TEACHERS AS RESEARCHERS: A QUANTITATIVE STUDY OF A

RESEARCH-FOCUSED PROFESSIONAL DEVELOPMENT

PROGRAM ON TEACHER PROFESSIONAL AGENCY


by


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**DEDICATION**

I dedicate this dissertation to my family without whose support, I would never have made it this far.

To my daughters, Deanna and Marissa. You have grown into compassionate, yet fierce, confident women who are the change agents this world needs. I am so proud to be your mother. To my son-in-law Kyle. It may sound cliché, but the day you married Marissa, our family became complete. I am so happy you and Marissa found one another and to have you as part of our quirky family. Thank you all for the support and encouragement. My wish as I started my educational journey was to change the trajectory of our family's future. But I soon realized it was not something I could do alone. We did this together. Thank you, Deanna, Marissa, and Kyle, for your unwavering support and love.

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| Abbreviation | Description |
|---|---|
| STEM | Science, technology, engineering, and math |
| TIMSS | Trends in Mathematics and Science Studies |
| NCLB | No Child Left Behind education reform act |
| ESSA | Every Student Succeeds Act |
| PLC | Professional Learning Community |
| LPP | Legitimate Peripheral Participation |
| DDDM | Data Driven Decision Making |
| RSI | Research Studies Instrument |
| CoP | Community of Practice |
| 3D-MEA | Data Driven Decision-Making Efficacy and Anxiety Inventory |
| IB | International Baccalaureate |

**ABSTRACT**

Lackluster performance on international assessments prompted US education reform initiatives reliant on high stakes testing and data driven decision making (DDDM) to determine education policies. Far removed from the classroom, these policies often diminish teachers as decision-makers in their own classroom. Reform policies have led to prescribed curriculum and teaching practices, further reducing teachers' ability to apply their own professional judgement to meet the needs of students. Policies based on a snapshot of data from high stakes testing led me to investigate teachers' level of professional agency if they generated, analyzed, and applied their own data within the classroom. To do so would require levels of proficiency in research methodologies and DDDM.

The professional development program, Teachers as Researchers, included modules addressing the application of research methodologies to the classroom, data literacy, and applying DDDM to the classroom. Anticipating participating teachers would have varying levels of experience with research methodologies and DDDM, the program applied a Community of Practice (CoP) framework. By applying a CoP framework, teachers were empowered to engage in discourse, learning from one another in a collegial setting.

Due to COVID-19 safety concerns, the program was changed from in-person to virtual, using Zoom. The program occurred over a four-day period with one three-hour module presented each day. Study participants were limited to secondary STEM content

teachers, grades 6th through 12th, with five or more years teaching experience. The rationale for limiting the study to experienced teachers was based on the assumption experienced teachers will have established teaching practices as well as a sense of their own professional agency from which to draw comparisons.

Path analysis was applied to this quantitative study to determine associations between research methodologies and DDDM and their impact on teaching practices and teacher professional agency. The study design applied a pretest/posttest model using four validated Likert-scales to assess change in each study variable: Perceived Research Competency Index (Davis & Jones, 2017), Data Driven Decision-Making Efficacy and Anxiety Inventory (Dunn et al., 2013), Teachers' Preferences for Learning Activities Scale (Louws et al., 2017) and the Multidimensional Professional Agency Scale (Vähäsantanen et al., 2019).

Due to the small sample size, I applied Bayesian analysis which indicated statistically significant associations between research methodologies and teaching practices ($\beta$=.64) and between research methodologies and teacher professional agency ($\beta$=.52). However, there were no statistically significant associations between DDDM and teaching practices ($\beta$=.17) or between DDDM and teacher professional agency ($\beta$=.052). Treating teaching practices as a mediating variable for teacher professional agency did not reveal a statistically significant association ($\beta$= -.063). The study did not reveal a correlation between research methods and DDDM ($\beta$=.013).

The findings of this study indicate the teaching practices and professional agency

of experienced secondary STEM teachers can be positively impacted when teachers increase their confidence in applying research methodologies to their classroom. The study suggests before teachers can effectively apply DDDM to their classrooms, additional training to expand teacher confidence with data literacy and data analysis skills are necessary.

## I. INTRODUCTION

Within the United States' K-12 education system, stakeholders seek to improve the system through education reform. Stakeholders include parents, students, politicians, federal and private funding resources, and the business community. A contributing factor to education reform is the nation's lackluster performance within science and math content when compared to that of other nations. Since 1959, the International Association for the Evaluation of Educational Achievement has administered the Trends in Mathematics and Science Studies (TIMSS) assessment to sample populations of fourth and eighth grade students on a global scale. The TIMSS assessments are comparative science and math benchmarks indicating the success of education systems. Since 1995, the United States has shown no improvement, remaining at the intermediate level in both disciplines (Mullis et al., 2016).

The report, Rising Above the Gathering Storm (2005), a collaborative effort between the National Academy of Science, National Academy of Engineering, and the Institute of Medicine identified a chronic shortage of science and math teachers at the secondary level. The report found evidence high school chemistry students have a 40% chance their teacher will have majored in chemistry. Without a scientifically literate workforce, the US continues to obtain stagnant outcomes from international assessments, such as TIMSS. As stated in Rising Above the Gathering Storm (2005) and substantiated by Rising Above the Gathering Storm Revisited (2010), there is a growing need within science, technology, engineering, and math (STEM) fields. In order to support an ever-growing STEM-career pipeline, the K-12 education system needs to retain current teachers through quality professional development addressing "knowledge content, solid

pedagogical skills, motivational abilities, and career-long opportunities for continuing education" (NAS et al., 2007, p. 113). International assessments and government reports indicate a need for education reform. Stakeholders from every level push local and federal agencies for continued education reform. However, "the lack of teacher voice and agency in policy design uncouples those making policy from those implementing it" (Good et al., 2017).

## Education Reform

The most recent federal reform education legislation, No Child Left Behind (NCLB), adopted in 2001, and Every Student Succeeds Act (ESSA), passed in 2015, utilize data generated from high stakes tests to determine individual student achievement, set policy, and assess teacher accountability. The very nature of high-stakes testing increases external control due to built-in systems of accountability designed to meet targeted outcomes. These controls, in turn, exert formal control on curriculum, resulting in a narrowing of curricular content while increasing fragmentation of knowledge by narrowing instruction topics to testable items (Appova & Arbaugh, 2018; Jeong & Luschel, 2018). In other words, teachers are constrained from making decisions regarding content and instructional strategies, and this can negatively impact teacher professional agency.

### Neo-Centralization

Education reform applies a top-down approach effectively removing teachers from decision making processes. Jeong and Luschel (2018) refer to this process as neo-centralization: as government involvement in setting school-related policies increases, teacher autonomy as a decision maker in the classroom decreases. An example of neo-

centralization is the introduction of scripted curriculum which is developed at levels far removed from the classroom (Jeong & Luschel, 2018; Wild, et al., 2018). To ensure uniformity of instruction through scripted curriculum, many schools implemented professional learning communities (PLC) as a monitoring mechanism for curriculum conformity (Jeong & Luschel, 2018). The website Glossary of Education Reform defines a PLC as a group of teachers who meet regularly, share expertise, and work collaboratively to improve teaching skills and the academic performance of students (https://www.edglossary.org). "The underlying assumption in professional learning communities is that peer collaboration has the potential of transforming teaching practices in ways that will bring about higher rates of student achievement" (Riveros et al., 2012, p. 204). However, when PLCs are used to ensure curriculum conformity, there is reduced opportunity for transformational peer collaboration which directly affects student achievement.

For PLCs to improve student achievement, there needs to be support for collaborative interactions among teachers to promote professional learning and problem solving within an environment which increases teacher agency (MacPhail, et al., 2014; Riveros, et al., 2012). The intent of school PLCs is to provide teachers with opportunity to engage in discussions with colleagues, exchange ideas, learn about and consider alternative perspectives, and engage in self-reflective practices (Riveros, et al., 2012). In short, PLCs should be opportunities for teachers to learn from and mentor to one another. However, within neo-centralization, PLCs are overly structured, designed to arrive a pre-determined outcome, thereby decreasing opportunity for teachers to engage in meaningful learning from their colleagues (Appova & Arbaugh, 2018). Instead of

learning from colleagues and engaging in mentorship between colleagues, PLCs serve as a dissemination mechanism.

*Mentoring*

Mentoring throughout the duration of a career provides support and guidance while contributing to retention. However, within the K-12 realm, mentoring throughout a teaching career is generally not fostered. Mentoring is largely confined to new or novice teachers with less than five years of teaching experience through induction programs (Aderibige et al., 2018; Betteney et al., 2018; Baker-Doyle, 2012). Mentoring during induction programs are designed to acclimate newcomers to school culture and familiarize them with policies and procedures. Induction programs for new teachers typically follow an expert/novice format. Lave and Wenger (1991) refer to this as legitimate peripheral participation (LPP) in which new teachers interact with a more experienced teacher mentor to become part of a community of practitioners (Lave & Wenger, 1991).

As new and novice teachers encounter challenging situations, such as classroom management and disciplinary issues, they turn to their more experienced mentor teacher for guidance (Hudson, 2012). From an LPP perspective, mentoring is a social activity where the mentee learns from experience as they develop a professional identity (Lave & Wegner, 1991). Under the watchful eye of the mentor/expert, the new teacher/novice incrementally moves toward full membership within the community of teachers (Lave & Wenger, 1991). However, the nature of induction mentoring programs for new teachers adheres to the binary of expert/novice as evidenced by critiques of induction programs. Induction mentoring programs create an unequal distribution of power between expert

and new teacher (Aderibige et al., 2018; Sewell et al., 2009) which can persist long after the induction mentoring program.

Applying an induction mentoring model to experienced teachers is not effective (Bressman et al., 2018). Unlike new teachers, experienced teachers possess skillsets which have developed from their years in the classroom. Therefore, a system based on power inequity will not serve the diverse needs of experienced teachers. As such, "a one size fits all model does not seem to be in order when seeking to meet the mentoring needs of experienced educators" (p. 168). Wenzlaff and Wieseman (2004) conducted a qualitative study investigating teacher learning within graduate cohorts (N = 22). Wenzlaff and Wieseman (2004) revealed teacher learning and empowerment increase when teachers are part of a collaborative environment where they can engage in meaningful discourse as part of a community of teachers. "Learning cannot be done to teachers or for teachers" (Wenzlaff & Wieseman, 2004, p. 123). Removing opportunities for discourse between teachers decreases learning and growth thereby impacting professional agency.

**Data-Driven Decision Making**

The fulcrum on which education reform balances is data-driven decision making (DDDM). Mandinach (2012) defines DDDM as "pertaining to the systematic collection, analysis, examination, and interpretation of data to inform practice and policy in educational settings" (p. 71). Within K-12 classrooms settings, most teachers are expected to use DDDM to assess student mastery, but on a deeper level, teachers are to use DDDM to inform their teaching practices (Dunn et al., 2012). Data-driven decision-making guides policies and sets accountability standards for teachers. Accountability

requirements derived from DDDM are aggressive and inherently punitive in nature (Bullough, 2014), especially given in-service teachers lack training on how to interpret data to inform their teaching practices (Mandinach & Gummer, 2016; Marsh et al., 2015).

Teachers regularly rely on formative and summative data to assess student academic progress, but these data indicate levels of student mastery and do not rise to the level of applying DDDM to inform teaching practices (Dunn et al., 2013; Walker et al., 2018). Teacher decisions regarding student mastery may be influenced by intuition rather than strictly based on assessment data (Vanlommel et al., 2017). According to Mandinach et al. (2015), "policy makers and researchers in the area of data-driven decision making have focused on teachers in a number of ways but have rarely addressed teacher preparation" (p. 4) regarding basic skills in DDDM. To effectively incorporate DDDM into teaching practices requires a level of data-literacy (Dunn et al., 2013); however, teachers lack training in data-literacy and DDDM (Mandinach & Gummer, 2016; Mandinach et al., 2015; Marsh et al., 2015). In other words, teachers are expected to apply DDDM to their teaching practices but are not provided with the support necessary to meet this expectation.

**Teacher Professional Development**

As part of education reform efforts, professional development hours are required to maintain teaching certifications. Schools are provided with funding to support teacher professional development to support such programs. Schools use the funds to provide mandatory professional development, yet with little or no input from teachers regarding the subject matter. According to Hargreaves and Dawe (1990), teachers associate mandated professional development programs with an implied knowledge deficit. Over

the course of a career, teacher attitudes toward mandated professional development decreases with every year of service, until experienced teachers become indifferent (Torff & Sessions, 2008). According to Meister (2010) teachers rarely credit their school or district with offering meaningful professional development. Instead, teachers seek out professional organizations or community resources for programs which address their professional development needs (Meister, 2010).

Teachers find professional development opportunities through local resources such as universities, professional organizations, and regional educational support centers (ESC). Texas is divided into 20 regions with each region serviced by an ESC. The ESC's offer "a wide variety of professional development opportunities to assist clients in improving student performance and increasing the efficiency and effectiveness of school operations" (https://www.esc20.net/apps/pages/pd-home, paragraph 1). As a contracted provider with individual districts, the ESCs are a source for teacher learning through conferences and workshops. Frequently, these programs are one-and-done and are not generally designed to promote teacher communities.

**Teacher Professional Agency**

Teacher professional agency is "a combination of a teacher's capacity to initiate and the enactment of this capacity to actively direct his/her professional life in accordance with his/her own will, judgement and choice" (Hadar & Benish-Weisman, 2018, p. 138). The dynamic process of education relies on complex interactions between all stakeholders, including teachers (Matteucci & Helker, 2018). Yet, education reform efforts rely primarily on DDDM to generate policies which promote neo-centralization, dictating what is taught and how it is to be taught, diminishing teacher agency by

discounting teachers as education professionals (Jeong & Luschei, 2018; Bullough, 2014).

### *Pilot Study*

In preparation for this study, I conducted a pilot study to gain insight into teachers' perceptions of and confidence with data literacy, understanding of research methods, incorporation of research into teaching practices, and teachers' perceptions of professional agency. I recruited participants from a population of science teachers attending a local STEM professional development conference. Thirty-eight teachers consented to participate. Of the 38 teachers, 32 had five or more years teaching experience, with 17 having a degree in a specific science content. The quantitative instruments for the pilot study included the Multidimensional Professional Agency scale (Vähäsantanen et al., 2019) and the Research Studies Instrument (Niemi & Nevgi, 2014).

Teacher responses to the Research Studies Instrument implied teachers were unsure how to apply research to their teaching practice (3.0/5.0), somewhat unaware of how to identify error sources in research (3.1/5.0) and had moderate understanding of research literature (3.1/5.0). These data provided evidence in support of previous research indicating teachers lack training in data-literacy (Dunn et al., 2013). The pilot study included the Multidimensional Professional Agency scale (Vähäsantanen et al., 2019), which consists of three subscales: influence at work (4.3/5.0), developing work practices (4.2/5.0), and negotiating professional identity (4.3/5.0). These data indicated participating teachers perceived high levels of professional agency within their department. When comparing these results to the Research Studies Instrument results, participating teachers indicated uncertainty regarding research and data literacy, yet

identified as having high levels of professional agency. Analysis of data, using SPSS,

indicate no correlation between the instruments. Yet, I questioned how teachers define

professional agency working in a neo-centralized environment which limits teachers as

decision makers.

## The Problem

Top-down education reform efforts rely on DDDM to set policies, effectively

removing teachers from decision-making processes. Although teachers regularly interpret

formative and summative data to determine student content mastery, application of

DDDM to teaching practices goes beyond assessment of student mastery. The lack of

DDDM and data-literacy training disenfranchises teachers from their own professional

practice as they adhere to prescribed lessons in a neo-centralization environment. Further

evidence of neo-centralization is how schools implement PLCs. Intended to promote

collaboration, discourse, and peer-driven learning between teachers, PLCs are

appropriated to advance pre-determined objectives which further removes teachers from

decision-making processes. In this restrictive environment, teachers' ability to direct their

own professional growth is curtailed.

As indicated by the pilot study, teachers are unsure how to apply research or use

research literature to inform their teaching practices, both of which are crucial to DDDM.

Data from the pilot study indicate participating teachers believe they are able to engage in

decision making at work (mean: 4.4/5.0) and transform their work practice (mean:

4.4/5.0). Education reform efforts, which include DDDM, have been in effect since 2002.

It is possible teachers with less than 20 years teaching experience know no other system.

Having spent an entire career in a neo-centralized system, teachers' perception of

professional agency may be skewed. Not knowing any other system, teachers may not recognize limitations in their work environment resulting from neo-centralization.

**Purpose of Study**

There is a gap in teacher professional development: lack of training in research methods (Mandinach, 2010), data literacy (Mandinach & Gummer, 2016; Mandinach et al., 2015) and application of DDDM to teaching practices (Dunn et al., 2013; Mandinach & Gummer, 2016; Vanlommel et al., 2017). This quantitative study seeks to determine if training teachers as researchers ultimately has a significant effect on teaching practices and teacher professional agency. Participating teachers engaged in a four-day professional development program consisting of four modules: Establishing the Mindset of a Researcher, Communicating Research Outcomes, Applying Data & DDDM to Inform Teaching Practices, and Integrating Research into the Classroom. Study participants were secondary teachers, grades six through twelve, from central Texas with a minimum of five years STEM-content teaching experience.

*Research Questions*

Given teachers often are untrained in data analysis, DDDM, and research, I sought to quantitatively assess the impact of such training on mid-to-late career teachers' teaching practices and perceptions of professional agency. I hypothesized the professional development training program, Teachers as Researchers, will increase teaching understanding of research methods and DDDM, thereby positively impacting teaching practices and teacher professional agency. The following research questions guided this study:

RQ 1: Is there a statistically significant relationship between Research

Methodology and Teaching Practices?

RQ 2: Is there a statistically significant relationship between Research

Methodology and Teacher Professional Agency?

RQ 3: Is there a statistically significant relationship between DDDM and

Teaching Practices?

RQ 4: Is there a statistically significant relationship between DDDM and Teacher

Professional Agency?

RQ 5: Is Teaching Practices a statistically significant mediator between Research

Methodology and Teacher Professional Agency?

RQ 6: Is Teaching Practices a statistically significant mediator between DDDM

and Teacher Professional Agency?

**Significance**

Under current education policies, a single snapshot of data generated from student

performance on standardized tests, determines the success of the education system.

Policies at the national, state, and local levels are guided by these snapshots of data.

Using data from standardized tests to set policy has been of some benefit. There is

evidence standardized tests have positively affected the K-12 education system by

highlighting academic gaps between subpopulations of students (Price, 2016), such as

race, socioeconomic status, and special populations. However, reliance on standardized

tests to set policies has effectively removed teachers from decision making processes

within the classroom. This is evidenced by scripted curriculum, orchestrated

collaborations in PLCs, and lack of training to address research methods, data literacy,

and DDDM to inform teaching practices.

*Practical*

Teachers function in a reform system dependent on data, yet lack training in research methods which include research design, implementation, data collection, and data analysis to inform their professional practices. Walker et al. (2018) conducted a confirmatory factory analysis of the Data-Driven Decision-Making Efficacy and Anxiety scale (3D-MEA), assessing the efficacy and anxiety levels of K-12 teachers (N = 365) regarding application of DDDM to their teaching practices. Walker et al. (2018) asserted "on-the-ground use of data by teachers to inform decisions…is notoriously complex and difficult" (p. 488). Their research show teachers who lack confidence in their data abilities are less likely to apply DDDM to their teaching practices and not associate a positive correlation between DDDM in the classroom and student achievement (Walker et al., 2018).

Training teachers to engage in research and how to apply DDDM to their teaching practice will inform instructional decisions (Datnow & Hubbard, 2015; Mandinach, 2010; Schildkamp et al., 2019) while providing teachers with the means to assess their own teaching practices through data generated by their own research (Taylor, 2017; Kyei-Blankson, 2013). Despite research which supports for the effectiveness of DDDM in the classroom, teachers remain largely untrained in DDDM. Training teachers in research methods and DDDM will better position teachers to understand external policies derived by DDDM while increasing application of research methods in the classroom.

Teacher professional agency is greatly influenced by their perception of their own level of authority within the school. Good et al. (2017) posited teachers perceive schools as hierarchical organizations, placing themselves near the bottom of the professional

hierarchy with little ability to influence policy which has a negative impact on professional agency. Time also contributes to low teacher professional agency. A teacher's daily work schedule is structured down to the minute: from instructional times rigidly monitored by the bell, conference periods absorbed by meetings and tutoring, brief lunch periods and additional duties assigned at the discretion of an administrator. The inflexible structure associated with teaching and teachers' own perceptions of their position within the organization increases risk for low professional agency.

In a neo-centralized education environment, teachers have limited freedom to determine the direction of their own professional development. Class schedules will continue to have set beginning and end times; however, engaging in classroom research can contribute to agentic growth. Training teachers as researchers requires engagement with education, content, and research literature, prompting collegial discussions with peers as they share outcomes of their own research projects within the structure of their schools. As teachers gain confidence in DDDM, including data literacy, and research methodologies, it is anticipated teacher professional agency will increase.

### *Theoretical*

As evidenced by the predominance of induction mentoring programs, the K-12 environment has endorsed an expert/novice approach which extends beyond induction into teacher professional development programs (Aderibige et al., 2018; Mortier, 2020). However, as teachers progress through their career, teacher expertise is regularly challenged by the introduction of new technologies, changing student demographics, and an ever-expanding workload (Bressman et al., 2018).

The theoretical framework for this study is communities of practice (CoPs).

Communities of practice consist of practitioners, in this case teachers, "who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis" (Wenger et al., 2002, p. 4). Within a learner-centered environment, CoPs provide teachers opportunity to move beyond the novice/expert model of induction programs and learn from one another's diverse experiences through discourse, undergoing "the generative process of producing their own future" (p. 58) as a practitioner.

The diverse nature of CoP members creates an environment for teachers to engage one another in fluid mentoring; transitioning between mentor and mentee as they interact with colleagues (Dunning et al., 2011). Communities of practice theory posit interactions engage members in collaborative decision-making which honors diversity and reflects shared power among all members (Thomas et al., 2011). In other words, CoPs place emphasis on "mutual understanding and consciousness raising…[members] arrive at a place together where difference is understood and accepted in a meaningful way" (Thomas et al., 2011, p. 346). Through the lens of CoP theory, teachers have a shared understanding of participatory mentorship where all members have a voice (Aderibige et al., 2018) and where teachers can support yet challenge one another, professional to professional, as they are exposed to alternative perspectives (Marsh et al., 2015; Riveros et al., 2012; Lave & Wenger, 1991).

## Definition of Terms

- Professional Agency: "a combination of a teacher's capacity to initiate and the enactment of this capacity to actively direct his/her professional life in accordance

with his/her own will, judgement and choice" (Hadar & Benish-Weisman, 2018, p. 138).

- Professional Learning Communities (PLCs): Communities of teachers engaged in educative discourse to learn from one another as they engage in problem solving (Wenger et al., 2002).

- Neo-Centralization: Top-down approach effectively removing teachers from decision making processes (Jeong & Luschel, 2018).

- Data Driven Decision Making (DDDM): decisions regarding education policies and teacher mandates based exclusively on hard data (Dunn et al., 2013).

## Positionality

This study focused on mid-to-late career STEM teachers with more than five years teaching experience. My rationale for focusing on this particular population is based on a national focus on STEM-related careers and the assumption experienced teachers have established teaching practices as well as a sense of their own professional agency. The focus on this population is also driven by observations obtained over two decades of experience within public education, including 10 years of personal experience as a secondary STEM teacher. Teachers function within a highly regulated environment with little time to engage colleagues in meaningful discourse. In other words, the culture of teaching does not provide time for nor promote teacher to teacher mentorship over the course of a career. Mentoring is primarily reserved for new and novice teachers through induction programs, but rarely available to experienced teachers.

As I advanced in my career, I observed a shift in professional development offerings which coincided with the introduction of No Child Left Behind in 2001.

Mandated professional development began to focus more on how to address accountability standards and less about developing my content knowledge and teaching practices. Accountability training consisted of data generated from standardized tests. These data included district comparisons between schools and individual teacher rankings determined by student performance on standardized tests. Shaming, not training, seemed to be the goal of professional development.

Ten years ago, I transitioned to a position at a medical school. In this position, I collaborate with STEM professionals, gaining insight into current bioscience research. I also collaborate with area teachers to identify content and pedagogy gaps in professional development offered through schools. Synthesizing the information, I create programs for STEM teachers at all grade levels, helping teachers remain current on science research while providing a means to address professional development needs beyond the sciences. Without the confines of education reform accountability standards, I generate professional development programs which are responsive to the needs of area STEM teachers rather than addressing mandated accountability standards.

## Delimitations of Study

The study is limited to secondary teachers, grade six through 12, with over five years teaching experience in a STEM-related content. STEM-related content is defined as general science and math courses, natural sciences, physical sciences, engineering, robotics, and computer sciences. Natural sciences include, but are not limited to biology, environmental systems, anatomy and physiology, and aquatic science. Physical sciences include but are not limited to chemistry, physics, and astronomy.

**Summary**

For nearly 20 years, education reform efforts have created a top-down, neo-centralized environment, in which teachers follow scripted curricula, have limited decision-making authority within the classroom, and are evaluated based on students' performance on high-stakes tests. Data from high stakes tests guide development of education policies and accountability standards which directly impact or even determine teaching practices. Data from high stakes tests are provided to teachers with the expectation teachers will use these data to apply DDDM practices to inform their teaching practices. Yet, literature indicates teachers are not trained in DDDM or research practices which generate data. This is supported by my pilot study data which show teachers are only somewhat sure how to incorporate research into their teaching practice. However, teachers in the pilot study, most of whom have only taught in neo-centralized education reform, self-identified as agentic when it comes to decision making at work and transforming their work practices.

Teachers with less than 20 years teaching experience have spent their career within this neo-centralized system which causes me to wonder if this results in a skewed perception of professional agency. In this quantitative study, I compared pretest and posttests of mid-to-late career secondary STEM teachers who participated in a research and DDDM professional development program, assessing the impact of research methods and DDDM on teaching practices and teacher professional agency.

## II.  LITERATURE REVIEW

As a dynamic profession, teachers are exposed to innovative strategies, new policies and procedures, and ever-evolving technology to enhance lessons. Yet, education reform efforts increased federally imposed mandates directly impacting the day-to-day responsibilities of teachers. "Public perception of teacher incompetence…has provided justification for an increasing teacher-deskilling process (Kincheloe, 2003, p. 34). The deskilling process contributed to the adoption of a neo-centralization approach for education reform, diminishing the voice of K-12 teachers (Kincheloe, 2003) by dictating prescribed curriculum and pedagogical practices while adhering to standardized accountability standards (Bressman et al., 2018; Jeong & Luschei, 2018; Bullough, 2014; Mooney Simmie & Moles, 2011).

### Education Reform Impact on Teachers

In their study, Jeong and Luschei (2018) analyzed questionnaires completed by principals from 33 countries whose students participated in the Programme for International Student Assessment (PISA). Like the TIMSS, the PISA is an internationally administered assessment. The TIMSS is administered to fourth and eighth grade students over science and math. The PISA is administered to high school freshmen in math, science and reading. Quantitative analysis of questionnaire responses by principals indicate education reform initiatives promote neo-centralization which removes teachers from decision-making processes within their schools and classrooms (Jeong & Luschei, 2018).

For example, curriculum and instruction have traditionally been the domain of teachers. The advent of neo-centralization resulted in rigidly implemented scripted

curricula. This approach ensured conformity to an education system reliant on standardization: students are exposed to the same material and comparable instruction in preparation for a standardized test. This approach limits teachers' ability to modify or adapt lessons to address individual student needs. The loss of decision-making power decreased teacher agency and job satisfaction, negatively affecting teacher retention which adversely impacted student achievement (Jeong & Luschei, 2018).

While research suggests scripted curricula have contributed to the loss of individual teacher agency (Jeong & Luschei, 2018; Wild, et al., 2017) scripted curricula have the possibility of increasing collective teacher agency. To further analyze this phenomenon, Wild et al. (2018) focused their qualitative case study on the implementation of a lock-step curricular model within a high school International Baccalaureate (IB) program. The lock-step curriculum was co-constructed by the four participating teachers who each taught physics. The IB program requires teachers to follow internationally accepted standards specific to content. Teaching a common curriculum provided teachers with shared experiences and fostered accountability as teachers divided tasks among themselves. Wild et al. (2018) observed experienced teachers mentoring and supporting one another: tutoring each other over challenging content and providing constructive feedback regarding observed instruction.

The teachers became "agents of change beyond their own classrooms by working collectively in self-determined communities" (Wild et al., 2018, p. 315). The qualitative case study revealed to implement lock-step curricula, teachers must work collaboratively, exchanging individual agency for collective agency. What sets this study apart from scripted curriculum associated with neo-centralization is the level of decision-making

teachers were able to assume by collaborating to develop the scripted curriculum. Teachers divided tasks among themselves, shared content and pedagogy knowledge and held one another accountable, validating one another within a community of practitioners.

## Professional Development within Teacher Communities

Schools are communities comprised of formal and informal relationships between teachers, staff, and administration. Supporting teachers' professional development throughout their careers "requires not only attending to the important formal structures, but also to the informal networks" (Daly, 2015, p. 2). Informal relationships among teachers play an important role in how quickly and firmly mandated strategies associated with reform efforts take hold. Furthermore, within informal teacher networks, teachers have freedom to take ownership of their role as decision-makers (Baker-Doyle, 2012).

### Teacher Networks

The success of informal teacher networks is dependent on the ability of teachers to engage in discussions with colleagues to exchange ideas, learn about and consider alternative perspectives, and engage in self-reflective practices (Riveros et al., 2012) in a safe environment. "Building and supporting professional relationships and networks is a critical way to sustain the work of teaching and learning" (Daly, 2015, p. 1). Teachers are more likely to respond positively to critiques and are more receptive of change when suggested by a trusted colleague. However, networking is not generally included in teacher professional development programs (Baker-Doyle, 2012) and is not often integrated into teacher culture (Hanraets et al., 2011).

Professional networks are a way for those with limited power to obtain resources and support. To establish and maintain a network of colleagues, teachers should adopt a facilitator mind-set without preconceived or anticipated outcomes (Hanraets et al., 2011). According to this research, successful network facilitators invite members to take ownership of network success. Data indicated teachers prefer face-to-face networking over online network communities (Hanraets et al., 2011). The data further highlighted there are keys to successful teacher networks: members being open to spontaneity as they explore and address needs and expectations of network members.

Successful networks provide training for members to address gaps in networking skills. But networking is more than bringing teachers together. Common planning periods are frequently viewed by administration as a networking opportunity for teachers. However, teachers view common planning as "merely providing time and directives to 'work together' [and] does not necessarily result in meaningful collaboration" (Daly, 2015, p. 3). Even with common planning periods, Daly asserted teachers lack social capital. This is demonstrated by the continued practice of isolating teachers from colleagues by adherence to traditional schedule formats and not investing in programs to develop teacher professional networks.

Network learning is an effective method of informal teacher professional development. Based on outcomes from a mixed-methods study of new teacher (N = 24) perceptions of school characteristics, Baker-Doyle (2012), indicated the professional culture of the school influences how teachers interact with colleagues within their school and beyond. Networks are a means through which teachers can increase exposure to fellow teachers outside of their school or district. These external colleagues provide

support, guidance, and exposure to different teaching practices and perspectives influenced by unique teaching environments.

*Conference Networks*

Conferences are examples are informal networks, providing "out of school support" (Navy et al., 2019). Through content-specific workshops, conferences provide teachers opportunity for teachers to learn new strategies to apply to their classroom while interacting with teachers outside of their school or district (Navy et al., 2019). Navy et al. (2019) discussed the importance of free choice afforded to teachers through conferences. Unlike other teacher communities where attendance may be required or teachers have limited or no input as to content, conferences provide teachers opportunity to select workshops or topics of their choosing. Navy et al. (2019) conducted a qualitative study with novice science teachers (N = 68) with less than three years teaching experience. Through surveys and written reflections, teachers indicated networking was the highlight of the conference. Attending the conference "allowed them [novice teachers] to share ideas and resources, *[sic]* and feel connected to a community of educators" (Navy et al., 2019, p. 418).

Although conferences are effective networking and learning opportunities, yet for lasting impact on teaching practices, the outcomes are not so clear. McElearney, et al. (2019) conducted a qualitative survey of teachers (N = 304) regarding commonly accessed professional development training. Of the teachers who responded, a majority (74%) had over 11 years teaching experience. When asked to rate impact of professional development formats on their teaching practices, conferences had less impact "than individual or collaborative research" (McElearney, et al., 2019, p. 449).

Despite the opportunity networks create for teachers to learn from one another, teacher networks are underdeveloped and underutilized within the K-12 environment (Hanraets et al., 2011). Through their research, Hanraets et al. (2011) found evidence indicating teacher networks have the potential to serve as informal, grassroots mentoring support for teachers at all stages of their career. "Networked learning means the use of social relationships to promote collaborative or cooperative connections between learners" (p. 86). Collaborative networks provide learning opportunities for teachers as they engage with colleagues from different grade levels, schools, content areas, and districts. Through engagement with fellow practitioners, teachers are exposed to different perspectives, collaborating to develop innovative strategies to enhance teaching practices.

**Professional Learning Communities**

Schools have taken steps to foster teacher networks by establishing professional learning communities (PLCs). Within a PLC, teachers meet regularly with colleagues to discuss strategies to improve student performance. Applying an historical tenet of adult education (Rose, 1996) PLCs engage teachers in group learning. PLCs afford teachers opportunity to address a shared task, collaborate, or problem solve (Thompson et al., 2018). Thompson et al. (2018) conducted a qualitative case study of one PLC for science teachers at a low-performing middle school. Through observations and analysis of PLC conversations, Thompson et al. (2018) suggested PLCs are effective for improving teaching practices; however, they caution the effectiveness of PLCs is dependent on the level of control teachers are afforded to run the PLC.

Through a qualitative meta-analysis study, Riveros et al. (2012), suggested PLCs can help teachers move from working in isolation to engaging in collaborative endeavors.

Professional learning communities were intended to effect positive change; however, Riveros et al. (2012) found most teachers have negative predispositions regarding PLCs. These teachers believe PLCs are implemented when decision-makers, far removed from the classroom, determine teachers are lacking in some capacity. Considered a deficiency indicator, Riveros et al. (2012) posited teachers view PLCs with suspicion. Being left out of decision-making processes, teachers are left to wonder how deficiencies are determined and are reluctant to engage in overly structured PLCs with pre-determined objectives.

Rather than using PLCs as a collaborative professional community of educators, administrators frequently implement PLCs as a mechanism to usher teachers toward support of proposed or mandated changes. Through semi-structured interviews of secondary STEM teachers (N = 600), Appova and Arbaugh (2018) revealed most teachers believe learning opportunities are missed when administrators establish pre-determined outcomes for PLCs. When led by an administrator, teachers are reluctant to engage in authentic discourse. The K-12 environment has a clear hierarchical structure (Appova & Arbaugh, 2018), and the presence of an administrator within a PLC represents the unequal distribution of power within the structure, impacting teachers' willingness to voice opinions (Appova & Arbaugh, 2018; Meister, 2010).

Another PLC approach observed by Appova and Arbaugh (2018) assigned a teacher to facilitate the PLC. However, the teacher facilitator was generally not trained nor provided with clear guidelines on effective facilitation of a PLC (Appova & Arbaugh, 2018; Thompson et al., 2018). Appova and Arbaugh (2018) observed teacher facilitators were provided with an overly developed PLC agenda, with detailed instructions to ensure

teachers within the PLC complied with a predetermined outcome. Within this structure, teachers may be more willing to engage in discourse, but the predetermined outcome reinforces the lack of power teachers have in the decision-making process (Appova & Arbaugh, 2018). Similarly, in a five-year study of collaborative teacher research, Thompson et al. (2018) found when teachers within a PLC "were given the agency to work on the problems of practice they understood to be relevant" (p. 1451), the PLC was an effective tool to positively impact teaching practices. Rotating facilitation duties between teachers was an effective method of engagement, but only after teachers came to a consensus as to the role of facilitator (Thompson et al., 2018).

The literature show PLCs have the potential to facilitate and advance teacher learning, resulting in professional growth and improved teaching practices. However, there is evidence PLC success is dependent on the level of authority teachers have within the PLC. When PLCs are the domain of teachers, there is increased impact on teaching practices and opportunity for teachers to engage and learn. Conversely, when PLCs include administrators, there is a perceived power shift which discourages teacher discourse and fluid mentoring. The end result is reduced teacher agency.

**Mentoring Relationships**

The nature of teaching in the K-12 profession is an isolating endeavor (Bressman et al., 2018; Riveros et al., 2012). Bressman et al. (2018) conducted an interpretive-qualitative study of teachers (N = 20) with more than five years teaching experience, to investigate the role of mentoring throughout their careers. Teachers reported most of their professional career is spent separated from colleagues, leading researchers to posit "isolation…can also lead to teacher apathy or disengagement resulting in a lack of

enthusiasm for those teachers well into their careers" (Bressman et al., 2018, p. 164). For this reason, Bressman et al. (2018) suggest mentoring programs for experienced teachers are vital to sustain teacher motivation. But mentorship for experienced teachers would need to be different than an induction mentoring program. Induction mentees are primarily within their early 20s, whereas teachers with five or more years of experience will include ages ranging from their late 20s to beyond.

Daloz (1999) likened mentoring adult learners to a journey with distinct stages. Early in the journey, mentors provide support but as the journey progresses, mentors present challenges and provide vision (Daloz, 1999). Sticking with the journey metaphor, Larson (2009, p. 28) described adult mentorship as "not so much interested in fixing the road as in helping the protégé [fellow teacher] become a competent traveler." According to Daloz (1999) as a result of life experiences, adult learners critically evaluate their experiences to refine their beliefs. Daloz (1999) proposed adult learners' perspectives are influenced by their environment, which, in turn, form the lens through which they develop meaning. Applying this to K-12 education, teachers who work together and mentor to one another are influenced by similar work environments providing a shared experience. It is this shared experience which fosters trust, a key element to exceptional mentoring (Larson, 2009).

Aderibige et al. (2018), through a mixed-methods study of mentors (N = 145) and new teacher mentees (N = 130), identified two mentoring approaches frequently used within the K-12 educational setting: managerial and participatory. The main difference between the two approaches is power and how it is distributed between the mentor and mentee. For example, education reform efforts emphasize conformity to standards which

may be best addressed by implementing a managerial approach to mentoring. Applying the binary model of expert/novice, there is an unequal distribution of power in the managerial approach. The majority of power resides with the mentor who is considered the expert, possessing the skills the mentee is expected to attain.

The second mentoring approach identified by Aderibige et al. (2018) is participatory. In this approach there is a mutual relationship in which both mentor and mentee have a voice. Rather than striving to attain the same skillset as the mentor, the mentee is encouraged to develop their own teaching style while learning about policies, procedures and school culture. Applying a participatory approach, the mentor creates a supportive environment where mentor and mentee share power. This approach can be likened to legitimate peripheral participation (Lave & Wenger, 1991) where the mentee learns through social interactions with other, more experienced members of the teaching community. Through the LPP process, the mentee learns from the community through participation rather than by instruction (Lave & Wenger, 1991). Through participatory mentoring, the mentee is accepted as a contributing member of the teaching community.

There is an abundance of literature concerning mentoring of pre-service and novice teachers, but literature geared toward mentoring programs designed for in-service teachers is lacking (Bressman et al., 2018). Within the K-12 education system mentoring decreases as years of experience increase, as evidenced by the lack of mentoring programs designed to meet the needs of in-service teachers. Through their research, Bressman et al. (2018) found applying an induction mentoring model to experienced teachers was not effective. The unique experiences, skillsets, and abilities of seasoned teachers means their needs are diverse; therefore, "a one size fits all model does not seem

to be in order when seeking to meet the mentoring needs of experienced educators" (p. 168).

Bressman et al. (2018) further posited mentoring programs for experienced teachers benefit schools by increasing teacher retention which provides a stable learning environment for students. In turn, students benefit from higher levels of engagement associated with educational expertise derived from years of teaching experience. But to meet the mentoring needs of experienced teachers, they stress the inclusion of teachers in decision-making processes regarding mentoring programs is central to fostering their continued professional growth.

Formal and informal communities provide teachers with opportunities to engage with colleagues. Formal communities, such as PLCs or mentoring relationships, are important for acculturation and learning; however, the level of input by teachers may be limited. Informal communities provide opportunity for teachers to take ownership of their participation and development. Informal communities, such as conference interactions, may be temporary but no less valuable as a learning experience. Communities which include teachers in decision-making processes are integral to the development of teachers throughout their career.

**Communities of Practice**

Wenger et al. (2002) defined CoPs as having three components: "a domain of knowledge, which defines a set of issues; a community of people who care about the domain; and the shared practice that they are developing to be effective in their domain" (p. 27). To be effective in addressing the issues, CoPs must provide members a safe

environment to engage in discourse and participate in a social learning environment. Safe environments "honor and take into account our colleagues' ways of knowing" (Drago-Severson & Blum-DeStefano, 2017, p. 52). When teachers mentor colleagues, it is important to understand meaning-making systems. Drago-Severson and Blum-DeStefano (2017) referred to meaning-making systems as ways of knowing.

Grounded in constructive-development theory, ways of knowing recognizes "people actively interpret or construct their experiences throughout their lives" (Drago-Severson & Blum-DeStefano, 2017, p. 37), "people's constructions and ways of knowing can evolve or become more complex over time" (Drago-Severson & Blum-DeStefano, 2017, p. 38), and finally, adult learners "grow and develop more complex internal capacities and ways of knowing" (Drago-Severson & Blum-DeStefano, 2017, p. 38). Within the safe environment of a CoP individuals' way of knowing can evolve as they discover *how* to learn from one another.

The success of a CoP is dependent on the level of trust between participants and their willingness to be vulnerable within the community of fellow practitioners (Lave & Wenger, 1991; Mortier, 2020; Trabona et al., 2019). Trabona et al. (2019) conducted a multi-year qualitative study of the impact of CoPs on cohorts of science teachers pursuing advanced degrees. Trabona et al. (2019) posited when teachers engage in collaborative environments, such as a CoP, they engage in critical reflection regarding their teaching practices resulting in positive impacts on teaching practices. According to Trabona et al. (2019, p. 484) teachers "need opportunities to work with partners for instructional change, where they can collaboratively examine practice and provide feedback to one another that extends and improves teaching" (p. 484).

Through case studies of CoPs, MacPhail et al. (2014) contend CoPs support professional development and professional learning. Professional learning "requires a shift from a view of teaching as the development of expertise [professional development] to teaching as the development of the scholarship of teaching" (MacPhail et al., 2014, p. 41). Wenger and Wenger-Trayner (2015) described characteristics of CoPs as enabling "practitioners to take collective responsibility for managing knowledge...create a direct link between learning and performance... [and] address the tacit and dynamic aspects of knowledge creation and sharing" (p. 4). In other words, for teachers to engage in a successful CoP, they must have the authority to assume responsibility for the direction and focus of the CoP. Teachers are equal members within the CoP who listen and engage in discussions, intent to learn from one another. Facilitation duties are determined by and shared by CoP members. And most importantly, teachers have the agency to exercise changes to teaching practices resulting from engagement with the CoP.

However, CoPs present challenges. As experienced by Grossman et al. (as cited in Trabona et al., 2019), CoPs can evolve into pseudo-CoPs. Pseudo-CoPs have a membership portraying shared beliefs giving the "illusion of consensus" (p. 475). Trabona et al. (2019) applied a CoP framework to a qualitative study of experienced teachers engaged in a professional development leadership program to develop vertical alignment. Discourse regarding teaching practices between members of the CoP was superficial. Members avoided uncomfortable or potentially contentious discussions resulting in a pseudo-CoP. In many ways, pseudo-CoPs are reminiscent of ineffectively administered PLCs in which teachers are reluctant to reveal anything to colleagues.

Applying a less-structured, more organic organization to the CoP prompted

teachers to assume collective ownership of the CoP, increasing discourse and reflection regarding decisions teaching practices. In their study, Trabona et al. (2019) revealed the importance of supporting the evolution of an organic CoP, thereby empowering teachers to generate meaning from shared experiences with fellow practitioners. Through interactions as equal members of the CoP, the issue of power no longer exists. Teachers engage in authentic discourse as they examine alternate perspectives and critically reflect on their own teaching practices. In other words, teachers participate in fluid mentorship. As teachers within the CoP work toward addressing shared issues, they provide and receive feedback from colleagues, reflect, and construct meaning which impacts how they individually address the shared issues within their own teaching practices. With equal membership within CoPs teachers evolve as practitioners and gain a measure of autonomy (Breen, 2015) even when functioning within restrictive mandates.

**Reforming Education Reform**

Professional development opportunities are vital for teachers, serving as the primary mechanism for continued learning throughout their teaching career (Mooney Simmie & Moles, 2011). Through professional development, teachers stay up to date on new teaching strategies, technology applications and content advances. Research within STEM-related fields is constantly changing, making professional development an important resource for teachers of STEM-related content to stay current ensuring classroom lessons incorporate accurate information. However, accountability standards associated with education reform have pushed schools and school districts to provide teacher professional development designed to address mandates in lieu of addressing teacher-identified needs (Bressman et al., 2018; Jeong & Lushei, 2018; Mooney Simmie

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& Moles, 2011).

There is an increased reliance on external experts instructing teachers on evidenced-based teaching practices resulting from standardized tests and DDDM. When strictly adhered to, these external experts promote strategies which will successfully address imposed mandates (Hargreaves & Dawe, 1990). On the surface, this approach seems reasonable yet has not proven effective (Daly, 2015; Hargreaves & Dawe, 1990; Riveros et al., 2012). Based on their review of literature regarding teacher agency and teacher learning, Riveros et al. (2012) contended the inclusion of teachers as decision-makers while creating opportunity for teachers to engage in discourse with colleagues improved teaching practices, resulting in positive impacts on school culture and student achievement. Including teachers as decision makers yields better results for student achievement than teaching strategies proposed by external experts.

**Data Driven Decision Making and Teaching Practices**

Through interviews with elementary teachers, (N=17), Vanlommel et al. (2017) suggested intuition derived from experience, rather than data, is used by teachers to assess student mastery and inform teaching practices (Vanlommel et al., 2017). However, in a DDDM environment, intuition no longer suffices. In her presidential address to the 118th American Psychological Association convention, Mandinach (2012) emphasized the need for teachers to integrate data into their decision-making processes, thereby providing evidence for decisions which inform their teaching practice (Mandinach, 2012). "Effective data use requires going beyond the numbers and their statistical properties to make meaning of them" (Mandinach, 2012, p. 73). She further asserted the advent of DDDM brings the expectation teachers will determine the most appropriate

instructional strategy based on data analysis. Data must inform teaching practices, "but first [teachers] must become data literate in order to use data effectively" (p. 73).

### *Importance of Data Literacy*

Teachers are rarely afforded training through their districts or schools in research methods, data collection, and data analysis (Dunn et al., 2013; Vanlommel et al., 2017). From a review of literature regarding the impact of data on teaching practices, Datnow and Hubbard (2015) extrapolated professional development focused on DDDM should include a wide range of assessments and types of data with support as to how teachers can use data to inform instructional practices. However, data literacy training needs to extend beyond numbers. Dunn et al. (2013), conducted a quantitative study of teachers (N = 600) using structured equation modeling, to investigate teacher anxiety and efficacy related to application of DDDM to classroom. Dunn et al. (2013) found a direct association between teachers' beliefs in their data literacy and willingness to incorporate DDDM into their teaching practices. Teachers with low levels of data literacy showed a decreased belief in their ability to interpret data which contributed to a reluctance to engage in DDDM. Dunn et al. (2013) recommend DDDM and data analysis training to address skill levels, but caution training should address anxiety teachers may have regarding DDDM. Doing so will increase teachers' willingness to apply DDDM to their teaching practices.

Providing training to elevate data-literacy skills positively impacts teachers' ability to evaluate and apply policies derived from DDDM at higher administrative levels (Taylor, 2017). According to Taylor, when teachers understand the data used to generate the policies, they are more likely to support these policies and implement them in a more

effective manner. Developing a data-literate teacher corps empowers teachers in multiple

ways. Data literacy training increases teachers' ability to evaluate real-time data on

current students to better meet their educational needs. Training teachers in data-literacy

increases teachers' ability to evaluate research to inform teaching practices (Taylor,

2017). Through reviewing data from literature, teachers are more familiar with research

processes.

### *Data Literacy Professional Development*

There is inconsistency within the K-12 education system regarding data, from

defining data literacy to determining what data are needed to how best to train teachers to

apply data to the classroom (Ebbeler et al., 2017; Mandinach & Gummer, 2016; Wayman

& Jimerson, 2014). Wayman and Jimerson (2014) conducted a qualitative study in three

Texas school districts (N = 110). In the study, teachers expressed being overwhelmed by

the volume of data, lacking data analysis skills and uncertainty as to how to apply data to

their teaching practices (Wayman & Jimerson, 2014). When asked about training

preferences, teachers preferred small groups to "better engage with the material, the

presenter, and each other" (Wayman & Jimerson, 2014, p. 30).

However, the training they received did not align with these preferences.

Professional development addressing data literacy was conducted in large group settings

without opportunity for discussion. In the large group format, training was not aligned

with specific grade levels or content and did not address teacher data literacy needs. In

other words, "data-related professional learning was delivered in ways counter to their

[teacher] desires and prior research" (Wayman & Jimerson, 2014, p. 31).

The findings from Wayman and Jimerson are echoed by Mandinach and Gummer

(2016, p. 368) "for teachers to use data effectively, data must be contextualized within the content domain and its learning progressions." Ebbeler et al. (2017) also found context is important to improve data literacy skills. In a mixed-methods, quasi-experimental study, Ebbeler et al. (2017) found data literacy improved when teachers could collaboratively use data connected to their own teaching environment. Teachers responded positively to structured training with explicit instructions, meaning data literacy training needs to have a clear connection to and provide support for classroom application (Ebbeler et al., 2017).

Data is the driving force within education reform. Data driven decision making influences all levels within K-12 education, yet contextually disconnected data contributes to teacher uncertainty as to how data can inform teaching practices. Data literacy would help teachers analyze and interpret data, but the literature show teachers lack training in data literacy. The literature also show inconsistency as to how to define data literacy and thereby, how best to train teachers to be data literate.

**Teachers as Researchers**

"Teacher research is not simply limited to data found in one particular classroom aimed at student outcomes. It is the living voice of teachers" (Schwarz & Ray, 2018, p. 53). Education reform efforts have effectively silenced teachers voices as professionals within the K-12 education system. Shortly after the introduction of No Child Left Behind in 2001, Kincheloe (2003) wrote "outside reforms of education emerge from an ungrounded knowledge base, and as such reforms are imposed, teachers are further disenfranchised and alienated" (p. 35). He goes on to state education research excludes teachers, providing a vision of what is occurring inside classrooms through a lens far

removed from the day-to-day experiences of teachers.

In 1989, the American Association of Colleges for Teacher Education defined teachers as "professionals, worthy and able to make reflective decisions or judgements" (Cochran-Smith & Lytle, 1993, p. 41). Teachers have a way of knowing which grows out of their lived experience. Cochran-Smith and Lytle (1993, p. 43) contended "research by teachers is a significant way of knowing about teaching". They advocated for teachers to engage in research, positing such research is grounded in practice without the need for translation in order to be understood by other teachers.

Through qualitative analysis of interviews with teachers who engage in classroom research practices, Schwarz and Ray (2018) asserted "teacher research should be a tool for teacher growth and independence as well as a tool for school improvement" (p. 51). As with data-literacy, research training programs for teachers are scarce. However, this does not mean teachers are not engaging in research. Teachers pursuing higher degrees may participate as research projects sponsored through a university. Teacher professional organizations, such as the Science Teachers Association of Texas (STAT) and National Science Teachers Association (NSTA) provide teachers opportunity to author and publish research papers. These organizations do not engage in peer-review processes; however, they provide a conduit for teachers to learn from teachers who share a way of knowing.

Teachers who design and implement research within their own classroom strengthen connections between theory and teaching practices (Kyei-Blankson, 2013). In her mixed methods study of teacher researchers (N = 25), Kyei-Blankson found teachers who conducted their own research were more apt to adjust teaching practices as a direct result of data generated from the research. She also found teacher researchers readily

shared research outcomes with colleagues, inviting collaboration on future research efforts.

Due to the ever-evolving nature of teaching Kincheloe (2003) recommended teacher researchers engage in action research. Unlike traditional research which seeks a cause/effect relationship or a generalizable conclusion, Kincheloe advocated teachers engage in action research which is more adaptable to changing contexts. There is a higher likelihood of teachers implementing changes to teaching practices from data derived from self-generated research (Taylor, 2017). However, teacher research is vulnerable to issues related to trustworthiness, "it is important for classroom practitioners to seek means of developing their knowledge and skills in relation to research" (Xerri, 2018, p. 40).

Teachers have the capacity to implement research within their own classroom, generating data relevant to their teaching practices. Despite the impact teacher developed research could have on teaching practices, professional development for teachers to develop research skills is scarce. However, when trained in research and provided support to implement their own research, the research outcomes directly impact teaching practices.

**Teacher Agency**

Through a meta-study which reanalyzed empirical data from five primary studies into teacher agency, Vähäsantanen et al. (2015) identified teacher agency as having three components: "influence on one's own work, involvement with an educational reform, and the negotiation of professional identity" (p. 9-10). Agency is influenced by an individual's motivation, values (Hadar & Benish-Weisman, 2018), and sociocultural environment (Wild et al., 2018).

Hadar and Benish-Weisman (2018) identified openness-to-change and conservation values as factors influencing teacher agency through a quantitative study of K-12 teachers (N = 767). Teachers who demonstrate conservation values are resistant to change and possess lower levels of professional agency. Such teachers view change only in relation to how it impacts them (Hadar & Benish-Weisman, 2018). When faced with change, teachers who value conservation question how the entire system will be affected, where is the change originating from, and how will teacher responsibilities be impacted (Zeid et al., 2017). Conversely, teachers who are open to change interpret potential changes as an opportunity to implement innovative teaching strategies and enhance professional growth without experiencing a loss of agency (Zeid et al., 2017). In other words, teachers who are open to change do not view change as a threat to their professional agency.

**Teacher Agency within a CoP**

Wild et al. (2018) divided agentic teachers into two categories: self-transcendent and self-enhancement. Teachers who put the needs of others first are considered self-transcendent whereas self-enhancement teachers are motivated to enhance their practice. Self-transcendent teachers have lower professional agency than self-enhancement colleagues. Self-transcendent teachers would appear positive additions to a CoP for experienced teachers. However, Wild et al. (2018) found self-enhancement teachers a better fit for CoPs in their level of participation to promote professional growth.

In their research on teacher motivation and professional growth, Appova and Arbaugh (2018) identified motivated teachers as those who engage in self-reflection, evaluating their teaching practices, identifying areas of concern, and seeking professional

development to address these needs. These behaviors are indicative of high levels of professional agency, making these teachers important participants in a CoP program. Learning experiences are more effective at elevating professional agency when conducted in collaborative settings (Riveros et al., 2012).

Factors influencing learning and teacher professional agency need to be considered when developing a training program within a CoP framework. These factors affect teacher behaviors and values which in turn, impact school culture and student achievement. Experienced teachers need opportunity to share unique experiences which have shaped them as professionals, reinforcing the need for dialogue within a training CoP (Mooney Simmie & Moles, 2011). "Teachers can be agents of change beyond their own classrooms by working collectively in self-determined communities" (Wild et al., 2018, p. 315).

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**Summary**

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The review of the literature identified areas of uncertainty within the K-12 education system regarding teacher agency in an education reform environment. Education reform efforts rely on data and DDDM to inform teaching practices. Yet teachers lack training in data analysis and DDDM application. Research conducted outside of K-12 classrooms generates data which decision-makers use to set education policies and classroom mandates. However, research generated by classroom practitioners is devalued. Teachers lack training in data-literacy, DDDM, and research methods: three key pillars of K-12 education reform. The literature identifies a clear need to address these gaps to train teachers as researchers capable of analyzing data and applying DDDM to inform their teaching practices.

## III.  METHODOLOGY

## Overview of the Analytic Method

The neo-centralization of the public education system follows a top-down DDDM model to set policies and accountability standards. These policies and accountability standards remove teachers as decision-makers in their own classrooms. Evidence suggests teachers are not trained in research methods or DDDM (Mandinach et al., 2015; Marsh et al., 2015), both of which are integral components of current education reform. I hypothesized the professional development training program, Teachers as Researchers, will increase teacher understanding of research methods and DDDM thereby positively impacting teaching practices and teacher professional agency. I quantitatively assessed each of the following research questions:

RQ 1: Is there a statistically significant relationship between Research

Methodology and Teaching Practices?

RQ 2: Is there a statistically significant relationship between Research

Methodology and Teacher Professional Agency?

RQ 3: Is there a statistically significant relationship between DDDM and

Teaching Practices?

RQ 4: Is there a statistically significant relationship between DDDM and Teacher

Professional Agency?

RQ 5: Is Teaching Practices a statistically significant mediator between Research

Methodology and Teacher Professional Agency?

RQ 6: Is Teaching Practices a statistically significant mediator between DDDM

and Teacher Professional Agency?

Figure 1 illustrates the hypothetical relationships between the study variables: research methodologies to teaching practices and teacher professional agency; DDDM to teaching practices and teacher professional agency; teaching practices to teacher professional agency; association between research methodologies and DDDM.

Research Methodologies — $\rho_{31}$ → Teaching Practices — $\rho_{34}$ → Teacher Professional Agency

Research Methodologies — $\rho_{41}$ → Teacher Professional Agency

$\rho_{12}$ (between Research Methodologies and Data Driven Decision Making)

Data Driven Decision Making — $\rho_{32}$ → Teaching Practices

Data Driven Decision Making — $\rho_{42}$ → Teacher Professional Agency

Teaching Practices ← 1 — $e_3$

Teacher Professional Agency ← 1 — $e_4$
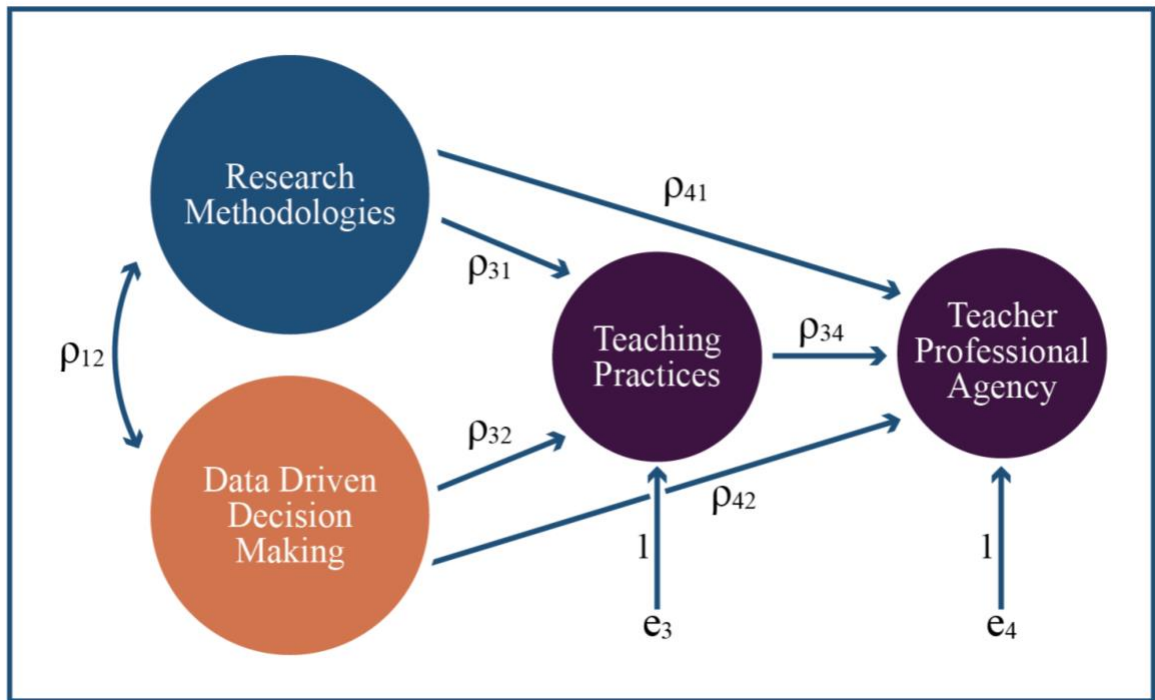
**Figure 1**

*Hypothetical Path Diagram between Program Interventions, Teaching Practices and Professional Agency*

*Note*: This figure illustrates the hypothetical relationships between exogenous variables (Research Methodologies and DDDM), mediating variable (Teaching Practices), and endogenous variable (Teacher Professional Agency).

*$\rho_{12}$ = denotes bivariate correlation between exogenous variables; $\rho_{xy}$ = path coefficients associated with causal pathways between variables; $e_4$= denotes error associated with non-identified variables

I structured the professional development as a CoP. In describing CoPs, Wenger and Wenger-Trayner (2015, p. 4) stated CoPs support knowledge creation as CoPs promote "autonomy, practitioner-orientation, informality, [and] boundary crossing". However, Wenger and Wenger-Trayner cautioned these very characteristics create challenges for CoPs when set within "traditional hierarchical organizations" (2015, p. 4). As this study engaged teachers outside of the hierarchical setting of school, applying a CoP framework enabled teachers to interact with colleagues who share a common interest to learn about research methods and DDDM. Communities of practice provide a framework for increased teacher agency as indicated by Good et al. (2017). In their case study, Good et al. identified teacher agency increased when teachers engage with other teachers "outside of the control structures in their schools where they can build capacity and be seen as professionals with expertise" (2017, p. 517).

## Study Population

### Recruitment

After defense of the proposal, the study was reviewed and deemed "exempt" by the Texas State Institutional Review Board (IRB). The IRB approved the plan to recruit teachers through multiple venues, including local STEM teacher professional development events. Notifications about the study were sent to approximately 400 area secondary STEM teachers through the Teacher Enrichment Initiatives (TEI), an organization which provides teacher professional development through the University of Texas Health San Antonio. In full disclosure, I am the Educational Development Specialist for TEI. The notifications provided interested teachers with instructions to email me for additional information. When contacted, I provided interested teachers with

the link to the study application, posted to Qualtrics, as approved by the IRB. Upon completion of the application, teachers were provided with links to the pretests associated with the professional development. Completion of the pretests served as consent to participate in the study as approved by the IRB.

**Inclusion Criteria**

The inclusion criteria for this study were current secondary teachers, sixth through twelfth grade, with a minimum of five years teaching experience within STEM content. Escalating national and international emphasis on developing STEM career pathways, as well as my experience as a high school science teacher, guided the decision to focus on secondary STEM teachers. For this study, STEM teachers were defined as teaching general science or math within middle school, grades sixth through eighth. High school STEM content included natural sciences and physical sciences. Natural sciences include but are not limited to biology, environmental systems, anatomy and physiology, and aquatic science. The physical sciences include, but are not limited to chemistry, physics, and astronomy. Engineering, robotics, math, and computer science teachers were also eligible to participate in the study. Teachers were not randomly assigned to participate in the professional development but applied to the program due to an interest in research methods and DDDM. Given this approach, the study was quasi-experimental.

As previously stated, my rationale for focusing on this particular population is based on a national focus on STEM-related careers. Since the endogenous variable for the study is professional agency, I assumed experienced teachers would have an established sense of professional agency as well as a greater depth of teaching practices from which to draw comparisons pre- and post-participation in the professional development.

Additionally, experienced teachers would have a history of professional development participation, including research methodologies and DDDM. This history would provide a basis for comparison for the Teachers as Researchers professional development program.

**Impact of COVID-19**

The research methods and DDDM professional development at the heart of the study were scheduled as an in-person event, from June 22 through 25, 2020, following completion of the traditional K-12 school calendar. Preliminary interest in the event led to an anticipated attendance of 50+ teachers. However, due to the advent of COVID-19 pandemic, the university Institutional Review Board implemented protocols to minimize virus transmission. As such, the program changed from an in-person format to an online format. This in itself was not an issue as I secured access to an online learning platform sufficient to meet the needs of the program. However, just as general population priorities shifted, so did those of teachers. Teachers who had previously indicated an interest in participating were understandably focused on more immediate concerns regarding personal safety, family health, and the impact the pandemic could have on the future of K-12 education and their teaching careers.

**Sample Size**

Despite the shift from in person delivery to an online format, 30 secondary STEM teachers registered for the professional development. Of the 30 registered teachers, one did not meet the criteria based on lack of teaching experience. This individual was included in the professional development program; however, data were not collected from this teacher. Of the remaining 29 teachers registered, six withdrew prior to

completing the study pretests. Two of the remaining 23 teachers completed the pretest but did not attend the professional development. Of the remaining 21 teachers, one teacher attended the professional development but did not complete the pretests. Although this teacher completed the program and three of the four posttests, these data were not included in the final data analysis. A total of 20 teachers who met the study criteria participated in all aspects of the study.

Sixteen of the teachers are female (80%), which is slightly higher than the percent of female teachers (75.5%) in the San Antonio region (Texas Education Agency, 2019). The range of teaching experience spanned from five years to 30 years, with an average of 13.75 years teaching experience. Figure 2 represents the distribution of teaching experience within the following ranges: five to 10 years, 11 to 15 years, 16 to 20 years, 21 to 25 years, and 26 to 30 years. There is a higher representation of teachers with 15 or fewer years teaching experience (65%) as compared to teachers with over 15 years teaching experience (35%).



**Figure 2**

*Years Teaching Experience*

According to Mertler and Reinhart (2017) the reliability of correlation coefficients derived from quantitative analyses are sensitive to the power of study participants. Tabachnick and Fidell (2007) indicated quantitative analysis studies with small sample sizes, < 50, have very poor reliability. However, Tabachnick and Fidell (2018) later stated "if there are strong correlations and a few, distinct factors, a smaller sample size is adequate" (p. 666). They cautioned smaller sample sizes may result in failure of the solution to converge. Due to the small sample size, I applied Bayesian analysis to the resulting data to estimate the hypothesis' probability as well as identify relationships between study variables (Kline, 2016).

**Prior Professional Development**

As part of the registration, teachers were asked to indicate attendance at previous professional development offered through their school or district related to research methodologies, research design, DDDM, data analysis, and teaching strategies. Teachers also provided information regarding formal coursework related to qualitative, quantitative, and general research methodologies, indicating the education level of each course. Finally, teachers were asked to self-identify their research experience level as novice, intermediate, or expert. Teachers were given the option to indicate not applicable for this category. These data are reflected in Table 1.

**Table 1**

*Pre-participation Professional Development*

| | School or District Professional Development | | | | | |
|---|---|---|---|---|---|---|
| | Research Methodologies | Research Design | DDDM | Data Analysis | Teaching Strategies | No Response |
| Teachers[*] | 1 (5%) | 2 (10%) | 5 (25%) | 6 (30%) | 16 (80%) | 5 (25%) |

| | Formal University Coursework | | | | | | |
|---|---|---|---|---|---|---|---|
| | Qualitative Research Methods | | Quantitative Research Methods | | General Research Methods | | No Formal Courses |
| Level | undergraduate | graduate | undergraduate | graduate | undergraduate | graduate | |
| Teachers* | 6 (30%) | 4 (20%) | 5 (25%) | 4 (20%) | 5 (25%) | 5 (25%) | 9 (45%) |

| | Self-Identified Research Experience Level | | | |
|---|---|---|---|---|
| | Novice | Intermediate | Expert | Not Applicable |
| Teachers | 7 (35%) | 2 (10%) | 1 (1%) | 10 (50%) |

[*] Individual teachers participated in multiple professional development and formal coursework.

Of the 20 participating teachers, one (5%) attended a professional development about research methodologies (5%), while two attended research design (10%). Five teachers previously attended DDDM professional development (25%) and six attended data analysis professional development (30%). Twenty teachers (80%) attended professional development about teaching strategies.

Teachers were also asked to indicate formal education courses related to qualitative and quantitative research completed prior to participating in this study. At the undergraduate level, six teachers (30%) completed qualitative research courses, while four (20%) completed quantitative research courses. At the graduate level, four (20%) indicated completion of both quantitative and qualitative research courses. Five of the remaining teachers completed a general research course at the undergraduate level (25%) and at the graduate level (25%). However, when asked to rate their level of expertise with research methods, seven (35%) self-identified as novice, two (10%) identified as

intermediate, and one (5%) identified as expert. The remaining 10 (50%) teachers selected not applicable.

On the registration document, teachers were asked to briefly describe why they were interested in participating in the professional development workshops and study. The most cited reason was to improve data skills to apply to instruction (55%), followed by to support student achievement or academic growth (45%). This was followed by interest in research (40%) and a general interest in learning for professional growth (30%). Of the 11 teachers who indicated a desire to improve data skills, nine (82%) indicated improving their data skills would support students.

**Teachers as Researchers Professional Development Program**

The professional development program was divided into three-hour sessions conducted over a four-day period. The program consisted of four modules: Establishing a Researcher Mindset, Communicating Research Outcomes, Applying Data and DDDM to Inform Teaching Practices, and Integrating Research into the Classroom. Table 2 outlines the training program and topics addressed.

**Table 2**

*Teachers as Researchers Program Modules*

| Program Modules | Topics |
|---|---|
| Module One: Establishing a Researcher Mindset | Defining "Researcher Mindset" Exploring Methodologies |
| Module Two: Communicating Research Outcomes | Applying Research Methods to the Classroom Consulting Literature, Research and Data |
| Module Three: Applying Data and DDDM to Teaching Practices | Data Culture in Work Environment Data Literacy and the DDDM Cycle |
| Module Four: Integrating Research into the Classroom | Interpreting Data Identifying Potential Classroom Research Developing Hypotheses and Potential Impacts |

A structured equation model (SEM) path analysis was used to determine correlations between Research Methodologies and DDDM training modules and any associated effects on Teaching Practices and Teacher Professional Agency. I selected path analysis for this study as it can reveal direct and indirect effects between variables as well as test overall fit between the actual resulting data and the hypothetical model (Mertler & Reinhart, 2017).

### Key Terms

- Bayesian analysis: "a set of methods for the orderly expression and revision of support for hypotheses as new evidence is gathered and combined with extant knowledge" (Kline, 2016, p. 23).

- Correlation: level of association that exists between variables in a standardized solution; in path analysis, correlations are measured between exogenous variables with Pearson's coefficient (r). However, due to the small sample size, Spearman's coefficient ($\rho$) was more appropriate (Kline, 2016).

- Covariance: level of association that exists between variables in an unstandardized solution (Kline, 2016).

- Direct causal pathway: linear effect between exogenous variable and endogenous variable (Mertler & Reinhart, 2017).

- Endogenous variable: a variable explained by a causal pathway within path analysis; analogous to a dependent variable although not the appropriate term in path analysis. (Mertler & Reinhart, 2017).

- Exogenous variable: a variable not explained by a causal pathway within path analysis; analogous to an independent variable although not the appropriate term in path analysis (Mertler & Reinhart, 2017).

- Indirect causal pathway: inclusion of mediating variable in path connecting exogenous and endogenous variables (Mertler & Reinhart, 2017).

- Mediating Variable: an intervening variable; "it transmits part of the effect of a causally prior variable to a third variable" (Kline, 2016, p. 134).

- Non-parametric data: due to the small sample size, no assumptions were made about the distribution of data (Hurlburt, 2012).

- Path analysis: multiple regression analysis used to determine causal relationships between variables; "method of analyzing correlations among a set of variables to determine pattern of causal relationships" (Mertler & Reinhart, 2017, p. 365).

- Path coefficients (aka: pattern coefficients): a statistical estimate of the direct effect or amount of change, each exogenous variable has on the mediating variable (teaching practices) and endogenous variable (teacher professional agency); also commonly referred to as factor loadings (Mertler & Reinhart, 2017).

- Quasi-experimental design: the study did not include a control group, therefore, all participants engaged in the research methods and DDDM professional development.

- Score reliability: "only one observed measure for each hypothetical construct" (Kline, 2016, p. 127) requiring each instrument used in the study have strong psychometrics.

## Study Variables

This study examined the impact of a research training program on teacher professional agency. Application of SEM path analysis provided a model for direct and indirect effects of exogenous variables on the mediating variable, teaching practices, and endogenous variable, teacher professional agency. Training modules one and two align with the exogenous variable, research methods, assessed with the validated instrument Perceived Research Competency Index (Davis & Jones, 2017). Training module three aligns with exogenous variable DDDM, assessed with the validated instrument Data Driven Decision-Making Efficacy and Anxiety Inventory, 3D-MEA (Dunn et al., 2013). Module four represents the mediating variable teaching practices, assessed by the Teachers' Preferences for Learning Activities Scale (Louws et al., 2017). At the conclusion of the professional development, teachers completed the Multidimensional Professional Agency Scale (Vähäsantanen et al., 2019) to assess the impact of the intervention on their professional agency. Teachers completed the scales which were posted on Qualtrics.

## Instrumentation

This study applied a posttest model using validated scales to assess each variable. The assessment instruments for research methods and DDDM are the Perceived Research Competency Index (Davis & Jones, 2017) and the 3D-MEA Inventory (Dunn et al., 2013), respectively. The mediating variable, teaching practices, was assessed through the Teachers' Preferences for Learning Activities Scale (Louws et al., 2017). The endogenous variable, teacher professional agency, was assessed by the Multidimensional Professional Agency Scale (Vähäsantanen et al., 2019).

Although the scales were validated, I assessed the reliability of the scales, comparing Cronbach's alpha scores from the pretests, including associated scale factors, to the Cronbach's alpha from the validation studies for each scale. The reliability results are presented in Table 3. Due to the small sample size, I elected not to run a confirmatory factor analysis.

**Table 3**

*Scale and Factor Reliability Comparison*

| Scale | Factor | Items (N) | Cronbach's Alpha Original | Cronbach's Alpha Pretest |
|---|---|---|---|---|
| Perceived Research Competency Index | No Factors | 19 | **.94** | **.95** |
| 3D-MEA | F1: Efficacy for application of data to instruction | 6 | **.92** | **.92** |
| | F2: Data driven decision making anxiety | 5 | **.87** | **.71** |
| | F3: Efficacy for data technology use | 3 | **.89** | **.83** |
| | F4: Efficacy for data identification and access | 3 | **.87** | **.77** |
| | F5: Efficacy for data analysis and interpretation | 3 | **.73** | .64 |
| Teachers' Preferences for Learning Activities Scale | F1: Reflection on practice and collaboration | 5 | **.70** | **.88** |
| | F2: Training and keeping up to date | 4 | **.70** | **.74** |
| | F3: Experimenting | 2 | **.70** | **.82** |
| Multidimensional Professional Agency | F1: Influencing at work | 6 | **.75** | **.80** |
| | F2: Developing work practices | 7 | **.74** | **.76** |
| | F3: Negotiating professional identity | 4 | **.75** | **.77** |

*Note*. acceptable values of Cronbach's alpha range from .70 to .95 and are shown in bold.

## Data Screening

I used SPSS to analyze the data. Due to the non-parametric data related to the small sample size and the use of Likert-scale surveys, I applied Spearman's correlation coefficient, rho ($\rho$), to measure the correlation strength between variables. Data inputs were screened for missing data and accuracy. However, there were no missing data as teachers who did not meet the content and years of service requirements as well as

completion of the four pretests and four posttests were excluded. All study instruments are Likert scales anchored one to five. The data were evaluated with descriptive statistics, such as means and standard deviations, and screened for normality by checking level of skewness (positive or negative) and kurtosis (positive or negative).

## Data Analysis

In this quasi-experimental study, I sought to identify the causal effect of a professional development program focused on research methodologies and DDDM on teaching practices and teacher professional agency. I selected path analysis for this study as it can reveal direct and indirect correlated effects between the variables within the hypothetical model (Mertler & Reinhart, 2017).

Most teachers lack access to professional development addressing research methods, DDDM (Datnow & Hubbard, 2015; Dunn et al., 2013; Vanlommel et al., 2017), and data literacy (Dunn et al., 2013; Taylor, 2017). Although I anticipated a positive impact of a professional development program addressing these deficiencies, I elected a-priori to conduct a non-directional, two-tailed analysis of the non-parametric data derived from the pretests (Table 4), the posttests (Table 5), and the pretests/posttests deltas (Table 6).

The significance values which fall below the standard criterion of .05 indicate statistically significant relationships between Perceived Research Competencies (Davis & Jones, 2017) and Teachers' Preference for Learning Activities (Louws et al., 2017) as well as between Perceived Research Competencies (Davis & Jones, 2017) and Multidimensional Professional Agency Scale (Vähäsantanen et al., 2019 )on the pretests (Table 4), posttests (Table 5), and pretests/posttests deltas (Table 6).

**Table 4**

*Pretests: Non-parametric Correlation Matrix*

|  |  | Multidimensional Professional Agency Scale | Perceived Research Competency Index | Teachers' Preference for Learning Activities Scale | 3D-MEA |
|---|---|---|---|---|---|
| Multidimensional Professional Agency Scale | Spearman Correlation | 1 |  |  |  |
|  | Sig. (2-tailed) | - |  |  |  |
|  | N | 20 |  |  |  |
| Perceived Research Competency Index | Spearman Correlation | **.54**[*] | 1 |  |  |
|  | Sig. (2-tailed) | .02 | - |  |  |
|  | N | 20 | 20 |  |  |
| Teachers' Preference for Learning Activities Scale | Spearman Correlation | .22 | **.51**[*] | 1 |  |
|  | Sig. (2-tailed) | .36 | .02 | - |  |
|  | N | 20 | 20 | 20 |  |
| 3D-MEA | Spearman Correlation | .33 | .11 | .07 | 1 |
|  | Sig. (2-tailed) | .16 | .64 | .78 | - |
|  | N | 20 | 20 | 20 | 20 |

[*] Correlation is significant at the 0.05 level (2-tailed) and shown in bold

**Table 5**

*Posttest: Non-parametric Correlation Matrix*

|  |  | Multidimensional Professional Agency Scale | Perceived Research Competency Index | Teachers' Preference for Learning Activities Scale | 3D-MEA |
|---|---|---|---|---|---|
| Multidimensional Professional Agency Scale | Spearman Correlation | 1 |  |  |  |
|  | Sig. (2-tailed) | - |  |  |  |
|  | N | 20 |  |  |  |
| Perceived Research Competency Index | Spearman Correlation | **.53**[*] | 1 |  |  |
|  | Sig. (2-tailed) | .02 | - |  |  |
|  | N | 20 | 20 |  |  |
| Teachers' Preference for Learning Activities Scale | Spearman Correlation | .21 | .35 | 1 |  |
|  | Sig. (2-tailed) | .37 | .14 | - |  |
|  | N | 20 | 20 | 20 |  |
| 3D-MEA | Spearman Correlation | .44 | .43 | .40 | 1 |
|  | Sig. (2-tailed) | .06 | .06 | .09 | - |
|  | N | 20 | 20 | 20 | 20 |

[*] Correlation is significant at the 0.05 level (2-tailed) and shown in bold

**Table 6**

*Delta: Non-parametric Correlation Matrix*

| | | Multidimensional Professional Agency Scale | Perceived Research Competency Index | Teachers' Preference for Learning Activities Scale | 3D-MEA |
|---|---|---|---|---|---|
| Multidimensional Professional Agency Scale | Spearman Correlation | 1 | | | |
| | Sig. (2-tailed) | - | | | |
| | N | 20 | | | |
| Perceived Research Competency Index | Spearman Correlation | **.63**[**] | 1 | | |
| | Sig. (2-tailed) | .00 | - | | |
| | N | 20 | 20 | | |
| Teachers' Preference for Learning Activities Scale | Spearman Correlation | .24 | **.53**[*] | 1 | |
| | Sig. (2-tailed) | .31 | .02 | - | |
| | N | 20 | 20 | 20 | |
| 3D-MEA | Spearman Correlation | .07 | .05 | .14 | 1 |
| | Sig. (2-tailed) | .78 | .85 | .55 | - |
| | N | 20 | 20 | 20 | 20 |

[**] Correlation is significant at the 0.01 level (2-tailed). [*] Correlation is significant at the 0.05 level (2-tailed) and shown in bold

## Summary

These data indicate strong correlations between research methodologies and professional agency ($\rho = .631$), as well as between research methodologies and teaching practices ($\rho = .528$). However, DDDM does not appear to have a significant impact on teaching practices ($\rho = .144$) or professional agency ($\rho = .068$).

# IV.  RESULTS

Through a professional development program, Teachers as Researchers, I sought to quantitatively identify associations between research methodologies and DDDM and the impact of these variables on teaching practices and teacher professional agency. I hypothesized the professional development training program, Teachers as Researchers, will increase teacher understanding of research methods and DDDM thereby positively impacting teaching practices and teacher professional agency. I quantitatively evaluated the hypothesis through the following research questions:

RQ 1: Is there a statistically significant relationship between Research Methodology and Teaching Practices?

RQ 2: Is there a statistically significant relationship between Research Methodology and Teacher Professional Agency?

RQ 3: Is there a statistically significant relationship between DDDM and Teaching Practices?

RQ 4: Is there a statistically significant relationship between DDDM and Teacher Professional Agency?

RQ 5: Is Teaching Practices a statistically significant mediator between Research Methodology and Teacher Professional Agency?

RQ 6: Is Teaching Practices a statistically significant mediator between DDDM and Teacher Professional Agency?

This study quantitatively assessed the responses of 20 secondary STEM teachers with five or more years teaching experience who participated in a professional development program focused on research methodologies and data driven decision

making. Using validated Likert-scales to assess study variables, I sought to identify

significant relationships between two exogenous variables, research methodologies and

DDDM, the mediating variable teaching practices, and the endogenous variable

professional agency. The professional development consisted of four modules: two

addressing research methodologies and two addressing data driven decision making. To

assess each variable, teachers completed pretests/posttests of validated scales aligned

with each variable. Descriptive statistics for each pretest/posttest are detailed in Table 7.

**Table 7**

*Pretest/Posttest Descriptive Statistics for Validated Scales*

| Variable | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| Pretest: Research Methodologies [a] | 20 | 3.3 | .63 | .14 |
| Posttest: Research Methodologies [a] | 20 | 4.2 | 38 | .09 |
| | | | | |
| Pretest: 3D-MEA [b] | 20 | 3.4 | .63 | .14 |
| Posttest: 3D-MEA [b] | 20 | 4.3 | .44 | .10 |
| | | | | |
| Pretest: Teaching Practices [c] | 20 | 3.8 | .72 | .16 |
| Posttest: Teaching Practices [c] | 20 | 4.2 | .58 | .13 |
| | | | | |
| Pretest: Professional Agency [d] | 20 | 3.7 | .46 | .10 |
| Posttest: Professional Agency [d] | 20 | 4.2 | .48 | .11 |

[a] Perceived Research Competency Index (Davis & Jones, 2017). [b] 3D-MEA Inventory (Dunn et al., 2013). [c]

Teachers' Preference for Learning Activities Scale (Louws et al., 2017). [d] Multidimensional Professional

Agency Scale (Vähäsantanen et al., 2019).

The mean values for the validated scales were: Perceived Research Competency

Index (pretest = 3.26; posttest = 4.20), 3D-MEA Inventory (pretest = 3.39; posttest =

4.32), Teachers' Preference for Learning Activities Scale (pretest = 3.76; posttest = 4.22),

and Multidimensional Professional Agency Scale (pretest = 3.70; posttest = 4.21). As

indicated by the 2-tailed test, as shown in Table 8, the resulting positive change between

the pretests and posttests for all assessments were significant.

**Table 8**

*Change from Before and After Professional Development*

| | t | df | Test Value = 0 Sig. (2-tailed) | Mean Difference | 95% CI of the Difference Lower | Upper |
|---|---|---|---|---|---|---|
| Perceived Research Competency Index | 7.7 | 19 | **.00***| .94 | .68 | 1.2 |
| 3D-MEA | 7.7 | 19 | **.00***| .93 | .68 | 1.2 |
| Teachers' Preference for Learning Activities Scale | 2.5 | 19 | **.02***| .46 | .07 | .86 |
| Multidimensional Professional Agency Scale | 5.1 | 19 | **.00***| .51 | .30 | .72 |

* The t-score is significant at the 0.05 level (2-tailed)

The differences in the mean values for each assessment instrument are represented in Table 8. I set the test value at zero, in essence measuring the results to the null hypothesis of no effect or impact resulting from the professional development modules. The greater the distance between the data and the null hypothesis, the larger the t-value. The positive mean difference between the pretest and posttest for each instrument indicates the professional development had a significant impact on each of the study variables. In general, the data indicate participating teachers had significant gains in each professional development module.

## Bayesian Analysis

To answer these research questions, I ran Bayesian analysis. Bayesian analysis is a technique that analyzes at interdependent relationships between variables using probabilistic analysis to examine the simultaneous relationship among variables. It differs from classical statistics in that it can be used for small sample sizes and/or non-parametric variables. The relationships between the variables is shown in Table 9 and Figure 3.

**Table 9**

*Bayesian Analysis: Delta of Study Variables*

| | Mean ($\beta$) | Std. Error | Std. Deviation | 90% Lower Bound | 90 % Upper Bound |
|---|---|---|---|---|---|
| **Regression Weights** | | | | | |
| Δ Teaching Practices [a] → Δ Professional Agency [b] | -0.063 | 0.003 | 0.14 | -0.29 | 0.16 |
| Δ Research Competence [c] → Δ Professional Agency | **0.52**[*] | 0.004 | 0.21 | 0.18 | 0.86 |
| Δ 3D-MEA [d] → Δ Professional Agency | 0.052 | 0.003 | 0.19 | -0.26 | 0.37 |
| Δ Research Competence → Δ Teaching Practices | **0.64**[*] | 0.008 | 0.38 | 0.025 | 1.3 |
| Δ 3D-MEA → Δ Teaching Practices | 0.17 | 0.006 | 0.39 | -0.47 | 0.81 |
| **Covariance** | | | | | |
| Δ Research Competence ↔ Δ 3D-MEA | 0.013 | 0.005 | 0.12 | -0.174 | 0.201 |

[*] reject $H_0$ (null hypothesis)

*Note*: Beta is the standard regression coefficient and is both a measure of statistical and practical significance. [a] Teachers' Preference for Learning Activities Scale (Louws et al., 2017). [b] Multidimensional Professional Agency Scale (Vähäsantanen et al., 2019). [c] Perceived Research Competency Index (Davis & Jones, 2017). [d] 3D-MEA Inventory (Dunn et al., 2013).

The sample size was limited because of COVID-19. This reduced the power of the study and may have impacted the findings. Specifically, the small power of the sample increased the likelihood of Type II error, meaning not finding significance where significance may exist.
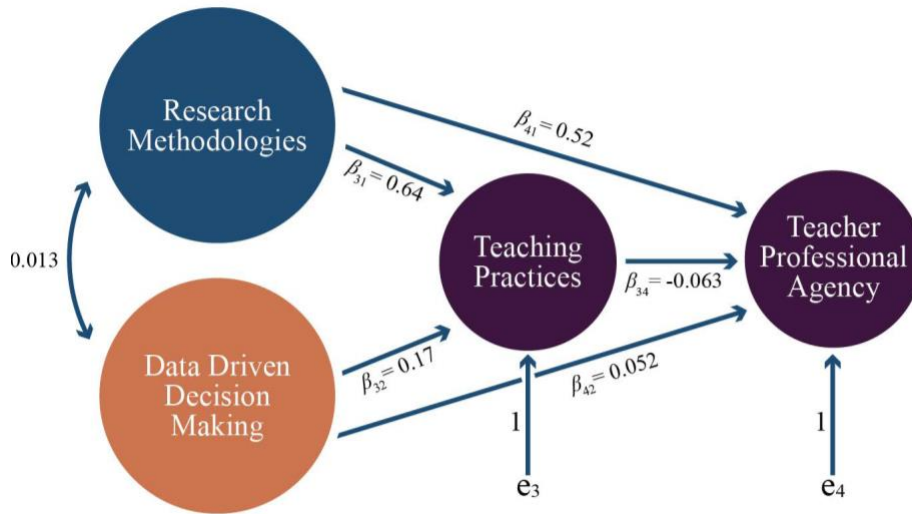
**Figure 3**

*Bayesian Analysis: Simultaneous Relationships Among Variables*

## Research Questions

### RQ1: Research Methodologies and Teaching Practices

RQ 1: Is there a statistically significant relationship between Research Methodologies and Teaching Practices? As indicated in Table 9, the non-parametric evaluation of the change in mean scores of pretests and posttests for each variable show a significant positive relationship ($0.025 < \beta < 1.3$) between the mean scores of the Perceived Research Competency Index (Davis & Jones, 2017) and the Teachers' Preference for Learning Scale (Louws et al., 2017). In other words, as participating teachers' self-identified level of confidence in research methodologies increased, there was an associated increase in teachers' self-identified preferences for teaching practices. Based on these data, I can reject the null hypothesis.

### RQ2: Research Methodologies and Teacher Professional Agency

RQ 2: Is there a statistically significant relationship between Research Methodologies and Teacher Professional Agency? As indicated in Table 9, the non-parametric evaluation

of the change in mean scores of pretests and posttests for each variable indicate a

significant positive relationship ($0.18 < \beta < .86$) between the mean scores of the

Perceived Research Competency Index (Davis & Jones, 2017) and the Multidimensional

Professional Agency Scale (Vähäsantanen et al., 2019). Based on these data, I can reject

the null hypothesis.

**RQ3: Data Driven Decision Making and Teaching Practices**

RQ 3: Is there a statistically significant relationship between DDDM and

Teaching Practices? As shown in Table 9, the non-parametric evaluation of the change in

mean scores of pretests and posttests for each variable do not indicate a significant

relationship ($-0.47 < \beta < .81$) between the 3D-MEA Inventory (Dunn et al., 2013) and

Teachers' Preference for Learning Scale (Louws et al., 2017). These data indicate I am

not able to reject the null hypothesis of $H_0 = 0$ as a beta weight of 0 is a possibility. In

other words, it is possible DDDM does not have an association with teaching practices.

**RQ4: Data Driven Decision Making and Teacher Professional Agency**

RQ 4: Is there a statistically significant relationship between DDDM and Teacher

Professional Agency? As shown in Table 9, the non-parametric evaluation of the change

in mean scores of pretests and posttests for each variable do not indicate a significant

relationship ($-0.26 < \beta < .37$) between the 3D-MEA Inventory (Dunn et al., 2013)

Multidimensional Professional Agency Scale (Vähäsantanen et al., 2019). These data

indicate I am not able to reject the null hypothesis of $H_0 = 0$ as a beta weight of 0 is a

possibility.

**RQ5 and RQ 6: Teaching Practices as a Mediator**

Research questions 5 and 6 center on Teaching Practices as if it is a significant

mediation between the Research Methodologies and the Teacher Professional Agency (RQ 5) and between DDDM and Teacher Professional Agency (RQ 6). As indicated in Table 9, the non-parametric evaluation of the change in mean scores of pretests and posttests ($-0.29 < \beta < .16$) for the Teachers' Preference for Learning Scale (Louws et al., 2017) and the Multidimensional Professional Agency Scale (Vähäsantanen et al., 2019) do not indicate a significant relationship as a mediating variable with either the Perceived Research Competency Index (Davis & Jones, 2017) or the 3D-MEA Inventory (Dunn et al., 2013) on the Multidimensional Professional Agency Scale (Vähäsantanen et al., 2019). These data indicate I am not able to reject the null hypothesis of $H_0 = 0$ as a beta weight of 0 is a possibility, indicating teaching practices is not a significant mediator for Research Methodologies or DDDM.

## Summary

Twenty secondary STEM teachers participated in this study. Due to the smaller than anticipated number of participants, Bayesian analysis was applied to the data, revealing significant associations between variables: Research Methodologies/Teaching Practices and Research Methodologies/Professional Agency. When comparing data from the pretests to the posttests, teachers experienced significant growth within each individual variable. However, the only exogenous variable which exerted a level of influence on other variables within study is research methodologies.

## V. DISCUSSION

Teachers work in an environment which is driven by data and education research; yet teachers are rarely afforded the opportunity to engage in professional development to develop research skills (Meister, 2010) or participate in data driven decision making which informs teaching practices (Jeong & Luschel, 2018). Within the hierarchical structure of schools, teachers perceive themselves as having little influence on policy (Good et al., 2017). There are indications teacher perceptions of placement within school structures combined with a lack of professional development addressing data literacy, DDDM, and research methods limits teachers as decision makers within the classroom, negatively influencing teaching practices and teacher professional agency (Appova & Arbaugh, 2018; Jeong & Luschel, 2018). These indicators suggest some associations between research methodologies, DDDM, teaching practices, and teacher professional agency. In this study, I sought to quantitatively determine those associations.

Study participants consisted of 20 secondary STEM teachers with five or more years teaching experience. The rationale for limiting the study to experienced teachers is based on the assumption this population of teachers will have established teaching practices as well as a sense of their own professional agency. In addition, this population of teachers has more experience with professional development programs, both mandatory and voluntary. As this study is grounded in the theory of communities of practice, it was important to focus on teachers who have a history of interactions with colleagues, whether through formal PLCs, conferences, and informal networking opportunities. These teachers possess a foundation of experiences which enable them to assess changes to their teaching practices and professional agency as a direct result of

their participation in the program.

I hypothesized a correlation between exogenous variables research methodologies and DDDM with each having a separate association with teaching practices and teacher professional agency. I further hypothesized teaching practices would serve as a mediator for research methodologies and DDDM on teacher professional agency. The exogenous variables of research methodologies and DDDM were presented in separate modules within a 12-hour professional development program, divided into four three-hour virtual sessions.

Bayesian analysis of changes to mean scores from the Perceived Research Competency Index (Davis & Jones, 2017), the Teachers' Preference for Learning Scale (Louws et al., 2017) and the Multidimensional Professional Agency Scale (Vähäsantanen et al., 2019) revealed the research methodologies module had a statistically significant effect on teaching practices ($\beta = 0.64$) and teacher professional agency ($\beta = 0.52$). However, Bayesian analysis of changes to mean scores of the 3D-MEA Inventory (Dunn et al., 2013) did not indicate significant changes to teaching practices ($\beta = .17$) or teacher professional agency ($\beta = .052$) as assessed by the Teachers' Preference for Learning Scale (Louws et al., 2017) and the Multidimensional Professional Agency Scale (Vähäsantanen et al., 2019). Additionally, when comparing the mean scores of the Teachers' Preference for Learning Scale (Louws et al., 2017) and the Multidimensional Professional Agency Scale (Vähäsantanen et al., 2019), there was no significant change ($\beta = -.063$), indicating teaching practices did not prove to be a mediating variable for research methodologies or DDDM on professional agency.

**General Overview**

Despite the small number of participants, the study data are reflective of the literature. As teachers' level of confidence in research methods increased, so did their professional agency. The data also a positive impact on teaching practices as teacher confidence in research methods increased. Prior research showed a positive connection between teacher-conducted research and professional agency (Thompson et al., 2018) and elevated teaching practices (Kyei-Blankson, 2013). Kyei-Blankson (2013) revealed teacher-led research increases the application of theory to teaching practices. Thompson et al. (2018) found when teachers apply research methods, their agency increases by empowering them to investigate and adjust teaching practices based on their own findings.

Comparisons between the pretest and posttest descriptive statistics show all participating teachers experienced statistically significant growth in the four study variables: research methods, DDDM, teaching practices, and professional agency. The standard deviation for three of the four scales decreased from pretest to posttest, but the standard deviation for the Multidimensional Professional Agency Scale increased by .02 when comparing mean pretest scores to mean posttest scores. Prior to starting module one, I shared my research interest with the teachers but did not provide a definition for teacher professional agency as part of the program. However, in module one and module four, teachers generated their own definition of professional agency. At the end of the program, teachers compared their definitions. The standard deviation increase for the Multidimensional Professional Agency Scale posttest may be explained by an increased awareness or change in perception of professional agency by teachers as they progressed

through the Teachers as Researchers program.

The lack of associations between DDDM and teaching practices and DDDM and professional agency is consistent with existing research which identify a lack of training for teachers regarding how to apply DDDM to the classroom (Dunn et al., 2013; Vanlommel et al., 2017; Walker & Jimerson, 2014) and training to increase data literacy (Mandinach & Gummer, 2016;Walker & Jimerson, 2014). Yet, despite evidence from literature and this study regarding the importance of data literacy and DDDM application training for teachers, the need still exists.

## Research Methodologies and Teaching Practices

This study indicates research methodologies had a significant impact on teaching practices (RQ 1). These outcomes align with other studies which indicate teachers should use research as a tool to adjust and improve teaching practices (Kyei-Blankson, 2013; Schwarz & Ray, 2018). Changes in teaching practices based on teacher-conducted research are more likely to be sustainable with positive impact on student achievement and professional agency (Kyei-Blankson, 2013; Schwarz & Ray, 2018; Taylor, 201).

To gain insight into prior related training, I asked teachers to identify professional development they had previously attended which was offered through their school or districts. Teachers were provided with the following choices: research methodologies, research design, DDDM, data analysis, teaching strategies, and no response. The most attended teacher professional development programs were teaching strategies as indicated by sixteen participants (80%). Research design and research methodologies were the least attended, with two teachers (10%) and one teacher (5%) attending, respectively.

Although this is a small teacher sample, they teach in diverse districts in terms of

size and resources. Participating teachers were from the fourth and eighth largest districts in the state while others teach in small, rural districts. Based on the information provided by the teachers, there is little emphasis on research training for teachers by schools and districts. The emphasis on teaching strategies align with the implementation of prescribed curriculum associated with neo-centralization. Education reform efforts seek improved student achievement which is a worthy goal. Implementing prescribed curriculum and prescribed teaching strategies is an attempt to limit variables within the complex system of education.

By its very nature, research does not guarantee outcomes. "Teacher research is itself an uncertain and risky process that does not offer sure answers" (Schwarz & Ray, 2018, p. 55). In a neo-centralized environment, sure answers are the goal. As a result of neo-centralization, teaching has become less innovative and more instrumental (Schwarz & Ray, 2018). However, Schwarz and Ray (2018) posited it is the uncertainty of teacher research and the questions such research generates that lead to improved teaching practices. From the onset, when describing why they were interested in participating, only two teachers (10%) associated research methodologies with student achievement. However, teacher research can have far-reaching and lasting impact on teachers and students:

> Teacher research can be the informative and altering kind of research that makes a difference in the real world because it reveals the daily details, conversations, activities, triumphs and frustrations – the uncertain human reality of teachers' lives with children in American schools. (Schwarz & Ray, 2018, p. 59)

**Research Methodologies and Professional Agency**

The data imply research methods had a significant impact on teacher professional agency (RQ 2). Professional agency is a complex construct. According to Vähäsantanen et al. (2015), professional agency is determined by "influence on one's own work, involvement with an educational reform, and the negotiation of professional identity" (p. 9-10). However, professional agency is also determined by a person's motivation (Appova & Arbaugh, 2018; Hadar & Benish-Weisman, 2018), values, and environment (Hadar & Benish-Weisman, 2018; Wild et al., 2018). How an individual defines their own professional identity can be a combination of some or all of these factors.

For this study, I applied Hadar and Benish-Weisman's (2018) definition of teacher professional agency which is determined by the level of empowerment teachers have to exercise their own professional judgement. Hadar and Benish-Weisman (2018) refer to this as "capacity" (p. 138). In other words, agentic teachers are empowered to use their professional judgement to assess and address their professional needs and the needs of their students. Within a neo-centralized education system, teachers' professional judgement regarding what and how to teach is directed from outside the classroom (Jeong & Luschel, 2018; Wild, et al., 2018).

Agentic teachers are empowered, or have the capacity, to assess their own professional learning needs and address those needs. They are able to make choices regarding how to best meet their own professional growth. However, education reform efforts directly affect teachers' professional agency by mandating professional development which focuses on accountability standards. As a result, the professional growth of individual teachers may be neglected resulting in a negative impact on

professional agency.

When registering for the professional development, teachers were asked why they were interested in participating in the program. Of the 20 teachers, seven (35%) indicated a desire to learn more about data. Each expressed their goal to learn how to analyze data to better support their students. This is an example of agentic teachers who have the capacity to identify a specific area for professional growth and the capacity to act on it by seeking out a program to foster their own continuing development.

Education reform brings change. In response to change, teachers seem to either value conservation or to be open to change (Zeid et al., 2017). Their findings indicate teachers who value conservation experience a loss of agency as a result of changes associated with education reform, while the professional agency of teachers open to change is less impacted. The teachers who participated in this study did so voluntarily, during their summer break, and during a pandemic. Given this, I believe it safe to assume these teachers are open to change.

### Data Driven Decision Making and Teaching Practices

The study outcomes did not reveal a statistically significant association between changes to mean scores on the 3D-MEA (Dunn et al., 2013) in relation to changes to mean scores of the Teachers' Preferences for Learning Activities Scale (Louws et al., 2017). Given the complexity of DDDM and lack of training available to teachers, the results were not surprising. According to Mandinach (2012), current education reform accountability measures direct teachers to base teaching practices on DDDM. To do so effectively, teachers require training in data literacy, yet teachers lack data literacy training (Mandinach & Gummer, 2016; Mandinach et al., 2015; Walker & Jimerson,

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2014), as well as guidance as to how to apply DDDM to teaching practices (Dunn et al., 2013; Mandinach & Gummer, 2016; Vanlommel et al., 2017; Walker & Jimerson, 2014).

Participating teachers identified how and when data are received as creating a challenge to the use of DDDM to inform teaching practices. During share outs, teachers in the study referred to data from standardized tests as "post-mortem", meaning it is too late for teachers to address issues. The question was raised about using the post-mortem data when planning for the following year. The point was made this post-mortem approach to data distribution was equivalent to comparing apples to oranges since the data were from a different pool of students. This observation aligns with findings by Mandinach (2012) who posited data are most meaningful when associated with a particular context. In other words, if data are provided post-mortem, its impact is diminished, even meaningless, as it is not associated with current students.

Prior to participating, teachers indicated they had participated in school or district professional development addressing data analysis (30%) and DDDM (25%). To apply DDDM to teaching practices, it is necessary to be proficient in data literacy (Dunn et al., 2013; Taylor, 2017). Teacher perceptions of their own data literacy directly affect their willingness to apply DDDM to their teaching practices (Dunn et al., 2013; Taylor, 2017; Walker et al., 2018). Increasing teacher confidence in data literacy correlates to increased application of DDDM to inform teaching practices (Dunn et al., 2013; Walker et al., 2018). According to Datnow and Hubbard (2015), "teachers feel underprepared to use data effectively, which has undermined their confidence and their efforts" (p. 19). The lack of significance between DDDM and teaching practices as shown by the data in the current study may be attributable to teacher confidence with their own data literacy.

**Data Driven Decision Making and Professional Agency**

The study did not reveal a statistically significant association between DDDM and teacher professional agency. A contributing factor to professional agency is the ability to exercise one's own choice and judgement to direct professional growth (Hadar & Benish-Weisman, 2018). Propelled by DDDM, an environment of neo-centralization limits teachers' ability to direct their professional trajectory. The role of teachers as decision makers within the classroom is curtailed by prescribed curriculum (Bressman et al., 2018; Jeong & Luschei, 2018), mandated teaching practices (Appova & Arbaugh, 2018; Jeong & Luschel, 2018), and a knowledge deficit approach to professional development programs (Meister, 2010; Torff & Sessions, 2008).

Of the 20 participating teachers, 17 (85%) have less than 20 years teaching experience, meaning their entire teaching career has been in a neo-centralized system. In a data driven environment teachers are largely data recipients, excluded from decisions which determine policy, curriculum, and teaching practices. Combine this with lack of training to address data literacy and how to apply DDDM within the classroom, the participating teachers did not associate DDDM as a determinant of their professional agency.

The association between DDDM and teacher professional agency was not significant ($\beta = 0.052$). The hierarchical structure of schools' place teachers at or near the bottom in terms of power and authority within the education system. Good et al. (2017) posited this hierarchy, along with time challenges and a schedule which isolates teachers from peers, contribute to teachers' lack of influence on policymaking. Education reform initiatives rely on DDDM to determine policy. Teachers cannot envision themselves as

legitimate participants in policy making, which can negatively influence how they view themselves as professionals (Good et al., 2017). As a result, I propose teachers minimize the impact of DDDM as a contributing determinant of their professional agency.

**Data Literacy**

The process of DDDM requires data literacy and data analysis skills. Only a few participating teachers self-identified as having received prior professional development in research methods (5%) and DDDM (10%) through schools and districts. Slightly more teachers had previously completed general research course work at the undergraduate (25%) and graduate (25%) levels. Some teachers indicated completion of qualitative course work at the undergraduate (30%) and graduate (20%) levels. Several teachers completed formal courses in quantitative methods at the undergraduate (25%) and graduate (20%) levels. Yet most teachers self-identified as novice (35%) or intermediate (10%). Perhaps most insightful were the number of teachers who self-identified as not having research skills (50%). The self-identified ratings indicate a low-level of confidence which appears to substantiate the need for programs designed to increase teachers' data literacy.

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**Teaching Practices as Mediator**

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Research questions five and six explored the mediating effects of teaching practices on research methodologies (RQ 5) and DDDM (RQ 6). The scores from the Teachers' Preferences for Learning Activities Scale (Louws et al., 2017) do not show a statistically significant mediating effect ($\beta$ = -0.063) on the Multidimensional Professional Agency Scale (Vähäsantanen et al., 2019). Based on information provided prior to their participation, 16 (80%) of participating teachers engaged in school or

district professional development focused on teaching strategies. However, within a neo-centralized work environment, Jeong and Luschei (2018) contended teachers are "losing their power and responsibility in classroom decisions" (p. 299).

Even though the majority of participating teachers had professional development experience with teaching strategies, the nature of prior professional development may not have fostered innovation, but rather reinforced prescribed teaching strategies associated with prescribed curriculum. Given the apparent limited control teachers have over their own teaching practices, teachers' perceptions of themselves as decision maker within the classroom may have greater association with professional agency than prescribed teaching practices. Policies which dictate teaching practices impede teachers' ability to "actively direct his/her professional life in accordance with his/her own will, judgement and choice" (Hadar & Benish-Weisman, 2018, p. 138), which may reduce any association teachers have between teaching practices and professional agency.

## Communities of Practice

The teachers who participated in this study volunteered due to a shared interest in learning about research methodologies and DDDM. Based upon this shared interest, I applied the theoretical framework of communities of practice to the professional development program. When teachers engage with other teachers outside of the confines of school structures professional agency increases (Good et al., 2017). Within the community of practice, teachers engaged in collegial discussions, shared experiences, posed questions, and engaged in problem-solving activities.

The structure of the school day is ruled by the bell. Instructional time, conference or planning periods, and even lunch breaks are dictated by the bell schedule. The bell

schedule is recommended by administration to the school board. Ultimately, school board members determine the structure of the school day which, in turn, sets the parameters of the teaching environment. This hierarchical structure within education limits time for teachers to engage with colleagues as the bulk of their day is spent in isolation with their students (Good et al., 2017). Daly (2015) argued the isolating nature of teaching leads to a lack of social capitalism.

Lesser and Storck (2001) envisioned CoPs as "an engine for the development of social capital" (p. 833). They found gains in social capital led to behavioral changes such as sharing knowledge which positively influenced performance. Lesser and Storck (2001) focused their research on the impact of CoPs within business communities which implement a hierarchical structure similar to that found in education. They determined CoPs create a common context which forges relationships leading to stronger networks of colleagues which, in turn, generate social capital. Introducing CoPs to the teaching community could increase the social capital of the profession.

According to Lesser and Storck (2001) increased networking is necessary to establish social capital. However, networking between teachers is not commonly promoted within the work environment (Hanraets et al., 2011). Unlike PLCs which are frequently overly structured to lead teachers to a predetermined outcome (Appova & Arbaugh, 2018), CoPs are driven by a shared interest by a community of practitioners (Lave & Wenger, 1991). It is the shared interest which sets CoPs apart from PLCs. Meister (2010) emphasized CoP's increase in effectiveness when participants teach related academic disciplines, asserting academic discipline alignment is more important than grade levels. "Understanding and respecting these content-specific biases are critical

to allowing teachers to create their own professional growth" (Meister, 2010, p. 894). In other words, teachers within any content area, including STEM disciplines, have a shared view regarding the importance of their respective disciplines.

Lesser and Storck (2001) determined CoPs "appear to be an effective way for organizations to handle unstructured problems and to share knowledge outside of the traditional structural boundaries" (p. 832). The level of attendance to the professional development program appears to support their conclusion. Over the four days of the program there was 100% attendance. Eight different districts and 20 different schools were represented by the participating teachers, each going beyond the traditional boundaries of their schools and districts, forging new or expanding existing networks. This supports findings by Trabona et al. (2019) who found teachers will seek opportunity to engage with colleagues in an environment where they can collaborate, provide feedback, and support one another.

The CoP which began with the program has continued on a monthly basis at the request of participating teachers. In my opinion, this CoP has provided teachers with an external support system as they contend with the extraordinary impact COVID-19 has had on teachers. Within this CoP, teachers share concerns and issues they may be unable or uncomfortable to share with co-workers or administrators. In the CoP, teachers identify common issues and mentor to one another as they collaborate to problem solve. Through the expanded network of the CoP, it is my opinion the professional agency of teachers is positively affected as they brainstorm proactive strategies to implement during the challenges of teaching during COVID-19. Through networking, teachers can gain social capital (Daly, 2015; Lesser & Storck, 2001) which has positively influenced their

professional agency despite the education hierarchy (Hanraets et al., 2011).

## Limitations of Study

This study was originally planned as an in person professional development, scheduled for mid-June 2020. At the time of the program, the country was experiencing an escalating pandemic, which undoubtably reduced the importance of participation in a teacher professional development program. The sample size may have been impacted by health and economic concerns related to COVID-19. As such, the sample size was small, lacking power and rendering the outcomes non-generalizable.

Another limitation related to COVID-19 was the program delivery. In response to safety precautions, the program was conducted virtually. The virtual format provided easier access for several teachers from rural communities; however, some teachers encountered connectivity issues which interrupted participation for brief periods. As part of the original program plan, teachers would participate in small group discussions, generate artifacts germane to group discussions, and engage in share outs. Although the virtual format included breakout rooms, discussion groups were not able to create artifacts related to their discussions. The virtual format also impacted planned group activities, specifically those involving data analysis. The complexity of the data analysis project was not well suited for a virtual presentation.

This study utilized four validated Likert-scale, self-report instruments to assess the professional development program. The use of self-report instruments can introduce biases such as participant interpretation variation based on instrument wording, or a desire by the subject to "provide responses that are socially acceptable or ... in line with the impression they want to create" (Kimberlin & Winterstein, 2008, p. 2281). Although

each instrument has a five-point Likert-scale, the terms associated with each point are subject to different interpretations by participants. Terms such as "very little" and "quite a bit" have the same numerical value as "slightly preferred" and "moderately preferred" on another instrument. How each individual teacher interprets these terms can vary.

## Call for Future Research

Education reform and data continue to shape the education system in the US. The role of teachers as stakeholders is in a state of flux. Add to that the challenges presented by COVID-19, and it becomes clear more research needs to be done as to the role of teachers as decision makers in the classroom. This study, conducted during the COVID-19 pandemic, had a small number of participants which reduced the power, resulting in standard deviations which overwhelmed the mean values, indicating a lack of significance. To address this issue, future studies would require a larger sample size. An alternative to a larger sample size would be the elimination of extraneous variables. Although all participating teachers were secondary STEM teachers, they represented different grade levels and content areas which introduced extraneous variables to the study. Future studies could eliminate extraneous variables by narrowing the inclusion criteria. Examples of steps to eliminate extraneous variables would be to a single grade level or content area, or schools with similar demographics.

This study indicates when teachers are provided with professional development focused on research methods, there is an impact on teaching practices and professional agency. Longitudinal studies need to be considered to assess the sustainability of the professional development. Longitudinal studies should be conducted assessing the frequency of classroom research, continued impacts on teaching practices, and

professional agency.

This study focused on secondary STEM teachers; however, research methods are not limited to STEM courses. Additional studies should be conducted assessing the effect of research methods on teaching practices and professional agency in other content areas and grade levels. The secondary STEM teachers were experienced teachers, with a minimum of five years teaching experience. The assumption was their previous experiences would provide a base of comparison as they completed the professional development program. However, what affect would such training have on the teaching culture if novice and new teachers were introduced to research methods and DDDM in the classroom early on in their careers, or during teacher preparation education?

Data driven decision making is at the heart of education reform, relying primarily on data derived from standardized tests. Longitudinal studies should be conducted investigating the impact of separate research methodologies and DDDM teacher professional development programs on student achievement. In a landscape of conformity within education, it would be valuable to examine the diversity of content provided within professional development programs addressing research methodologies and DDDM within the classroom.

Another issue is the lack of teacher voice within the current system of education reform. Further understanding of the impact of the Teachers as Researchers program is possible if the study was conducted in a face-to-face setting applying qualitative methods to ascertain measurable benefits of the program on teacher perceptions of applying research methods and DDDM within the classroom. A qualitative study would provide a detailed description of teacher perspectives as they progress through the program.

Conducting longitudinal qualitative studies could provide insight into how teachers respond to and implement research methods and/or DDDM into the classroom following participation in the program. Given the inconsistency in how data literacy is defined, qualitative studies to investigate teachers' understanding and confidence in data literacy and the application of DDDM to the classroom would be helpful to expand on or improve the existing Teachers as Researchers professional development program.

## Conclusion

This study indicates when teachers are provided with professional development focused on research methods, their confidence to apply research methods within their classroom increases. As their confidence in research methods increase, they perceive a positive impact on teaching practices and professional agency. Such research would generate data within the context of the classroom, empowering teachers to exercise professional judgement to inform teaching practices. However, to do so requires some level of proficiency with data literacy. Yet, as teachers are primarily data recipients, schools do not provide teachers with professional development programs to address data literacy therefore impeding teachers' ability to process data from classroom research to inform teaching practices and impact professional agency.

To improve student achievement and the global comparative standing of the US education system, it will take a collaborative effort on behalf of all stakeholders, including teachers. As stakeholders within the education system, teacher voice is missing from the conversation regarding education reform. Rather than passive recipients of research or data, teachers should be active participants. The neo-centralization of current education reform initiatives removes teachers as decision makers within their own

classrooms. Restrictive policies negate teacher expertise as professionals which limits

professional growth and thereby diminishes teacher professional agency.

Appendix A

**Data Driven Decision-Making Efficacy and Anxiety Inventory (3D-MEA)**

**Directions**: Read each statement and select one item that best describes your response. Please complete all 20 statements.

| | Strongly Disagree | Disagree | Neither Disagree or Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|
| 1. I am confident in my ability to access state assessment results for my students. | | | | | |
| 2. I am confident that I know what types of data or reports I need to assess group performance. | | | | | |
| 3. I am confident that I know what types of data or reports I need to assess student performance. | | | | | |
| 4. I am confident I can use the tools provided by my district's data technology system to retrieve charts, tables or graphs for analysis. | | | | | |
| 5. I am confident I can use the tools provided by my district's data technology system to filter students into different groups for analysis. | | | | | |
| 6. I am confident that I can use my district's data analysis technology to access standard reports. | | | | | |
| 7. I am confident in my ability to understand assessment reports. | | | | | |
| 8. I am confident in my ability to interpret student performance from a scaled score. | | | | | |
| 9. I am confident in my ability to interpret subtest or strand scores to determine student strengths and weaknesses in a content area. | | | | | |
| 10. I am confident that I can use data to identify students with special learning needs. | | | | | |
| 11. I am confident that I can use data to identify gaps in student understanding of curricular concepts. | | | | | |

| | Strongly Disagree | Disagree | Neither Disagree or Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|
| 12. I am confident that I can use assessment data to provide targeted feedback to students about their performance or progress. | | | | | |
| 13. I am confident that I can use assessment data to identify gaps in my instructional curriculum. | | | | | |
| 14. I am confident that I can use data to group students with similar learning needs for instruction. | | | | | |
| 15. I am confident in my ability to use data to guide my selection of targeted interventions for gaps in student understanding. | | | | | |
| 16. I am intimidated by statistics.* | | | | | |
| 17. I am intimidated by the task of interpreting students' state level standardized assessments.* | | | | | |
| 18. I am concerned that I will feel or look "dumb" when it comes to data driven decision-making.* | | | | | |
| 19. I am intimidated by my district's data retrieval technology.* | | | | | |
| 20. I am intimidated by the process of connecting data analysis to my instructional practice.* | | | | | |

*reverse scored items

Dunn, K. E., Airola, D. T., Lo, W.-J., & Garrison, M. (2013). Data Driven Decision-Making Efficacy and Anxiety Inventory [Database record]. Retrieved from PsycTESTS. https://dx.doi.org/10.1037/t27939-000

Appendix B

# Perceived Research Competency Index

**Directions**: For each statement, select only one item to best describe your response. Please complete all 19 statements.

| | None | Very Little | Some | Quite a Bit | Very Much |
|---|---|---|---|---|---|
| 1. Understanding current issues in your major or field of study. | | | | | |
| 2. Judging the quality of research studies or creative works. | | | | | |
| 3. Explaining the advantages and limitations of different methods to approaching a question or problem in your field. | | | | | |
| 4. Understanding how to add to a scholarly or professional conversation through research and writing. | | | | | |
| 5. Understanding the research or creative process in your field. | | | | | |
| 6. Understanding the difference between personal beliefs and evidence in supporting a position or drawing conclusions. | | | | | |
| 7. Understanding how research is relevant to what you are learning in your classes. | | | | | |
| 8. Career- or work-related knowledge and skills. | | | | | |
| 9. Understanding terminology that is specific to your field. | | | | | |
| 10. Matching a scholarly question to the appropriate theories and methods. | | | | | |
| 11. Learning ethical conduct in my field. | | | | | |
| 12. Collecting appropriate data or evidence for a research question or creative purpose. | | | | | |
| 13. Dealing with obstacles faced in the research or creative process. | | | | | |
| 14. Analyzing data or information relevant to the project. | | | | | |
| 15. Writing clearly and effectively. | | | | | |
| 16. Evaluating scholars' positions or statements to determine how well-supported by evidence they are. | | | | | |

| | None | Very Little | Some | Quite a Bit | Very Much |
|---|---|---|---|---|---|
| 17. Communicating well orally in a presentation, performance, or discussion of your work. | | | | | |
| 18. Articulating the broad implications or 'big picture' of what you learned in the course or project. | | | | | |
| 19. Creating new ideas, solutions, or creative works based on what you learned in the course or experience. | | | | | |

Adapted from: Davis, S. N., & Jones, R. M. (2017). Perceived Research Competency Index [Database record]. Retrieved from PsycTESTS. https://dx.doi.org/10.1037/t66384-000

Appendix C

**Teachers' Preferences for Learning Activities Scale**

**Directions**: For each statement, select the one item that best describes your response.
Please complete all 11 statements.

| **Reflection on Practice & Collaboration** | Not Preferred | Slightly Preferred | Somewhat Preferred | Moderately Preferred | Strongly Preferred |
|---|---|---|---|---|---|
| 1. Critical reflection on teacher's experiences. | | | | | |
| 2. Asking students for feedback in the lessons. | | | | | |
| 3. Reciprocal classroom visits with colleagues. | | | | | |
| 4. Preparing lessons with colleagues. | | | | | |
| 5. Assembling a school working group or committee with colleagues. | | | | | |
| **Training & Keeping Up to Date** | | | | | |
| 6. Participating in STEM conference | | | | | |
| 7. Consulting books, subject-specific journals, etc. | | | | | |
| 8. Participating in a training course. | | | | | |
| 9. Visiting educational sites on the Internet. | | | | | |
| **Experimenting** | | | | | |
| 10. Trying out new teaching methods in my lesson. | | | | | |
| 11. Testing alternative teaching materials in class. | | | | | |

Louws, M. L., Meirink, J. A., van Veen, K., & van Driel, J. H. (2017). Teachers' self-directed learning and teaching experience: What, how, and why teachers want to learn. *Teaching and Teacher Education, 66*, 171-183. https://dx.doi.org/10.1016/j.tate.2017.04.004

Appendix D

**Multidimensional Professional Agency Scale**

**Directions:** Please indicate your level of agreement by circling one of the following choices for each statement. Where statement refers to "unit", substitute school.

| Decision Making at Work | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| 1. I can participate in the preparation of matters in my unit. | SD | D | N | A | SA |
| 2. I can make decisions regarding my own work. | SD | D | N | A | SA |
| 3. I can participate in decision making in my unit. | SD | D | N | A | SA |
| **Being Heard at Work** | | | | | |
| 4. My opinion is taken into consideration in my unit. | SD | D | N | A | SA |
| 5. My views are taken into consideration in the work community. | SD | D | N | A | SA |
| 6. I am heard in matters relating to my own work. | SD | D | N | A | SA |
| **Participation in Shared Work Practices** | | | | | |
| 7. I ask or comment actively in my unit. | SD | D | N | A | SA |
| 8. I actively bring up my own opinions in the work community. | SD | D | N | A | SA |
| 9. I actively collaborate with others in my unit. | SD | D | N | A | SA |
| 10. I take part in the development of my unit's actions. | SD | D | N | A | SA |
| **Transforming Work Practices** | | | | | |
| 11. I develop my ways of working. | SD | D | N | A | SA |
| 12. I make developmental suggestions regarding collective work practices. | SD | D | N | A | SA |
| 13. I try out new ideas in my work. | SD | D | N | A | SA |
| **Negotiating Professional Identity** | | | | | |
| 14. I can act according to my own values in my work. | SD | D | N | A | SA |
| 15. I can realize my professional goals in my work. | SD | D | N | A | SA |
| 16. In my work I can focus on things that interest me. | SD | D | N | A | SA |
| **Constructing a Professional Career** | | | | | |
| 17. I can advance my career in my work. | SD | D | N | A | SA |

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Appendix E

**Research Studies Instrument**

**Directions**: Retrospective scales are given after training. For each statement, select the item that best describes your response *prior* to training and *after* training. Please complete all 20 statements.

| **Critical Research Literacy:** | Very Little | Little | Somewhat | Much | Very Much |
|---|---|---|---|---|---|
| 1. Development of readiness for inquiry | VL | L | S | M | VM |
| 2. Development of independent thinking | VL | L | S | M | VM |
| 3. Understanding research literature | VL | L | S | M | VM |
| 4. Questioning knowledge and phenomena | VL | L | S | M | VM |
| 5. Development of critical thinking | VL | L | S | M | VM |
| 6. Development of methods for knowledge creation | VL | L | S | M | VM |
| 7. Conscientiousness of error sources of research | VL | L | S | M | VM |
| 8. Applying research knowledge into practice | VL | L | S | M | VM |
| **Research for Profession:** | Very Little | Little | Somewhat | Much | Very Much |
| 9. Considering teaching profession as continuous developmental task | VL | L | S | M | VM |
| 10. Considering working as a teacher as a continuous growth | VL | L | S | M | VM |
| 11. Becoming conscious of societal significance of teaching profession | VL | L | S | M | VM |
| 12. Increasing societal consciousness | VL | L | S | M | VM |
| 13. Understanding significance of research at classrooms and schools | VL | L | S | M | VM |
| 14. Development of my own personality | VL | L | S | M | VM |
| 15. Increasing responsibility in teaching profession | VL | L | S | M | VM |
| 16. Understanding students' learning processes | VL | L | S | M | VM |
| 17. Increasing a teacher's ethical responsibility | VL | L | S | M | VM |
| 18. Research based development of school | VL | L | S | M | VM |
| 19. Clarification of significance of a teacher's work | VL | L | S | M | VM |
| 20. Development of educational responsibility | VL | L | S | M | VM |

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