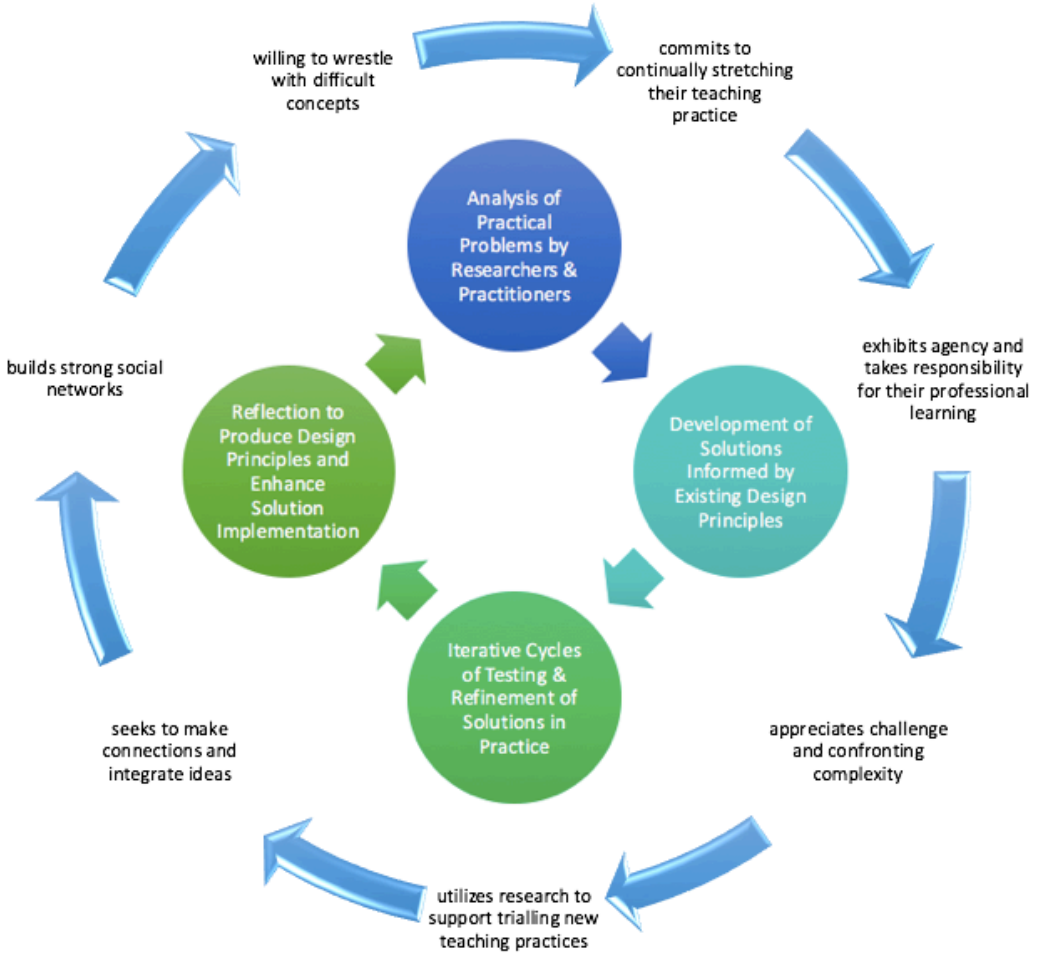

Figure 20: Amended version of Education Design Research (EDR)

By identifying the characteristics of teachers who engaged in and significantly benefited from the EDR initiative, the discussion can now shift to how these can be cultivated effectively in

teacher professional learning. This has implications for all levels of the educational system and it is essential schools, districts and systems understand more about teachers' learning dispositions when they are developing professional learning experiences and evaluating the impact of these experiences on teachers. This also has implications for ITE and how the teaching profession can more effectively be presented to aspiring teachers.

7.5 Major theme 2: Educational Design-Research (EDR) supports the cultivation of innovative teacher practices

As stated design thinking denotes the problem-solving approach which equips *design* and *non-design* professionals with a methodology for producing reliably innovative results in *any* field (Miller, 2015). With design thinking, which explicitly utilized in EDR, the traditional way designers think has been enriched with a user-centered (student centered) and empathic focus, a collaborative way of working, and self-conscious reflection on the design process. EDR begins with the assumption that existing practices are inadequate or can at least be improved, the curiosity and desire to seek alternative practices that will benefit the students seems to be a key criterion that enhances the impact of EDR. This student centered focus is an important distinction and represents a shift in mindset for teachers.

This claim is supported in this study where teachers reported a significant improvement in instruction (see Study 2), as a result of the EDR initiative, also reported an innovative design thinking mindset (see Study 3B). The large and moderate growth teachers were open to new experiences, took calculated risks to prototype new practices and were action oriented. Indeed, this type of thinking represented a significant proportion of teachers within the study, as 46% of teachers reported large growth and 26% reported moderate growth. It can be concluded that the majority of teachers working within an EDR framework were developing and innovating their

teaching practices as part of the research initiative. So the key advancement of the debate is that is it prudent that future teacher professional learning approaches consider how to cultivate the types of thinking, dispositions and capabilities that are required to undertake practitioner inquiry processes in a meaningful way. To moved beyond seeing practitioner inquiry as a lockstep process, but as a way of thinking to generate new knowledge and practices.

7.5.1 Innovation versus risk in an educational setting

As indicated above, design thinking and EDR usually begins with the assumption that existing practices are inadequate or can at least be improved; it seeks to develop practical and context specific interventions informed by current research. By carefully studying progressive approximations of ideal interventions in their target settings, researchers and practitioners construct increasingly workable and effective interventions (Collins et al., 2004; van den Akker, 1999). As EDR is exploratory by nature, it also has the potential to be perceived as inherently risky. It should be noted that developing new interventions and searching for new practices may lead to alternatives with unsatisfactory outcomes for students or teachers. The opportunity for EDR to cultivate innovation is one that carries inherent risk. However, this risk is mitigated by the fact that EDR should "be research-driven" (Edelson, 2006, p. 104). That is, the interventions need to be firmly grounded in the research evidence, so while the practices may be innovative for the teacher, they should be evidence-based. As previously referenced, Hattie (2009) emphasizes, "innovation occurs when a teacher makes a deliberate action to introduce a different (not necessarily new) method of teaching, curriculum, or strategy that is different from what he or she is currently using" (p. 251). To mitigate the inherent risk in innovation design, the proposed design is grounded in existing research or sound theory (Edelson, 2006). One of the key roles within an EDR framework is the role of the lead external researcher, whose primary role is to oversee and guide the research process

by ensuring the project is grounded in theory. This minimizes and mitigates the risk of unsatisfactory outcomes.

7.5.2 Educational Design-Research (EDR) and innovation

EDR is about changing practice by analyzing students' achievement and context, educational research, current practices and, through this, developing clearer understandings. It is about teachers becoming producers as well as consumers of knowledge (Zeichner & Noffke 2001). EDR is aimed at analyzing and developing local existing knowledge and creating new relevant, practical knowledge (Enthoven & de Bruijn, 2010). This cooperative inquiry includes elements of teacher agency, where the focus is on the group setting the agenda, participating in the data collection and analysis, and controlling the use of results. EDR should be highly practical with the intention of having immediate benefits to teaching and learning. Within this study, teachers were continually prototyping, analyzing and refining their practices. This led to teachers consistently improving their classroom teaching practices over a sustained period of time, as evidenced in Study 2 of this thesis.

7.5.3 Education Design Research (EDR), innovation and the system

System and school leaders across educational jurisdictions are working to design, implement and evaluate evidence-based initiatives to improve the quality of student learning outcomes. Globally the level of scrutiny on system reform and improvement is beyond anything previously experienced by education systems (see for example OECD, 2015; TIMMS, 2016). Many educational jurisdictions have formulated new visions and strategies for improvement. One example is the vision for reform in Ontario, called 'Achieving excellence: A renewed vision for education in Ontario' (2014). Similarly, in Australia, the Melbourne Declaration on Educational Goals for Young Australians (2008) outlines a strategy to "achieve new levels of engagement with

all stakeholders in the education of young Australians" (p. 5). Both of these improvement strategies highlight the need for a continued emphasis on innovative and evidence-informed teaching practices. Yet, leading meaningful innovation and progress in learning and teaching is complex.

Globally teachers are accountable for growing expectations around progress in student learning. In the Australian context, schools are being asked to: ensure the growth in skills, knowledge and capabilities (ACARA, 2014) for an increasingly diverse group of learners; analyze and adopt evidenced-informed practices; and gather evidence of student progress in learning. These intersecting pressures are creating substantial challenges for teachers, who are often provided with one-off workshops highlighting 'best practices', or professional learning processes for implementing change, which in many cases add to the complexity of their work, rather than supporting the development of their expertise. As evidenced by the longitudinal data in Study 2, teachers who work within a supportive framework, exhibit quite dramatic improvements in their instruction and professional capabilities.

In contrast to complicated problems, changes in teaching practices and improvements in student learning progress, across a range of valued outcomes, are complex problems that require a process of continual experimentation, learning and adjusting. There are no ready-made instructional solutions that can simply be 'replicated' to cater for unique classroom and school contexts. Critically, the changes that are sought involve enabling students, teachers and school leaders to shift their daily behaviors and attitudes around learning and teaching. This creates often-overlooked complexities in our change work, with the potential for unanticipated responses and consequences (Axelrod & Cohen, 1999; Miller & Page, 2007). Take, for example, the implementation of a new research-based approach to early-years literacy. Whilst the development of an approach to literacy that is based on the best available research evidence is a complicated

activity, the effective implementation of the program across diverse school contexts is truly complex (Meyers & Brandt, 2014). There is no clear recipe of steps that educational leaders can use to move through from beginning to end, to ensure an improvement in literacy learning outcomes. The introduction of a literacy program will involve substantial changes and learning for many teachers and students, all of whom will need to engage in sustained behavioral and attitudinal change (Spillane, Reiser & Reimer, 2002). The classrooms themselves, even within the same school, will differ substantially depending on the diversity of student learning needs. Teachers will vary considerably in their background knowledge, pedagogical expertise and relationships with students (Coburn, 2004). Yet despite this evidence, many large-scale teacher professional learning interventions are conceptualized with a lockstep approach, where rigid adherence to process (fidelity) is undertaken at the cost of individual learning (rigor). So teacher professional learning needs to be re-conceptualized beyond the status quo where the focus is imparting knowledge and skills in a lockstep, one-size-fits-all approach. As evidenced by this study, an approach that enables groups of teachers to collaboratively design, implement, and evaluate practices has benefits for teachers at any stage of their teaching career.

When exploring education improvement, there is often substantial variability in the results of improvement efforts due to the inherent complexity of implementation across diverse classroom and school contexts (Durlak & DuPre, 2008; Lendrum & Humphrey, 2012). Whilst the growing educational research evidence-base can support the design of frameworks and interventions that are based on 'best practices' (e.g. Hattie, 2008; EEF, 2016, Evidence for Learning, 2017), the core challenge is to find ways to ensure best practices are explored as practices that can be delivered with increasing expertise and complexity. Rather than a one-size-fits-all approach, it needs to be acknowledged that best practices can be delivered with differing levels of understanding, expertise

and, therefore, impact. For example, understanding a best practice such as learning intentions requires a link to success criteria, formative assessment, teacher feedback, self-regulation, peer feedback and meta-cognitive practices (to name a few). This highlights the notion that best practices are not something teachers implement, they need to learn to use them in increasingly sophisticated ways as they develop their expertise and improve students learning.

Teacher professional learning needs to be approached with the mindset that best practices are complex and are not simply practices you are taught to replicate. If the complexity is embraced, then the approach will most likely end with teachers gaining more than a superficial understanding. If the complexity is explored with depth, then teachers have the opportunity not only to understand 'what' the practice is, but also to understand 'why' the practice is important for learning. These practices need to be learned over time, with support, and with clear impact measures and meta-cognitive processes built in so the subtlety, nuance and connections to other practices can not only be understood, but also leveraged. Teacher professional learning that cultivates this mindset is more likely to develop the sophisticated teacher practices that will cater for the diverse contexts and classrooms inherent in every school system.

The results from this thesis outline an approach that system and school leaders could focus on to explicitly develop the mindset and dispositions of teachers, not just their skills and knowledge, in order to accelerate practices that lead to improved student learning. This is evidenced by Study 2 and 3B where teachers that reported moderate to large growth for the academic year also displayed similar dispositions in the way they approached their learning journey. The question that remains is did they already come to the EDR initiative with these dispositions? Or did the EDR initiative cultivate and nurture this way of thinking?

Equipping teachers with a rigorous framework to support their own learning (with school leadership support) is particularly important in a context of increasing change and uncertainty. A framework where teachers have the ability to inquire, adapt and change based on the needs of their students, leads to a more adaptive and agile approach to large scale teacher professional learning. That is, in order to make meaningful impact on student learning outcomes, school leaders and teachers who display an inquisitive disposition are better equipped to respond to change as it happens and to prototype and develop evidence-informed practices to suit their unique contexts. The 'inquisitive teacher' working within the EDR framework has the capacity to respond thoughtfully and adapt to change as it happens. An inquisitive disposition is a stance that enables teachers to learn, adjust and iterate throughout an implementation process, in order to gain their desired impact on student learning and teaching practice. Adopting an inquisitive mindset shifts the work of improvement from implementation-as-process towards implementation-as-learning.

EDR offers an alternative to the more linear approaches to teacher professional learning. Rather than engaging in efforts to create perfect detailed plans and milestones and then implementing the strategy over time, *design* approaches embrace the inherent complexity and ambiguity of change processes. This is achieved by intentionally and explicitly developing the teacher's skills, knowledge and dispositions to be adaptive, so the need for teacher professional learning interventions to be prescriptive is diminished. EDR offers the opportunity for groups of teachers to work within responsive teams, through sequences of short, focused instruction prototyping cycles. The intention is to use student learning outcomes (academic, affective or psychomotor) and educational research to drive the response, so teachers can respond in a timely manner to change and better meet the needs of their students. Over the last decade, design approaches have now taken root across many diverse sectors (Rigby, Sutherland, & Takeuchi,

2016). In broad terms, design approaches to innovation and change focus on setting up teams to respond, learn from and adapt to change as they are working to solve complex problems.

7.6 Major theme 3: Perceived behavioral control is a key variable to predict the behavioral intent for teachers undertaking Educational Design-Research (EDR)

There is increasing evidence that teacher professional learning can facilitate educational reform, creating significant changes in the professional knowledge base and instructional practice (Borko & Putnam, 1996). Crucial to the understanding of how reform comes about is adequate evaluation of the methods by which the change is facilitated. This research has shed some light on the role of the EDR as a form of teacher professional learning and the importance of adequate evaluation metrics. Study 1 applied the tenets of the TPB (TPB) in order to establish the behavioral intent of the teacher participating in the EDR initiative.

In study 1, a regression analysis demonstrated that the combination of the three variables (subjective norm, attitude and perceived behavioral control) was a significant predictor of behavioral intent. The establishment of the combined predictor variable scores as a significant predictor of behavioral intention supported further analyses of the individual predictor variables and provided further support for the TPB as a viable conceptual framework for assessing behavioral intention of the EDR initiative teachers. Supporting for the hypothesis that the combined predictor scores would predict behavioral intention.

As pointed out by Greaves, Zibarras and Stride (2013), the TPB has both theoretical and practical implications. First, from a theoretical perspective it highlights the importance of engaging with the target population to elicit their salient beliefs, to ensure the targeted behaviors are relevant to that population. This study highlighted a possible framework for collecting formative data that explores the perspectives of participants that could be used to inform the district professional

learning theory of action. By addressing specific behaviors, rather than more general behaviors, the TPB constructs explained a significant proportion of the variances in behavioral intentions. Secondly, by investigating the antecedent beliefs of the three constructs, we begin to not only answer the question of *whether* the TPB constructs account for variance in behavioral intentions, but also to explain *why* this is so (Greaves et al., 2013). It is important for researchers to understand the enablers and inhibitors that contribute to teachers engaging (or not) in professional learning. Theoretically, this is important because it enables researchers to understand more clearly why teachers engage (or not) in specific professional learning initiatives. By researching this further, it may be possible to establish some generalizable principles for engagement in teacher professional learning.

From a practical point of view, the findings from the Study 1 (BIQ) are important, as the results have been useful to the school district from where the data was collected. In particular, the antecedent variables were used to indicate targets for specific interventions designed to improve the effectiveness of the professional learning theory of action. For example, the participating district implemented a number of changes based upon the findings, such as designated collaborative planning time for teachers, the establishment of teacher peer coaching triads, and principal workshops where school leadership teams designed implementation strategies to support the district-wide professional learning strategy. These were deemed priorities due to the collection and analysis of perceived behavioral control data. This also illustrates the value and importance of developing context specific instruments to establish behavioral intent. It also highlights that the TPB can be an important tool for organizations to investigate the specific barriers to, and facilitators of, behavior in schools. While this data does not ensure the professional learning strategy will ultimately be effective, by carefully considering specific factors identified by

participants it does mitigate the risk of embarking on a journey that participants perceive as flawed from the outset.

From a practical point of view, by acknowledging the importance perceived behavioral control, subjective norm and attitude have on behavioral intention the district used this framework to inform the future direction of the professional learning. As the results indicated the significance perceived behavioral control had on behavioral intention, future professional learning sessions with principals and teachers focused on developing solutions to resourcing issues (availability of resources, administrative organization support, etc.), to ensure these did not become a barrier for the professional learning.

7.6.1 The theory of planned behavior is an effective framework for analyzing behavioral intent of teachers participating in professional learning

The results of Study 1 could also inform future evaluation of teacher professional learning initiatives in terms of predicting the actual behavior of participants. With increased accountability in all levels of education and the need to illustrate outcomes as a result of expenditure, most government-funded professional learning initiatives require an evaluation component to measure effectiveness. Use of the TPB could provide part of a measure for predicting the impact of varying professional learning initiatives. Haney et al. (1996) demonstrated the TPB's applicability in a nationally-funded project in the prediction of teachers' intentions to implement state science education reform strands in their teaching. Smith (1996) suggested that national curricular reform projects could be presented in in-service program formats and the future level of implementation could be predicted using the TPB.

In terms of the broad research area of attitude measurement, this study has major implications. Attitude has been demonstrated to contain more than emotional and evaluative

impressions concerning the behavior in question. The results of this study support, although less strongly than those of other investigators (Haney et al., 1997; Smith, 1996), the inclusion of a measure of control in the evaluative process. Control, whether it is impacted by internal or external factors, is an important aspect in assessing intentions to perform instruction-related behaviors. Teacher education reform (in-service and pre-service) will be severely hampered, despite positive participant attitudes, if the implementation of activities is thwarted by lack of control in either finances or support, for example (external factors), or skills and knowledge (internal factors).

The validation of the TPB as an effective formative tool has the potential to impact pre-service and in-service teacher education professional learning on numerous levels and scales. For example, professional learning feedback loops based on the TPB could effectively predict the short-term impact of the professional learning and highlight potential inhibitors and enablers that teachers perceive to be significant. This would allow professional learning designers to modify their plans based on the feedback and insights of participating teachers.

Teachers face a myriad of issues to contend with when undertaking practitioner research, such as EDR. The importance of perceived behavioral control in this study highlights the point that we still know very little about the characteristics or context that support teacher growth with practitioner research. It is possible that when schools and systems approach teacher inquiry as a form of teacher professional learning, the focus is mainly on the process or stages of inquiry. Examples of this are: look, think, act (Stringer, 2008); or plan, act, observe, reflect (Riding, Fowell, & Levy, 1995). However, the importance of perceived behavioral control highlights the notion that teachers' research skills and dispositions also need to be cultivated concurrently with the process. Through an examination of cognitive theory and dispositions (Perkins et al., 1993), it could be concluded that conceptualizing teachers' professional learning as a transformative journey, with

an emphasis on developing an inquiry disposition, may be an approach warranting further exploration.

7.7 Major theme 4: Conceptualizing a typology for the disposition of a teacher undertaking practitioner inquiry

This study presents insights into teachers self-reported inquiry dispositions throughout their engagement with the EDR initiative. This concept, defined as a teacher's habit of mind to engage with an inquiry process (EDR) to improve their own practice and contribute to shared knowledge, offers a promising approach to the professional learning of teachers. Despite its relevance for improving teachers' practices, this concept has been underexplored in the professional learning literature. Teacher inquiry disposition is presented as a concept focusing on the development of a teacher's role as both a 'teacher and learner'. This is an explorative study that attempted to offer insights into the concept of a teacher's inquiry disposition. The findings add to the body of literature in several ways.

First, a definition of teacher inquiry disposition is presented. This definition is based on the work of Tack and Vanderlinde (2014), who explored the research disposition of teacher educators. A teacher's inquiry disposition is broadly defined as the habit of mind to engage in inquiry. This description is specified by explaining three components: an affective aspect referring to an inclination or a felt tendency towards research; a cognitive aspect concerning the actual ability to engage in research; and a behavioral aspect involving a sensitivity to research opportunities (Perkins et al., 1993). Together, this triad offers the ability to explain why some teachers report significant improvements as a result of an inquiry process (EDR) and why others do not. With Perkins et al.'s (1993) analytical lens to deconstruct an inquiry disposition, an inquisitive teacher is defined as a

teacher who engages in inquiry on their teaching practices, modifies those practices according to the evidence base, and shares the findings within a collaborative framework.

Second, based on the theoretical framework of inquiry disposition, a typology with four different types of teachers can be identified: 'the inquisitive teacher' large impact (Type 1), 'the best practice teacher' moderate impact (Type 2), 'the technical teacher' small impact (Type 3) and 'the transmissive learner' reverse impact (Type 4).

The inquisitive teacher has an orientation to get beneath the surface, they are the opposite of passive. They are interested in questioning, critically thinking, developing social resources, as well as making connections between research and practice. The inquisitive teacher is less likely to accept information uncritically without the reasoning behind it. The inquisitive teacher is a teacher who fully possesses an inquiry disposition as defined in the theoretical framework (Perkins et al., 1993). Individuals in this group have the ability to engage in inquiry and naturally conduct inquiry processes regarding his/her teaching practices because he/she is convinced that engaging in inquiry is an effective learning framework to continued improvement in teaching practices.

The best practice teacher displayed similar characteristics to the inquisitive teacher, however they were more focused on embedding effective teaching practices explored during the EDR initiative, whereas the inquisitive teacher appeared to also critically examine these practices, by objectively evaluating practices and considering alternatives and multiple perspectives. The best practices teacher values the role of inquiry in their professional learning and has developed knowledge and understanding of inquiry, usually during previous experience. However, this group does not systematically detect occasions to undertake inquiry as a normal part of their teaching practice. They are still more inclined to view inquiry as implementation-as process rather than implementation-as-learning.

The technical teacher is beginning to recognize the shortcomings of textbook, worksheet driven teaching. Similar to the transmissive learner, they implemented activities presented during the EDR workshops and acknowledge their learning is iterative and that greater learning will occur with further professional learning (reading, collaborating, prototyping, testing, evaluating and refining). This disposition only involves the affective aspect of Perking et al. theoretical framework (1993) and refers to a clear recognition and appreciation of a teacher's role as both teacher and learner. So while there is an inclination or a felt tendency towards research, this is not complemented (yet) with a cognitive aspect concerning the actual ability to engage in research; or a behavioral aspect involving a sensitivity to research opportunities

The transmissive learner is a teacher who has a 'basic' disposition towards inquiry. The transmissive learner attempts to implement ideas and practices explored during an inquiry process (EDR), however, they find it difficult to adapt these practices to suit their classroom context, and to connect these activities to the broader classroom curriculum. They displayed feelings of professional isolation and discussed a lack of support from school's leadership to implement collaborative teacher learning structures in their school. The school district conceptualized the professional learning strategy as a form of teacher inquiry that is; collaboratively designed with practitioners who seek improvement and solutions to daily classroom issues. It is plausible to conclude that unless the teachers' perceived the school to have the organization and structures in place to support collaborative teacher teams to collaborate as a normal part of their working day, then they would consider this an unsustainable practice. The transmissive teacher was also inclined to view learning as a passive activity, that is, they were searching for activities that work (Appleton, 2003) and wanted to be told what to do and how to do it.

Most teachers (72%) participating in this study could be categorized as 'inquisitive teachers' and 'best practices teachers'. Only a small group made up the 'technical teacher' (10%) and 'transmissive teacher' (18%). This typology indicates that, in line with previous research (Livingston, 2009) personal histories and school context play an important role in defining a teacher's inquiry disposition. Indeed, their experiences with inquiry and supportive school context for collaborative learning appeared to impact the extent to which an individual was categorized as a 'Type 1' or a 'Type 2' teacher. For example, a common characteristic identified in the qualitative Study 3 (B) illustrated that a significant proportion of transmissive teachers felt the school context did not enable them to undertake the work associated with EDR in a meaningful way. This parallels with Study 1 where perceived behavioral control was seen as a significant inhibitor to behavioral intent. While not the focus on this research, further exploration into the role school context and culture plays in the experience of teachers undertaking EDR is required.

The study also emphasizes that an inquiry disposition can be developed and cultivated by further supporting each of the three dimensions outlined by Perkins et al. (1993). In this respect, this study has important implications on the organization and conceptualization of teacher professional learning programs. First, the definition of 'inquiry disposition' can be used as a framework to determine what is required from teachers who aim to engage in classroom inquiry. Second, the inquiry disposition typology has the potential to be used as a self-assessment tool for teachers to evaluate their own professional learning needs as an 'inquiring teacher'. Third, each type of teacher will have different professional learning needs, implying that both the organization of these practitioner research initiatives and the support during these initiatives (Lunenberg, Dengerink & Korthagen, 2014) should be adapted to meet each type's specific needs.

7.8 Major theme 5: The importance of longitudinal studies into teacher professional learning

To support students in learning the more complex and analytical skills required with modern curriculum reforms, teachers also need to be supported to learn in ways that develop their critical thinking and practice. To develop the sophisticated understanding of teaching and learning, a continued focus on approaches that lead to meaningful teacher professional learning is required. As with students, meaningful learning is a slow and non-linear process, with some elements more easily changed than others, depending on the interplay with teachers' deeply-rooted beliefs and attitudes (Borko, 2004; Franke & Kazemi, 2001; Greeno, 2003; Shulman & Shulman, 2004). AS already discussed, the findings of this study highlight the importance of conceptualizing teacher learning as implementation-as-learning rather than implementation-as-process. Implementation-as-learning considers and accommodates the active individual construction of knowledge, skills and dispositions, through the enculturation into social practices. Implementation-as-learning is explicitly linked to the collaborative nature of EDR, where changes in practice are constructed in socially organized experiences, and individuals' development of knowledge, skills and dispositions are key aspects of their participation in the social practices inherent within the EDR framework.

By understanding the complexity and longitudinal nature of effective teacher professional learning, consideration must be given to how we evaluate the effectiveness of teacher professional learning experiences. For example, as illustrated in Study 2 of this research, if the duration and extent of this study was based on the impact between Waves 1 and 2, the experiences of teachers would be defined as substantially different to the experiences of teachers when analyzing data over a full academic year (or longer). Figure 25 highlights that data collected in a short timeframe may

not be an accurate reflection of the experiences of teachers undertaking sustained teacher professional learning. The LGC modeling between Wave 1 and Wave 2 (October-December) in Study 2 outlined an interesting proposition. While there was a 10-week gap between the data collected in Waves 1 and 2, teachers reported gains in textbook use (largest gain), student mathematical practices and planning for ELLs, while simultaneously reporting a slight decline in teaching practices. This raises the question: how can teaching be declining, yet student practices improving? It is not until the data for the full academic year is considered that a clearer picture of the teacher experiences is uncovered. Perhaps the key message is that teachers need to be convinced of more long term changes before they completely adopt the routines that led to this change. That is, they change their perceptions and beliefs after they see change, and not before. This is contrary to how many professional learning initiatives operate, where the focus is on changing teacher beliefs and perceptions by focusing on what works. However, the reverse is evident in this study. The teachers continually made incremental (small) changes to practices in a collaborative framework that led to a significant change in behavior throughout the course of the academic year. As displayed in Chapter (see Figure 19) teaching practices and planning for ELLs improved, quite rapidly as the year progressed (between Wave 2, 3 & 4).

The major theme from Study 2 is the effectiveness of EDR in promoting changes in teacher practices that occur when within an EDR framework over a sustained period of time. Teachers who were involved in the EDR initiative reported sustained growth in their practices, planning for ELLs, as well as in the mathematics practices of their students. The more competent they became in their teacher practices, the less reliant they became on the district prescribed mathematics textbook. The sharp increase in textbook use between Wave 1 and 2 (shown in Figure 25) is more effectively explained by teachers trialing the new resource that was made available to them (there

was significant uptake of the resource within the district). However, the increases in student practices and planning for ELLs was due to the changes in teaching practice occurring as a result of the EDR initiative.

This leads to the second key aspect of the importance of longitudinal studies with multiple waves of data collection. The self-report results for perceived changes in student practices illustrate teachers attributed a consistent positive upward trend for their students based on the ideas and experiences explored as part of the EDR initiative. As stated previously, teacher's reported growth in student practices while simultaneously reporting a decline in teaching practice between Waves 1 and 2 data collection. As discussed in Chapter 5, the most obvious explanation for this is that the teachers recalibrated their own level of expertise between Wave 1 and Wave 2, through deeper exploration of the CCSS and accompanying instructional shifts and realized they may have been generous in their initial appraisal of their current level of skill and understanding. So, while they were implementing, reflecting and improving practice between Waves 1 and 2, this was not readily observable until the entire longitudinal data was explored. Educational research advocates that teacher learning should be embedded in the daily life of the school and provide opportunities to inquire systematically about teaching practices, their impact on students and about other issues of teachers' work (Birman, Desimone, Porter & Garet, 2000; Boyle, Lamprianou & Boyle, 2005; Desimone, 2009; Guskey, 2000; Hofman & Dijkstra, 2010; Sato, Wei & Darling-Hammond, 2008). Likewise, it is imperative that metrics developed to establish the effectiveness of such teacher professional learning should aim to explore the longitudinal nature of such a complex undertaking.

7.9 Limitations of the present research and future directions

While the current research features a number of strengths, including a systematic literature review, longitudinal focus, a mixed methods approach using empirically tested measures, and sophisticated statistical procedures, it has a number of limitations. Several limitations were uncovered that mean care is needed for generalizing the findings of this research.

In Study 1, the low response rate (45%) for the BS had an impact on drawing conclusions about behavioral intent. As the BS was administered in the summer of 2013 and teachers volunteered to participate, the responses may have been from highly motivated teachers within the randomly selected sample. This may have limited the ability of the BS to capture a representative sample of salient beliefs of teachers within the district.

Added to this, another limitation with Study 1 was there was no link of actual behavior to behavioral intention. The researcher neither visited the participants' classrooms nor examined curriculum to establish actual changes in behavior. However, several researchers have found high levels of accuracy in self-reported data. (Koziol & Burns, 1986; Newfield, 1980; Traub & Weiss, 1982) have found that self-reports can gather reliable data on instructional practices, that teachers can accurately report their own behaviors, and that teacher self-reported data may be more accurate than typically believed. To minimize the limitations of self-reported data, it is recommended that triangulation approaches be used, including methodological triangulation using multiple methods to collect data (Dass, 1999), which leads to to the design of Study 3B, where the self-reported data was matched to the qualitative teacher reflections in an attempt to triangulate and deepen the lines of inquiry.

With regards to the limitations of Study 2, the LGC model was an imperfect fit to the existing data and so interpretation must be undertaken with caution. SEM models are relatively

new to education and have not been widely used in teacher professional learning research (Kim, Petscher, Schatschneider, & Foorman, 2010). However, these models can be very valuable in understanding what constructs may be highly related to teacher professional learning and can be effective in handling multi-variate, correlated variables such as are common in the literacy field (Kim, Petscher, Schatschneider, & Foorman, 2010).

A further limitation to the research identified in Study 2 relates to LGC modeling, which is carried out using SEM methodology and shares many of the same strengths and weaknesses with regard to statistical methodology (Duncan & Duncan, 2004). As pointed out, some of the strengths of the LGC approach include an ability to test the adequacy of the hypothesized growth form, to incorporate both fixed and time varying covariates, to correct for measurement error in observed indicators, to incorporate growth on several constructs simultaneously, and to develop a common developmental trajectory from the data, thus ruling out cohort effects (Duncan & Duncan, 2004). The more commonly cited limitations of SEM programs for estimating LGC models include the assumption of multi-normally distributed variables and the necessity of large samples, although recent Monte Carlo simulations have demonstrated that basic LGC models hold up well with relatively small numbers (e.g. Muthen & Muthen, 2002). Therefore, the requisite number largely depends on the specific empirical context (e.g. psychometric behavior of indicators, amount of missing data, size of effects, etc.) and design aspects, such as the number of assessment points. With regards to this study, the cancellation of one of the professional learning days due to severe weather meant that one wave of data for the grade 4 and 5 teachers was not obtained. While missing data can be safely estimated in longitudinal models using multiple imputation (Graham, 2009), this was not ideal and the multiple imputation dealt with more missing data than was anticipated in the original research design.

The identified limitations for Study 3 (B) were, firstly, the relatively small sample. This meant that caution needed to be used before generalizing the results to the broader group of teachers.

As this study is subject to the limitations described above and still leaves several issues underexplored, there are opportunities for further research. While this study does provide a necessary step toward gaining insights into teacher inquiry disposition, further research is needed in some critical areas to understand the aspects of EDR that enable teacher growth. Firstly, a quantitative study could further improve the typology as presented in the findings. A quantitative study could be used to empirically validate the typology. Added to this, a necessary next step is to conduct intervention studies into the conditions (both personal and contextual) that may lead to the development of a teacher's inquiry disposition. It is one thing to have a typology, it is another to understand how to support teachers explicitly to develop an increasingly sophisticated inquiry disposition and their professional capabilities within the typology.

7.10 Concluding comment

The major objective of this research was to examine the experiences of teachers participating in practitioner research, specifically EDR, and to explore its potential for teacher professional learning. To ascertain this, the research sought to generate data to determine whether EDR positively impacted the teaching practices of teachers involved in the district-wide professional learning initiative. The findings from this study illustrate that the EDR initiative enabled the majority of teachers to positively evolve their teaching practices and offers insights into the specific characteristics and dispositions of the participating teachers.

Findings from this study indicate that teacher professional learning initiatives need to consider how to effectively cultivate a teacher's inquiry disposition, not just their skills and

knowledge. In this respect, this study has important implications for the organization and conceptualization of teacher professional learning programs. First, the definition of 'inquiry disposition' can be used as a framework to determine what is required from teachers who aim to engage in practitioner research. When schools, district and/or systems are considering the use of practitioner research as a form of teacher professional learning there needs to be an explicit focus on how to effectively cultivate a teacher's 'inquiry disposition'. The evidence presented in this thesis offers insights into the type of design thinking that is required to complement the design (inquiry) process. The premise is that gaining a deeper understanding of teachers' individual learning habits will enable more effective teacher professional learning and improvement strategies in an increasingly complex educational environment. Increasingly, the importance of individual aptitudes and dispositions are being recognized for the critical role they play. This in turn means education leaders need to consider how to actively develop and support the cultivation of these aptitudes and dispositions. That is, how do we create the conditions and climate for teachers to be rigorous inquirers? This also reinforces the need for new directions in, not only the way in which improvement interventions are designed, planned and implemented, but also how they are evaluated.

Secondly, the inquiry disposition typology has the potential to be used as a self-assessment tool for teachers to evaluate their own professional learning needs as 'inquiring teachers' and for systems to guide the cultivation of teachers in developing an increasingly complex inquiry disposition. Focusing on 'how' they are learning not just 'what' they are learning represented a shift in mindset for many teachers who participated in this research. With limited energy and resources, as evidenced in Study 1 by the impact these have on behavioral intention, it is essential to focus on the aspects that have the potential for highest gains in teacher performance. The results

from this study suggest that focusing on developing a combination of skills, knowledge and dispositions is an important consideration. Learning by doing, through iterative design cycles, enables teams of teacher to work out how to make 'what works best' work in their unique classroom and/or school context. Prototyping with evidence ensures a disciplined improvement process, where teachers seek out robust feedback to steer efforts towards the final desired impact for learners.

In the long term, effective teacher professional learning must focus on strong leadership to ensure quality and a progressive movement towards cultivating teachers' skills, knowledge and capabilities. A move to deliver the kinds of investments in human capital that enhance teacher learning and deliver on the potential of practitioner research as a form of teacher professional learning, requires a rethinking of the priorities of the sector.

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Appendices

Appendix A: Belief survey

CCSS Math Educational Design-Research Initiative

The purpose of this questionnaire is to solicit your perceptions on implementation of the CCSS math Educational Design-Research (EDR) initiative. For each of the items, please list **as many responses as possible** that come to mind. These responses will be used to design evaluation instruments to be used in upcoming academic year. Thank you for your cooperation.

1. What do you perceive the advantages of using the ideas and practices explored during the EDR initiative with your students will be?

2. What do you perceive the disadvantages of using the ideas and practices explored during the EDR initiative with your students will be?

3. Who are the groups or individuals who would approve of your being involved in the EDR initiative?

5. Who are the groups or individuals who would disapprove of your being involved in the EDR initiative?

6. Are there any other groups or individuals who come to mind when you think about using practices and ideas explored in the EDR initiative with your students in the 2013/2014 academic year?

7. What things could happen that would make it easier for you to use the practices and ideas explored in the EDR initiative with your students in the 2013/2014 academic year?

8. What things could happen that would make it difficult for you to use practices and ideas explored in the EDR initiative with your students in the 2013/2014 academic year?

9. What other things come to mind that might influence whether you use the practices and ideas explored in the EDR initiative with your students in the 2013/2014 academic year?

Appendix B: Letter accompanying the belief survey

Date, 2013

Dear Classroom Teachers,

I write to ask for your support. I am a doctoral student at the University of Melbourne in Victoria, Australia. As the topic of my dissertation, I have chosen to study teachers' beliefs, intentions, and behaviors regarding the implementation of the Educational Design Research Project you will be participating in during the 2013/2014 academic year. A key component of the research will be to explore your experiences of the enablers and barriers that teachers encounter when looking to implement the ideas and practices in their classroom. The survey that you complete will enable me to develop a more comprehensive survey to be distributed to the 2013/2014 teachers at the beginning of the EDR initiative.

I would appreciate if you could complete the open-ended survey and the demographic data form attached in this email.

I appreciate your time and effort assisting me with this project. If you have any questions about the study or would like a copy of the results, please contact me via email (ryan.dunn@generationready.com) or by phone on 347 574 2007.

{insert survey link here}

Sincerely,

Ryan Dunn

Appendix C: Belief survey coding

AB
Learning experiences interesting and rigorous
Students are engaged
Requires more teacher preparation time
Enhances student thinking
Develops critical thinking skills
New type of learning for students
SN
Students
Administration
Curriculum developers
Other teachers
PBC
More time to develop activities
Additional funding
Time to collaborate
More instructional ideas
Requirement to implement specific standards

Appendix D: Raw data and frequency distributions from belief survey

Attitude toward Behavior (AB)	Frequency	Cumulative Frequency
Learning experiences interesting and rigorous	9	9
Students are engaged	8	17
Requires more teacher preparation time	8	25
Enhances student thinking	6	31
Develops critical thinking skills	6	37
New type of learning for students	5	42
**********75%**********		
Improves cognition	4	46
Congruent with standards	3	49
Promotes cooperative learning	1	50
Activities are constructivist	1	51
New way of learning math content	1	52

Subjective Norm (SN)	Frequency	Cumulative Frequency
Students	5	5
Administration	3	8
Curriculum developers	2	10
Teacher Colleagues	2	12
**********75%**********		
Curriculum Coordinators	1	13
Math Coaches	1	14
Parents	1	15

Perceived Behavioral Control (PBC)	Frequency	Cumulative Frequency
More time to plan and develop activities	6	6
Additional funding	5	11
More time to collaborate	5	16
More instructional ideas	4	20
Requirement to implement specific standards	3	23
**********75%**********		
Administrative support	3	26
Alignment with curriculum	1	27
Availability of support resources	1	28
Increased workload	1	29
Additional supplies	1	30

Appendix E: Salient beliefs identified from the belief survey

Attitude Toward the Behavior (Outcomes associated with use of ideas and practices explored in the EDR initiative)

1. Student learning experiences will be interesting and rigorous
2. Students are more engaged and more likely to take ownership of learning
3. Students are more engaged and more likely to take ownership of learning
4. Activities will align well with the math CCSS
5. Activities promote cooperative learning and reasoning among students
6. Activities are inexpensive to implement.
7. Activities are easy to implement
8. Activities take extra time to implement
9. Loss of control of the teaching and learning process

Subjective Norm (Persons Associated with EDR Implementation)

- Students
- Administrators or Supervisors
- Colleagues
- Curriculum or Course Coordinator

Perceived Behavioral Control (Factors associated with EDR implementation)

- Additional funds or supplies
- More support from administration
- Additional preparation time
- Availability of additional, new math CCSS curriculum resources
- More opportunities to communicate with teacher colleagues implementing the math CCSS
- Requirement to teach to a specific curriculum

Appendix F: Behavioral intent questionnaire (BIQ)

Belief	Question	5-point Likert Scale	
PBC	I have knowledge necessary to use the CCSS Math workshops for professional learning	Strongly Disagree	Strongly Agree
PBC	I feel able to use the CCSS Math workshops for professional learning	Strongly Disagree	Strongly Agree
SN	When considering to trial new teaching strategies I discuss this with teaching colleagues first	Strongly Disagree	Strongly Agree
BI	I intend to embed professional learning from CCSS Math workshops in my regular teaching practice	Strongly Disagree	Strongly Agree
BI	When I make up my mind to do something, I do it	Strongly Disagree	Strongly Agree
BI	I intend to use CCSS Math workshops for professional learning	Strongly Disagree	Strongly Agree
SN	People who are important to me professionally think I should engage in CCSS Math workshops	Strongly Disagree	Strongly Agree
PBC	I have the resources and time necessary to use the CCSS Math workshops for my professional learning	Strongly Disagree	Strongly Agree
SN	People who influence my behavior think I should engage in CCSS Math workshops	Strongly Disagree	Strongly Agree
AB	Using the ideas generated from the CCSS Math workshops with students will be	Very Inappropriate	Very Appropriate
AB	Using the CCSS Math workshops for my professional learning is	Extremely Useless	Extremely Useful
AB	The idea of using CCSS Math workshops for my professional learning is	Very Poor	Very Good

Appendix G: Level of Implementation Questionnaire

CCSS-M Teacher Quarterly Survey

Please mark answers on bubble sheet using #2 lead pencil.
Teacher ID Number: Please use the last 4 digits of your phone number.

(A) 0 – 20%	(B) 21 – 50%	(C) 51 – 80%	(D) 81 – 100%

Form: October=A, December=B, February=C, May=D
Period: Mark grade level(s) you teach; mark 0 for Kindergarten and 9 for Math 1

Since the start of this school year. . .
When given the opportunity, approximately what percentage of your students consistently:

1. Keep trying even when problems are challenging (SMP 1)
2. Justify their strategy for solving a problem (SMP 3)
3. Find errors in their work and make revisions as necessary (SMP 1-FAP)
4. Work collaboratively with each other (SEL-SA)
5. Are willing to share their ideas in class (SEL-RDM)
6. Build on each other's ideas (SEL-RS)
7. Understand and can explain how to approach problems in multiple ways (SMP 1, 6)
8. Analyze similarities and differences among representations, solutions, or methods (SMP 7)
9. Apply what they know to a real-world situation (SMP 2, 4)
10. Identify and use specific tools, technology, or relevant external math resources to understand and/or solve problems (SMP 5)
11. Demonstrate mastery of the content most recently taught (Content)

Since the start of this school year. . .
How often do you:

(A) ≤ once per month	(B) 2-3 times per month	(C) 1-2 times per week	(D) Every day

12. Plan for instruction by beginning with deeply understanding the content standards and determining acceptable evidence (Focus-BDP)
13. Plan lessons that incorporate both the content and practice standards
14. Pose rigorous questions and problems that prompt students' engagement and thinking about the content of the lesson (Rigor-Exp.A)
15. Use variation in students' solution methods to strengthen other students' understanding of the content. (Coherence-Exp. B)
16. Provide opportunities for students to engage in conversations about each other's thinking, critique each other's thinking, and construct viable arguments. (SMP 3-Exp. C)

17. Use a formative assessment process to provide feedback to help students revise their thinking and work. (FAP-Exp. D)

Plan lessons that support:

18. Students with special needs (SpEd)
19. English Language Learners
20. Gifted learners

Since the start of this school year. . .
Rate your level of skill with:

(A) Weak	(B)	(C)	(D) Strong

21. Incorporating the Standards for Mathematical Practice into daily instruction
22. Posing rigorous questions and problems that prompt students' engagement and thinking about the content of the lesson

How to use the textbook as a resource to:

23. Differentiate instruction
24. Plan and/or deliver instruction
25. Select rigorous tasks for instruction

How to use the district curriculum map as a resource to:

26. Differentiate instruction
27. Plan and/or deliver instruction
28. Select rigorous tasks for instruction