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THE EFFECT OF USING DRAGONBOX ON THE MATHEMATICS TEACHING EFFICACY OF PRESERVICE MIDDLE GRADE TEACHER

Monica Cates

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This dissertation, THE EFFECT OF USING DRAGONBOX ON THE MATHEMATICS TEACHING EFFICACY OF PRESERVICE MIDDLE GRADE TEACHER, by MONICA L. CATES, was prepared under the direction of the candidate's Dissertation Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree, Doctor of Philosophy, in the College of Education and Human Development, Georgia State University.

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**The Effects of Using DragonBox on the Mathematics Teaching Efficacy of Preservice
Middle-Grade Teachers**

by

Monica Cates

Under the Direction of Dr. Iman Chahine

ABSTRACT

The purpose of this study was to examine the effects of using the mathematical simulation games of DragonBox on preservice middle-level teachers' mathematics teaching efficacy. The study employed an embedded, exploratory case study design using mixed methods techniques. The study comprised of 33 preservice middle-level mathematics teachers enrolled in a course designed to prepare middle childhood educators to teach mathematics in urban, suburban or culturally diverse middle school classrooms. The purpose of the course was also to provide current and future middle school teachers with the mathematics content, essential concepts, methodology, activities, and resources to both learn and teach mathematics in grades 4-8. Quantitative and Qualitative data were collected using five instruments: Mathematics Teaching Self-Efficacy Scale (MTSES) (Ryang, 2010), researcher's journal, observation logs, interview protocols and artifacts. Quantitative data analysis was conducted using Wilcoxon Signed-Rank nonparametric test and reliability measure. The qualitative data were analyzed

using Lichtman's (2013) six-step coding protocol through Dedoose's (2017) web application. The units of analysis for the qualitative data consisted of episodes where the preservice mathematics teachers engage with DragonBox gaming environment. Results of the Wilcoxon Signed-Rank test showed no statistical significance (at $p = .216$) in the MTSES posttest median score compared to the MTSES pretest median score, which indicated no change in the level of mathematics teaching efficacy.

Six themes emerged as a result of qualitative data analysis related to teacher perceptions and factors associated with teaching middle-level mathematics using DragonBox. The data gathered was triangulated from the qualitative data. Through the themes, participants indicated they perceived the use of DragonBox as a learning tool, differentiate way to engage future students, and goal-directed learning tool that still relied heavily on teacher support. Participants also expressed that conceptual understandings and careful planning were needed to connect with a highly technology-driven society. The themes that transpired from the triangulation of qualitative data and the quantitative data was reviewed through the lens of the causal model of triadic reciprocal causation.

Overall, this study showed that upon engaging with DragonBox gaming environment, preservice teachers had a more positive perception of the usefulness of DragonBox in teaching middle-level mathematics.

INDEX WORDS: Preservice teachers, mathematics teaching efficacy, mathematics simulation games and mixed method techniques

THE EFFECTS OF USING DRAGONBOX ON THE MATHEMATICS TEACHING
EFFICACY OF PRESERVICE MIDDLE-GRADE TEACHERS

by

MONICA CATES

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Mathematics Education – Teaching and Learning

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Middle and Secondary Education

in

the College of Education and Human Development

Georgia State University

Atlanta, GA

2018

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DEDICATION

Thank You, Father GOD, for the strength and endurance to make it through, and for placing people in my life to help me get through this journey.

To my husband, Dernard, thank you for being my love, support, best friend and encouragement through the years. Thank you for believing in me when I did not believe in myself.

To my parents, Marvin and Crystal, thank you for making me believe that I can become and be anyone I choose to be. Thank you for your constant support and always being there to help no matter what.

To my children, Elizabeth, Aliyah, Elijah, and Dernard thank you for making me want to be a better person every day. You are strong, intelligent, creative and loved unconditionally. You are capable of great things. You were designed to make the world a better place, live in your calling.

To my family and friends, you know who you are, thank you for your uplifting encouragements and prayers. Thank you for reading my many drafts and listening to me. I truly appreciate you being there for me.

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ABBREVIATIONS

DGBL	Digital Game-Based Learning
GBL	Game-Based Learning
GTE	General Teaching Efficacy
MTEBI	Mathematics Teaching Efficacy Belief Instrument
MTOE	Mathematics Teaching Outcome Expectancy
MTSE	Mathematics Teaching Self-Efficacy
MTSES	Mathematics Teaching Self-Efficacy Scale
PMTE	Personal Mathematics Teaching Efficacy
PSTE	Personal Science Teaching Efficacy Beliefs
PTE	Personal Teaching Efficacy
RAND	Research and Development
SCT	Social Cognitive Theory
SLT	Social Learning Theory
STEBI	Science Teaching Efficacy Belief Instrument
STEBI-B	Science Teaching Efficacy Belief Instrument-Preservice
STOE	Science Teaching Outcome Expectancy

CHAPTER 1

Introduction

Problem Statement

According to the Nation's Report Card (2017) on the National Assessment of Educational Progress, most K-12 students in the U.S. are not demonstrating solid academic performance and proficiency in mathematics. For example, U.S. students in fourth and eighth grades averaged a score in mathematics of 240 and 283 on a 0-500-point scale respectively. This data indicates that only 40% of fourth-grade students showed to be at or above proficient. Eighth-grade data revealed that only 33% of students performed at or above proficient. There was no significant change in overall math scores for fourth and eighth grades students from 2015 to 2017.

Preservice middle-grade mathematics teachers will eventually hold the responsibility of preparing students to perform at proficiency and beyond and provide a mathematical foundation for high school and the workforce. Ensuring the preparedness of preservice teachers is essential to the future understandings of K-12 mathematics students. Increasing preservice teachers' mathematics teaching efficacy, the belief in their capability to deliver high-quality instruction in teaching mathematics, is a key to ensuring a higher rate of student success. Ross (1994) found that the mastery of teaching techniques could increase a teacher's efficacy. Ross (1994) also argues that higher teacher effectiveness pairs with teachers' willingness to implement methods that are innovative and student-centered.

Currently, instructional games (including simulation games and computer games that are designed specifically for educational learning) have produced interest in education to be utilized as a tool for promoting learning (Kebritchi, 2008). As technology continues to advance studies are finding that the potential of incorporating game-based learning through instructional simulation games can contribute to the increased interest and learning of students

(Divjak&Tomic, 2011; Hays, 2005; Ke, 2008; Mitchell & Savill-Smith, 2004). Preparing preservice teachers to incorporate game-based learning through instructional simulations has the potential to increase teaching efficacy and student achievement and interest.

The Study Purpose

The purpose of this case study was to explore the effects of using the mathematics simulation games of DragonBox, on preservice middle-level teachers' mathematics teaching efficacy. While many studies include teacher input (Pange, 2003; Vogel, Vogel, Cannon-Bowser, Bowser, Muse & Wright, 2006; Hess & Gunter, 2013), we do not see many that discuss the importance of making sure that the teachers are comfortable with using simulation games in the classroom to improve teacher efficacy. Ensuring the readiness of preservice teachers for this challenge becomes the responsibility of teacher education programs. Increasing preservice teachers' efficacy, "belief in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura & Walters, 1977, p. 3), is one way to equip them.

Preservice middle school teachers must have training concerning the appropriate use of technology, content knowledge and effective methods of discipline. Whenever a course presents a new instructional tool, it is vital to consider the instructional support needed for that new instructional tool. Knotts and Keys (1997) state that students must have guides to prompt, motivate, and sometimes force them to learn from their experiences. When incorporating a simulation game for a mathematics course, appropriate guidance is an essential element to consider. The teacher must be proficient in the mathematics simulation games and understand how it is helping the students to learn. Therefore, choosing teachers that are proficient and comfortable with using mathematical simulation game is crucial. Moreover, it is vital to ensure

that preservice teachers benefit from using mathematical simulations to help with their sense of teaching efficacy.

Research Questions

1. How are preservice middle-level teachers' mathematics teaching efficacy affected using the mathematics simulation games of DragonBox during the study?
2. How do preservice mathematics teachers perceive the use of mathematics simulation games in teaching middle-level mathematics during the study?
3. What are the factors that affect the preservice middle-level teachers' mathematics teaching efficacy as they engage in mathematics simulation games during the study?
Moreover, what are the affordances/constraints associated with using mathematics simulation games concerning mathematics teaching efficacy?

Hypothesis

The study hypothesized that preservice middle-level mathematics teachers will have increased teaching efficacy and have more confidence to use mathematical simulation games in their future teaching. The hypothesis was tested by conducting a single, embedded, exploratory case study incorporating mixed method techniques.

Definition of Terms

This case study uses the following definitions to answer the research questions.

Preservice middle-level mathematics teachers. Individuals in a program to prepare for initial teacher certification in teaching mathematics to the middle-level students in grades 4-8.

Mathematics teaching efficacy. Ryang (2010) defines mathematics teaching efficacy as “a teacher’s capability to organize and execute courses of action during mathematics instruction to accomplish a specific teaching task within a particular context” (p. 2).

Mathematics simulation games. A mathematics simulation game is a tool designed to support specific instructional objectives that facilitate learning through practice in a repeatable, focused environment that has a challenge, a set of rules, a clear finishing point, and concrete mathematics cognitive objectives. This definition comes from the research and conclusions that Aldrich (2004), Dickey (2005), Randel, Morris, Wetzel, and Whitehill (1992), and Oldfield (1991).

Affordances. Salomon (1993) defines affordances as “the perceived and actual properties of a thing, primarily those functional properties that determine just how the thing could possibly be used” (p. 51).

Constraints. Constraints would be any physical or logical limitations. Salomon (1993) further provides that constraints limit the way in which an object can be used.

Factors. The factors are any influences or forces that contribute or take away from the outcome (Salomon, 1993).

Conceptual Framework: Social Cognitive Theory

The theoretical perspective that was used to interpret and frame this study was Social Cognitive Theory (SCT), which was developed by Bandura (1986). SCT was formed from Social Learning Theory (SLT) and posited that learning happens in a social context with the dynamic and reciprocal interaction of the person, environment, and behavior (Denler, Wolters & Benzon, 2014). The primary tenets of SCT founds itself on a causal model of triadic reciprocal causation in which personal factors, environmental influences, and behavior interact and affect each other bi-directionally. SCT explains human adaptation and change regarding environmental influences, behavior, cognitive, biological, and other personal factors as operating as interacting determinants that alter each other, and it is through this process of two-way causation that people are both producers and products of their environment (Bandura, 1986). This dynamic interplay is

the foundation of Bandura's (1986) concept of reciprocal determinism. Bandura (2001) describes the interactions between reciprocal determinism by stating that: "In social cognitive theory, people are neither driven by inner forces nor automatically shaped and controlled by the environment...they (people) function as contributors to their motivation, behavior, and development within a network of reciprocally interacting influences" (p. 8). Figure 1.1 provides a depiction of the delineation of Bandura's Reciprocal Determinism.

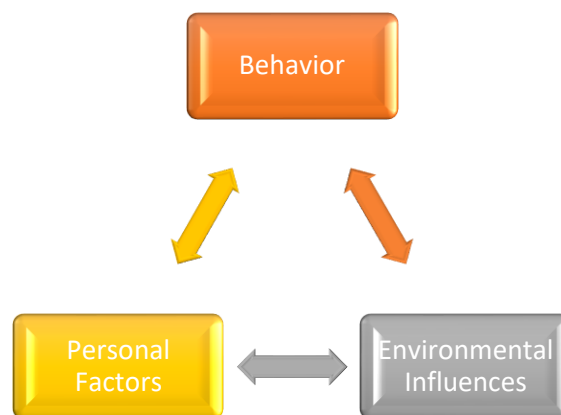


Figure 1.1. Researcher's depiction of a Model of Bandura's Reciprocal Determinism. Adapted from "Social foundations of thought and action: A social cognitive theory," by A. Bandura, 1986, Prentice-Hall, Inc.

Bandura (1986) also provides that reciprocal causation does not imply that the different factors are of equal strength, nor do they occur simultaneously. From Figure 1.1, we can see the interaction between thought, affect (personal factors) and action (behavior); a person's expectations, beliefs, self-perceptions, goals, and intentions give shape and direction to behavior (Bandura, 1986). In other words, stating that the way in which a person thinks, believes and feels will affect the way in which he or she behaves (Bandura, 1986). Next, from Figure 1.1, we can see the interactive relationship between personal characteristics (personal factors) and

environment (environmental influences). A person's expectations, beliefs, emotional inclinations and cognitive competencies are developed and modified by social influences that transmit information and trigger emotional reactions through modeling, instruction and social persuasion (Bandura, 1986). Lastly, Figure 1.1 shows the bidirectional influence of behavioral and environmental influences. People are producers of their environment because they can affect the nature of their accustomed environment through selection and creation of situations (Bandura, 1986).

Self- Efficacy is grounded within the larger theoretical framework of SCT and is the beliefs that one has about their ability to perform (Bandura, 1997). Teacher efficacy, which comes from self-efficacy because of the need to be content and domain-specific, is the beliefs that a teacher has about their abilities to perform in the classroom to help their students (Bandura, 1997). Self-efficacy determines the views of how people feel, think and motivate themselves to behave (Bandura, 1994). Bandura (2006) argues that the self-efficacy belief systems are not global traits. Instead, self-efficacy belongs to sets of self-beliefs that link to distinct realms of functioning. Mathematics teaching efficacy constructs through these multi-domain measures self-efficacy.

Building on the theoretical assumptions of Bandura (1986, 1997), Gibson and Dembo (1984), and Tschannen-Moran and Hoy (2001) provide that mathematics teacher efficacy is a teacher's capability to construct and implement a plan during classroom mathematics instruction to bring about a precise teaching task within a situation. Gibson and Dembo (1984) further identified two dimensions of efficacy: personal efficacy and teaching efficacy, which are like Bandura's two dimensions of self-efficacy of personal expectancy and outcome expectancy. Personal efficacy represents the teacher's belief that they have the personal skills to influence

student learning. Teacher efficacy represents more general beliefs about the relationship between teaching and learning, and the teacher's ability to bring about change. This change limits the factors that are external to a teacher such as home environment, family background, and parental influences. The conceptual model for this study included triadic reciprocal causation of a teacher's personal factors, teaching environmental influences and teaching behavior. Figure 1.2 depicts the conceptual model for mathematics teacher efficacy.

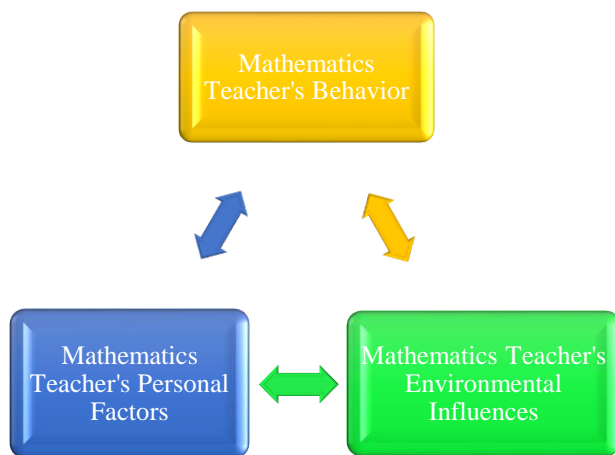


Figure 1.2. Researcher's depiction of Conceptual Model for Mathematics Teaching Efficacy.

The qualitative and quantitative data from this embedded case study was interpreted and analyzed through the aspect of SCT. The quantitative data explored mathematics teacher personal factors from Bandura's (1986, 1997) reciprocal determinism. More specifically, personal factors in the form of mathematics teacher efficacy were examined quantitatively and answered if mathematics teaching efficacy was affected using the mathematics simulation games of DragonBox. Additionally, mathematics teacher efficacy and mathematics teacher's personal factors were explored qualitatively by probing into how mathematics teacher's behavior and mathematics teacher's environmental influences all affect each other bi-directionally. Preservice mathematics teacher's perceptions of the use of mathematics simulation games was measured by

reviewing their behavior. The factors that affected the preservice middle-level teachers' mathematics teaching efficacy as they used mathematics simulation games during the study was considered regarding mathematics teacher's environmental influences, personal factors, and behavior.

Significance of Study

Theoretical Significance

The theoretical significance of this study was to add to the body of literature in two-folds; regarding increasing mathematics teaching efficacy by incorporating simulation games as an effective teaching tool, and regarding curriculum design that integrates simulation games. Teacher preparation programs that help preservice teachers incorporate technology in the classroom could assist in ensuring that preservice teachers are continually using innovative teaching tools with their students and designing appropriate curriculum.

Practical Significance

The practical significance of this study is also two-folds; to ensure that preservice teachers are prepared to use innovative technological tools with their students continually, and to prepare preservice teachers to incorporate simulation games in their mathematics classrooms. Quing Lilemieux (2013) states that a radical impact on society has been made in the last few decades regarding technology. From the popularity of digital social networks to the ever-popular cell phone, how we interact with citizens and how the global economy operates has dramatically changed (Qing LiLemieux, 2013). The citizens of this new world now require a different set of skills to be productive, functioning contributors to society (Tobias & Fletcher, 2011). Because of this, educators are being called upon to help students develop 21st-century skills. Therefore, by ensuring the preparedness of preservice teachers regarding technology use becomes essential as the need for students to be creators as well as navigators of technology.

The effects of using the mathematical simulation games of DragonBox on the mathematical teaching efficacy of preservice mathematical teachers was explored in this case study. The literature review will provide a background of the appropriateness of SCT as a theoretical framework, and the research regarding using simulation games.

CHAPTER 2

Literature Review

This review of the relevant research literature is organized in the following two sections with their delineated subsections:

- 1) Mathematics Teaching Efficacy Construct
 - a. Teaching Efficacy Beliefs
 - b. Development of Teacher Efficacy Construct
 - c. Development of Teacher Self-Efficacy Scales and Tests
 - d. Teacher Self-Efficacy Research
 - e. Major Critiques
- 2) Simulation Games in Education
 - a. Simulations as Games Debate
 - b. Defining Simulation Games through: Games in General, Game-Based Learning, and DragonBox
 - c. Mathematics Simulation Games
 - d. Simulation Games in Research in Education

Mathematics Teacher Efficacy Construct

Mathematics teaching efficacy is an essential construct used to predict teachers' future behaviors in mathematics education (Ryang, 2012). Understanding preservice teachers' efficacy beliefs is an important factor in knowing how or whether new teachers will be successful in their future teaching practice (Ryang, 2012). Also, by taking a closer look at teacher efficacy, the impact of training teachers to use mathematics simulations can be explored further.

The concept of self- efficacy, which is rooted in Bandura's (1986) Social Cognitive Theory (SCT), is defined as the forecasting of beliefs about the level of competence a person

expects that they will show in each situation (Tschannen-Moran, Hoy & Hoy, 1998). In this sense, self-efficacy has to do with self-perception of a person's competence and not their actual ability level. However, it does possess the capacity to predict how active or how much effort an individual will provide in a given context. Bandura (2006) ascertains that self-efficacy beliefs are not global traits but are characteristics of self-beliefs that link to distinct realms of functioning. Therefore, it is logical for Bandura (1986) to apply the theory of self-efficacy to teacher efficacy, which is an individual's belief in their ability to perform future actions about teaching. Bandura (1997) explains that teachers' efficacy beliefs are related to teaching efforts in education, teacher goals, and teacher persistence. Berman, McLaughlin, Bass, Pauly, and Zellman (1977) defined teacher efficacy as "the extent to which the teacher believes he or she can affect student performance" (p. 137). Another definition of teacher efficacy is "teachers' belief or conviction that they can influence how well students learn, even those who may be difficult or unmotivated" (Guskey & Passaro, 1994). Furthermore, teacher efficacy is both context and subject-matter specific (Tschannen-Moran et al., 1998).

It is possible to explore mathematics teacher efficacy exclusively. Ryang (2010) defines mathematics teaching efficacy as "a teacher's capability to organize and execute courses of action during mathematics instruction to accomplish a specific teaching task within a particular context" (p. 2). Inspired by the definitions prevalent in the literature, it is easy to ascertain that teacher efficacy can help us determine the effectiveness of a teacher and finding ways to increase teacher efficacy can contribute to improving student achievement.

Teaching Efficacy Beliefs

Bandura (1997) discusses that teachers' efficacy beliefs are related to teaching efforts in teaching, teacher goals, and teacher persistence. Teachers' efficacy beliefs are also influenced by mastery experiences, verbal persuasion, vicarious experiences and physiological arousal. As

proposed by Bandura (1997), Tschannen-Moran and Hoy (2007) provide a breakdown of how these influences are demonstrated specifically in teachers. These influences include:

1. **Mastery Experiences** – The most powerful for teaching because it is the actual teaching accomplishments that occur when a teacher is working with students. A teacher's efficacy beliefs increase if a teacher perceives that their efforts are successful. This increase in efficacy beliefs, in turn, adds to a teacher's expectations of future performances. However, a teacher's efficacy beliefs decrease if the teacher perceives that their efforts were not successful, which in turn contributes to their convictions that future efforts will also not be successful.
2. **Verbal persuasion** – The verbal interactions that a teacher receives about their efforts are considered verbal persuasion. Verbal interactions occur from school administrators, colleagues, parents, and members of the community. They also contribute to the way in which teachers view their efficacy beliefs.
3. **Vicarious experiences** – When someone else (colleague, teaching coach, administrator, professor, etc.) models a targeted activity this is known as a vicarious experience. The impact that the modeler has depends on the degree to which the observer can self-identify with the modeler. When the teacher is not able to identify with the modeler, no matter the extent of the efforts, for reasons such as level of experience, training, gender, or race, then the teacher's efficacy beliefs may not be increased.
4. **Psychological and emotional arousal** – If a teacher feels joy or pleasure from a successful teaching experience this can increase the teacher's efficacy beliefs. However, if a teaching experience brings on feelings of anxiety, stress, or inadequate control, then the teacher's efficacy beliefs can be lowered.

A closer look at these experiences were explored when analyzing the data from this case study.

Development of the Teacher Efficacy Construct

The concept of teacher efficacy first appeared when researchers from the RAND (Research and Development), an American nonprofit global policy think tank added two items to an extensive questionnaire, and the results were impressive (Armor, Conroy-Oseguera, Cox, King, McDonnell, Pascal, Pauly, & Zellman, 1976). Using the work of Rotter (1966) as a theoretical base, the RAND researchers conceived of teacher efficacy as the standard to which teachers give credence to their ability to control the reinforcement of their actions. Teacher efficacy also was purposed as to whether the power of support resides within the teacher or in the environment (Tschannen-Moran & Hoy, 2001). While student's motivation and performance are providing significant support for teaching behavior, teachers with high levels of efficacy believe they can control or strongly influence student achievement and motivation. The RAND researchers found that teachers who thought that influences of the environment overwhelm a teacher's ability to have an impact on a student displayed a belief that reinforcement of their teaching efforts is external and lies outside their control. On the other hand, teachers that expressed confidence in their ability to teach difficult or unmotivated students displayed a belief that their teaching remained within their control, which was known as internal (Tschannen-Moran et al., 1998).

A second conceptual strand of teacher efficacy came from Bandura (Tschannen-Moran et al., 2001). Bandura (1977) identifies teacher efficacy as a type of self-efficacy, which is a cognitive process where a person can construct beliefs about their ability to perform at a provided level of attainment. Self-efficacy beliefs influence how much effort a person will provide, how long a person will persevere in the face of obstacles, and how they can deal with failures (Bandura, 1997). Bandura (1997) clarifies the difference between self-efficacy and

Rotter's (1966) internal-external locus of control by providing data that shows that the two are not essentially the same phenomenon.

Development of Teacher Self-Efficacy Scales and Tests

The development of many surveys and tests came from the theory of teacher efficacy. (Tschannen-Moran & Hoy, 2001). Figure 2.1 shows the development of relevant teacher efficacy scales, culminating with the Ryang (2010) scale employed in the present study.

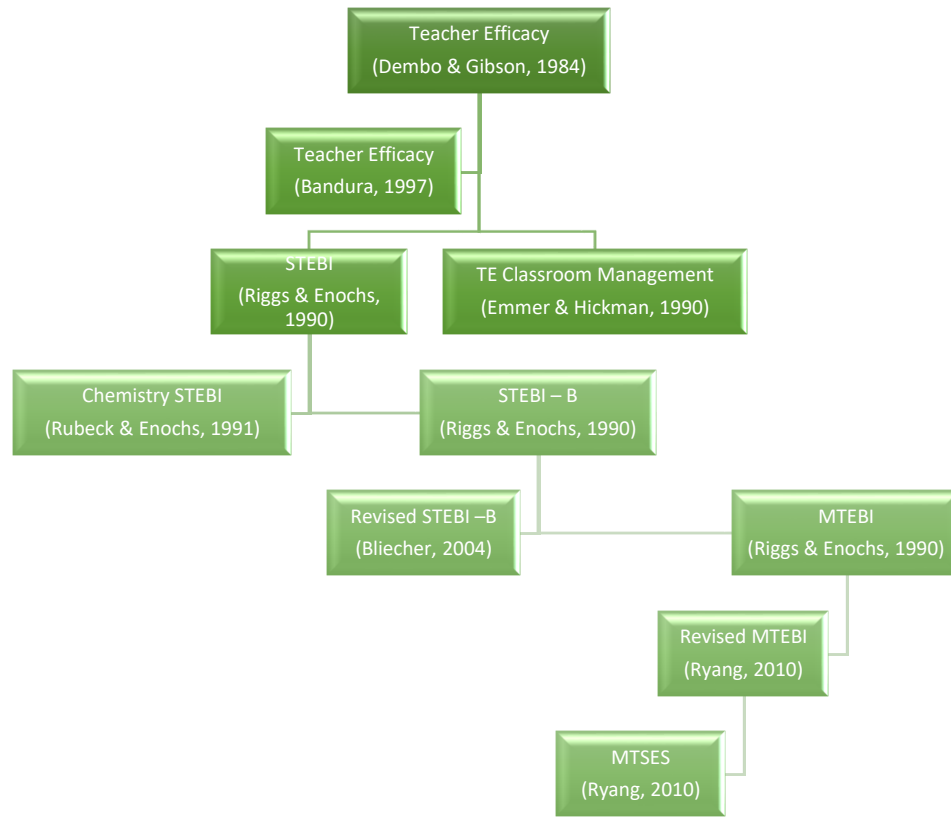


Figure 2.1. Researcher's Depiction of the Development of Teacher Efficacy Scales and Tests.

Figure 2.1 depicts the start of teacher efficacy scales and tests with the development of Gibson and Dembo's Teacher Efficacy Scale. Gibson and Dembo, in the early 1980s, developed a measurement of teacher efficacy that began with the RAND studies but relied heavily on the conceptual underpinnings of Bandura. The developed instrument has two scales. The first scale is used to measure teachers' beliefs that they could help improve student achievement, which

was called personal teaching efficacy (PTE) (Bleicher, 2004). PTE is specific and individual to the teacher and relates to a teacher's past experiences. The second scale measures teachers' beliefs that external factors can limit their impact on student achievements, such as student's socioeconomic background and home environment, which is called General Teacher Efficacy (GTE) (Bleicher, 2004). GTE is the belief that a teacher can affect students positively regardless of the power of external factors that are also influencing the student.

By starting with teacher interviews and analyses of previous teacher studies where teachers were reported as having a robust teacher efficacy, Gibson and Dembo (1984) created a 30-item measure of teacher efficacy. A multitrait-multimethod analysis that supported both convergent and discriminant validity, across two methods of measurement, analyzed data from three traits, which included teacher efficacy, verbal ability, and flexibility (Gibson & Dembo, 1984). Factor analyses confirmed the existence of two factors, PTE with $\alpha = .75$ and GTE with $\alpha = .79$ (Gibson & Dembo, 1984). Using the Gibson and Dembo items, other researchers have confirmed the existence of the two factors (Anderson, Greene, & Loewen, 1988; Burley, Hall, Villeme, & Brockmeier, 1991; Hoy & Woolfolk, 1993; Moore & Esselman, 1992; Saklofske, Michayluk, & Randhawa, 1988; Soodak & Podell, 1993) with alphas ranging from .75 to .81 for PTE and alphas ranging from .64 to .77 for GTE.

Figure 2.1 also depicts how other researchers modified of Gibson and Dembo's instrument to explore teacher's sense of efficacy within curriculum. The modified instruments include:

- The Science Teaching Efficacy Belief Instrument (STEBI) created by Riggs and Enoch (1990), and bases on Gibson's and Dembo's (1984) approach, but it measured, more precisely, science teaching.

- Emmer and Hickman's (1990) adaptation of the Gibson and Dembo(1984) instrument to reflect the domain of classroom management (Tschannen-Moran et al., 1998).
- Using a greater level of subject matter specificity, Rubeck and Enoch (1991) also explored teaching efficacy by developing the chemistry teaching efficacy, a modified version of the STEBI.
- Riggs and Enochs (1990) developed the Science Teaching Efficacy Belief Instrument-Preservice (STEBI-B) in 1990 for preservice science teachers.
- Bleicher (2004) revised the STEBI-B and re-examined the internal validity and reliability of the instrument.
- With the development of teacher efficacy scales on the rise, the theoretical father, Bandura (1997), developed the Teacher Efficacy Scale from his concept of self-efficacy.

More specifically related to this research study, the need for an instrument to determine teacher efficacy of mathematics teacher arose. Therefore, Enoch and Riggs developed a teacher efficacy instrument that was specific to mathematics teaching, which is also in Figure 2.1. The Mathematics Teaching Efficacy Belief Instrument (MTEBI) for the preservice teacher was a result of the modification of the STEBI-B (Enochs, Smith, & Huinker, 2000). The MTEBI contained 21 items, 13 from Personal Mathematics Teaching Efficacy (PMTE) subscale and eight items on the Mathematics Teaching Outcome Expectancy (MTOE) subscale (Enochs et al., 2000). The first MTEBI had 23 items like the STEBI-B, however, from subsequent analysis of validation, two items were dropped (Enochs et al., 2000). Reliability analysis produced an alpha coefficient of 0.88 for PMTE and 0.75 for MTOE. After confirmatory factor analysis, the two

scales, PMTE and MTOE, showed to be independent, which adds to the construct validity of the MTEBI (Enochs et al., 2000).

Figure 2.1 further displays the revised MTEBI that was created by Ryang (2010) because the hypothesis of the original version was not tenable for other cultures. Through research, Ryang (2010) also determined that there was a need for an instrument for secondary preservice teachers due to the conceptual difference between middle level and elementary teachers. The contributions of the revised instrument provide mathematics teacher education programs with an evaluative method to reform programs if needed. The revised version of the MTEBI is now named the Mathematics Teaching Self-Efficacy Scale (MTSES). Cross- validity of MTSES was verified by Ryang (2010) by testing various statistical analyses over two different data sets so that the instrument would be valid. The two different data sets were Mathematics Teaching Self-Efficacy (MTSE) and MTOE. Convergent and discriminant construct validity was tested by Exploratory Factor Analysis and Confirmatory Factor Analysis. Reliability was also examined by Cronbach internal consistency, and standard error curve and marginal reliability that was run by Item Response Theory through the Graded Response Model. The MTSE subscale was found to be the only data set that can provide trustworthy information in a research study. Therefore, the MTSES only consists the one subscale MTSE (Ryang, 2010).

Although the Gibson and Dembo's (1984) measure have been the most popular of the teacher efficacy instruments and numerous tests have been derived from it, there are problems that have occurred both conceptually and statistically (Tschannen-Moran & Hoy, 2001). The absence of certainty about the meaning of the two factors (PTE and GTE) and the factor structure's instability make this instrument questionable for researchers (Tschannen-Moran & Hoy, 2001). While using a 16-item version of the Gibson and Dembo instrument, Soodak and

Podell (1993) found that one item loaded on the PTE factor and another item did not have a strong enough loading on either factor. Hoy and Woolfolk (1993) used a more abbreviated version with just ten items, five from each factor, and found reliabilities for both subtests within the range of the original version. However, they urge researcher to conduct factor analysis on their data because of numerous inconsistencies across studies.

Bandura's (1986) framework provides insights into some of the reasons for the data discrepancies. Outcome expectancy is a judgment of likely consequences of an action (Bandura, 1986). Outcome expectancy did not add much to the explanation of motivation because of the outcome a person expected from that person's assessment of their capabilities and expected the level of performance, does not necessarily correlate with possible outcomes. The items from the second factor that were used to measure teacher efficacy, the potential impact of teachers in general (GTE), cannot be considered an outcome expectancy (Woolfolk & Hoy, 1990). Bandura asserts that because outcome expectations stem from a projected level of confidence, they add little to the predictive power of efficacy measures (Tschannen-Moran et al., 1998). Outcome expectancies that are in the form of physical or social rewards, recognition, punishments, criticisms or self-evaluations can provide incentives and disincentives for behavior (Bandura, 1986, 1997).

Teacher Efficacy Research

Teacher belief studies are becoming one of the most important psychological constructs of teacher education where perspectives and morals have already been an influential establishment (Pajares, 1992). The following will highlight some of the related major teacher efficacy research studies.

Allinder (1995) found a positive correlation between teacher efficacy and student achievement in mathematics. This investigation studied the connection between special

education teachers' personal efficacy and teacher efficacy, their use of formative evaluation method, and the amount of growth they affected among their students. A total of 19 special education teachers monitored two students with disabilities for 16 weeks in math computation using curriculum-based measurement. One of the methodological tools used was the Teacher Efficacy Scale (Gibson & Dembo, 1984). Teachers with high teacher efficacy and high personal efficacy could set end-of-year goals more often for their students. Teachers with high personal efficacy affected significantly greater growth in their student's achievement.

To determine the middle school mathematics teachers' beliefs and perceived self-efficacy beliefs about using origami in mathematics education Arslan and Isiksal-Bostan (2016) investigated. The study included 299 purposefully selected middle-level preservice mathematics teachers from three different universities in Turkey. The preservice teachers all had experience with origami from elective courses related to using origami in mathematics education. The study used the Origami in Mathematics Education Beliefs Scale and Origami in MTSES. The results showed that preservice teachers believed that origami is beneficial in mathematics education. However, their perceived self-efficacy beliefs were slightly higher than normal levels.

To investigate the effect of using curriculum-generated play instruction on the mathematics teaching efficacy of 35 early childhood education preservice teachers, Sancar-Tokmak (2015) used a pretest/posttest of the MTEBI. After the pretest had been administered, preservice teachers were then involved in curriculum-generated play instruction for 16 weeks. The methods of curriculum-generated play comprised of teachers structuring play to teach curriculum content, teachers watching children play during their free play and focusing on the children's interest to help the children to become engaged in the curriculum (Pramling-Samuelsson & Johansson, 2006). Results of the study indicate that mathematics teaching efficacy

increased. The study also suggests that future research should be conducted to determine if using technology generated play will help improve the efficacy of instruction for teachers.

Another study conducted by Isiksal-Bostan (2016) used longitudinal mixed methods approach to examine 30 preservice teachers' mathematics teaching efficacy beliefs during their enrollment in a teacher education program and at the end of their first year of instruction. The study investigated the factors that strengthen or hindered the preservice teachers' efficacy beliefs and how these influences change their mathematics efficacy during their first year of teaching. The investigated factors included classroom management, communicating with students, communicating with parents, mathematical knowledge for teaching, material usage, and textbook usage. Findings of the study indicated that during the teaching programs, preservice teachers had a high mathematics teaching efficacy. However, this decreased after their first-year teaching.

An exploration of mathematics teaching efficacy of preservice elementary teachers was conducted by Briley (2012). The study investigated 95 preservice elementary teachers enrolled in a mathematics content course. The preservice teachers were administered three surveys to measure their mathematics teaching efficacy, mathematics self-efficacy, and mathematical beliefs. The surveys included: MTEBI to evaluate mathematics teaching efficacy, the Mathematics Self-Efficacy Scale-Revised to evaluate mathematics self-efficacy, and the Conceptions of Mathematics Inventory-Revised to assess mathematical beliefs, or beliefs of how well one would perform in mathematics. The outcome of the study indicated that preservice teachers who registered high confidence in their ability to teach mathematics were more likely to have sophisticated expectations as well as have more confidence in mathematical problem-solving. The study also concludes that teacher education programs should acknowledge that there is a robust correlation between mathematical beliefs and mathematics teaching efficacy.

Simulation Games in Education

Bandura (1997) contends that improving student interest and motivation is directly related to teacher's efficacy and greater teacher efficacy links directly to student achievement. Gee (2008) found that simulation games can contribute to the increased interest in students. Additionally, Simpson (2009) observes that young people are fascinated by technology and those teachers that can discover ways to transform their students' favorite devices into agents of instruction can expect positive results. Prensky (2001a) also agrees and states that simulations can be a beneficial way to learn. By taking a closer look at the effects of using simulation games in the mathematics classroom, a better understanding of how mathematical simulation games' impact on preservice teachers' mathematics teaching efficacy can be ascertained.

Simulations as Games Debate

Simulation games have many conflicting definitions and usages in education. Hays' (2005) review of the literature regarding instructional games found the terms simulation, games, simulation games and computer games used interchangeably. It is from this reasoning that Tobias and Fletcher (2011) firmly provide that simulations are a subset of games. In contrast Young, Slota, and Bai (2012) argue that games are not a subset of simulations; however, they do agree that there are some instances of overlap.

One of the arguments made by Young et al. (2012) is that if the term simulation is to have any authenticity in its meaning, it should be strictly aligned to a real-world process. Any deviation from this alignment can result in participants misinterpreting valid real-world processes. However, there are some instances of real-world processes that allow a game and a simulation to overlap. Figure 2.2 shows how simulations and games can overlap; however, it also indicates that not all simulations are games and not all games are simulations.

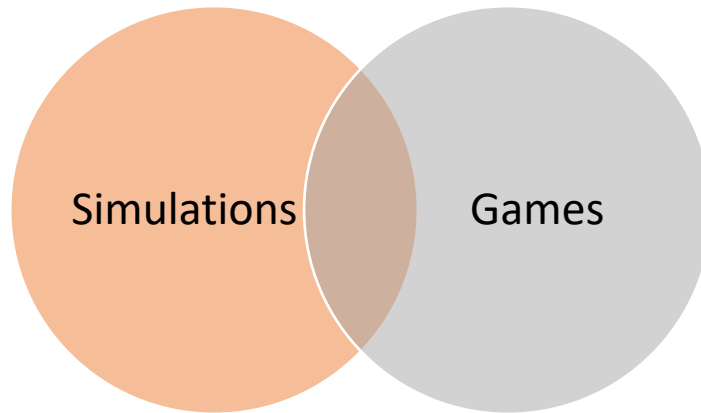


Figure 2.2. Researcher's depiction of the possible overlap of simulation and games. Interpreted from “Comments on reflections on ‘a review of trends in serious gaming’” by. M. Young, S. Slota and B. Lai, 2012, *Review of Educational Research*, 82(3).

A simulation can be defined as a game when it includes fun, play, rules, goals and winning (Prensky, 2001b). It is important to explore simulations as games further by studying simulations as models. Hays (2010) explains that simulations and models are often confused, and our understanding of these two words can help us understand their application in instructional games. Hays (2010) uses the U.S. Department of Defense’s (DoD) definition of model and simulation because it is one of the largest users of models and simulations. A model can represent selected aspects of the real world for specific purposes. A model does not represent all aspects of reality because if it did, it would no longer be a model, it would be the real thing. Models serve as the foundation for dynamic simulations by providing the rules and the data that allow a simulation to function in a specific way to meet a purpose. A simulation is a way for a model to be carried out over time. Figure 2.3 expands upon this concept more. All simulations are some model, and all games are some simulation.

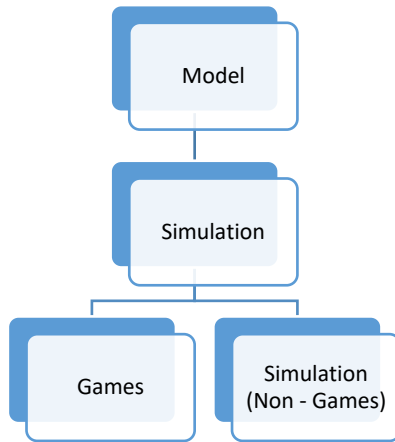


Figure 2.3. Researcher’s depiction of components of types of simulations. Adapted from “Making games more effective in the classroom,” by R. Hays, 2010, *Playing games in schools: Video games and simulations for primary and secondary education*, 249-276.

Hays (2005) goes further to provide that only if a simulation incorporates aspects of games, should it then be called a simulation game.

It is also important to note that not all digital simulations are suitable for educational purposes (Squire, 2008). An educational digital simulation is one that provides students with the opportunities to engage in critical thinking (Gee & Levine, 2009). Squire (2008) also provides that an appropriate educational digital simulation is one that provides clear goals, feedback mechanisms, varying levels of difficulty, and surprise aspect that suits students’ skills and interests.

Balasurebramanian and Wilson (2006) state that even though researchers are continually trying to interpret and set apart games from simulations, there are more similarities than differences between them. When designed well, both simulations and gaming environments can help to promote students’ learning of specific domain knowledge and domain concepts including several cognitive skills like pattern recognition, decision-making and problem-solving.

Defining Simulation Games

Through a review of the literature, one of the recommendations that Young, Slota, Cutter, Mullin, Lai, Simeoni, Tran and Yukhymenko (2012) make is to create a working definition of educational simulation games that are separate from video games. The previous authors call for unity in researchers' definition. It is from this reasoning that this section begins by asserting the definition mathematical simulation game for this case study. A mathematics simulation game is a tool designed to support specific instructional objectives that facilitate learning through practice in a repeatable, focused environment that has a challenge, a set of rules, a clear finishing point, and concrete mathematics cognitive objectives. This definition comes from the research and conclusions that Aldrich (2004), Dickey (2005), Randel et al. (1992) and Oldfield (1991) provide. The following will highlight the research and conclusions that justify this definition of mathematical simulation games.

Games in general. A closer look at games is needed to understand educational simulations and the contributions made to the field of education. Randel, Morris, Wetzel, and Whitehill (1992) defined games as any interpersonal interactions, with or without computers, used to achieve specified goals that are likely to depend on skill and may involve chance, competition, and imaginary settings. According to Gough (2015), children and adults enjoy playing games. Games provide learners a way in which to be engaged in fun and play, and games motivate students (Prensky, 2001b; 2002). Betrus and Botturi (2010) found that in the first book of Institutes of Oratory, an emphasis on dealing with amusement and learning provided that children need to enjoy (not dislike) instruction so that they will be inspired to continue to learn as they grow older. Games can be an innovative way to help students to learn. Games contribute to building student's academic confidence, developing their social problem-solving skills, promoting teamwork, and assisting in providing academic achievement (Steinberg, 2011).

When discussing games, play is a concept that also needs to be considered. Play is reviewed extensively with regards to student learning. Prensky (2002) brings together different meanings of ‘play’ to come up with a definition that more closely relates to learning by using digital games, video, and computer games, and it states that: “Play is something one chooses to do. Play is intensely and utterly absorbing “(p. 112). Tobias and Fletcher (2012) expand upon this idea more and state that learning through play is critical because it is one of the underpinnings of culture. Huizinga (1955) argues that playing and knowing have evolved primarily from the same thing, they cannot separate from each other. Tobias and Fletcher (2012) have also found through their research that play is fundamental to the developmental processes of greater mental faculties and are central to the learning theories of Dewey, Piaget, and Vygotsky. Betrus and Botturi (2010) provide that while playing is a natural mode of learning, structured play, or playing games is a way to make playing more determined.

Consideration for motivation is another important concept when discussing games. Denis and Jouvelot (2005) describe motivation as the reasons that explain or justify action. Play and fun are both related to motivation and learning. More specifically Denis and Jouvelot (2005) credit the reason why motivation is so useful in video games is that they are fun, and a source of intrinsic motivation. Dicheva and Dichev (2015) state that games have extraordinary motivational power and that they utilize some components to push people to engage with them. Prensky (2002) says that more generally, students’ influences for learning are a combination of intrinsic goals and extrinsic rewards, joined with psychological agents such as fear and need to please. Bisson and Luckner (1996) expand upon this idea and state that the role that fun plays with regards to intrinsic motivation in education is two-fold; Intrinsic motivation promotes the

desire for repetition of the involvement, and fun can motivate learners to engage themselves in activities that they have little or no previous experience.

Furthermore, the relationship between games and motivation is explained by Siegle (2015) by providing that games can increase motivation by fostering a growth mindset. Games are also able to provide players with immediate, concrete feedback that documents their growth because of the attempt that they have made. Fun creates relationships and motivation through the learning process. The links allow the learners to take in things more quickly, and the motivation allows the student to put forth effort without resentment. Denis and Jouvelot (2005) also note that motivation also leads to the activation of efficient cognitive strategies for long-term memory processes like monitoring, elaborating or organizing information. Motivation, therefore, is a critical part of games and their meaning.

Games are encompassed members of both play and fun, and both can be formally structured through the powerful institution of games (Prenkysy, 2001). Betrus and Botturi (2010) note that games are a form of playing that can derive from human beings' natural tendency to play. Figure 2.4 demonstrates how games are types of organized play. Figure 2.4 also goes on to further categorize games as being competitive and non-competitive and then breaks down competitive games either further as intellectual or physical.

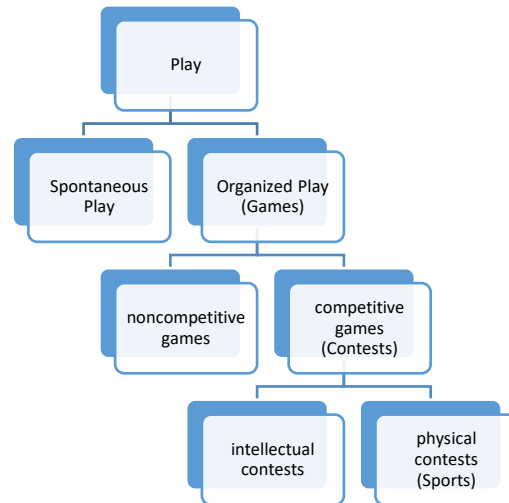


Figure 2.4. Play composed of spontaneous play and organized play. The figure further shows types of games under organized play. Researcher’s depiction that is adapted from “Fun, play and games: What makes games engaging,” by M. Prensky, 2001, *Digital Game-Based Learning*, p. 118. Copyright 1999-2000 by Encyclopedia Britannica Inc.

Six structural elements of games provided by Prensky (2001) include; Rules, Goals and Objectives, Outcomes and Feedback, Conflict/Competition/ Challenge/ Opposition, Interaction, and Representation or Story. Rules are what makes games different from other types of play and they force all players to take specific paths to reach goals (Prensky, 2001). Betrus and Botturi (2010) further provide that rules in games are also sets of rigid structures. Goals and objectives are important in games because they are important factors that motivate the players, and humans are naturally goal-oriented species (Prensky, 2001). Hays (2005) discusses how the goals can be the same or change over time, goals may consist of sub-goals, and that players can set their objectives. Players of games use the outcome and feedback from games to measure their progress against the goals, and actual learning takes place from the feedback in games. (Prensky, 2001). Conflict, Competition, Challenge, and Opposition are the problems that the players are trying to solve in the game; they also get the players excited about playing the game (Prensky,

2001). Hays (2005) says that a player can compete with players or team members by beating them to a goal, players can compete with the system, or players can compete with themselves. The interaction could refer to being either an interaction between the computers or interaction between other players/people. Representation means that the game is about something, or that the game can be concrete, direct or indirect. Representation could also mean that a game could have a narrative or story element present within the game. Representation or story is also important for games because they allow for the creation of a virtual world. These items combine to compose a game.

Mathematics games are explicitly defined by Oldfield (1991) as activities that (1) have a challenge, usually against one or more opponents, (2) have a set of rules and have a clear structure, (3) have a typically clear finishing point and (4) specific mathematics cognitive objectives. Mitchell and Savill-Smith (2004) expand upon the use of math games more and state that interactive exploratory games are beneficial for instruction in math, especially when standards are challenging to picture or manipulate with concrete materials. Students can develop expert behaviors such as pattern recognition, problem-solving, qualitative thinking, and principled decision-making as their expertise increase with game usage (Van Deventer & White, 2002).

While games are influential in motivating students, their usage is not straightforward. Betrus and Botturi (2010) found that the very makeup of games helps students to learn because they can provide goals, rules, and feedback structures that can naturally turn a students' attitude toward playing into a constructive force for learning. The authors further highlight several advantages of playing games: increased motivation, sophisticated understanding, reflective learning and feedback and self-regulation. On the other hand, the disadvantage of playing games

includes: subversion of rules, time that the games take up, teachers' loss of control, traditional learning may seem dull, learners may be accustomed to more professional games. Ritchie (2010) notes that some educators and researchers express concerns that the use of digital technology in the classroom could dwindle students' ability to focus. However, it is also debated that students are not engaged because they are not provided with opportunities to learn with digital learning simulation games (Gee & Levine, 2009).

Game-Based Learning. Game-Based Learning (GBL) is a new approach to facilitate student-centered learning. Hays (2005) describes the essence of GBL best by stating that games are for instruction, if and only if they are designed to support specific instructional objectives and logically incorporate into an instructional program. Alaswad and Nadolny (2015) found that GBL is a developing educational approach that motivates a deeper understanding of learning, and the research is expanding in its use and potential. Cicchino (2015) offers the following six principles of GBL; critical thinking, challenge, opportunities for players to construct their knowledge, fictional world, social and winnable.

While GBL helps us to discuss students' learning, Digital Game-Based Learning (DGBL) helps us to look specifically at learning using digital computer game-based learning. Lenhart, Kahne, Middaugh, Macgill, Evans, and Vitak (2008) found that 97% of Americans between the ages of 12 and 17 play digital games. Knowing that most students are engaged in digital games, it is beneficial to explore how education can expand upon students' interest in digital games and use it for learning educational content. Prensky (2001b) defines DGBL as "any marriage of educational content and computer games" (p. 145), or as "any learning game on a computer or online" (p. 146). Nussbaum and de Sousa Beserra (2014) further provide that DGBL is the reaction to the balance between learning and gaming elements. Bellotti, Kapralos, Lee, Moreno-

Ger, & Berta (2013) stipulate that DGBL has two essential elements that include fun and learning.

DragonBox

This case study examined the mathematics simulation game DragonBox, and how the effects of using it impacts preservice mathematics teachers' mathematics teaching efficacy. The rationale for employing DragonBox in this study is that it fits the study's definition of mathematical simulation game. DragonBox Algebra 12+ is a mathematical simulation game that helps to develop students' conceptual understanding of solving equations. DragonBox Elements is a mathematical simulation game that helps develop students' sound understanding of Geometry.

The DragonBox suite of DragonBox Algebra 12+ and DragonBox Elements provides a conceptual understanding of solving equations by having players to solve equations and learning the properties of basic shapes by using a more symbolic route. The DragonBox suite also provides procedural fluency by providing players with multiple levels and stages to practice and apply the rules of solving equations and understanding proofs. The games provide strategic competency by using monsters, die, and boxes to solve mathematical problems. The adaptive reasoning applies to players having to figure out how to progress through the simulation. Players cannot advance through the simulation without using and then understanding the rules of solving equations or understanding the properties of basic shapes. Productive dispositions apply as students are successful in the game and realize, with the help of the teacher, that they can solve equations or understand proofs. From these descriptions of the DragonBox suite, we can conclude that: (a) there are specific instructional objectives, (b) learning occurs through practice in a repeatable, focused environment, (c) there is a challenge, (d) there is a set of rules, (e) a clear finishing point, and (f) concrete mathematics cognitive objectives.

DragonBox in Literature. Siew, Geoffrey and Lee (2016) conducted a quasi-experimental study with 30 experimental and 30 control group eighth-grade students to study the effects that DragonBox Algebra 12+ had on algebraic thinking and attitudes. The results of the study displayed that students that used DragonBox Algebra 12+ showed significantly higher mean scores in algebraic thinking and attitudes as compared to the control group.

Similarly, Kluge and Dolonen (2015) conducted a mixed method study with 75 participants from two different schools located in Norway. The first school did not have instructional support as they played DragonBox while the second school did have teacher supported instruction while playing DragonBox. The results of the study found that students with support had statistically significant increases in learning outcomes while students without teacher support declined in learning outcomes. The study concluded that instructional support is effective in increasing student learning outcomes as the engage with video games.

Students' attitudes of mathematics and learning mathematics was shown to be affective using DragonBox Algebra 12 + in a study conducted by Katirci (2017). Katirci (2017) conducted a qualitative study with four seventh-grade students for a total of five weeks. Results from the study included that students had more self-confidence in their mathematics ability and students were able to better visualize and verbalize mathematics.

Mathematics Simulation Games

A mathematics simulation game is a manipulative that can be used to provide students with a model, to help promote a better conceptual understanding of mathematics. Aldrich (2004) defines simulations as tools that facilitate learning through practice in a repeatable, focused environment. Additionally, he states that simulations are safe, flexible, resource efficient, accessible globally when based on the web, and useful in helping students develop visual and conceptual models. Mathematical simulation games provide a simulated world in which students

can perform real-world mathematical problems and where students can focus on the thought process (Devlin, 2011). Additionally, while simulation games provide real-world applications, they also provide students with the opportunity and motivation to practice a skill multiple times until they are proficient in it.

Furthermore, simulations are useful in education because they mimic real-world events or processes and provide students with genuine learning opportunities (Juckett & Feinberg, 2010). Providing students with simulation games provide different positions that will contribute to shaping the way students think about mathematics. Students can come to their conclusions better through simulations rather than only being given an algorithm to follow. Therefore, teachers providing alternative ways of helping students understand mathematical concepts through simulation games is essential to facilitate conceptual understanding of ideas.

Simulation Games in Research in Education

I agree with Young et al., (2012) when they provide that an accepted definition of educational simulation games need to be made. However, after a review of the literature of 300+ articles, Young et al. (2012) determined that researcher categorize video games and simulation games differently. Additionally, Young et al. (2012) argue that while there are many educationally interesting games, their impact on student achievement is limited especially in the field of math. This literature review asserts the need for the educational community to improve the way they examine video games as a learning and instructional tool. The following will examine additional studies that have reviewed educational computer, video or simulation games. A distinction has not been made because there is not an agreed-upon distinction.

A review of 27 research studies, of which 21 found a positive impact of using mathematical computer games was conducted by Divjak and Tomić (2011). The study results indicated that mathematical computer games for teaching contribute to more efficient and

quicker realization of educational goals. Additionally, they concluded that using mathematical computer games for teaching influenced the formation of the positive attitude of pupils of different ages towards mathematics. The mathematical computer games were also found to contribute to boosting students' motivation, quicker acquisition, and long-term knowledge when compared to teaching without computer games.

A literature review, conducted by Hays (2005), examined instructional games focusing on the empirical data. One of the purposes of this research was to explore the effectiveness of using games for instruction and learning. The study was carried out to provide the Navy, Department of Defense, and private industry with valid, empirical research to decide if utilizing instructional games is effective. Some of the major conclusions were that:

- The experimental research on the validity of instructional games is fragmented.
- Although research has shown that some games can provide active learning for many students regarding different tasks (e.g., math, attitudes, electronics, and economics), this does not tell us whether to use a game for instructional assignments. We ought not to oversimplify from research on the validity of a single game in a single learning area for a single group of learners to all games in all learning areas for all learners
- Instructional support to help students know about using the games escalates the instructional strength of the gaming encounter by granting learners to pinpoint the instructional information as oppose to only fulfilling the requirements of the game.
- Methodological challenges plague the results.

An across-stage, mixed methods study conducted by Ke (2008) examined if educational computer games, compared to traditional paper and pencil drills, would be more useful in facilitating comprehensive math learning outcomes. The study included data from 358 students

from eighteen 5th grade public schools in central- Pennsylvania. The study findings suggest that computer games, compared to paper-pencil-drills are more efficient in promoting motivation through learning, but it did not show a significant difference in facilitating cognitive math test performance and metacognitive awareness. The study started with 487 students but reduced because of absences during the pretest and posttest.

The effects of using the computer game, DimensionM, students' mathematical achievement, motivation, prior knowledge, computer skills, and English language proficiency was examined by Kebritchi, Hirumi, and Bai (2010). A total of 193 Algebra and Pre-Algebra students and ten teachers from an urban high school in the Southeast United States were used in the study. A mixed method of quantitative and interviews was used with Multivariate Analysis of Co-Variance to analyze the data. Results demonstrated a greater progression of the students that used the computer games when compared to the students that did not. The study also found that there were no significant differences in student motivation. A possible methodical challenge in this study was that the control group teachers in this study tried to make their students more interested in mathematics as they were aware of the experiment. Therefore, no significant difference between the motivations of treatment versus control group was found in the motivation survey.

Using internet games and traditional classroom activities, Pange (2003) conducted a study that considers teaching probability and statistics to a group of 17 preschool children; ages range from four to five. The children demonstrated improvement in their understanding of probability. Teachers also reported that they liked using the game, and the excitement of their students from the games made teaching more interesting. Methodological issues prevented determination about the separate effects of the different games.

A study, conducted by Laffey, Espinosa, Moore, and Lodree (2003), attempted to evaluate the likelihood of interactive computer technology for teaching math skills to young, low-income, urban children. The exploratory study with 61 Pre-K, Kindergarten, or First-grade students randomly assigned to a control group and treatment group. Both groups received the same math instruction, and the treatment group interacted with the interactive computer technology bi-weekly for eight weeks. Hays (2005) provides that it is not possible to conclude from the study because details are not provided. The treatment group also has more math instruction because they are permitted to interact with the game bi-weekly for eight weeks.

The use of math simulation games was studied by Hess and Gutner (2013). This study looked at using video games in an online learning environment, and a mixed methods approach was used. The qualitative sample of teachers included four teachers from the courses that were included in the study. The findings were that 92 students that were enrolled in a game-based online course performed significantly better and took significantly longer to complete the course compared to the students that were not on a game-based online course. A possible weakness of this study was that the courses in the study were not properly aligned. Hess and Gutner (2013) stated that it is possible that students in the online game-based course could have taken longer because of other factors such as additional and more in-depth assignments than students in the nongame-based online course.

Similarly, Brennan and Vos (2013) in their study examined whether participants could benefit from quantitative skills while engaging in simulation games. The study was a single-institution exploratory study and consisted of 76 students in a final year course in strategic marketing in the UK. Students did not show great gains in financial skills from the use of the simulation game, and the researchers suggested that a baseline understanding of financial

concepts were needed first. There were issues with students not being able to take both tests that were necessary for the study. Also, there were limitations on the external validity of the study.

A meta-analysis was conducted by Vogel et al. (2006) on 32 studies to decipher which teaching method, games, and interactive simulations or traditional is the most successful. It was determined that across people and situations, games and interactive simulations are more dominant for cognitive outcome gains. Vogel et al. (2006) also reported that many methodological issues prevented them from drawing accurate conclusions. One of the problems was that many of the articles that they found were not usable because of the methodological and reported flaws in the articles. The lack of a control group was the most frequent issue that was discovered as a methodological flaw in the literature, without the comparison it is impossible to conclude if the given intervention accounted for the change in results. Multiple studies also failed to include any statistical data in their reports, the absence of data leaves the research unusable. Finally, many of the studies also failed to describe the programs and activities that were used as interventions to determine if they were true interactive simulations.

The use of simulation games that focused on sociology was reviewed by Dorn (1989). Dorn (1989) believed that simulation games base themselves on the model of experiential learning which states: learners first act within an instance of the application, learners' attempts to understand the effects of their behavior and decisions in a case, and then learners seek to understand the principles under which the instance falls. The results were mixed. There were consistent results that showed that games generate interest and motivation in learners. The results also showed that simulations games appeared to be as effective as other techniques for teaching information, principles, and concepts. From this study, Dorn concluded that instructional games

must: be selected to accomplish a goal or meet a specific educational standard, not be inserted into a course as a haphazardly, and include a debriefing after the game.

A quantitative analysis of simulation games compared to instructional procedures was ran by VanSickle (1986). The results showed that there was the faint outcome for simulation games over other approaches, such as classroom lecture. Hays (2005) states that the conclusion is weak for many reasons. VanSickle did not describe the characteristics of the simulation games used in his analysis, and six of the twenty-two studies did not correlate students who engaged in simulation games with other forms of instruction. VanSickle also applied several mathematical transformations to his data before obtaining his results, which could have introduced errors to his results.

A review of 22 research studies that were used in sociology and social science course was performed by Pierfy (1977) and found that simulation games had no more effect than conventional classroom instruction. Pierfy (1977) did find that some research indicated that the uses of games might improve retention of learned information, and the ability to change students' attitude and interest. The major weakness of these conclusions come from sparse instrumentation and methodology in the studies reviewed.

Summary

The research concerning the effectiveness of using mathematics simulation games is fragmented. Feinberg (2011) cautions that simulations games have diverse designs which discourages universal outcomes. Therefore, it is reasonable to review the evidence that the use of some simulation games in the classroom could potentially help to engage more students. Increased engagement of students could lead to increased mathematical competency in students which could also lead to increased mathematics teaching efficacy in teachers. Lee and Lee (2014) found that preservice teachers could improve in technology efficacy towards technology

integration through a course that focuses and teaches preservice teachers how to implement in the classroom. It is important that preservice teachers are provided with the necessary tools to help students learn and to ensure that they are also confident in their abilities as well.

The current literature provides that increasing teacher efficacy could be a key in ensuring the success of students (Pajares, 1992). Furthermore, the existing research provides the usefulness of using simulation games, the impact of teaching efficacy on student achievement, and the effectiveness of the teacher efficacy measuring tools. Additionally, from the studies conducted by Katirci (2017) and Siew, Geoffrey and Lee (2016), it was shown that DragonBox Algebra 12+ could be useful in increasing students' algebraic thinking and understanding. While Arslan and Isiksal-Bostan (2016) provided a study to determine the perceived usefulness of Origami on preservice teachers' teaching efficacy, information is still missing concerning using mathematical simulation game to increase teaching efficacy. This study aims to fill the specific gap in the literature to discuss the possibility of increasing teaching efficacy through the use of a mathematical simulation game.

CHAPTER 3

Methodology

The purpose of this study was to examine the effects of using mathematical simulation games on preservice middle-level teachers' mathematics teaching self-efficacy. This study hypothesized that learning to incorporate simulation games increases preservice middle-level mathematics teachers' teacher efficacy and their confidence to use mathematical simulation games in their future teaching. Specifically, the study targeted the following research questions:

1. How are preservice middle-level teachers' mathematics teaching efficacy affected using the mathematics simulation games of DragonBox during the study?
2. How do preservice mathematics teachers perceive the use of mathematics simulation games in teaching middle-level mathematics during the study?
3. What are the factors that affect the preservice middle-level teachers' mathematics teaching efficacy as they engage in mathematics simulation games during the study?
Moreover, what are the affordances/constraints associated with using mathematics simulation games concerning mathematics teaching efficacy?

Theoretical Framework

The theoretical perspective that used to interpret and frame this study is Social Cognitive Theory (SCT) which was developed by Bandura (1986). The foundation of SCT major tenets is a causal model of triadic reciprocal causation in which personal factors, environmental influences, and behavior interact and affect each other bi-directionally. The conceptual model for this study included triadic reciprocal causation of a teacher's personal factors, teaching environmental influences and teaching behavior. The factors that affect the preservice middle-level teachers' mathematics teaching efficacy as they use mathematics simulation games during

the study were regarding mathematics teacher's environmental influences, personal factors, and behavior. Figure 3.1 depicts the conceptual model for mathematics teacher efficacy.

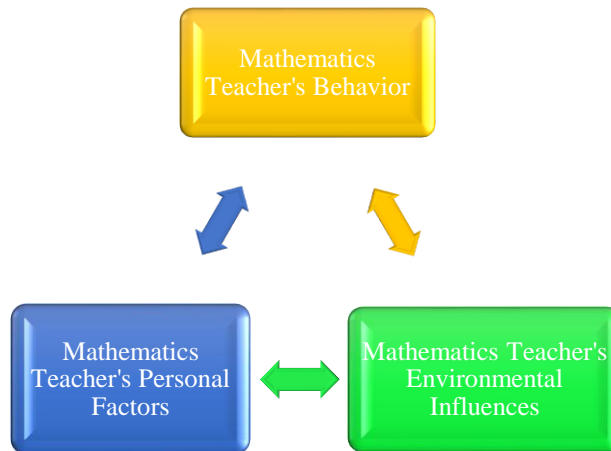


Figure 3.1. Researcher's depiction of Conceptual Model for Mathematics Teaching Efficacy.

Study Context

A research intensive, Ph.D. granting institution located in the southeastern part of the United States was the location of the study. The University is an urban public university that offers 100 fields of study and 250-degree programs through eight colleges. The student to faculty ratio is around 22:1 and the student demographic is majority females. The majority of students are Black or African American with the next highest ethnicity being White. Collected data came from a three-credit hour methods course for teaching middle childhood mathematics education. The purpose of this course is to prepare middle childhood education teachers to teach mathematics in urban, suburban or culturally diverse middle school classrooms. The course is designed to provide current and future middle school teachers with the mathematics content, essential concepts, methodology, activities, and resources to both learn and teach mathematics in middle grades. The study comprised of 33 preservice teachers enrolled in the three-credit hour methods course. Students meet twice a week for 3 hours per session. The researcher was given permission to host one module of the course by the instructor of the course for 6 non-consecutive

weeks. The researcher provided instruction only regarding using the simulation games of DragonBox and did not assign grades.

Participants

The sample comprised of 33 students purposely selected from the population of students who were enrolled in the three-credit hour methods course for teaching middle childhood mathematics education. Participants provided information on their gender and race, and Table 3.1 presents this information.

Table 3. 1

Participants Demographics

Gender	Race/Ethnicity				Total
	Hispanic/Latino	Black/African American	White/Caucasian	Asian/Pacific Islander	
Male	0	4	0	0	4
Female	3	17	6	3	29
Total	3	21	6	3	33

As shown in Table 3.1 of the 33 participants many were females ($n=29$, 87.9%) and the remaining were males ($n= 4$, 12.1%). African-Americans ($n=21$, 63.6%) made up the majority of the ethnic population. The remaining 11 participants identified as White/Caucasian ($n=6$, 18.2%), Asian/Pacific Islander ($n=3$, 9.1%) or Hispanic ($n=3$, 9.1%).

Mason (2011) provides there are numerous factors used to figure out a sufficient sample size for qualitative studies; however, many researchers avoid suggesting a sample size. Guest, Bunce, and Johnson (2006, p. 59) (as cited in Mason, 2011) provide “although the idea of saturation is helpful at the conceptual level, it provides little practical guidance for estimating sample sizes for robust research prior to data collection.” The following are qualitative sample size guidelines found by Mason (2011):

- Bertaux (1981) provides that “fifteen is the smallest acceptable sample” (p.35) (adapted from Guest et al., 2006).
- "25 [participants are] adequate for smaller projects" (Charmaz, 2006, p. 114).
- Ritchie et al. (2003) suggest that qualitative samples often "lie under 50" (p. 84).
- Green and Thorogood (2018) state that "the experience of most qualitative researchers (emphasis added) is that in interview studies little that is 'new' comes out of transcripts after you have interviewed 20 or so people" (p. 120).

This study will adhere to the suggestions of the research and stay within the 15- 50 participant range for qualitative sample sizes and use the entire sample of 33 participants. The use of 33 participants suggests that saturation will be avoided.

Interviewed participants. Four participants volunteered out of 33 for three interviews. All 33 participants were invited to participate in interviews before and after class, and from the group, four agreed to participate in interviews. Out of the four interviewed participants two were Hispanic females, one was a Black female, and one was White female. The interviewed participants were given pseudonyms to protect their privacy and were called: Ester, Oprah, Naomi, and Ruth.

Ester is a 37-year-old Hispanic woman and a mother of two boys of middle-grade age. Ester is in the secondary education program and is double majoring in Middle-Level Education with a concentration in Mathematics and Science. During the study, Ester was performing her practicum at a middle school that her son would have attended if her family continued to stay in the school’s district. Ester felt extremely comfortable at her practicum school because she knew a lot of the students and parents. Ester did not currently engage in video games, but she did when

she was younger. Ester is an advocate for using video games for instruction because her sons have greatly benefited from playing them. Ester made a note of how the simulation games of Minecraft helped her son. Ester also noted that when referring to her practicum "my students, they love games. They love it. Like, they are very competitive. They love technology. So, I believe that I am going to enjoy it myself because I am very hands-on" (Ester, first interview).

Oprah is a 21-year-old Hispanic woman. Oprah is in the secondary education program and is majoring in Middle-Level Education with a concentration in Science and minoring in Mathematics. Oprah provided she was actively engaged in playing video games when she was in middle school. Therefore, Oprah understands her current practicum students' passion for playing video games.

Naomi is a 35-year-old Black woman with one ten-year-old son. Naomi is in the secondary education program and is majoring in Middle-Level Education with concentrations in Mathematics and English Language Arts. Naomi currently plays games frequently by herself and with her young son to relax and bond. Naomi and her son enjoy playing sports games together. Naomi is an advocate for technology and games in the classroom because she feels that many of her students enjoy playing games and games keeps her practicum students engaged.

Ruth is a 27-year-old White woman. Ruth is in the secondary education program and is majoring in Middle-Level Education with concentrations in Mathematics and English Language Arts. Ruth plays and researches video games frequently throughout the week. Ruth enjoys games that provide a storyboard for students to progress through.

Study Design

An embedded, exploratory case study design using mixed methods techniques was chosen to investigate the influence of using the mathematical simulation games of DragonBox, on preservice middle-level teachers' mathematics teaching efficacy. The need for a case study

comes from a desire to understand social phenomena, and a case study allows a researcher to focus on a “case” and gather holistic and real-world perspective while studying small group behavior or school performance (Yin, 2013). A case study can provide a unique example of real people in real situations, and this allows the readers to understand the ideas of the research more clearly rather than presenting the reader with abstract theories or principles (Cohen, Manion, & Morrison, 2000). Cohen et al. (2000) further explain that the strength of case studies is that they observe effects in real contexts. Yin (2011) also stipulates that the use a case study will cloud the boundary line between the phenomenon and its meaning because a case study is the study of a case within its context. This case study, according to its outcome, was exploratory. Yin (2013) provides that exploratory case studies be for testing theories, and the studies can act as pilots that generate hypotheses that can test larger scales. An exploratory case study allows the researcher to explore the different phenomenon in the data (Zainal, 2007).

Case studies recognize and accept that there can be many variables that operate within a case, and to catch all the implications of the variables will usually require more than one tool for data collection and many sources of evidence (Cohen, Manion, & Morrison, 2000). Cohen, Manion, and Morrison (2000) also provide that case studies can blend numerical and qualitative data. For this study, mixed methods techniques will be used to address a combination of both forms of data to provide a complete analysis of the research questions (Creswell & Clark, 2011). Choosing a mixed methods research approach offers a compliment for case study research because it allows the researcher to take the empirical data that comes from the case studies and apply either quantitative or qualitative method to the data (Kitchenham, 2010). This case study employed the utilization of an embedded design in which qualitative data becomes integrated into a major design intervention trial.

This study addressed the effects of using the mathematical simulation games of DragonBox, on preservice middle-level teachers' mathematics teaching efficacy. The embedded design involved qualitative data embedded within a major design intervention trial. The embedded design's purpose is to answer different questions that require different types of data (Creswell & Plano, 2011). The quantitative data was used to measure whether mathematics simulation games will positively influence the mathematics teaching efficacy for middle-level mathematics preservice teachers. The embedding of the qualitative data was in this broader design intervention trial for determining; how preservice mathematics teachers perceived the use of mathematics simulation games in teaching middle-level mathematics during the study and what were the factors that affected the preservice middle-level teachers' mathematics teaching efficacy as they engaged in mathematics simulation games during the study.

Cohen, Manion, and Morrison (2000) argue that case studies do not have the external checks and balances that other forms of research have, however, case studies still must abide by rules of reliability and validity. To ensure construct validity the different methodological tools of the study applied the ideas and definition of SCT. Using an interpretation of the data from supported findings helped ensure internal validity. To ensure external validity the interpretation of the study was within the definition and meaning of SCT, more specifically within the context of mathematics teaching efficacy. The mixed methods approach ensured concurrent validity. The IRB approval and university's classroom setting provided ecological validity. Writing steps and documenting procedures so that another person can repeat the study with the same results ensured reliability. I made a conscious effort when collecting and analyzing data to avoid confirmation bias.

Data Collection Methods

There was a collection of quantitative and qualitative data. The primary methodology was qualitative, and the secondary was quantitative. There was one quantitative instrument, the Mathematics Teaching Self-Efficacy Scale (MTSES) (Ryang, 2010). The four qualitative tools used were direct observations, researcher's journal, artifacts, and interviews.

Mathematics Teaching Self-Efficacy Scale (MTSES). The quantitative data was used to test the hypothesis that the mathematical simulation games, DragonBox, could positively influence the mathematics teaching efficacy of middle-level mathematics preservice teachers. The instrument, the Mathematics Teaching Self-Efficacy MTSES (Ryang, 2010) used consists of 10 items on a 5-point Likert scale: 1=Strongly Disagree (SD), 2=Disagree (D), 3=Uncertain (UN), 4=Agree (A), and 5=Strongly Agree (SA). Cross- validity of MTSES was verified by Ryang (2010) by testing various statistical analyses over two different data sets so that the instrument would be valid. The two different data sets were Mathematics Teaching Self-Efficacy (MTSE) and Mathematics Teaching Outcome Expectancy (MTOE) because Bandura (1977, 1997) provides that efficacy beliefs focus on two associated variables, personal Self-Efficacy, and Outcome Efficacy. Exploratory Factor Analysis and Confirmatory Factor Analysis tested convergent and discriminant construct validity. Reliability was also examined by Cronbach internal consistency, and standard error curve and marginal reliability that was run by Item Response Theory through the Graded Response Model. The MTSE had the marginal reliability that was $\rho = 0.8591$ which indicates that this subscale is reliable. The MTOE had low marginal reliability that was less than .60, which showed that this subscale was not reliable as a single variable describing mathematics teaching efficacy. Therefore, only the MTSE subscale can provide trustworthy information in a research study, and the MTSES only consists the one subscale, MTSE (Ryang, 2010). The Cronbach alpha for scores for the MTSES is $\alpha = .823$.

Direct observations. Direct observations involved observations of participants and the natural setting and the target individuals (Yin, 2009). Direct observations also cover events in real time and include events that happen in the context of the study. The observation journal documented the direct observations. I used the method of jotted notes to record the direct observations of the preservice teachers as they engaged with the mathematical simulation games of DragonBox. Jotted notes are “words, phrases, or sentences that are recorded during the day’s events as primary aids to memory” (Dewalt & Dewalt, 2010, p. 160). Dewalt and Dewalt (2010) further explain that notes are better if the researcher has taken time and introspection to anticipate the personal impact of the theoretical approaches. I was sure to jot notes about the teachers’ personal factors, the teaching environment, and their teaching behavior.

Yin (2013) describes limitations of observations can be that they are time-consuming, selective in the content observed, and reflexive as the observer’s presence may change the course of events of the participants’ behavior. I entered the research process with an awareness of these limitations and considered the reflexivity of the participants in the observation process. The jotted notes aimed to be as inclusive as possible before applying codes to be as unbiased as possible.

Researcher’s journal. The researcher’s journal was used to summarize, reflect and record the direct observation from the interactions with preservice teachers (Dewalt & Dewalt, 2010). There was a total of 33 preservice teachers encouraged to lead discussions, work to find solutions and ways of incorporating the use of the simulation games in lesson plans, activities, and assessments.

During the class sessions, for the six of the non-consecutive weeks, discussions that participants had while engaging with the game were documented through jotting. While

preservice teachers were involved with the simulation game, the researcher walked around and jotted notes from the discussions that preservice teachers were having with each other and jotted notes from their reactions to the simulation game. Preservice teachers could interact with the game individually for 50-60 minutes while completing a companion worksheet (Appendix C and Appendix D) for two of the class sessions of the six non-consecutive weeks. After their interaction with the mathematical simulation games, preservice teachers were asked to present their findings to the entire class in small groups. These small groups were chosen differently (random selection or student choice) at each class session and hosted between two-four students. Preservice teachers had opportunities to present their findings, observations, and feelings from their interactions with the game. Preservice teachers were given 20- 25 minutes to discuss, agree and prepare their group presentations. As groups of preservice teachers presented their presentations, the researcher jotted notes from a total of four presentations that lasted approximately 15 – 20 minutes. After each class session, for the six non-consecutive weeks, I provided a reflection or narrative of the jotted notes from the direct observations in the researcher’s journal. Also, to ensure validity and reliability, the researcher’s journal will be triangulated with the other methodological tools of the study. I offered to share the observations with the preservice teachers to serve as a form of member checking to further account for the potential limitations of the observations.

Artifacts. The artifacts for this study included; participant reflections, game companion guides (Appendix C and Appendix D), and student work samples. The 33 participants were asked to reflect three times, on their experiences with games in the mathematics classroom and on their thoughts of using games in the mathematics classroom. Preservice teachers submitted a 1-page minimum, single-spaced reflection after being provided with a prompt (Appendix I).

Participants wrote reflections proceeding the class activities, and participants were requested to provide their thoughts within 30 hours of the class. The reflections were like interview prompts. The reflections allowed the participants to elaborate, reflect, and provide insights missed during observations.

Preservice teachers also engaged in other classroom activities that produced student work samples such as collaborative presentations and game companion guides (Appendix C and Appendix D). A demographic questionnaire (Appendix B) was given at the beginning of the study as well. A triangulation of artifacts and other methodological tools helped to ensure validity and reliability.

Interviews. The three-interview series by Seidman (2013) was used to inform the conduction of interviews. Following Seidman’s interview series, the four participants were interviewed three times. Seidman (2013) provides that the first interview should focus on the life history of the participant as it pertains to the study. The first interview for this study focused on determining participants’ history and current interactions with playing video games. The first interview was informal and lasted between 10 – 15 minutes. The second interview should provide details of the experience. “The purpose of the second interview is to concentrate on the concrete details of the participants’ present lived experience in the topic area of the study” (Seidman, 2013, p. 18). For this study, the second interview was semi-structured, relied on an interview protocol as a guide and focused on participant’s present experiences with the using games and manipulatives in their practicum classrooms. The second interviews lasted between 15- 30 minutes. The third interview, as provided by Seidman (2013), should be a reflection on the meaning of their experience. The third interview was also semi-structured, relied on an interview protocol as a guide and focused on participants’ reflecting on the meaning of their

experience with the simulation games. The third interview lasted between 15-30 minutes. The interviews were audio recorded and transcribed. The interviews were used to help understand the interpretations of the study's findings and to understand the experiences had by the participants (Dowling, Lloyd, & Suchet-Pearson, 2016). Participants verified transcripts of interviews for reliability checks. The interview data triangulated with the other methodological tools of the study to ensure validity and reliability of the study.

Intervention: DragonBox

The intervention occurred for six non-consecutive weeks during the semester. Participants were engaged in the two simulation mathematics games from a DragonBox series titled DragonBox Algebra 12+ and Dragonbox Elements. The DragonBox series provides mathematical simulation games that help players to develop conceptual understandings of mathematics. The DragonBox can be purchased from the App Store, Google Play or for Windows Desktop Computer. Participants were provided with two 50-60-minute sessions to engage with the simulation games of DragonBox.

The purpose of DragonBox Algebra 12+ is to have players balance equations. The equations are unique and range from getting boxes on one side, eliminating monsters, combing like die, and so on. Players solve equations with characters before an actual standard looking equation becomes evident. The players must make decisions that are algebraic which allow players to gradually see how getting rid of monsters has the same implications as getting rid of integers. Players are also able to isolate a treasure box on one side of the board by doing the opposite operations just as an Algebra student would when solving for a variable with solving equations. The players must make decisions to solve problems by emphasizing the relationship of solving equations over varying interacting inputs and targeted outcomes. Figure 3.2 shows

getting the treasure box alone by doing the opposite operation of getting rid of the monster.

Figure 3.3 shows the real equations that show up in higher levels of the game.

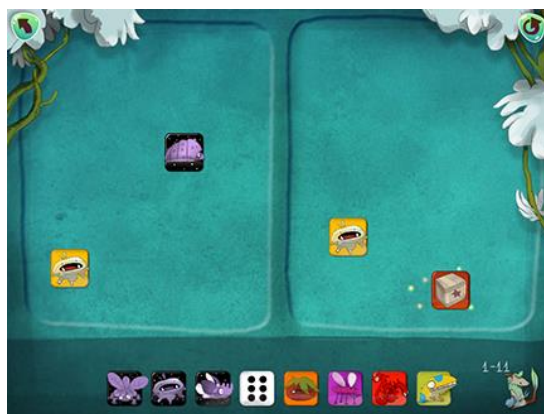


Figure 3.2. Screenshot from the game DragonBox Algebra. The bottom characters represent opposite characters that should be used to help get the box along. From WeWantToKnow. (2014). DragonBox Algebra 12+ [Mobile Application Software]. Retrieved from <http://itunes.apple.com>.

$$\frac{(3 \cdot x + (-3) \cdot x)}{(-2 \cdot x + 5)} + \frac{(x + (-3))}{6} = \left(\frac{2 \cdot x}{3} + (-5) \right)$$

Figure 3.3. Screenshot of an advanced level of the simulation game DragonBox Algebra. The advanced level shows an equation using numbers. From WeWantToKnow. (2014). DragonBox Algebra 12+ [Mobile Application Software]. Retrieved from <http://itunes.apple.com>.

DragonBox Elements is a mathematical simulation game that helps develop students' sound understanding of Geometry. DragonBox Elements is designed to have players learn the properties of essential shapes to recruit an army to defeat an evil dragon. DragonBox Elements

makes learning the properties of proofs interactive for players. The players must make decisions to solve problems by emphasizing the relationship of properties of basic shapes over varying interacting inputs and targeted outcomes. Figure 3.4 shows a scene about learning properties of parallel lines and circles.

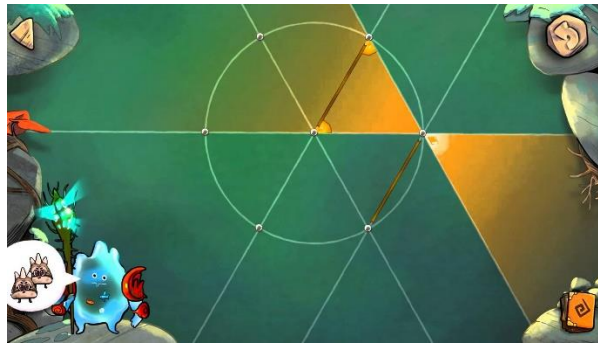


Figure 3.4. Screenshot of DragonBox Elements and properties of parallel lines. From WeWantToKnow. (2015). DragonBox Elements [Mobile Application Software]. Retrieved from <http://itunes.apple.com>.

The DragonBox simulation games chosen for this study provides a conceptual understanding of Algebra and Geometry by having players to solve equations and learn the properties of basic shapes by using a more symbolic route. Procedural proficiency was once a focus on mathematics instruction, and it remains important today. However, conceptual understanding has now become an equally important goal (National Council of Teachers of Mathematics [NCTM], 2000; National Research Council, 2001). DragonBox provides procedural fluency by providing players with multiple levels and stages to practice and applies the rules of solving equations and understanding proofs. The simulation games offer strategic competency by using monsters, die, and boxes to solve mathematical problems. The adaptive reasoning applies to players having to figure out how to progress through the simulation game. Players cannot advance through the simulation game without using and understanding the rules of solving

equations or understanding the properties of basic shapes. Productive dispositions apply as students are successful in the game and realize, with the help of the teacher, that they can solve equations or understand proofs, and be good at it.

WeWantToKnow (2018) provides a history of DragonBox and its creator, Jean- Baptiste Huynh, a mathematics teacher. Huynh found that many of his young and intelligent students were struggling with Algebra. Huynh decided that his students' abilities were not the issue, but instead, how he taught the subject. When Huynh realized this problem, he and cognitive scientist Patrick Marchal decided to co-found the Norwegian game company WeWantToKnow.

DragonBox 5+ was the first game from WeWantToKnow, and it was the first version of DragonBox Algebra 12+. DragonBox 5+ was a learning tool that WeWantToKnow describes as a game that "secretly teaches" students Algebra. Toppo (2015) describes DragonBox 5+ as a game that presents players with a strange scenario:

a mysterious box arrives, for no apparent reason, with a wide-eyed, omnivorous baby dragon inside, packed in straw. Also, for no apparent reason, the dragon wants to be alone. He must be alone before he'll eat. Don't ask, just play (p. 93).

The game board divides into two sides, and the baby dragon is on one of the sides. Both sides have cards that have random images of lizards, horned beetles, deep-sea fish, and angry tomatoes. To get past a level, the players must touch, tap and drag cards to get rid of them from the dragon's side. After the players have gotten rid of everything, the dragon eats everything that remains on the other side; the box is alone; the level is complete. As the game progresses, the cards have alter egos of night cards, these stand for the negative numbers. Players must strategize which card to get rid of first, which is a reference to the order of operations. As the game continues to progress, the dragon box becomes an x , and the characters slowly become numbers.

When Huynh began to craft DragonBox, his primary concern was ensuring that the child was at the center of the learning process. “It’s about the experience and not games” (Toppo, 2015, pg. 91). Huynh states to Toppo (2015), “It’s not an algebra app...It’s not about algebra” (p. 89). Instead, Huynh argues, it is about speed and imagination. “Mathematics is creativity. It’s play. You take an object, and you ask. ‘What if?’” (p. 89). Huynh is also careful to note that DragonBox does not take the place of the educator/teacher. “DragonBox does 50% of the job. We need to teach the rest” (p. 89). WeWantToKnow provides a list of key common core standards associated with its simulation games (Appendix J).

Procedure

At the beginning of the study, participants were read the recruitment script (Appendix E) and given an informed consent form (Appendix F) describing the purpose of the research and soliciting voluntary participation in the study. Preservice teachers that agreed to participate in the study were then given the MTSES questionnaire (Appendix A), a demographic survey (Appendix B), the first reflection question (Appendix I, Question Set 1), and informal first interviews were conducted. The next class session the four participants selected using criterion-based sampling were interviewed. Participants then engaged with the mathematical simulation game DragonBox Algebra 12+, completed the companion worksheet (Appendix C), and then completed the second reflection question (Appendix I, Question Set 2). The third-class session, participants were asked to engage with the mathematical simulation game of DragonBox Elements, fill out the companion worksheet (Appendix D), and then complete the third reflection question (Appendix I, Question Set 3). The fourth-class session, participants, engaged in preparing a lesson that included using that one of the games of DragonBox. Participants shared results, and one volunteer was able to conduct their lesson plan with their practicum students. The fifth-class session, participants engaged in a class discussion, prepared group findings of the

game and presented lesson plans and presented findings to the class. The final class session, participants, took the post-MTSES and second interviews occurred. During four of six non-consecutive weeks in which the participants were engaged with the simulation games I: 1) jotted notes as students interacted with the game through direct observations, 2) jotted notes as students presented and shared the group work samples through direct observations, and 3) reflected and summarized jotted notes after each class in the researcher's journal. A total of three interviews were given to four participants using criterion-based sampling. The interviews were audio recorded and the first two interviews occurred before the first intervention, and the third occurred after the intervention.

The study was conducted over a period of six nonconsecutive weeks. Chambers (2003) provides that the length of time a preservice teacher spends in student teaching does not affect teacher efficacy. Gorrell and Capron (1989) found that when preservice teachers had direct instruction followed by a student teacher demonstrating how to employ task with students, preservice teachers displayed higher levels of teacher efficacy. These studies agree with Bandura (1997) who provides that teachers' efficacy beliefs are influenced by mastery experiences, verbal persuasion, vicarious experiences and physiological arousal. When preservice teachers equipped with one of the past influences, teacher efficacy can increase or decrease depending on the impact of the influence. Participants were provided with direct instruction regarding the intervention and given time to interact with the simulation games.

Data was triangulated from multiple sources and was collected to provide evidence to address the research questions. Table 3.2 displays the design techniques, data collection instruments, and data analysis techniques.

Table 3.2

Data Collection Matrix

Research questions	Design Techniques	Data collection instruments	Data analysis technique
How are preservice middle-level teachers' mathematics teaching efficacy affected using the mathematics simulation games of DragonBox during the study?	Quantitative	MTSES – pre/post	Wilcoxon Signed-Rank test Reliability analysis using Cronbach's alpha
How do preservice mathematics teachers perceive the use of mathematics simulation games in teaching middle-level mathematics during the study?	Qualitative	Artifacts Interviews Observation Logs Researcher's journal	Six-Step Coding Protocol (Lichtman (2013))
What are the factors that affect the preservice middle-level teachers' mathematics teaching efficacy as they engage in mathematics simulation games during the study? Moreover, what are the affordances/constraints associated with using mathematics simulation games concerning mathematics teaching efficacy?	Qualitative	Artifacts Interviews Observation Logs Researcher's journal	Six-Step Coding Protocol (Lichtman (2013))

Data Analysis

Quantitative Data. The MTSES was given as a pretest and a posttest. A Wilcoxon Signed-Rank test was conducted to compare the median scores of the pre-test results of

preservice middle-level mathematics teaching efficacy to posttest results of preservice middle-level mathematics teaching efficacy after the intervention, DragonBox

A Wilcoxon Signed-Rank test is a statistical test that is nonparametric that matches to the paired sample t-test which is a parametric test (Sullivan, 2011). A parametric test is used when data confirms to certain assumptions with one of the central assumptions being that the data is normally distributed (Sullivan, 2011). The need to use the Wilcoxon Signed-Rank test arose from the pre and posttest data not being able to meet the assumptions of a paired samples t-test. There are four assumptions for paired sample t-test are: the dependent variable is continuous (i.e., interval or ratio level), the observations are independent of one another, dependent variables are approximately normally distributed, and there are no extreme scores or outliers in the dependent variables.

There is much debate as to if Likert scales are continuous. Jamieson (2004) provides that Likert scales as ordered categories, the intervals that are between the scale values are not equal, and any numerical operation applied to them is invalid. Other scientists suggest that although they might not be considered continuous, using Likert scales in parametric tests are valid in situations where the data meets all the assumptions of the parametric test (Lubke & Muthen, 2004; Glass et al., 1972). Therefore, I first tested the normality of the pre and posttest. One of the normality tests that are available in SPSS is Shapiro-Wilk (W). Park (2015) provides that the W statistic is recommended for samples sizes greater than or equal to seven and less than or equal to 2,000. The sample size for this study was $N = 33$. The W statistic is reported as a positive number that is less than or equal to one. A normal distribution of data will have a W statistic that is close to 1. Table 3.3 presents the results of the Shapiro-Wilk test.

Table 3.3

Tests of Normality: MTSES Scale Score (N=33)

	Shapiro-Wilk		
	Statistic	df	Sig.
MTSES pretest	.936	33	.053
MTSES posttest	.894	33	.004

The results of Table 3.3 show the Shapiro-Wilk test showed p-value greater than 0.05 for the pretest. However, the posttest scale of the MTSES showed a p-value that was less than 0.05. Hence the null hypothesis that the data came from a normally distributed population is rejected, and normality is not satisfied.

Vieira (2016) investigated and showed that a t-test is a valid analysis to compare groups where variables are measured using Likert scales, and the populations do not have to have a normal distribution. However, the assumption that the data does not have extreme values or outliers were not included in this study. Therefore, I reviewed the Stem-and-leaf plot provided by SPSS.

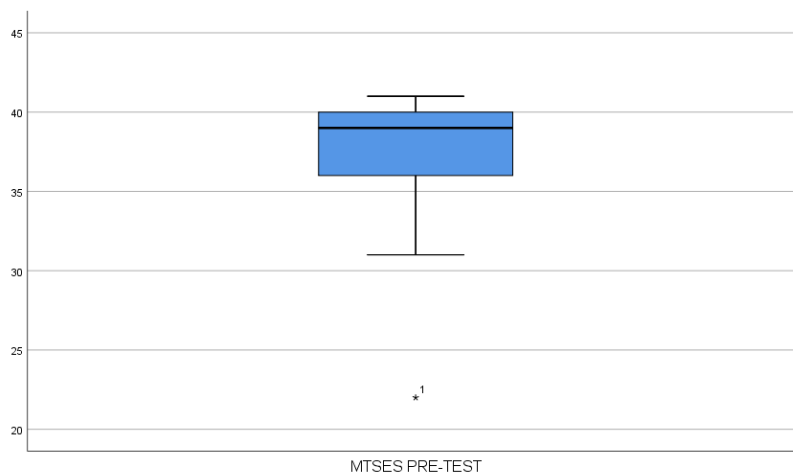


Figure 3.5. Steam-and-Leaf Plot: MTSES Pre-Test Scale Scores (N=33).

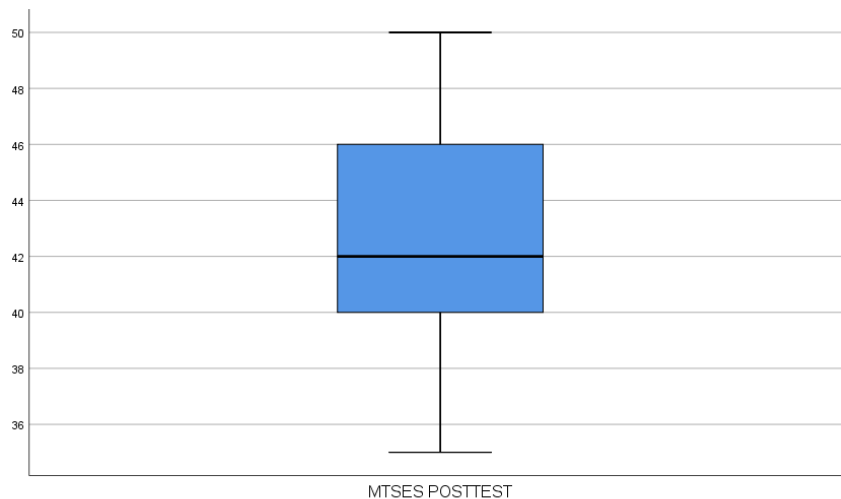


Figure 3.6. Steam-and-Leaf Plot: MTSES Posttest Scale Scores (N=33).

While the results Figure 3.6 show that MTSES Posttest Scale did not have any outliers, the results of Figure 3.5 show that the MTSES Pretest Scale did have one outlier. Therefore, a nonparametric statistical test was determined to be more reliable.

A Wilcoxon Signed-Rank test is used to test the medians from two independent samples (Sullivan, 2011). The hypothesis is given below, and the test will run on a confidence interval of 95% using the statistical software package SPSS:

H₀: There was no difference in pretest and posttest median MTSES scale scores

H₁: There was a difference in pretest and posttest median MTSES scale scores.

More specifically the hypothesis is that preservice teachers would show an increased mathematics teaching efficacy with the use of the mathematical simulation games of DragonBox. The MTSES has a total of 10 questions. Therefore, there was a total of 10 variables tested. The statistical criteria for rejecting the null hypothesis was $p < .05$.

Qualitative Data. The qualitative data analysis focused on themes that emerged through a detailed examination of the transcribed interviews, artifacts, and direct observations and

researcher journal. The unit analysis consisted of episodes where the preservice mathematics teachers engaged with the simulation mathematics games of DragonBox. The unit of analysis was the primary entity for analyzing the qualitative data in this study (Trochim & Donnelly, 2001). The episodes, where preservice mathematics teachers engaged with the simulation game, was viewed using the aspects of reciprocal determinism of teachers' personal factors, the teachers' environmental influences, and teaching behaviors. More specifically, episodes, where preservice mathematics teachers engaged with the simulation game, will be viewed regarding mastery experiences, vicarious experience, verbal persuasion, and psychological and emotional arousal.

The artifacts, the direct observations and the researcher's journal and interviews were analyzed using coding. Coding in "qualitative inquiry is most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/ or evocative attribute for a portion of language-based or visual data" (Saldana, 2016, p. 4). The essence of coding; reduces data by capturing important ideas or issues, helps the researcher understand the phenomenon, develop constructs by developing themes and categories, and develop theories (Saldana, 2016).

A six-step protocol that was provided by Lichtman (2013, p. 252) was used to code. The six steps provided by Lichtman include:

- Step 1: Initial coding. Going from responses to summary ideas of the responses
- Step 2: Revisiting initial coding
- Step 3: Developing an initial list of categories
- Step 4: Modifying initial list based on additional rereading
- Step 5: Revisiting your categories and subcategories
- Step 6: Moving from categories to concepts (Lichtman, 2013, p. 252).

Litchman (2013) also provides an overview of how to complete each of the six steps to coding. Step one involves the researcher reading through the text and assigning an initial code. Revisiting the codes found in step one will help to reduce the number of codes. Step three

involves the researcher organizing the made codes into categories. Revisiting the categories and modifying them further will be done in step four. Step five requires that the researcher modify the list of categories yet again by to make sure that they fit within the purpose of the research. The final step requires that the researcher move the categories into concepts.

The data from the artifacts, the direct observations and pre and post-interviews were reviewed for evidence of triadic reciprocal causation of a teacher's personal factors, teaching environmental influences and teaching behavior. Using Lichtman generic 6-step coding, the researcher extracted an initial list of codes (Step 1), then simplified and condensed the list (Step 2) to create more versatile and descriptive terms that responded to the research questions. The researcher then placed the codes into assigned categories (Step 3). After rereading the codes and categories (Step 3), the codes that needed to be removed or joined were evident (Step 4). Essential interpretations of the data began to emerge (Step 5) by using the codes and categories Step 1 through Step 4. Additionally, the triadic reciprocal causation of a teacher's personal factors, teaching environmental influences and teaching behavior was possibly revealed (Step 6) as preservice teachers engaged with the simulation games of DragonBox.

Qualitative data was analyzed using Dedoose (2017), an online software program that analyzes word- and image-based data for qualitative and mixed method research. Users of Dedoose (2017) can insert qualitative data into the program then code through traditional data analysis methods. The data linked to forced-choice quantitative data, known as descriptors, to sort and analyze the coded data to greater depths as opposed to using separate data analysis methods (Taylor & Treacy, 2013). Figure 3.5 shows a more detailed way in which Dedoose (2017) is used. The media represents the qualitative data. The descriptors are the way in which the participants are described, and they linked to the different media/ qualitative data. A code

tree is created based on the hypothesis/concepts and key themes. Experts from the media are then identified that contain the indicated codes. Dedoose (2017) is then able to use its analytic features to display and analyze the data.

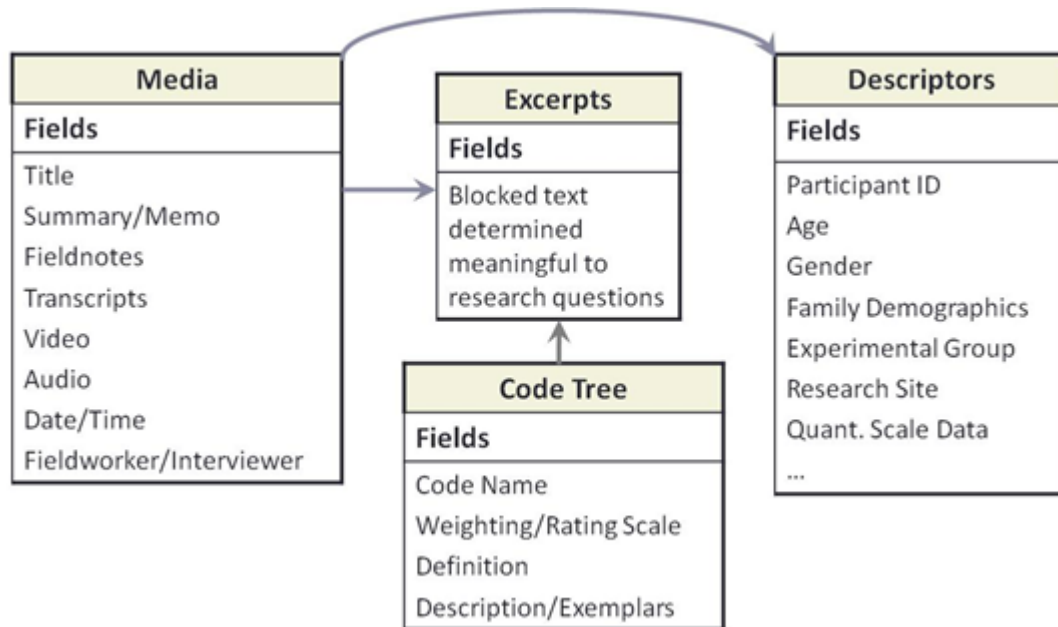


Figure 3.7. Dedoose’s illustration of analyzing the data. Reprinted from Version 8.0.23, web application for managing, analyzing, and presenting qualitative and mixed method research data (2013). Los Angeles, CA: SocioCultural Research Consultants, LLC. Retrieved from <http://www.dedoose.com/userguide>.

Study Limitations

Case studies are known for their lack generalizability and lack of transferability to other settings because they are a bounded case (Pearson, Albon, & Hubball, 2015; Ruddin, 2006; Miles, 2015). Nisbet and Watt (1984) further provide that the results of a case study may not be generalizable except where other readers/researchers can see their application. However, there have been many social scientists that have disputed this generalizability critique and state that those criticisms show a mistaken and over-simplified assumption about case studies and their value as a context-dependent investigation of practice (Flyvberg, 2006; Ruddin, 2006; Stake, 2003; Miles, 2015). Ruddin (2006) states that: “Case study reasoning should be seen as an active

form of hypothetic deductive theorizing, not as a weak form of statistical inference” (p. 801). Flyvbjerg (2001) and Mitchell (2000) both agree that things cannot be inferred “from” case studies. Instead, researchers impose a construction or a pattern of meaning, “onto” the case. Another limitation of case studies is that they are not easily open to cross-checking because they are or can be selective, biased, personal and subjective (Nisbett & Watt, 1984). Nisbett and Watt (1984) also provide that case studies are prone to problems of observer bias, despite attempts made to address reflexivity.

Teacher Efficacy construct is another limitation considered. Ryang (2012) lists four limitations, and they include an appropriate degree of specificity of subject matter, the level of validity and reliability of the various instruments, the degree of the changeability of efficacy beliefs of teachers during their teacher life, and the possible cultural effects that influence a teacher’s efficacy beliefs. Ryang (2012) makes sure to address these limitations in his MSTES. Teacher efficacy was also difficult to measure because of the multiple factors outside of the study. Participants were additionally engaged in the course, that did not only focus on the intervention. Participants were also engaged in other courses to complete for graduation and they were all completing practicum work and projects. These additional factors could have also contributed to their mathematics teaching efficacy.

The sample size of this study is another limitation of the study. While a sample size of 30 is considered by many to be an acceptable size, larger sizes tend to yield better results for quantitative data (Cohen, Manion, & Morrison, 2013).

Finally, this research was done in isolation, therefore member checking on whether themes and if interpretations of participant statements were accurate were not performed (Kvale & Brinkmann, 2009). The case study is more prone to observer bias despite the researcher’s

best attempts to address reflexivity. Also, as an observer and researcher, there could be internal validity in the preservice teachers being truly forthcoming during our interactions (Nisbett & Watt, 1984).

Researcher's Subjectivity

The researcher in a qualitative study builds “a complex, holistic picture, analyzes words, reports detailed views of informants, and conducts the study in a natural setting” (Creswell, 2013, p. 15). The role of the researcher in qualitative research is also to be a data collection instrument (Hatch, 2002). The qualitative data that I collected for this study includes interviews, observations, and artifacts. As a researcher in this case study, I facilitated a six-week module and did not teach the course, hence I did not issue grades for the work that participants submitted.

Creswell (2013) argues that the researcher's reflexivity provides validity by disclosing their assumptions, beliefs, and biases. I tried to be as objective as possible by being an active participant in the course and tried not to interject my assumptions and beliefs onto the participants and rely on the results of the data. I assured the participants that I did not create the simulation games of DragonBox, and that I would appreciate their sincere feedback. I also made sure to explain to the participants that their views regarding DragonBox would not affect the acceptance of this research study.

My interest in the simulation games of DragonBox developed from my intense interest in providing students with hands-on learning. I have always been particularly interested in games and technology. Throughout my teaching career as a high school mathematics teacher, I have incorporated many lessons that included students playing games. It was because of my interest in technology and games that I was referred to a simulation games course. Through this course, I was introduced to DragonBox. I began to use DragonBox with my students and even ran a small pilot study with one of my high school courses. I was impressed with the way students intuitively

understood how to play, and the way the class was able to engage in productive dialogue regarding DragonBox and Algebra. I felt like DragonBox would be a useful tool for teachers to use. I worked to not express my personal feelings about DragonBox to the participants in this study by not discussing my prior experience.

As the researcher, I was an active participant in the study. There was direct interaction between myself and the participants. I served as the primary data collection and interpretation tool of qualitative data for the study. My major academic adviser served as the reviewer for the coding process. I observed participants and participated in the course before the study began. I also conducted the interviews. During interviews, the participants discussed themselves and their experiences with the mathematical simulation games. I transcribed and coded data from the interviews, artifacts, and researcher's journal. My major academic adviser reviewed the coding of the data. I emailed interview transcripts to participants for verification. I was responsible for the collection and storing of data. The coding process included looking for themes in the qualitative data.

Ethical Considerations

There was a collection of participants' work samples. When gathering information about participants, it is essential that participants be regarded with respect, dignity, and care throughout the research process (Pearson, Albon, & Hubball, 2015). It was also crucial that confidentiality and identity were protected, and consent freely given (Pearson, Albon, & Hubball, 2015). To protect students and ensure confidentiality, students' names were kept anonymous throughout the research process with the use of pseudonyms for identification purposes. The Institution Review Board (IRB) approved the research methods that were employed to collect data. There were reliability and validity issues when it comes to the instrument, MTSES used. Reliability analysis was used to measure internal consistency using Cronbach's alpha. To address reliability of the

coder, the major academic adviser served as reviewer. The use of six stages of coding should help to ensure more reliability.

Data Management Plan

The paper study documents such as; tests, questionnaires, interviews (recorded) and student work samples (reflections, companion guides) was stored in a locked file cabinet at my home during and after the study. Additionally, all electronic documents were stored on my personal identification locked computer. The raw data and analyzed data that was uploaded to Dedoose (2017) was password protected. The participants' name and other facts that might point to a participant do not appear. The findings are summarized and reported in group form, and pseudonyms were given to any identified participant.

CHAPTER 4

Results and Analysis

The purpose of this case study is to examine the effects of using the mathematics simulation games of DragonBox, on preservice middle-level teachers' mathematics teaching efficacy. The hypothesis of the study is preservice middle-level mathematics teachers will have increased teaching efficacy and increased confidence to use mathematical simulation games in their future teaching. The research questions for the case study are:

1. How are preservice middle-level teachers' mathematics teaching efficacy affected using the mathematics simulation games of DragonBox during the study?
2. How do preservice mathematics teachers perceive the use of mathematics simulation games in teaching middle-level mathematics during the study?
3. What are the factors that affect the preservice middle-level teachers' mathematics teaching efficacy as they engage in mathematics simulation games during the study? Moreover, what are the affordances/constraints associated with using mathematics simulation games concerning mathematics teaching efficacy?

To examine this case study qualitative and quantitative data were collected from 33 preservice mathematics teachers enrolled in a methods course for teaching middle-level mathematics. The researcher used an embedded, exploratory case study design with mixed methods techniques. The embedded design involved qualitative data embedded within a major design intervention trial. The primary data collected was qualitative, and was triangulated using four techniques: direct observations, artifacts, interviews, and researcher's introspection. Analysis of the quantitative data included two methods, reliability analysis using Cronbach's alpha to measure the internal consistency of the MTSES instrument and Wilcoxon Signed- Rank

test to test the hypothesis that the mathematical simulation games, DragonBox, could positively influence the mathematics teaching efficacy of middle-level mathematics preservice teachers.

This chapter provides an overview of the analysis methods and a detailed examination of the major themes that emerged describing the effects of using the mathematical simulation games of DragonBox, on preservice middle-level teachers' mathematics teaching efficacy.

Analysis and Findings

Quantitative Analysis

The quantitative data was used to answer the question, “How are preservice middle-level teachers’ mathematics teaching efficacy affected using the mathematics simulation games of DragonBox during the study?” The Mathematics Teaching Self-Efficacy Scale (MTSES) (Ryang, 2010) was utilized to measure mathematics teachers’ sense of teaching efficacy pre- to post-intervention. The MTSES items have Likert-type response scoring where 1=Strongly Disagree (SD), 2=Disagree (D), 3=Uncertain (UN), 4=Agree (A), and 5=Strongly Agree (SA). The MTSES has four reverse-coded items (items 1, 2, 4, and 10). These four pretest and posttest items were re-coded (i.e., 1=5, 2=4, 3=3) to align with the other six items. I analyzed quantitative data using two methods, reliability analysis, and the Wilcoxon Signed-Rank test.

Reliability analysis. Cronbach’s alpha is one of the most commonly used ways to measure the internal consistency of a scale (McCrae et al., 2011). This speculation is mostly correct because Cronbach’s alpha can be easily administered for multi-item scales (John & Soto, 2007). Gliem and Gliem (2003) also provide that when using Likert-type scales it is essential that the Cronbach’s alpha coefficient is calculated and reported for internal consistency reliability for any scale one might be using. Cronbach’s alpha was computed to determine the inter-item reliability of the MTSES scale. Table 4.1 shows the results of the Cronbach’s alpha for the MSTSE scale is .692. Most statisticians concur that the lowest acceptable Cronbach’s

alpha is .65 and that Cronbach's alphas between .70 and .94 indicate good to excellent inter-item reliability (Croasmum & Ostrom, 2011; Gaderman, Guhn, & Zumbo, 2012; Ho, 2013; Mohamad, Sulaiman, Sern, & Salleh, 2015). Specific methodological and survey factors may lower a scale's Cronbach's alpha, including small sample size and a smaller number of items that comprise the scale (Gaderman, Guhn, & Zumbo, 2012; Mohamad et al., 2015).

Table 4.1

Cronbach's Alpha Test: Reliability Statistics of MSTES (N=33)

Reliability Statistics					
Cronbach's Alpha	Cronbach's Alpha Based on		N of Items		
.692	Standardized Items		10		
Item-Total Statistics					
Scale	Mean if	Scale	Corrected	Squared	Cronbach's
Item	Item	Variance if	Item-Total	Multiple	Alpha if Item
Deleted	Deleted	Item Deleted	Correlation	Correlation	Deleted
Question 1	35.6212	19.285	.329	.267	.679
Question 2	36.0909	17.469	.374	.336	.665
Question 3	36.3333	17.303	.240	.637	.697
Question 4	36.3333	17.426	.239	.599	.696
Question 5	37.1364	16.243	.341	.459	.676
Question 6	36.1667	16.910	.577	.535	.637
Question 7	36.1970	18.068	.438	.622	.661
Question 8	36.0909	19.315	.262	.561	.684
Question 9	36.2576	17.117	.486	.634	.648
Question 10	36.7727	15.194	.478	.456	.642

Table 4.1 shows that there are no significant changes in Cronbach's alpha values if any of the items are deleted.

Tests for assumptions. Before performing the Wilcoxon Signed-Rank test, assumptions were considered. There are three assumptions for Wilcoxon Signed-Rank test, and they include dependent samples, independence, and ordinal level measurement. Since the same sample is pre-

tested and post tested, the assumption of dependent samples is met. The assumption of independence of observations is reasonably assumed since the data was collected from preservice teachers who are independent of one another. The MTSES is based on a Likert scale, which is ordinal (Norman, 2010). Therefore, the assumption of ordinal level measurement is met.

Assumptions are tenable; hence, I ran a Wilcoxon Signed-Rank test.

Wilcoxon Signed-Rank Test. A Wilcoxon Signed-Rank test was conducted to address the research question, “How are preservice middle-level teachers’ mathematics teaching efficacy affected using the mathematics simulation games of DragonBox during the study?” This analysis allowed for the determination as to whether teachers’ MTSES median scores significantly differed from pretest to posttest, upon completion of the DragonBox simulation game intervention. The hypothesis is given below, and the test was run on a confidence interval of 95% using the statistical software package SPSS:

H₀: There was no difference in pretest and posttest median MTSES scale scores

H₁: There was a difference in pretest and posttest median MTSES scale scores.

More specifically the hypothesis is that preservice teachers would show an increased mathematics teaching efficacy with the use of the mathematical simulation games of DragonBox. The MTSES has a total of 10 questions. Therefore, there was a total of 10 variables tested. The statistical criteria for rejecting the null hypothesis was $p < 0.05$.

Table 4.2 presents the results of the Wilcoxon Signed-Rank Test of the Totaled MTSES Pretest and Posttest.

Table 4.2

Wilcoxon Signed-Rank test: Total MTSES Pretest to Posttest Median Scale Scores (N=33)

Ranks

		N	Mean Rank	Sum of Ranks
MTSES Posttest – MTSES Pretest	Negative Ranks	13 ^a	13.27	172.50
	Positive Ranks	17 ^b	17.21	292.50
	Ties	3 ^c		
	Total	33		

Notes. a. MTSES Posttest < Pretest

b. MTSES Posttest > MTSES Pretest

c. MTSES Posttest = MTSES Pretest

The Wilcoxon Signed-Rank test shows that the observed differences between both measurements (mean rank of 13.27 vs. 17.21) are not significant with $p = .216$ and the $Z = -1.237$. Such results indicate that there was no significant difference in teaching efficacy levels from pretest to posttest median MTSES scale scores.

The results shown in Table 4.2 reveal that 13 of the 33 preservice teachers had a higher total score on the pretest of the MTSES compared to their posttest score on the MTSES. This means that 13 of the 33 preservice teachers had some decrease in mathematics teaching efficacy. 17 of the 33 preservice teachers had a higher total score on the posttest of the MTSES compared to their pretest score on the MTSES. This means that those 17 preservice teachers had some increase in mathematics teaching efficacy. There were three preservice teachers that scored the same on the pretest of the MTSES compared to their posttest results of the MTSES. This means that there was no change in mathematics teaching efficacy for those three preservice teachers. The median values of pretest and the posttest of the MTSES were both equal to 40. This further validates that there was no change for the overall group of 33 preservice teachers in their mathematics teaching efficacy. Additionally, the effect size was calculated to be $r = .15$, which is small. Effect size is another way to of quantifying the difference between groups (Coe, 2002).

Coe (2002) further provides that effect size quantifies the size of the difference between two groups and may be a truer measure of significant difference. The effect size of $r = .15$ further validates that difference between the pretest and posttest scores of the 33 preservice teachers on the MTSES is extremely small.

To study whether there were any significant differences on specific questions of the MTSES, a Wilcoxon Signed-Rank test was conducted on each question of the MTSES. This analysis allowed for the determination as to whether individual questions from MTSES median scores significantly changed from pretest to posttest, upon completion of the DragonBox simulation game intervention (See Table 4.3)

Table 4.3

Wilcoxon Signed-Rank test: MTSES Individual Question Median Scale Score (N=33)

Question	Posttest - Pretest Z	Sig.
Question 1 I will not be very effective in monitoring students' mathematical learning through activities in the classroom	-1.000	.317
Question 2 I do not know what to do to engage students in mathematics in the future	-1.311	.190
Question 3 I will have difficulty in using manipulatives and/or simulation games to explain to students why mathematics works	-.229	.819
Question 4 I will be able to answer students' questions about mathematics.	-.832	.737
Question 5 I will be able to give an answer for any mathematical questions from students	-.336	.737

Question 6 I certainly will teach mathematics well in a class to the public.	-1.072	.284
Question 7 I will be able to teach students to easily understand mathematics	-2.134	.033
Question 8 I will be able to explain mathematics easily to get students who think of mathematics as being difficult to understand it.	-1.414	.157
Question 9 When a student has difficulty with a mathematics problem, I will usually able to adjust it to the student's level	-1.537	.124
Question 10 I will not explain some mathematical concepts very well	-.093	.926

Note. Based on Negative Ranks

As shown in Table 4.3, only Question 7 in MTSES is statistically significant at $p = .033$, with $p < 0.05$. Table 4.4 provides the detailed results of question seven.

Table 4.4

Wilcoxon Signed-Rank test results: Question 7 of MTSES Pretest to Posttest Median Scale Scores (N=33)

		Ranks		
		N	Mean Rank	Sum of Ranks
MTSES PostQ7	Negative	4 ^s	7.50	30.00
- MTSES PreQ7	Ranks			
	Positive Ranks	12 ^t	8.83	106.00
	Ties	17 ^u		
	Total	33		

Notes. s. $MTSES\ PostQ7 < MTSES\ PreQ7$

t. $MTSES\ PostQ7 > MTSES\ PreQ7$

u. $MTSES\ PostQ7 = MTSES\ PreQ7$

Question 7 from the MTSES is: I will be able to teach students to easily understand mathematics. Table 4.4 shows that for 33 preservice teachers for Question 7 from pretest to posttest there was a statistical difference in mathematics teaching efficacy. The results show a mean rank of 7.50 vs. 8.83, which means that that the mean of the W statistic of the MTSES posttest was higher than the mean rank of the W statistics of the MTSES pretest.

In summary, there was no significant difference in the median scale scores of the MTSES from the pretest and posttest. However, there was a significant difference on the posttest particularly for Question 7 which measures preservice perceptions of being able to easily teach students to understand mathematics. This could be interpreted to indicate that to a certain extent preservice teacher feel more confident in being able to teach mathematics and that there was an increase in mathematics teaching efficacy regarding this question.

Qualitative Analysis

Qualitative methods were employed to address the questions, “How do preservice mathematics teachers perceive the use of mathematics simulation games in teaching middle-level mathematics during the study?” and “What are the factors that affect the preservice middle-level teachers’ mathematics teaching efficacy as they engage in mathematics simulation games during the study? Moreover, what are the affordances/constraints associated with using mathematics simulation games concerning mathematics teaching efficacy?”

Coding. The online qualitative research software, Dedoose (2017), was used to analyze qualitative data, which included collected artifacts, researcher’s journal, and pre and post transcribed interviews. A total of 168 media files were inputted into the Dedoose (2017)

software. The Dedoose (2017) software allows for the qualitative data to be coded through traditional qualitative data analysis methods but links the data to forced-choice quantitative data, known as descriptors, to sort and analyze the coded data to a greater depth. It should be noted that the same participant could have repeated themselves across in the interviews and/or artifacts, also some passages were double coded for double meaning.

The coding methods of Saldana (2016) and Lichtman (2013) were heavily relied upon to guide the coding process. More specifically, Lichtman’s (2013) six-step coding protocol was used to help guide the coding process. Lichtman (2013) provides that there are three C’s of data analysis that include coding, categorizing, and concepts. Figure 4.1 provides a visualization of the way this study analyzed the qualitative data.

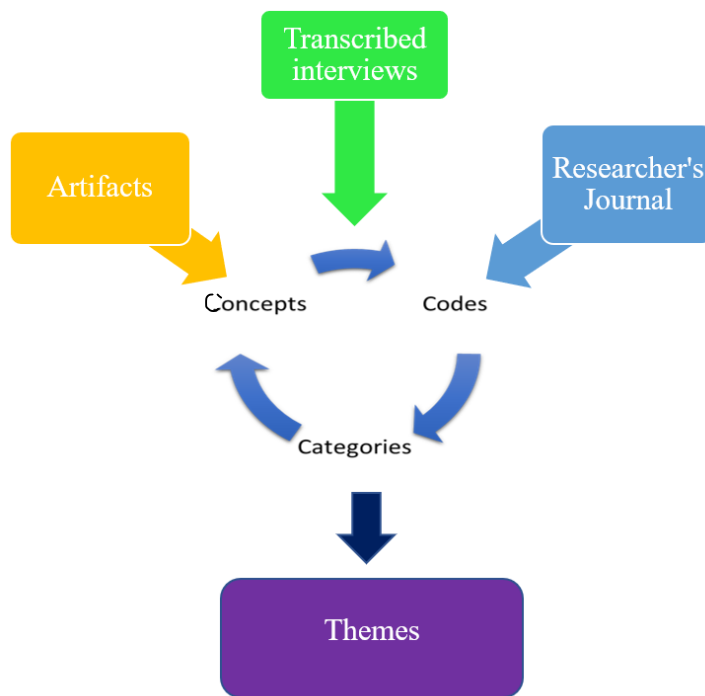


Figure 4.1. Researcher’s depiction of a model of Lichtman’s Three C’s. Adapted from “Qualitative Research in Education: A User’s Guide,” by M. Lichtman, 2013, SAGE Publications, Inc.

The following provides the steps used in the coding process.

Step 1: Initial coding. Going from responses to summarize ideas extracted from responses. Saldana (2016) provides that the essence of coding; reduces data by capturing important ideas or issues, helps the researcher understand the phenomenon, develop constructs by developing themes and categories, and develop theories. Coding in “qualitative inquiry is most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data” (Saldana, 2016, p. 4). The first ‘precoding’ round of coding took place by highlighting participant quotes and passages considered as worthy of attention (Boyatzis, 1998). The initial round of coding was raw and were of my first thoughts that I noticed while reading through the qualitative data. From the initial step, 68 codes unfolded: (1) engagement (2) student learning (3) fun, (4) play, (5) frustration, (6) cost, (7) learning, (8) understanding, (9) algebraic ideas, (10) geometric ideas, (11) student learning, (12) perception, (13) collaboration, (14) affordances, (15) behavioral influences, (16) constraints, (17) environmental influences, (18) environmental influence, (19) personal factors, (20) teaching, (21) teaching goals, (22) teacher persistence, (23) competition, (24) lack of instructions, (25) engagement, (26) appropriateness, (27) differentiation, (28) visuals, (29) real- world, (30) application, (31) participation, (32) age appropriate, (33) content appropriate, (34) interdisciplinary, (35) standards based, (36) rigor, (37) accessibility, (38) personalized learning, (39) critical thinking, (40) school resources, (41) interdisciplinary, (42) instructional resource, (43) participation, (44) reward, (45) love of technology, (46) application, (47) video game usage, (48) computer usage, (49) school required use of technology, (50) abstract, (51) lack of understanding, (52) confusion, (53) progress through the simulation game, (54) lack of instructions, (55) anti-video game, (56) gamer, (57) uncomfortable with video games, (58) peer views, (59) advancing within the game, (60) researching the simulation games,

(61) personal enjoyment of the game, (62) inspiration, (63) encouraged to use technology, (64) expectations, (65) future lessons, (66) teacher goals, (67) teaching, (68) search for more simulation games.

Step 2: Revisiting initial coding. Lichtman (2013) provides that the codes obtained in step one will most likely be redundant. For this reason, there is a need to collapse and rename the codes. Saldana (2016) also adds that coding is a circular act, and rarely is the first cycle of coding perfected. After the initial codes developed in step one, the codes were collapsed and consolidated into refined codes. During this process, I focused on “removing redundancies, renaming synonyms, or clarifying terms” (Lichtman, 2013, p. 253). For example, the causal model of triadic reciprocal causation was used to identify further any coding that was related to the different entities (personal factors, environmental influences, behavior). The personal factor terms (lack of understanding, confusion and too abstract) were all re-coded concerning preservice teacher’s cognitive understandings. In step two, codes were combined into categories to concentrate on the relevant and compelling features emerging from the qualitative data. The resulting list of revised codes include: (1) Algebraic Ideas, (2) Geometric Ideas, (3) Middle-grade Math Standards, (4) Visually Appealing, (5) Facilitates Critical Thinking, (6) Increasing Levels, (7) Promotes Competition, (8) Lack of Instructions, (9) Differentiation of Learning, (10) Student Engagement, (11) Rigorous Concepts, (12) Real-World Application, (13) Gamer, (14) Increase in Conceptual understandings, (15) Non-gamer, (16) Lack of Conceptual Justification for use, (17) Lack of Background Knowledge, (18) Researching simulation games, (19) Observing peer interaction with DragonBox, (20) Persisting through DragonBox, (21) Not Persisting through DragonBox, (22) Advocacy of Technology, (23) Required Technology use,

(24) Mentor Teacher's Support, (25) Cost of Implementation, (26) Lack of Resources, (27) Lack of Mentor Teacher's Support.

Step 3: Developing an initial list of categories. Through the coding process, the codes clustered together into categories that founded on similarities based on a need to answer the research questions. The result was an initial list of categories related to teacher perceptions and factors that affect teaching efficacy. At this stage, codes were organized into two major categories: game-related and teacher related.

Step 4: Modifying the initial list based on additional readings. During step four, the initial codes developed in step 1 were reviewed, refined, and combined as needed. As Saldana (2016) suggests, “[a]s you code and recode, expect – or rather, strive for- your codes and categories to become more refined [...] your first cycle codes may be later subsumed by other codes, relabeled, or dropped altogether” (p. 12). During this stage, the codes reorganized into two major categories: preservice teachers’ perceptions with respect to using DragonBox and mathematics teaching efficacy factors associated with using DragonBox.

Step 5: Revisiting categories. From step four, categories were further aligned to describe the qualitative data collected. Using the qualitative research questions as a guide, I categorized the codes to provide evidence for: teacher perceptions with respect to using DragonBox and factors associated with mathematics teaching efficacy with using DragonBox. The revised list of categories included: (1) Perceived Relationship of DragonBox to Middle-Level Math Standards, (2) Perceived Game Features, (3) Perceived connection to higher-level thinking, (4) Perceived Features of Student Learning with regards to DragonBox, (5) Personal Factors of preservice teachers with regards to DragonBox, (6) Behavior practices of preservice teachers while engaged with DragonBox, (7) Environmental Influences on Preservice Teachers’ regarding DragonBox.

Step 6: Moving from categories to concepts. In step six, major notable concepts were identified that reflected the meaning of the qualitative data collected (Lichtman, 2013). In using the first five steps from Lichtman (2013) the patterns began to come about, and the codes were clustered together into categories and these categories helped to identify the key concepts. Table 4.5 shows the extracted 27 codes. Table 4.5 also provides that the two categories and seven concepts.

Table 4.5

Codes, Concepts and Categories

Codes	Concepts	Categories
<ul style="list-style-type: none"> • Algebraic Ideas • Geometric ideas • Middle- grade Math Standards 	Perceived Relationship of DragonBox to Middle-Level Math Standards	
<ul style="list-style-type: none"> • Visually Appealing • Increasing Levels • Promotes Competition • Lack of Instructions 	Perceived Game Features	
<ul style="list-style-type: none"> • Facilitates Critical Thinking • Rigorous Concepts 	Perceived connection to higher-level thinking	Preservice Teachers' Perceptions with Respect to Using DragonBox
<ul style="list-style-type: none"> • Differentiation of Learning • Student Engagement • Real-World Application 	Perceived Features of Student Learning with regards to DragonBox	

<ul style="list-style-type: none"> • Gamer • Increase in Conceptual Understandings • Non-gamer • Lack of Conceptual Justification for use • Lack of Conceptual Background Knowledge 	<p>Personal Factors of preservice teachers with regards to DragonBox</p>	
<ul style="list-style-type: none"> • Researching Simulation Games • Creating Plans • Observing Peer Interaction with DragonBox • Persisting through DragonBox • Not Persisting Through DragonBox 	<p>Behavior practices of preservice teachers while engaged with DragonBox</p>	<p>Affordances and Constraints of Mathematics Teaching Efficacy Factors Associated with Using DragonBox</p>
<ul style="list-style-type: none"> • Advocacy of Technology • Required Technology use • Mentor Teacher's Support • Cost of Implementation • Lack of Resources • Lack of Mentor Teacher's Support 	<p>Environmental Influences on Preservice Teachers' regarding DragonBox</p>	

Emerging Findings

Six themes emerged describing preservice teachers' perceptions regarding the use of DragonBox in teaching middle-level mathematics as well as affordances and constraints that the

game provides on their teaching efficacy. In relation to teacher perceptions concerning using DragonBox in teaching, the following three themes were extracted:

1. Preservice teachers saw the use of DragonBox as a sensory immersive, learning tool to further middle-grade students' conceptual understandings.
2. Preservice teachers saw the use of DragonBox as a differentiated way to engage middle-grade students and promote a sense of embodiment within a digital environment.
3. Preservice teachers viewed the use of DragonBox as a goal-directed experience and a dependent tool that still heavily relied upon teaching to support student learning.

Regarding mathematics teaching efficacy factors associated with using DragonBox, three themes emerged:

4. Preservice teachers required conceptual understandings of the topics presented in DragonBox to value its use with middle-grade students.
5. Preservice teachers determined that planning and careful analysis of DragonBox is needed for supporting active, subjective and situated learning.
6. Preservice teachers saw the use of DragonBox as a way to connect with a highly technology-driven society.

Preservice Teachers' Perceptions with Respect to Using DragonBox

The themes from the category of Preservice Teachers' Perceptions with respect to using DragonBox, came from a need to answer the first qualitative research question: "How do preservice mathematics teachers perceive the use of mathematics simulation games in teaching middle-level mathematics during the study?". There were three themes that associated with this category.

Theme 1: Preservice teachers saw the use of DragonBox as a sensory immersive, learning tool to further middle-grade students' conceptual understandings. Computer games, which include simulation games, have been anticipated as a potential learning tool with great motivational value (Ke, 2009). The usefulness of DragonBox as a learning tool to further middle-grade student conceptual understandings, as ascertained by the preservice teachers in this study, was inferred from observations, artifacts, and interviews during and after the intervention. During observations, the associated benefits of DragonBox as a learning tool for preservice teachers in this study were made known. Preservice teachers openly discussed the different concepts that they noticed DragonBox displayed as they were engaged in the simulation games.

As participants engaged with DragonBox Algebra and DragonBox Elements, I jotted notes of the conversations that were occurring. Participants discussed the associated mathematical concepts present within DragonBox as they played the game. After DragonBox was played, whole class discussions would continue with the different concepts noticed while playing DragonBox. The following researcher's journal excerpt provides an example of the how participants noticed the mathematical concepts within DragonBox:

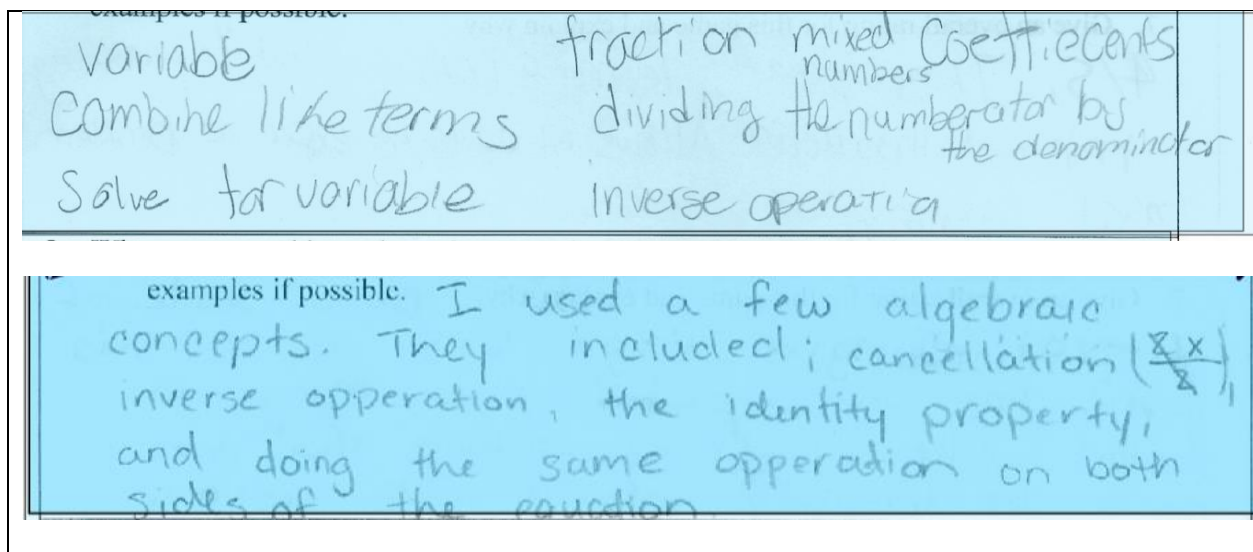
Participants were having open discussions during play and after playing the simulation games concerning the appropriateness of its use. Participants were making lists of the different mathematical concepts presented in DragonBox Algebra 12+. Participants were also listing when it would be appropriate to play the simulation game according to the standards addressed. (Researcher journal, session two excerpt).

Naomi was able to articulate her perceived notions of how DragonBox Elements was a learning tool:

It made you draw equilateral triangles; it made you draw an isosceles triangle. They made you do a square or a rhombus or whatever; it made you actually draw those shapes out. In order for you to be able to go to the next level you actually had to draw shapes within shapes. It taught you about angles and things of that nature, so I liked it (Naomi, third interview excerpt).

Naomi was able to express students had to perform specific steps and that students would be learning by doing. John Dewey (2007) argues that learning by doing is an ideal in which optimal learning happens through experience, and learning tasks require active participation of the student with hands-on opportunities.

Companion guides (Appendix C and Appendix D) were part of the artifacts provided for participants to fill out as they played DragonBox. The first question asked preservice teachers to list the mathematical concepts they saw present within DragonBox.

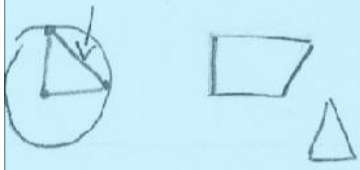


examples if possible.
 I saw concepts of combining like terms, use of the Addition and subtraction properties of equality and dividing something by itself is another way to write one and one times anything is just itself.

Figure 4.2. Algebra 12+ First play example from participants 14, 25 and Ruth listing algebraic concepts observed.

examples if possible.
 Properties of triangles
 Properties of quadrilateral
 Properties of inscribed circles
 vertical angles

line segments in a circle, geometric shapes, diameter, congruent angles and sides.



2. What are some things about the game that you find engaging?
 For isosceles triangles and equilateral, it shows that you need to have equal angles and equal sides in order to find your peeps.

Figure 4.3. DragonBox Elements First play examples from participants Ruth, 21, and 15 listing geometric concepts.

Figures 4.2 and Figure 4.3 are of lists that participants made of the mathematical concepts present within DragonBox. The perceived concepts from DragonBox Algebra 12+ included concepts such as: adding like terms, inverse operations, identity property, solving for variables,

and so on. Similarly, the perceived concepts present for DragonBox Elements were noted and included concepts such as properties of triangles, properties of quadrilaterals, congruent angles and so on.

Reflections were also used to have participants ponder their experiences with DragonBox. The following reflections are of how the concepts presented in DragonBox were also presented in their textbook, *Teaching today's mathematics in the middle grades* (Johnson & Norris, 2006).

The Dragon box app tied right into chapter six. The game showed a lot of the number operations and once I understood the concepts that I could apply to math it became a lot easier (Participant 26, reflection two excerpt).

Participant 23 similarly discussed how DragonBox tied in with their textbook while simultaneously explaining the benefits that the visualizations of the simulation game.

This particular DragonBox game tied in a few topics from the textbook. One thing in particular is visualization. Van Hiele has levels of geometry, and one of them is in fact visualization. In the first few levels of DragonBox Elements, students are able to visualize and interact with the different types of triangles. Eventually it moves on to quadrilaterals, and students are able to interact and visualize those as well. I've always liked Geometry despite the fact that I did not have games to help me learn it. For students that are not like myself, I think this game is an excellent resource for them to be able to visualize and learn the basic concepts of Geometry including vocabulary like scalene, isosceles, and equilateral triangles (Participant 23, reflection five excerpt).

Oprah and Ruth were also able to describe ways in which DragonBox could positively invoke different senses of their future students.

The elements of DragonBox that were engaging were the colorful creature...(Ruth, reflection three excerpt).

It was a very engaging game especially for someone like myself because I was always trying to collect all of the stars and if I don't (get a star) I would go back to see where I went wrong. (Oprah, reflection three excerpt).

These reflections showed how preservice teachers' perceived DragonBox to be a sensory immersive learning tool with specific mathematical concepts that relate to middle-grade mathematics standards.

The 33 participants were able to discuss and identify the different middle-grade mathematical concepts that were present in DragonBox. These identifications were made evident through the researcher's journal, interviews, and artifacts. This data was drawn together to show how preservice teachers perceived the use of DragonBox as a learning tool to further middle-grade students' conceptual understandings of mathematics.

Theme 2: Preservice teachers saw the use of DragonBox as a differentiated way to engage middle-grade students and promote a sense of embodiment within a digital environment. Games are a way to differentiate more traditional learning because gameplay actively immerses students in a productive learning environment (Tobias & Fletcher, 2012). The idea of DragonBox being a differentiated way to engage middle-grade students was interpreted through participants' artifacts, interviews, and the researcher's journal.

The perceived impression of DragonBox being a differentiation tool came from observing a whole group discussion during the fourth session when dialogue concerning lesson

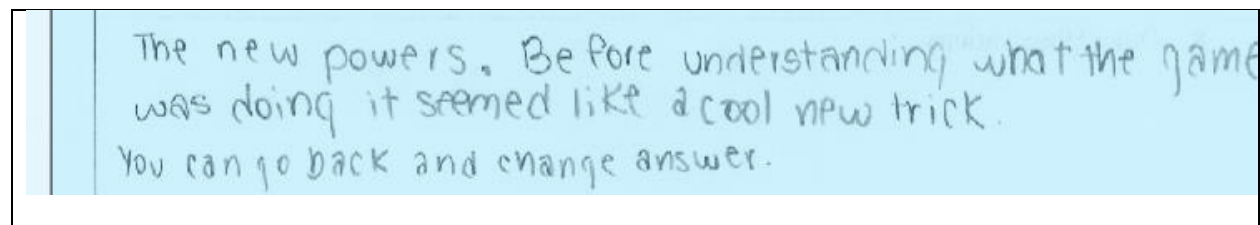
plans occurred. Participants first brainstormed what part of the lesson DragonBox should be introduced. The placement of DragonBox in the lesson sparked a conversation about DragonBox being a differentiation tool for students. An excerpt from the researcher's journal during the lesson planning session is provided below.

Preservice teachers then described ways of how DragonBox could be used for differentiation. There were suggestions that DragonBox should be used to re-enforce the lesson. There were suggestions that DragonBox be used for students that did not understand the lesson or who were struggling with the concepts. Others suggested that it be a reward for students that were doing well with the lesson. (Researcher's Journal, fourth session excerpt).

This conversation regarding DragonBox being viewed as a differentiation tool also transpired in participants' reflections. Participant 29 provides an example of this shared view.

Alongside being a way to integrate technology into my lessons; dragon box can also be used for differentiation (Participant 29, reflection five excerpt).

From this perception of DragonBox being a way to differentiate learning tool, there also came a need for DragonBox to be an engaging, differentiated learning tool. The need for the tool to be engaging comes from the idea that the learning tool needs to contribute to a student's increased interest in learning new ideas (Gee, 2009). Examples of the ideas preservice teachers provided concerning differentiation were found on their companion guides (Appendix C and Appendix D) which were completed while they were engaged in DragonBox Algebra 12+ game.



The new powers. Before understanding what the game was doing it seemed like a cool new trick. You can go back and change answer.

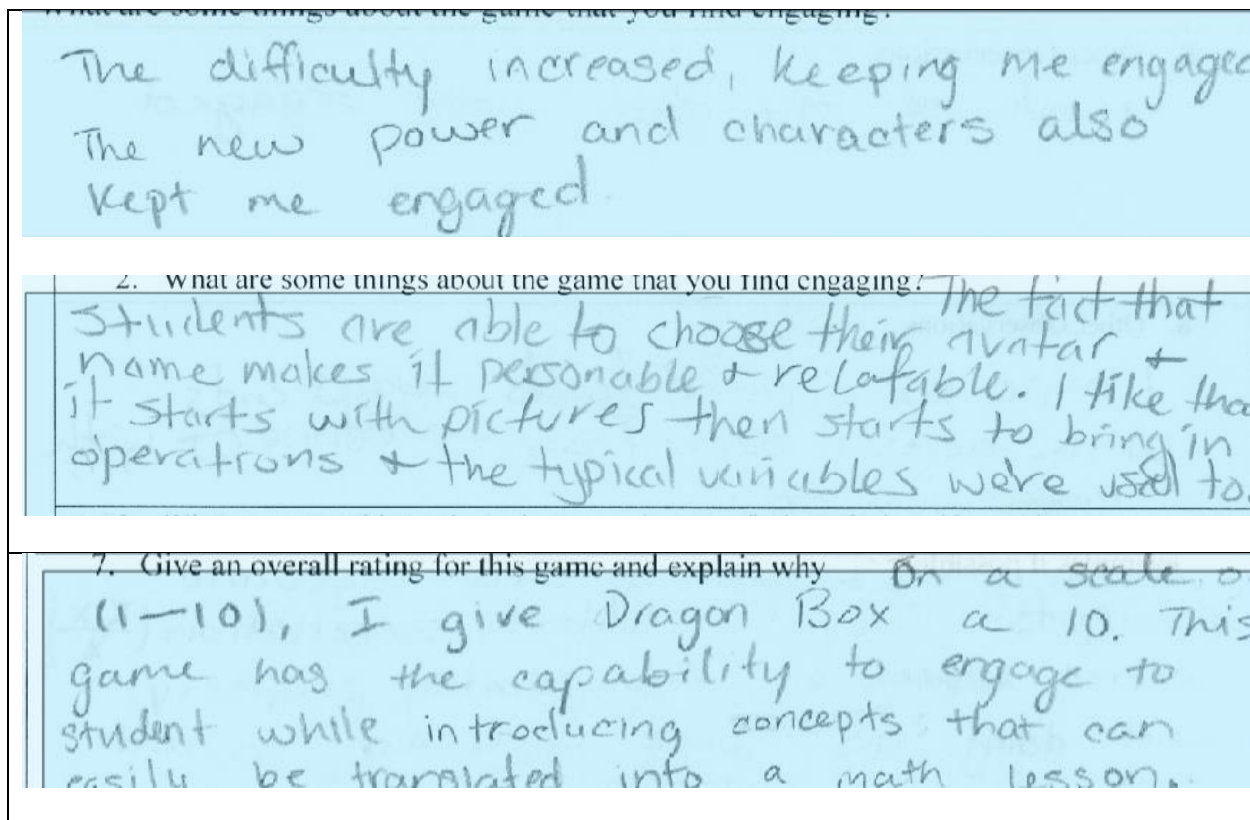


Figure 4.4. DragonBox Algebra 12+ First play examples of participants 8, 21, 20 and 18 listing engaging attributes.

The perceptions of DragonBox being an engaging tool was also seen in participant reflections as shown in the following:

I like the concepts that the game offers and its relation to math. I feel like implementing more games like that in my classroom will keep my students engaged and eager to learn math. One of the challenges with teaching math is keeping the students interested and teaching the information so that it relates to their lives. By finding more games like this, I feel like it could help more teachers become better, effective teachers (Participant 26, reflection four excerpt).

I like this game because it simply is fun for students. It doesn't necessitate fear or intimidation unlike some math courses or activities can stir within the student populous.

The algebraic concepts are presented more like rules to a game, but those rules actually teach students math. Students are rewarded with stars for their hard work and understanding after completing a level or, in other words, solving an algebraic equation. It is a fun, interesting, and nontraditional educational approach to teaching students Algebra. I would have benefitted greatly from using this as a student and I believe I would've been less intimidated and more apt to learn had this been used in my math classrooms (Participant 18, reflection five excerpt).

Oprah observed and commented that “It is a great way for my kids to engage in mathematical practices. It gives them a way of understanding mathematical concepts.” (third interview excerpt) All participants were able to discuss and identify the uses of simulation games as a differentiated way to engage middle-grade students. DragonBox being used as an engaging differentiation tool was made evident through the researcher’s journal, interviews, and artifacts.

Theme 3: Preservice teachers viewed the use of DragonBox as a goal-directed experience and a dependent tool that still heavily relied upon teaching to support student learning. Participants regularly grappled with practical ways to implement DragonBox in their future classrooms. The first whole group discussion conducted after first playing DragonBox Algebra 12+ started a criticism of the approach that was chosen to deliver DragonBox to them. Most of the preservice teachers stated that they would not initially have the students play DragonBox without an introductory lesson. The majority of the group agreed that a lesson covering the topics needed to occur before introducing DragonBox to students. Huynh, one of the creators of DragonBox, provides that the simulation games are not meant to take the place of teachers, teachers will still need to teach the concepts and help students to connect (WeWantToKnow, 2018).

One of the most viewed apprehensions about the simulation games was of lack of instructions. Participants felt that the tool heavily relied on the teacher to be an expert before they could feel comfortable with presenting to students. Participant observations of those apprehensions are provided below.

I found myself enjoying The DragonBox game even though I felt there should have been more instruction with the game (Participant 28, reflection six excerpt).

To me, unlike dragon box algebra, dragon box elements did not give enough instructions when it first began. It confused me a little (Participant 15, reflection five excerpt).

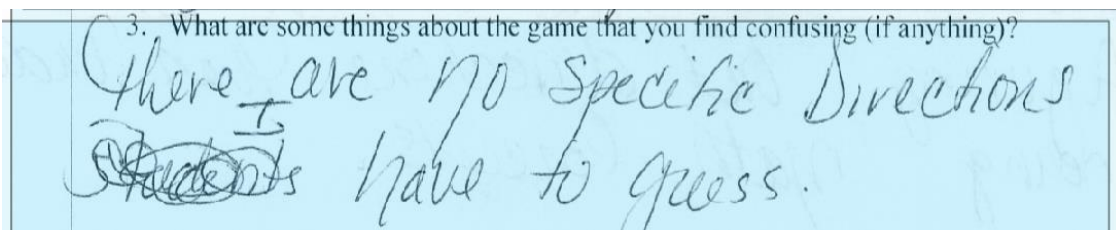


Figure 4.5. DragonBox Elements First play example of lack of instructions from Esther.

Some participants' view about the lack of instructions caused them to completely disregard DragonBox.

the lack of direct instruction would be an example of what the reading described as incorporating rigor in the class which should prompt high level thinking of student, but my role as student playing this game was more frustrating than high level thinking. I did set the game to the highest level, but I also heard some of the same complaints from my classmate who set their games to the easiest setting. I even used the hints and was stuck on a level without any idea how to achieve the desired goal. If Dragon Box Elements would include a bit more instruction I might change my mind but as of now I would not use or teach Dragon Box Elements in class (Participant 14, reflection three excerpt).

Participant 14 expressed a view that a lot of the other participants shared. DragonBox Elements was particularly tricky for the preservice teachers in this study to progress. Participant also showed that more of a direct correlation needed to be made between similar problems that middle-level students will see on the standardized test.

I still worry about how it will help students fair in standardized test. I doubt the math on those exams will show little monsters and stuff. But if the students can connect the dots I can see how it can be a wonderful tool used in and outside if the classroom (Participant 22, reflection four excerpt).

From participant 22, the openness of using DragonBox is there. However, they were not able to fully ascertain if the tool would help further student learning without direct help from the teacher. Participant 22 does identify that DragonBox is a ‘wonderful tool.’ However, they feel the role of the instructor is still crucial. Participant 22 was even able to acknowledge DragonBox could be used outside of the classroom to help students learn.

All participants were able to discuss and identify the uses of simulation games as a differentiated way to engage middle-grade students. DragonBox was perceived to be an engaging differentiation tool that still relied heavily on teachers being able to provide goal-directed learning through the researcher’s journal, interviews, and artifacts.

Mathematics Teaching Efficacy Factors Associated with Using DragonBox

The themes from the category of Mathematics Teaching Efficacy Factors Associated with Using DragonBox, came from a need to answer the second qualitative research question: “What are the factors that affect the preservice middle-level teachers’ mathematics teaching efficacy as they engage in mathematics simulation games during the study? Moreover, what are the

affordances/constraints associated with using mathematics simulation games concerning mathematics teaching efficacy?” There were three themes that identified with this category.

Theme 4: Preservice teachers required conceptual understandings of the topics presented in DragonBox to value its use with middle-grade students. Participants regularly reflected on how their comfort levels with DragonBox and how their degree of comfort and understanding of the concepts presented in DragonBox influenced their perceived usefulness. Some of the participants reflected on how as their level of comfort with the DragonBox increased, so did their perceived value of DragonBox. Examples of this change in comfortability are provided below.

When I started the game [DragonBox] I was a little confused. I didn't see any mathematical relationship with the game until I was almost finished with the first level. Also, I wouldn't have understood it if I didn't hear another classmate say “what you do to one side you do to another”. That's when I start seeing mathematics implemented into the game. I finally start enjoying the game when I reached level two and variables became a part of the game (Participant 26, reflection three excerpt).

The Dragon box app is very interesting but when I was first introduced to the game I was a little confused (Participant 12, reflection six excerpt).

However, sometimes the levels were tough because I did not immediately recognize what concept I was supposed to be learning (Participant 23, reflection three excerpt).

The participants remarked on how not readily understanding the concepts made it difficult to progress through DragonBox. Standard relationship guides and resources, provided by

WeWantToKnow (2018), was presented to the preservice teachers after they played the game for 20 minutes. For some participants, this guide was not initially helpful as noted below.

As the participants continued playing the DragonBox Elements, conversations and debates started to arise. Participants were raising their hands asking questions concerning DragonBox to each other and myself. I shared the standards companion guide, worksheets, and videos that were provided by WeWantToKnow. For some this helped a little, however most of the participants were stuck longer than they wanted. Some of the participants also became visibly frustrated. (Researcher's journal, session three)

Ruth describes a change in comfort level in her third interview session: "I was more comfortable with the material of representing variables and equations. But as I got better with the geometry section, then I feel like I would be more comfortable with using the elements". From the interviews, it was made known that Ruth was not comfortable overall with the Geometry. Some of the other participants, during discussions, observations, and interviews also openly admitted to not being comfortable with Geometry. The examples below are of participant 21 that seems to recognize or elude to some conceptual misunderstandings in mathematical concepts.

I have not taken a geometry class since my sophomore year here... and had forgotten a lot about Geometry up until this past week. Also feel like I learned a bit about geometry. To be specific, the concept I was most receptive about was proving an equilateral triangle to be an equilateral triangle using a circle's diameter. I'm not sure exactly how to explain this, since I did not get far beyond this. If given the chance to play again I feel I would understand this concept more fully. Geometry is my least favorite math subject, but this game made it interesting to me and I really didn't want to put it down. This is exactly why I would want to introduce this game, and games like it, to my students. They easily

grab the attention of the user and make it interesting. It makes you want to learn more. It makes you question what you're doing and want to continue on a quest to figure it out. I honestly feel like it is a valuable resource to have in the classroom. I definitely see myself using something like this in my own classroom (Participant 21, reflection four excerpt).

The above participant reflects on their misunderstandings with Geometry and how the simulation game of DragonBox Elements helped to expand their understanding. Ruth, Ester, and Naomi all expressed that they were most uncomfortable with being able to teach Geometry in their first interviews. The interviewed participants all showed great interest in being able to see a simulation game that could help them learn more about Geometry and engage students.

When I told the participants that we were going to be playing a Geometry simulation game today, there were many groans. Participants expressed that they did not enjoy Geometry. However, there were some murmurings that a simulation game with Geometry concepts might be entertaining (Researcher's journal, session three excerpt).

The above excerpt shows that I also observed through observation logs that participants were apprehensive about playing a game with Geometry concepts. Participants were able to discuss and identify how their conceptual understandings influenced their perceived usefulness of the simulation games. Participants were able to review through reflection, presentations, and discussions, and determine how their conceptual beliefs affected their perceived comfortability with using DragonBox.

Theme 5: Preservice teachers determined that planning and careful analysis of DragonBox is needed for supporting active, subjective and situated learning. The preservice teachers in this study had strong desires to plan. From class discussions, and observations during

and after the interventions, the participants regularly shifted the conversation of DragonBox to how to include DragonBox in a lesson plan. Before sharing with the participants that one of our sessions will be a lesson planning session, the participants asked that I demonstrate what a lesson plan would look like with DragonBox in it. The following is an excerpt from the researcher's journal describing one of these moments.

Participants were engaged in the discussion today concerning creating a lesson plan to incorporate the simulation games of DragonBox. This activity was planned, however in reflections many students expressed their desire to create a lesson plan. During the pre-brain storming session, all participants were actively engaged and providing ideas (Researcher journal, session four excerpt).

In the following reflections, participants note how they would include DragonBox in a lesson plan or unit plan.

I would use Dragon box after I have taught a lesson and the students have had many times to practice the material. I will use the game as extra practice and just to see if my students really understand the information and that they are able to apply the concepts to real life (Participant 26, reflection two excerpt).

I would implement Dragonbox throughout the year in a sixth-grade setting. Students begin sixth grade with a basic understanding for fractions, etc. We would start the year by playing this game for five minutes each day as a warm up activity for class. As we progress with our mathematical learning on rational numbers, Dragonbox would be progressing with them. Students will start to make connections between the fractions, ratios, etc. that they are seeing in Dragonbox

to what they are learning in class. These connections are on a level that they will relate to and understand (Participant 2, reflection two excerpt).

When applying this to my lesson plan, I would have students use the app and then write a paragraph as the ticket out the door afterwards in which they make a connection between the application and what they have learned in math class. It would give students a great reflection activity and allow them to make connections to reflect on their own learning (Participant 24, reflection four excerpt).

Participant seven noted how the reflections helped them plan and visualize how to use the DragonBox.

The reflections allowed me to picture how I would use dragon box in the classroom (Participant 7, reflection six excerpt).

Although lesson planning was requested and performed during the study, participant 20 noted on its importance and meaning to them.

Firstly, I realized that incorporating a game or app into a lesson takes intensive planning in order for it to be beneficial to students. Lastly, although educators are always pressed for time, materials used in class should be tested and tried before incorporating it into a lesson (Participant 20, reflection six excerpt).

Oprah, Naomi, and Ruth all expressed a desire to use the simulation games in their future classes. Esther also expressed a desire; however, it came more from a need to provide students with technology as opposed to enjoying the DragonBox. Some participants observed the

behavior and reactions of their peers and were able to gain perceptions about the simulation games in this way was well.

The other thing that I enjoyed the most is every one's favorite game-Dragon Box. This game has really set this course on top of the others. I see how it had the whole class engaged and I could only imagine how it would have the middle school students engaged (Participant 17, reflection six excerpt).

A rectangular box with a light blue background and a thin black border. Inside the box, the text "Most of my class were engaged." is written in a cursive, handwritten style in black ink.

Figure 4.6. DragonBox Algebra 12+ First play example of course engagement from participant 5.

Participants were able to discuss and identify how they would plan ways to implement the DragonBox effectively. These discussions were made evident through the researcher's journal, interviews, and artifacts.

Theme 6: Preservice teachers saw the use of DragonBox as a way to connect with a highly technology-driven society. Simpson (2009) argues that young people are attracted to technology and those teachers that can transform their students' favorite devices into agents of instruction can expect positive results. The preservice teachers in this study were aware of this connection to students and technology. When I first introduced myself, the participants seemed to be excited about learning how to use different technology. A few discussed, during our first meeting, how many of their students loved technology. Participants also noted in their reflections, their observations of students' transfixion with technology.

Most middle school students have laptops, smart phones and stuff. So incorporating technology would be a great asset as far as teaching is concerned (Participant 22, reflection five excerpt).

Students pride themselves and consider themselves Master of Technology, especially games (Participant 4, reflection five excerpt).

So many of my student loves to play games on their devices at lunch. Any chance they are able, they have their devices out participating in some type of media (Participant 5, reflection one excerpt).

Currently, students love being able to incorporate technology into their learning process. I believe it serves as a great opportunity for educators to include student interest through cultural understanding, the culture of technology (Participant 20, reflection six excerpt).

To put myself in the position of a sixth or seventh grade student. They enjoy being interactive with their learning. The students of this generation learn almost everything through technology (Participant 3, reflection three excerpt).

Esther also provided in her third interview her view on how students felt about technology.

They are all about technology. They come into the classroom talking about Minecraft and what they built. They talk about gaming. I did a survey where they said that they spend 3-4 hours on gaming. Sometimes in the night time. Don't understand how parent allow that but that's what they do. So, I know how important it is for them (Esther, second interview excerpt).

With the requirements to use more technology in the classroom, the preservice teachers in this study also reflected how their different practicum schools required technology use.

Because education now requires us to implement a lot of technology into the classroom, this game allows teachers to do just that (Participant 6, reflection three excerpt).

Dragonbox has encouraged me to use more technology in the classroom, which is also a personal struggle of mine. In my Practicum observation feedback, that is always the area that I need to most development in. I have since thought about using the iPad carts available at the middle school for Kahoot! quizzes and online simulations and lino boards for discussion. So educational apps are just another way to incorporate technology and engage students. Students spend hours on video games, so if as educators we can develop games that capture their interests, appeal to both sexes and are educational, then it is a win-win situation (Participant 20, reflection six excerpt).

Participants also had a strong sense of tools available to them at their current practicum schools. Participants also noted that they might end up teaching at schools that have more or fewer resources than they currently are accustomed. These uncertainties are documented below.

I think Dragon Box is a wonderful resource for students. Whether I would use it in my classroom or not depends on the resources that I am provided with if my school has an abundance of Apple-related or Android products, then I would definitely use DragonBox in my classroom (Participant 23, reflection four excerpt).

The only technology that we have access to on a daily basis is the desktop computer that the teacher has in her classroom and the promethean (active) board that is connected to it. There are not any iPad or tablets accessible to the students in the school, and we have a very strict no phones policy. So, the students in our classroom have no access to an

application like this, therefore I would never be able to use this with the students that I have now (Participant 24, reflection one excerpt).

It does cost money, though, which can be a problem. And the fact that it requires an iPad or similar technology presents other issues. In the school I'm at currently, using this game would not be something my school would be able to provide for students, but I'm sure there are games or manipulatives similar to this that could be provided for them without the added price tag of an iPad (Participant 18, reflection three excerpt).

One concern is that the school where I do my practicum is the Title I school. Not only the parents are low-income households, also school is financially struggle as well. With the condition like this, it is not realistic to provide every student with an iPad, or even having a classroom set of iPad (Participant 12, reflection four excerpt).

Naomi also commented on her uncertainty in her interview.

You know a lot of schools do not have the same funding as other schools. So, I think that being able to get them the iPad or the computer or the Chromebook and being able to make sure that they have access to those sets of materials that they need to be able to play the simulation games is very beneficial[...] So that is the only obstacle I see being faced with because a lot of kids don't have the Chromebook...you have be able to check out from the media center and all of that kind of stuff in order to have it (Naomi, third interview excerpt).

Some participants were unable to comprehend a situation where they would not be afforded the use of technology. These accounts are documented below.

Today in most schools' principals are requiring teachers to use some type of technology in their lessons. At the school that I am currently doing my practicum at all teachers have to check out either the iPad or MacBook cart at least once a week (Participant 15, reflection four excerpt).

Actually, now technology is used in the classroom more than ever. At my school alone, teachers are required to check out different technology sources and use it in their classrooms at least once a week. I think it is an excellent idea (Participant 27, reflection four excerpt).

Participants were able to discuss and identify how their sense of connection between environmental influences (practicum school and middle-level students) and their ability to envision using the simulation games with future students. These discussions were made evident through the researcher's journal, interviews, and artifacts.

Summary

An embedded, exploratory case study design using mixed methods techniques was chosen to investigate the effects of using the mathematical simulation games of DragonBox, on preservice middle-level teachers' mathematics teaching efficacy. The quantitative data was used to measure whether mathematics simulation games positively influenced the mathematics teaching efficacy for middle-level mathematics preservice teachers. The data showed that there were no statistically significant differences in the median ranks from the pretest to the posttest.

The embedding of the qualitative data was in this broader design intervention trial for determining; how preservice mathematics teachers perceived the use of mathematics simulation games in teaching middle-level mathematics during the study and what were the factors that affected the preservice middle-level teachers' mathematics teaching efficacy as they engaged in

mathematics simulation games during the study. As participants engaged with the simulations games of DragonBox, six themes emerged that helped explain the effects of using DragonBox on preservice teachers' mathematics teaching efficacy. Data triangulated from researcher's journal, artifacts and transcribed interviews. Participants indicated that they perceived the use of DragonBox as a learning tool, differentiate way to engage future students, and goal-directed learning tool that still relied heavily on teacher support. Participants also expressed that conceptual understandings and careful planning were needed to connect with a highly technology-driven society. The themes that transpired from the triangulation of qualitative data and the quantitative data will be reviewed through the lens of the causal model of triadic reciprocal causation.

CHAPTER 5

Discussions

The primary aim of this study was to determine if the mathematical simulation games of DragonBox affected the mathematics teaching efficacy of preservice mathematics teachers. An embedded, exploratory case study design using mixed methods techniques was chosen to investigate this study and was guided by Social Cognitive Theory (SCT) framework. Three research questions guided this study:

1. How are preservice middle-level teachers' mathematics teaching efficacy affected using the mathematics simulation games of DragonBox during the study?
2. How do preservice mathematics teachers perceive the use of mathematics simulation games in teaching middle-level mathematics during the study?
3. What are the factors that affect the preservice middle-level teachers' mathematics teaching efficacy as they engage in mathematics simulation games during the study?
Moreover, what are the affordances/constraints associated with using mathematics simulation games concerning mathematics teaching efficacy?

This concluding chapter will revisit the major findings, situate the findings of the study within the literature, implications for actions, and recommendations for further research. This chapter also includes interpretation of the research findings as guided by SCT framework.

Major findings

In examining the effects of using the DragonBox on preservice teachers' mathematics efficacy, six themes emerged. Appropriately, three themes emerged describing teacher perceptions concerning DragonBox, and they include:

1. Preservice teachers saw the use of DragonBos as a sensory immersive, learning tool to further middle-grade students' conceptual understandings.

2. Preservice teachers saw the use of DragonBox as a differentiated way to engage middle-grade students and promote a sense of embodiment within a digital environment.
3. Preservice teachers viewed the use of DragonBox as a goal-directed experience and a dependent tool that still heavily relied upon teaching to support student learning.

Additionally, three themes emerged concerning mathematics teaching efficacy factors associated with using DragonBox:

4. Preservice teachers required conceptual understandings of the topics presented in DragonBox to value its use with middle-grade students.
5. Preservice teachers determined that planning and careful analysis of DragonBox is needed for supporting active, subjective and situated learning.
6. Preservice teachers saw the use of DragonBox as a way to connect with a highly technology-driven society.

Situating the Findings within the Literature

In reviewing studies that measured the mathematics teaching efficacy of preservice teachers (Arslan & Isiksal-Bostan, 2016; Briley, 2012; Isiksal-Bostan, 2016; Sancar-Tomak, 2015), there were similarities to the current study in the way mathematics teaching efficacy was measured. Broadly, simulation games are seen to be effective tools to help increase student understanding (Prensky, 2001b).

The results of my research study indicated that the preservice teachers did not show any change from pre to post DragonBox intervention. The lack of significant change in mathematics teaching efficacy could be attributed to the fact that the duration of immersion using DragonBox

was not sufficient to provide a mastery experience with participants. Due to short exposure, preservice teachers were unlikely to develop an elevated sense of confidence in affecting student learning using DragonBox. Mastery experience is one of the most potent aspects of teaching efficacy beliefs (Bandura, 1997; Tschannen-Moran and Hoy, 2007). I argue that a mastery experience would have allowed the participants to use their created DragonBox lesson plans with their practicum students. In a study regarding the source of teaching efficacy beliefs, Can (2015) studied five preservice science teachers and determined that mastery experiences do play an important role in increasing teaching efficacy beliefs. Aslan, Tas, and Ogul (2016) conclude after their study, which included 73 in-service pre-school teachers and 100 preservice teachers, in-service teachers had higher science teaching efficacy beliefs than preservice teachers. The study also inferred that the most important factor in increased science teaching efficacy beliefs was mastery experience. Al-Awidi and Alghazo (2012) also performed a study with 62 preservice teachers and used 16 purposefully selected participants, to determine that mastery experience and vicarious experience were the most influential sources of efficacy when learning to integrate technology. Aydeniz and Ozidilek (2014) performed a similar study with 40 preservice elementary science teachers that showed statistical significance in self-efficacy. The intervention lasted for 11 weeks and consisted of improving preservice teachers' self-efficacy through argumentation. One major difference in the intervention for Aydeniz and Ozidilek's study as opposed my research study was that the preservice students were required to teach their argumentation created lesson plans at least three times with their practicum students. This opportunity to teach their practicum students was a mastery experience and was at least one of the reasons why there was an increase in self-efficacy.

In a similar vein, Ketelhit and Schifter (2011) facilitated a cross-case study discussing the development of a teacher professional development for a games-based science curriculum for middle school students. The development of the program lasted for more than three years. Important findings from Ketelhit and Schifter's study revealed that sufficient time is needed for teachers to develop comfort with the technology intervention, models for success needs to be provided for successful implementation, as well as support mechanisms throughout the intervention process. The authors also investigated the difficulties that schools and teachers have in developing comfort with technology at a pace that is like students. The study focused on helping teachers overcome technology fears and concentrated on helping teachers to develop efficacy in using technology. Comfort with using technology could have also been another reason preservice teachers did not show significant gains in mathematics teaching efficacy.

When using instructional games, it is essential to consider other factors like gender and cultural aspects (Lukosch et al., 2017). Most participants in this study were female (87.9%). While this gender makeup was representative of the population, this overwhelming percentage of women could have influenced the results of the study. This study did not explore gender and cultural differences in gaming. However, Sigurdardotti, Skevik, Ekker, and Godejord (2015) found that while boys and girls both recognize the worth of DGBL, they tend to play different types of games in their free time. This conclusion is interpreted as different kinds of games can be more appealing to different genders and researchers, curriculum developers, and teachers have to try to be cognizant of this. Additionally, the researchers found that as boys and girls grow older that young women tend to grow more skeptical towards DGBL, "and the 16-18-year-old participants seems to have an internalized perception of gender differences" (Sigurdardotti et al.,

p.1485, 2015). A high female population could have also been another reason preservice teachers did not show significant gains in mathematics teaching efficacy.

An interesting finding of my research study is preservice teachers' impactful change as they reflected on their ability to help students understand mathematics before and after engaging in Dragonbox gaming environment. Such finding highlights teachers' beliefs about their ability to be able to teach mathematics overall effectively and encompasses all the factors associated with Bandura's (1986) reciprocal determinism, the primary tenant of Social Cognitive Theory. Reciprocal determinism is where personal factors, environment, and behavior interact with each other bi-directionally (Denler, Wolters & Benzon, 2014). Preservice teachers could have realized that they are endowed with some personal factors or mental capabilities necessary to teach students easily. Preservice teachers must have the knowledge and the ability to articulate that knowledge to their students. Being able to teach students easily also requires that preservice teachers possess certain behaviors to be able to teach mathematics easily. Anthony and Walshaw (2009) describe the behavioral characteristics of effective mathematics teachers, and a few include: making connections, arranging for learning (or providing an environment for learning), providing tools and representation, and building on student thinking. I argue that immersing preservice teachers within the DragonBox gaming environment has honed and made visible the behavioral characteristics described by Anthony and Walshaw (2009).

Preservice teachers were able to list many tools and resources gained from their engagement in the DragonBox gaming environment to be able to use with their future students. However, such exposure to gaming activities did not necessarily provide a mastery experience. On the other hand, nuanced influences were detected in preservice teachers' perceptions of their

mathematics teaching efficacy and the potential usefulness of DragonBox gaming environment on mathematics learning.

The following will discuss the themes that emerged from the qualitative data and how they are situated within SCT. The themes that emerged from the qualitative data can all be related to human agency. Human Agency is one of the cornerstones that Schunk and Pajares (2009) state help provide a better understanding of SCT. Bandura (2006) explains that SCT is rooted in the notion of human agency. Bandura (2001) argues that in SCT, people are agentic operators (personal factors). Being an agentic operator means that the things that occur in a person's environment (environmental influences) do not control a person, nor are people merely reacting (behavior) to things that occur around them. Bandura (1999) provides that human agency does not just regard socio-structural and psychological factors. Instead, the triad of reciprocal determinants must be used where socio-structural influences (environmental influences) operate through psychological mechanisms (personal factors) to produce behavioral effects (behavior). SCT subscribes to a model of the emergent interactive agency which states that learners make intentional decisions to invest in learning and enact behavior change (Bandura, 2001).

Preservice Teachers' Perceptions with Respect to Using DragonBox

Similarly, to the research done in the Literature Review, the qualitative research findings were split between simulation games in education and mathematics teaching efficacy. The three themes that related to teacher perceptions concerning DragonBox better interpreted through the literature that discusses using simulation games in education.

Preservice teachers saw the use of DragonBos as a sensory immersive, learning tool to further middle-grade students' conceptual understandings. The preservice teachers

discussed and described DragonBox as a meaningful tool for teaching middle-grade students. Many of the participants were able to list the different standards and concepts that were present within DragonBox. Participants also commented and discussed with each other, and I of how visually appealing and engaging the game would be for middle-level students. Garris et al. (2002) agrees with the findings and provides that simulation games can produce an intensity of engagement in students. Furthermore, Virk, Clark, and Sengupta (2015) agree with the visual appeal of DragonBox and provide that “DragonBox provides a nice example of how graphical representations precede the gradual introduction of symbolic representations” (p. 300).

Preservice teachers saw the use of simulation games as a differentiated way to engage middle-grade students. Prensky (2001b) provides characteristics of a player’s engagement include: enjoyment, intense involvement, structure, motivation, learning, doing, ego gratification, learning, and so on. These characteristics were some of the same attributes that the preservice teachers noticed about DragonBox. Preservice teachers were also able to note using DragonBox was a way to differentiate learning for students. Differentiated learning is notable because the National Council of Mathematics Teachers (NCTM, 2000) provides the importance of realizing the different needs of students, so there is confidence students learn the appropriate material. Likewise, it is important for teachers to be able to provide different ways of learning (Tobias & Fletcher, 2012).

Preservice teachers saw the use of DragonBox as a differentiated way to engage middle-grade students and promote a sense of embodiment within a digital environment. Many of the preservice teachers found DragonBox to be engaging. Preservice teachers in this study also noted that DragonBox can be used as a differentiation strategy. It is important for teachers to be able to provide different ways of learning (Tobias & Fletcher, 2012). Balasurbram

& Wilson (2006) include that students desire for a more digital learning environment, and teachers that are willing to provide one can expect good results.

Devlin (2011) elegantly states that: “Mathematics is almost entirely about doing” (p.52). Therefore, it is important to allow students to see how mathematics is used in the real world and not to focus on core competencies, but the thinking process. Preservice teachers were able to note that DragonBox provides a simulated world in which students can perform real-world mathematical problems and where students can focus on the thought process (Devlin, 2011). Additionally, while video games provide real-world application, they also provide students with the opportunity and motivation to practice a skill multiple times until they are proficient in it. Through a meta-analysis of 46 empirical studies, Lamb et al. (2018) found affordances associated with using educational simulations, serious games and serious educational games. These affordances included increased student achievement, cognition, and effect. Gee (2008) argues that video games could contribute to the increased interest in students.

Mathematics Teaching Efficacy Factors Associated with Using DragonBox

Bandura (1997) discusses that teachers’ efficacy beliefs are related to teaching efforts in teaching, teacher goals, and teacher persistence, this is the triadic reciprocal causation. Teachers’ efficacy beliefs also influence mastery experiences, verbal persuasion, vicarious experiences and physiological arousal. These accounts were evident in this study. Participants that were willing to explore and spend more time with the simulation games were also able to benefit more from the mastery experiences of playing DragonBox first hand. Verbal persuasion was also witnessed throughout this study. Positive and negative remarks regarding the simulation games were noted in observations and participant reflections, and these remarks influenced participants views as well. Vicarious experiences were noted in student’s reflections as they commented on the

researcher's delivery of the simulation games. Physiological arousal was also witnessed as participants discussed how playing the simulations games made them 'feel,' how the simulation games influenced their interest regarding the colors, sounds, and characters. The three themes that relate mathematics teaching efficacy factors associated with using DragonBox are interpreted through the literature that discusses using teaching efficacy.

Preservice teachers required conceptual understandings of the topics presented in DragonBox to value its use with middle-grade students. There were some participants in this study that provided they did not have the proper conceptual understandings to be able to engage with DragonBox fully. Not having the personal factors or human capabilities, lessened their belief that they could play DragonBox, progress in DragonBox and use it in their future classroom. Human capabilities provide a cognitive means in which to influence a human's destiny (Schunk & Parjares, 2009; Pajares, 2003). To be able to see the benefits of DragonBox, participants had to have the conceptual understandings.

According to Bandura's (1986) SCT, individuals possess a self-system that allows them to have some control over their thoughts and abilities. This self-system envelops a person's cognitive and effective structure and provides reference mechanisms and a subset of perceiving, regulating and evaluating behavior, which then results in the interplay between the system and the environment (Pajares, 2002). Through self-reflection, a uniquely human capability, a person can evaluate and alter their thinking and behavior (Bandura, 1986). These self-evaluations include perceptions of self-efficacy. The way in which individuals interpret the results of their performance feats informs and alters their environment and their self-beliefs, which in turn inform and alter their subsequent performances (Pajares, 1996). Participants that did not feel that

they were good with certain mathematical concepts found it more difficult to perceive the usefulness of DragonBox.

Preservice teachers determined that planning and careful analysis of DragonBox is needed for supporting active, subjective and situated learning. Participants in this study desired more mastery experiences. Therefore, they desired and requested to walk through lesson planning together. The preservice teachers in this study desired to learn more about DragonBox and get as close as possible to implementing with students. The participants wanted to prepare lessons and regularly discussed lesson planning in their reflections. This behavior of wanting to prepare and plan for students showed that participants were increasing in mathematics teaching efficacy and displaying forethought.

Forethought is another human capability that is a physical extension of the agency that goes beyond forward-direct planning (Bandura, 1986). Bandura (1999) explains that “[f]orethought guides the selection of actions, and the results produced by those actions verify the adequacy of the chosen course” (p. 7). With forethought, a person will set a goal for themselves, anticipate the likely consequence, and then select and create a course of action that is most likely to produce desired outcomes while avoiding detrimental ones (Bandura, 1986).

Through forethought, a person can construct outcome expectations, which originate from observed conditional relationships between environmental events in the world around them and the outcomes given (Bandura, 1986). When a person can produce anticipated outcomes on current events, this then produces predictable behavior which allows a person to transcend the order of their current environment, to shape and regulate their present so that they create the desired future (Bandura, 2001). By regulating their behavior through outcome expectations, a person can adopt courses of action that are likely to produce positive outcomes and get rid of

courses of actions that will produce unrewarding or punishing outcomes (Bandura, 2001; Denler, Wolters & Benzon, 2014). Outcome expectancies may be physical (behavior), social (environmental influences), or self-evaluative (personal factors) in nature, and it usually associates with positive or negative behavior (Bandura, 1986, 2001). Preservice teachers demonstrated that forethought and planning were needed to use with middle-grade students.

Hyung, one of the creators of DragonBox supplied that he did not intend for DragonBox to take the place of the teacher (WeWantToLearn, 2018). Teachers still need to be preset to connect the concepts for students. Students still need a guide as they explore and learn. Preservice teachers in this study wanted it to be known that they did not want DragonBox to teach the students, the participants had a strong desire to make sure students were learning with them as the primary learning modality. Barzilai and Blau (2014) findings agreed with the sentiments of the preservice teachers. Providing learners with external conceptual scaffolding before learners played a business simulation games was shown to be statistically significant in a study performed by Barzilai and Blau (2014). Using 186 participants, learners showed that being presented with a lesson before playing the digital simulation game, learners increased in their problem-solving assessment.

Another hindrance that was noticed and observed was lack of sufficient instructions. Most of the participants commented that they did not feel that DragonBox has sufficient instructions for students. Although most preservice teachers did not feel that DragonBox had adequate instructions, all participants were able to see how the concepts of Algebra and Geometry were present in the simulations games, how the concepts built on each other and how the concepts present within DragonBox matched the standards of middle-level mathematics.

Similarly, in a mixed method study on the effects of game design with 50 teachers conducted by An and Cao (2017), teachers had reservations regarding using digital games in the classroom. The study found that initially, teachers felt that digital games in the classroom could be a distraction, students could become dependent on the game, the game would not be effective, students would become more focused on the game instead of learning. However, concluding the game design, teachers became more confident with using digital games in the classroom. The preservice teachers from this study shared some of the same sentiments. Having more mastery experience could have helped to alleviate these feelings.

Preservice teachers saw the use of the simulation games to connect with a highly technology-driven society. All participants discussed their practicum students' love of technology or their practicum school's requirements to use technology. The environmental influences of their practicum schools also weighed heavily in their views of being able to use DragonBox in their future classrooms. Some preservice teachers did not even consider being in a school without technology, while others could not imagine being in a school with technology. Most participants felt the pressure of being able to use technology in some way. Chahine (2013) argues that teachers are expected to be well trained in all the newest learning technologies to prepare students for the digital work force. The environmental influences of their practicum school and other outside factors helped to shape their views of using DragonBox.

The results were like the results found by Kennedy-Clark (2011). A study was conducted with 28 preservice science education teachers investigating their attitudes towards using multi-user virtual environments (MUVES) (Kennedy-Clark, 2011). MUVES are game-like environments that allow users to engage in scientific learning environments (Kennedy-Clark, 2011). The preservice teachers found usefulness in using the technology in their classroom.

However, the preservice teachers cited barriers to using the MUVES such as cost, access to technology, differences in student ability and issues with behavior management. Cost and access to technology are some of the same environmental concerns that the some of the participants of this study also shared.

Bandura (1997) explains that in SCT, the environment is not a monolithic entity. Instead, it is distinguished between different types of environmental structures which include: imposed environments, selected environment, and constructed environment. The different types of environment are representations of the orderings of changeability that require the exercise of increasing levels of human agency (Bandura, 1997, 1999). Bandura (1999) provides the following descriptions of the different types of environment. The imposed environment is an environment that is forced upon the person whether they like it or not; however, the person does have space in how they interpret and react to it. An example of an imposed environment would be when participants felt that they were forced to use technology at their practicum school. Another example would be when participants were at practicum schools with little to no technology. The selected environment is an environment where one can choose the associates, activities, and location. The constructed environment is an environment that people construct through productive efforts, as in participants being able to apply to particular schools to work at. These different environmental structures affect the nature of the reciprocal interplay between personal, behavioral and environment (Bandura, 1999).

SCT posits that while the environment can shape a person's behavior, a person has the potential abilities to alter and construct environments to suit their needs. This dynamic also allows individuals to work with others in organizations and social systems to achieve environmental changes that benefit the entire group (Glanz et al.,2008). The participants realized

that being able to incorporate technology into student learning is beneficial. Consequently, participants seemed to arrive at the consensus that using DragonBox, or some other technology game, could be helpful in them bridging technology and mathematics learning for middle-grade students.

The results of the quantitative and qualitative data seemed to be contradictory. The quantitative data showed that there was no statistically significant change in teaching efficacy, while the qualitative data showed that preservice teachers were able to not the benefits of using DragonBox. The results of this study are like the findings of Bourgonjon et al. (2013). Reviewing teacher's beliefs concerning video games Bourgonjon et al. (2013) found that 505 teachers were not convinced video games are useful in increasing their effectiveness as a teacher. Contrarily, teachers did believe that video games provide opportunities for learning. Additionally, teachers provided if they do not plan to use video games in the future.

Implications for action

There needs to be an increase in technology integration in the higher education classrooms. Having teacher preparation programs that help preservice teachers incorporate technology in the classroom could assist in ensuring that preservice teachers are continually using innovate teaching tools with their students and designing appropriate curriculum. Additionally, by preparing preservice teachers to incorporate simulation games in their classrooms, new teaching tools could emerge. Preservice teachers also need to be able to have mastery experiences with using simulation games to help better shape their teaching efficacy. Preservice teachers also need more time to engage with different technology and more opportunity to use that technology in the field.

Additionally, I agree with Gee (2013) when he provides that “Games have a place in teaching, as do a multitude of other tools. But, games are no silver bullet. Great teachers designing great experiences, on the other hand, can change the world” (p. 152). I concur with the research that provides that DragonBox is a great instructional tool (Gee, 2013; Siew, Geoffrey, & Lee, 2016; Katirci, 2017). However, it takes great teachers to provide those great experiences so that students can learn. Preservice teachers must be provided with opportunities to explore, grow and learn with different tools so that they are able to create great experiences for their future students.

Recommendations for Further Research

While findings from this research study are promising and have possible implications for practice, the results may not be generalizable from this case study to the larger population of mathematics preservice teachers. Some identifiable limitations of this study include small sample size, a limited number of interviews, and specificity to one university. All of this would contribute to the lack of generalizability (Locke, Silverman, & Spirduso, 2010). It is suggested that new research is done involving the use of additional simulation games on preservice mathematics teachers.

It is important to note that self-efficacy, or more specifically teaching efficacy beliefs, are essential for designing and implementing effective professional development for teachers (Demir & Ellet, 2014). I agree with these findings and suggest that consideration for teaching efficacy is also important in developing effective teacher preparation programs. When developing teacher programs mastery experiences, verbal persuasion, vicarious experiences, and psychological and emotional arousal need to be considered. A more longitudinal study that ensures that teachers are provided with sufficient time and opportunity to encounter mastery experiences in the form of using simulation games with students would be beneficial. More specifically, preservice teachers

should be provided with a variety of technological tools to learn to incorporate with students. Preservice teachers should be provided with additional time to become familiar with using the different tools, and preservice teachers should be provided with multiple opportunities to use with practicum students. Instructors or mentor teachers should also provide feedback.

The use of games in the mathematics classroom can provide ways for students to be engaged and motivated (Prensky, 2002). Therefore, the continued research, development and understanding of how games can be properly utilized to contribute to student's conceptual understandings is essential. Games have the potential to contribute to students' academic confidence and assist in providing students with academic achievement (Steinberg, 2011). The Nation's Report Card (2017) provides that only 33% of eight grade students are proficient in mathematics. It is evident that a drastic change must be made in the mathematics classrooms. Further research should be done that helps teachers to incorporate games in the mathematics classroom.

Mocanu and Nichimis (2018) observe that we are living in a highly technological social context. Technology and its use is all around us. It is important that we provide opportunities for our students to learn and grow with technology. Additionally, uncovering ways to ensure that teachers are properly prepared to utilize simulation games in the classroom is of equal importance. Incorporating technology in the classroom cannot be done successfully without the proper preparation and development. Continued research and exploration should be done concerning effective implementation practices of using simulation games in the mathematics classroom.

Future Directions

Findings of this study suggest that effects of using the mathematical simulation games of DragonBox on the mathematical teaching efficacy of preservice mathematical teachers were

mixed. Preservice teachers displayed no significant increase in efficacy quantitatively. The results of the median scores on the MTSES showed a no significant difference of the scale scores. From a triangulation of qualitative data, six themes emerged. The themes displayed that preservice teacher saw the value in using DragonBox with students.

Bringing technology into the classroom has the potential to reach a variety of students in many differentiated ways. Ensuring that learning is individualized is truly a daunting task, however with the help of technology such as digital games and simulations, multiple student styles could be met through one medium. Proper teacher development and courses are essential to ensuring that students do not miss this opportunity to learn mathematics in fun, innovative, engaging ways. Simulation games are not meant to replace the teacher but meant to enhance the learning experience. Preservice teachers have the potential to make using technology the norm in the classroom. We are already in a technology-enriched world, and it is essential that our teachers are helping students learn and maneuver through it. Proper courses that provide preservice teachers with the opportunity to use and explore lesson planning and implementation with simulation games could be the key to helping more students have higher levels of conceptual mathematical understandings.

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Appendices

Appendix A

Mathematical Teaching Self-Efficacy Survey

Mathematics Teaching Self-Efficacy Scale	
<p>Indicate how much you agree or disagree with each statement below by circling the appropriate letters to the right of each statement.</p> <p style="text-align: center;">SA = Strongly Agree; A = Agree; N = Neutral; D = Disagree; SD = Strongly Disagree</p>	
1	I will not be very effective in monitoring students' mathematical learning through activities in the classroom
2	I do not know what to do to engage students in mathematics in the future
3	I will have difficulty in using manipulatives to explain to students why mathematics works
4	I will be able to answer students' questions about mathematics.
5	I will be able to give an answer for any mathematical questions from students
6	I certainly will teach mathematics well in a class to the public.
7	I will be able to teach students to easily understand mathematics
8	I will be able to explain mathematics easily to get students who think of mathematics as being difficult to understand it.
9	When a student has difficulty with a mathematics problem, I will usually able to adjust it to the student's level

10	I will not explain some mathematical concepts very well	SA	A	N	D	SD
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Appendix B

Demographic Information Questionnaire

Name: _____

To keep your full name under a veil, please show your last name and initials of the first name only. For example, Cates M or MC for Cates, Monica.

Answer the following demographic items by circling the appropriate response or by writing appropriate words.

A. Indicate your gender.

- a. Male b. Female

B. State your age as of today: _____

C. Indicate which program you are enrolled in:

- a. Elementary teacher education program
b. Secondary teacher education Program
c. Other: _____

D. Choose one of the following:

- a. Mathematics major (or intensive) including double-majors
b. Mathematics minor. Then, what is your major? _____
c. No major/minor in Mathematics. Specify your major and minor: _____

E. Indicate one of which:

- a. Freshman b. Sophomore c. Junior d. Senior
Other: Please specify: _____

F. Choose one that you reflect your overall college grade point average.

- a. None yet, entering freshman b. Over 4.0 c. 3.5 – 3.99 d. 3.0 – 3.49 e. 2.5 – 2.99
f. Below 2.5

G. How would you classify yourself?

- a. Arab b. Asian/ Pacific Islander c. Black
d. Caucasian/ White e. Hispanic f. Indigenous or Aboriginal h. Latino
i. Multiracial. Please specify: _____
j. Other. Please specify: _____

H. Indicate all of which you already complete in a local school:

- a. Observational practice
b. Participation practice
c. Both a. and b. above at the same time
d. Professional teaching practice

I. How often do you play sports?

- a. Daily 3 or 4 times each week
- b. Once a week
- c. Once a month
- d. hardly ever

J. Have you ever played a computer game?

- A. Yes
- B. No

K. How old were you when you first played a videogame?

- a. < 5 years
- b. < 10 years
- c. < 15 years
- d. other: _____

L. How often do you play videogames?

- a. Daily 3 or 4 times each week
- b. Once a week
- c. Once a month
- d. hardly ever

M. Who do you usually play videogames with?

- a. Self
- b. Family or Friends

N. Do you play games online?

- a. Yes
- b. No

O. When you play videogames, how long do you play?

- a. >1 hours
- b. > 3 hours
- c. > 5 hours
- d. > 8 hours

P. What makes a good videogame? List the three things that are most important to you.

- 1.
- 2.
- 3.

Appendix C

DragonBox Algebra 12+ First Play

Name: _____

DragonBox Algebra 12+

Before you start to write, play the game. Try to complete the game. If you have played the game before, play it again to have it fresh in your mind.

1. What mathematical concepts, if any, do you see present within the game? Provide examples if possible.
2. What are some things about the game that you find engaging?
3. What are some things about the game that you find confusing (if anything)?
4. Is there something that you did not expect when playing the game?
5. Is there a specific part of the game that reminds you of something else?

6. How does this game compare with other games that you have seen or that you have played in a mathematics classroom?
7. Give an overall rating for this game and explain why
8. Other Observations

Appendix D

DragonBox Elements First Play

Name: _____

DragonBox Elements

Before you start to write, play the game. Try to complete the game. If you have played the game before, play it again to have it fresh in your mind.

*** If you get stuck please view the following videos for a guide:
https://www.youtube.com/watch?v=1dY-6H2BDTk&list=PLW_0-IW_ebQY2IDMwQn43UdW7a3rcRcnh

1. What mathematical concepts, if any, do you see present within the game? Provide examples if possible.

2. What are some things about the game that you find engaging?

3. What are some things about the game that you find confusing?

4. Is there something that you did not expect when playing the game?
5. Is there a specific part of the game that reminds you of something else?
6. How does this game compare with other games that you have seen or that you have played in a mathematics classroom?
7. What titles would you provide for each chapter of the game and why?
8. Give an overall rating for this game and explain why
9. Other Observations

Appendix E

Recruitment Script

Good morning class. Today I would like to invite you to be part of a research study. This study's purpose is to examine the effect of using mathematical simulation games on mathematics teachers' mathematics teaching efficacy. As part of class, all students will be engaged in the class activities and will be asked to use the mathematical simulation games DragonBox Algebra 12+ and DragonBox Elements for 6 assigned weeks during a mathematics simulation game module of the course. Study participants will be asked to interview to describe your experiences with the simulation games. Study participants will be asked to reflect in writing regarding the simulation games of DragonBox. Study participants will write a reflection once a week for 6 weeks, for about 10-15 minutes each time.

It is expected that you spend 3 hours of class time and in addition, study participants will spend 20 minutes each for interviews for 6 non-consecutive weeks for a total of 18 hours and 40 minutes. The activities and discussions will take place during regular class meeting times and location. Interviews will take place before or after class at the same location. Only after you consent to participate in this study will you be asked to reflect for data analysis.

Participation in this research study is voluntary. If you do not consent to be part of this research study, we will not include any of your observation data and you will not be required to reflect. You will not have any penalty if you do not participate, nor will it affect your grade in the course. You do not have to be in this study. If you decide to be in the study and change your mind, you have the right to drop out at any time and we will not use any of your data in the analysis. You can also inform the teacher that you do not want your data and reflections to be

used in the research. Whatever you decide, you will not lose any benefits to which you are otherwise entitled.

Appendix F

Informed Consent

Georgia State University
Department of Middle and Secondary Education
Informed Consent

Title: The Effect of Using DragonBox on Pre-Service Middle Grade Mathematics Teachers' Self-Efficacy

Principal Investigator: Dr. Iman Chahine

Student Principal Investigator: Monica Cates

I. Purpose:

You are invited to participate in a research study because you are enrolled in preservice teacher mathematics course (EDMT 4460) for fall 2017. This study's purpose is to examine the effect of using mathematical simulation games on nine pre-service middle-level teachers' mathematics teaching efficacy.

II. Procedures:

Regular classroom activities, if you decide to participate in this study you will do the following:

- 1) You will be asked to reflect in writing regarding the simulation games of DragonBox. You will write a reflection once a week for 6 weeks, for about 10-15 minutes each time.
- 2) From the nine participants, six will be randomly selected for a pre and post interview during the course of the study. Interviews will take place before and after class and will last approximately 20 minutes each. Interviews will be audiotaped. Interviews will be conducted by the Student Principal Investigator, Monica Cates.
- 3) During your regularly scheduled course time, in class, you will be observed by the Student Principal Investigator, Monica Cates. Observations will include instances where you are engaging with the simulation games of DragonBox. Observation will last 60 – 90 minutes and will include attributes of efficacy in using the simulation games of DragonBox. Participants that have consented will be audiotaped during presentations and class discussions.

All students are that enrolled in EDMT 4460 will be invited to participate in the study, however participation is not required nor will it affect your grade if you choose to not participate. Participants may choose to drop out of the study at any time without penalty.

III. Risks:

In this study, you will not have any more risks than you would in a normal day of life.

IV. Benefits:

This research may not benefit participants personally. Participation in this study will provide participants with resources and activities to use in future middle grade mathematics classes that will benefit you personally.

V. Voluntary Participation and Withdrawal:

Participation in research is voluntary. You will not have any penalty if you do not participate, nor will it affect your grade in the course. You do not have to be in this study. If you decide to be in the study and change your mind, you have the right to drop out at any time. You may skip

GSU
APPROVED IRB NUMBER: H17368
IRB APPROVAL DATE: 09/27/2017
IRB EXPIRATION DATE: 09/26/2018

questions on the interview or stop participating at any time. You can also inform the teacher that you do not want your responses and reflections to be used in the research. Whatever you decide, you will not lose any benefits to which you are otherwise entitled.

VI. Confidentiality:

We will keep your records private to the extent allowed by law. Dr. Iman Chahine and Monica Cates will have access to the information you provide. Information may also be shared with those who make sure the study is done correctly (GSU Institutional Review Board, the Office for Human Research Protection (OHRP)). We will use pseudonyms rather than your name on study records. The information you provide will be stored on firewall-protected computers. Your name and other facts that might point to you will not appear when we present this study or publish its results. The findings will be summarized and reported in group form. You will not be identified personally.

VII. Contact Persons:

Contact Dr. Iman Chahine at (404)413-8407, ichahine@gsu.edu, and Monica Cates at (404)316-5635, mcates3@student.gsu.edu if you have questions, concerns, or complaints about this study. You can also call if you think you have been harmed by the study. Call Susan Vogtner in the Georgia State University Office of Research Integrity at 404-413-3513 or svogtner1@gsu.edu if you want to talk to someone who is not part of the study team. You can talk about questions, concerns, offer input, obtain information, or suggestions about the study. You can also call Susan Vogtner if you have questions or concerns about your rights in this study.

VIII. Copy of Consent Form to Participant:

We will give you a copy of this consent form to keep.

If you are willing to volunteer for this research and be audio recorded, please sign below.

_____	_____
Participant	Date
_____	_____
Principal Investigator or Researcher Obtaining Consent	Date

GSU IRB NUMBER: H17368
APPROVED IRB APPROVAL DATE: 09/27/2017
IRB EXPIRATION DATE: 09/26/2018

Appendix G

2nd Interview Protocol Form

Title: The Effect of Using DragonBox on Pre-Service Middle Grade Mathematics Teachers' Self-Efficacy

Date _____

Time _____

Location _____

Interviewer _____

Interviewee _____

Release form signed? _____

Notes to interviewee:

Thank you for your participation. I believe your input will be valuable to this research and in helping grow all our professional practice.

Confidentiality of responses is guaranteed

Approximate length of interview: 15 minutes, two major questions

Purpose of research: This study's purpose is to examine the effect of using mathematical simulation games on pre-service middle-level teachers' mathematics teaching efficacy.

1. What do you expect to gain from this course?
 - a. In what ways do you think this course will help your future teaching?
 - b. What areas of teaching mathematics makes you feel nervous, and in what areas do you desire more support?
 - c. What things are you interested in learning more about?

Response from Interviewee:

Reflection by Interviewer:

2. Can you describe your thoughts and experiences with playing video games?
Do you personally play games, or have you ever played games?

Have you ever experienced a teaching environment in which you played a video game?

How do you feel about playing video games to teach your students?

Response from Interviewee:

Reflection by Interviewer

3. What are your thoughts about using simulation games in the classroom?
 - a. What are your thoughts about incorporating simulation games in your student teaching?
 - b. What are your thoughts about incorporating simulation games in your future classroom?

Reflection by Interviewer

- Closure
 - Thank you to interviewee
 - reassure confidentiality

- ask permission to follow-up _____

Appendix H

3rd Interview Protocol Form

Title: The Effect of Using DragonBox on Pre-Service Middle Grade Mathematics Teachers' Self-Efficacy

Date _____

Time _____

Location _____

Interviewer _____

Interviewee _____

Release form signed? _____

Notes to interviewee:

Thank you for your participation. I believe your input will be valuable to this research and in helping grow all our professional practice.

Confidentiality of responses is guaranteed

Approximate length of interview: 15 minutes, two major questions

Purpose of research: This study's purpose is to examine the effect of using mathematical simulation games on pre-service middle-level teachers' mathematics teaching efficacy.

4. What is one of the most memorable things that you can take away from the module on simulation games?
 - a. In what ways do you think simulation games will help your future teaching?
 - b. Why do you feel that simulation games will not be able to contribute to your future teaching?
 - c. What areas of teaching mathematics with simulation games do you feel more confident? What areas do you feel are lacking from simulation games?
 - d. What things are you interested in learning more about simulation games?

Response from Interviewee:

Reflection by Interviewer

5. How have your views about playing simulation games for instruction changed?
Have your ideas for playing simulation games evolved in any way?

How do you plan to incorporate simulation games of any sort in your classroom?

How do you feel about playing simulation games as a way to teach your students?

Response from Interviewee:

Reflection by Interviewer:

6. What are some factors that influence your views about incorporating simulation games in your future teaching?
 - a. Do you feel that there are any constraints that inhibit your use of simulation games?
 - b. Do you feel that there are any benefits to your use of simulation games?

Response from Interviewee:

Reflection by Interviewer

Reflection by Interviewer

- Closure
 - Thank you to interviewee
 - reassure confidentiality
 - ask permission to follow-up _____

Appendix I

Reflection Questions

Question Set 1

What are your views about using games for learning? Can you describe a time when you saw the use of video games incorporated in a mathematics class? How often do you video games of any kind?

Question Set 2

What are your views about playing DragonBox Algebra? What were some things that you liked/did not like about playing DragonBox Algebra? How did playing DragonBox Algebra make you feel?

What are some reasons why you would or would not use DragonBox Algebra to teach students?

Question Set 3

What are your views about playing DragonBox Elements? What were some things that you liked/did not like about playing DragonBox Elements? How did playing DragonBox Elements make you feel?

What are some reasons why you would or would not use DragonBox Elements to teach students?

Question Set 4

What are your views about planning to use DragonBox in the classroom? What were some things that you liked/did not like about planning to use DragonBox in the classroom? How did planning to use DragonBox in the classroom make you feel?

Appendix J

DragonBox Algebra 12+ Related Middle Grade Common Core Standards

6.NS.B:	Compute fluently with multidigit numbers and find common factors and multiples.
6.NS.B.4.	Find the greatest common factor of two whole numbers less than or equal to 100 and the least common multiple of two whole numbers less than or equal to 12. Use the distributive property to express a sum of two whole numbers 1–100 with a common factor as a multiple of a sum of two whole numbers with no common factor. For example, express $36+8$ as $4(9+2)$
6.EE.A:	Apply and extend previous understandings of arithmetic to algebraic expressions.
6.EE.A.2	Write, read, and evaluate expressions in which letters stand for numbers
6.EE.A.3.	Apply the properties of operations to generate equivalent expressions. For example, apply the distributive property to the expression $3(2+x)$ to produce the equivalent expression $6+3x$; apply the distributive property to the expression $24x+18y$ to produce the equivalent expression $6(4x+3y)$; apply properties of

	operations to $y+y+y$ to produce the equivalent expression $3y$.
6.EE.B:	Reason about and solve one variable equations and inequalities
6.EE.B.4	Identify when two expressions are equivalent (i.e., when the two expressions name the same number regardless of which value is substituted into them).
6.EE.B.6	Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.
6.EE.B.7	Solve real-world and mathematical problems by writing and solving equations of the form $x+p=q$ and $px=q$ for cases in which p , q and x are all nonnegative rational numbers.
7.NS.A.1.c	Understand subtraction of rational numbers as adding the additive inverse, $p-q=p+(-q)$. Show that the distance between two rational numbers on the number line is the absolute

	value of their difference and apply this principle in real-world contexts.
7.NS.A.2.	Understand that a two-dimensional figure is congruent to another if the second can be obtained from the first by a sequence of rotations, reflections, and translations; given two congruent figures, describe a sequence that exhibits the congruence between them
7.RP.A.2.c.	Use informal arguments to establish facts about the angle sum and exterior angle of triangles, about the angles created when parallel lines are cut by a transversal, and the angle-angle criterion for similarity of triangles. For example, arrange three copies of the same triangle so that the sum of the three angles appears to form a line, and give an argument in terms of transversals why this is so.
7.NS.A.3.	Solve real-world and mathematical problems involving the four operations with rational numbers.
7.EE.A.	Use properties of operations to generate equivalent expressions

7.EE.A.1	Apply properties of operations as strategies to add, subtract, factor, and expand linear expressions with rational coefficients.
7.EE.B.	Solve real-life and mathematical problems using numerical and algebraic expressions and equations
7.EE.B.3	Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies
7.EE.B.4	Use variables to represent quantities in a real-world or mathematical problem and construct simple equations and inequalities to solve problems by reasoning about the quantities.
7.EE.B.4.a	Solve word problems leading to equations of the form $px+q=r$ and $p(x+q)=r$, where p , q , and r are specific rational numbers. Solve equations of these forms fluently. Compare an

	algebraic solution to an arithmetic solution, identifying the sequence of the operations used in each approach.
8.EE.C.7	Solve linear equations in one variable
8.EE.C.7.a	Give examples of linear equations in one variable with one solution, infinitely many solutions, or no solutions. Show which of these possibilities is the case by successively transforming the given equation into simpler forms, until an equivalent equation of the form $x=a$, $a=a$, or $a=b$ results (where a and b are different numbers).
8.EE.C.7.b	Solve linear equations with rational number coefficients, including equations whose solutions require expanding expressions using the distributive property and collecting like terms.
HSA.REI.A.1	Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.

HSA.REI.A.2	Solve simple rational and radical equations in one variable, and give examples showing how extraneous solutions may arise
HSA.REI.B.3	Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters

Appendix K

DragonBox Elements Related Common Core Middle Grade Standards

7.G: Draw, Construct, And Describe Geometrical Figures and Describe The Relationships Between Them.	
7.G.2	Draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions. Focus on constructing triangles from three measures of angles or sides, noticing when the conditions determine a unique triangle, more than one triangle, or no triangle.
8.G: Understand Congruence and Similarity Using P	
8.G.2	Understand that a two-dimensional figure is congruent to another if the second can be obtained from the first by a sequence of rotations, reflections, and translations; given two congruent figures, describe a sequence that exhibits the congruence between them.
8.G.5	Use informal arguments to establish facts about the angle sum and exterior angle of triangles, about the angles created when

	<p>parallel lines are cut by a transversal, and the angle-angle criterion for similarity of triangles. For example, arrange three copies of the same triangle so that the sum of the three angles appears to form a line, and give an argument in terms of transversals why this is so.</p>
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