The Impact of Integrating Mathematics into Elementary Physical Education

by

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Abstract

Positive findings regarding integrated curriculum in the classroom setting (Chen & Yang, 2019; Kurt & Pehlivan, 2013; Vars, 1996) and movement integration during the school day (Donnelly et al., 2009; Duncan, Birch, & Woodfield, 2012; Mahar et al., 2006; Reed et al., 2010), suggest a movement-based setting, such as physical education, could be another site for successful integration. Of the few empirical articles integrating classroom content into physical education, two quantitative studies provided guidance for the present study (Cecchini & Carriedo, 2020; Derri et al., 2010). These studies found that integration in physical education resulted in increases in academic performance.

The purpose of the present study was to examine the effects of integrating mathematics into physical education. One-hundred and thirty-two fourth grade students from four physical education classes at two schools participated in this study. In-tact physical education classes were randomly assigned to intervention and control groups. In this eight-week study, ten-minute mathematics activities (Cosgrove & Richards, 2019) were integrated into the intervention group's physical education classes, while the control group participated in regular physical education.

Data collection included assessments of mathematics performance, mathematics attitudes, mathematics perceived competence, athletic perceived competence, and physical education interest. These data were collected pre- and post-intervention from both the intervention and control groups. Data were analyzed using mixed nested ANOVA and independent samples *t*-test.

Results showed that across all measures of mathematics performance students in both groups significantly improved from pre- to post-intervention. Significant differences based on

the interaction of time (pre-/post-test) and group (intervention/control) were only evident in mathematics unit assessments and not present in the global measures of mathematics performance of mathematics grades and mathematics standardized test scores. The intervention group reported greater situational interest in physical education than the control group. No significant differences were observed across other measures of mathematics attitudes, mathematics perceived competence, and athletic perceived competence. These findings add to the growing body of literature of integrated curriculum in physical education.

Acknowledgments

As I'm sure almost every Ph.D. student has felt, arriving at this moment was not always easy. I could not have made it here without the help, contributions, support, and encouragement of a number of people. To properly thank each individual, I would need to write another five-chapter dissertation. However, I will attempt to briefly express my sheer gratitude for the many people who aided me throughout this journey.

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CHAPTER I

Introduction

The primary focus of physical education is to develop students' knowledge and skills related to movement. Additionally, physical education could also be a site for improving knowledge across other academic areas through integrated curriculum. Before understanding why or how curriculum can be integrated in physical education, we first must define curriculum integration in its simplest form. While this may seem easy, a number of terms are used to describe curriculum integration making it difficult to explicitly recognize. Terms such as integrated, interdisciplinary, cross-curricula, cross-disciplinary, multidisciplinary, transdisciplinary, among others are often used to describe similar if not the same approach to curriculum integration. In addition to the dictionary of terms used to describe curriculum integration, prominent curriculum integration theorists struggle to agree on a definition, where some situate integration on a continuum (Drake, 1998; Fogarty, 1991, 2002, 2009; Jacobs, 1989) and others take an all-or-nothing stance (Beane, 1995, 1997). Despite their disagreements, these experts agree on the limitations of the separate-subject approach traditionally adopted in schools. Teaching subjects independently of one another does not allow students to make connections between content areas (Beane, 1995, 1997; Drake, 1997; Fogarty, 1991, 2002, 2009; Jacobs, 1989).

The definition that best aligns with the design of this dissertation is "integrated curriculum". More specifically, I will be utilizing the term "connected integration" (Cone, Werner, & Cone, 2009) to describe the type of curriculum integration employed in this study. Connected integration is one of three terms to describe the complexity of integration. This term was coined by physical education researchers as a means to simplify the variety of integrated curriculum approaches found in the literature (Cone, Werner, & Cone, 2009).

The body of literature regarding integrated curriculum in physical education is relatively small, so related bodies of literature were reviewed. I explored research involving integrated curriculum in the classroom setting and incorporating movement into the classroom setting were explored. Integrated curriculum in the classroom setting speaks to connecting core subject area content. A number of reviews, meta-analyses, and individual studies found that students who participated in integrated curriculums performed just as well if not better than students who did not participate in integrated curriculums (Chen & Yang, 2019; Kurt & Pehlivan, 2013; Vars, 1996). These findings were encouraging when rationalizing the need for integrated curriculum in physical education.

Furthermore, previous educational research has shown a link between physical activity and performance in the classroom (Donnelly et al., 2009; Duncan, Birch, & Woodfield, 2012; Jensen, 2000; Mahar et al., 2006, Reed et al., 2010), where time-on-task improved (Mahar et al., 2006) and fluid intelligence increased (Reed et al., 2010). This evident connection between learning and movement in the classroom setting could be replicated in a naturally movement-based setting, such as physical education, yet very few studies have done this. Of the seven studies that have explored this work, the majority are qualitative in nature (Chen, Cone, & Cone, 2007, 2011; Hastie, 2011; Rovegno and Gregg, 2007) and only two collected objectively measured academic performance (Cecchini & Carriedo, 2020; Derri, Kourtessis, Goti-Douma, & Kyrgiridis, 2010). To address this gap in the literature, the purpose of this study was to examine the effects of integrating mathematics into physical education.

Research Questions

1. Does integrating mathematics in physical education influence mathematics performance?
    a. Does integrating mathematics in physical education influence mathematics grades?
    b. Does integrating mathematics in physical education influence mathematics standardized tests?
    c. Does integrating mathematics in physical education influence mathematics unit assessments?
2. Does integrating mathematics in physical education influence mathematics attitudes?
3. Does integrating mathematics in physical education influence mathematics perceived competence?
4. Does integrating mathematics in physical education influence athletic perceived competence?
5. Does integrating mathematics in physical education influence situational interest in physical education?

Hypotheses

The following hypotheses have been made concerning the research questions:

1. Mathematics performance will improve after integrating math into physical education.
2. Mathematics attitudes will improve after integrating math into physical education.
3. Mathematics perceived competence will improve after integrating math into physical education.
4. Athletic perceived competence will not differ after integrating math into physical education.

5. Situational interest in physical education will improve after integrating math into physical education.

Operational Definitions

1. *Connected integration:* Integration that reinforces content from one subject in another class – the simplest form of integration according to the continuum created by Cone, Werner, and Cone (2009). This is the integrated curriculum approach adopted in this dissertation's intervention.
2. *Integrated:* An adjective used to describe how content areas are combined.
3. *Integrated curriculum:* Umbrella term that challenges the traditional approach to curriculum by organizing curriculum by problems or themes not by subject areas. Students address these problems or themes by utilizing knowledge across multiple subject areas (Beane, 1995, 1997; Drake, 1997; Fogarty, 1991, 2002, 2009; Jacobs, 1989).
4. *Interdisciplinary curriculum:* Curriculum approach that falls under the "integrated curriculum" umbrella. This approach "consciously applies methodology and language from more than one discipline to examine a central theme, issue, problem, topic, or experience." (p. 8, Jacobs, 1989)
5. *Movement:* Frequently used interchangeably with "physical activity" in the literature, "movement" will be used throughout this dissertation to describe the interventions.
6. *Partnered integration:* Integration that reinforces a theme by pulling knowledge from two or more subjects – the most complex form of integration according to the continuum created by Cone, Werner, and Cone (2009).

7. *Physical activity:* Frequently used interchangeably with "movement" in the literature, "physical activity" will be used throughout this dissertation to describe the measurements and outcomes of the movement interventions. More specifically, physical activity is defined as any bodily movement that is produced by the contraction of skeletal muscle and that substantially increased energy expenditure (Pangrazi, Dauer, & Pangrazi, 2007).
8. *Physical education:* Movement education found in school settings (Pangrazi, Dauer, & Pangrazi, 2007).
9. *Separate-subject approach:* Knowledge is organized into subject areas and taught independently of one another (Beane, 1995, 1997; Drake, 1998; Fogarty, 1991, 2002; Jacobs, 1989).
10. *Shared integration:* Integration that reinforces content from one subject in another class – the second most complex form of integration according to the continuum created by Cone, Werner, and Cone (2009).

CHAPTER II

Review of the Literature

As stated in the National Physical Education Standards, physical education is a site for knowledge and skill development (SHAPE America, 2013). While the focus of physical education is movement education, physical education has the potential to be a site for learning other academic content through curriculum integration. In this chapter, integrated curriculum will be defined, particularly the terminology utilized in this study. The impacts of integrated curriculum and movement in the classroom setting and integrated curriculum in physical education will also be discussed. Lastly, supported by the presented literature, a rationale for the present study will be explained.

Defining Integrated Curriculum

Explaining curriculum that is integrated and/or interdisciplinary is challenging because experts use different terminology, as well as various definitions. Terms in the literature include integrated, interdisciplinary, cross-curricula, cross-disciplinary, multidisciplinary, transdisciplinary, among others. These terms are often used interchangeably; however, some curriculum theorists argue each has a unique definition and place within the curriculum. In this section, I will review the terminology and definitions used by the most notable curriculum integration theorists.

Beginning with the most progressive use of the term “curriculum integration” is Beane’s (1995, 1997) definition. Integrated curriculum is organized around real-world problems, sometimes called "themes". An integral part of the selection of problems and themes are the students; student voice is critical in adding relevancy to the curriculum. With input from the students, teachers specifically plan the themes to require knowledge across various subject areas, and that knowledge is used to address the problem at hand. In this curriculum integration approach, subject division is unnecessary because students are encouraged to gather and use information in an organic way. Teachers in this type of integrated curriculum facilitate student learning by adopting the role of generalists first and specialists second.

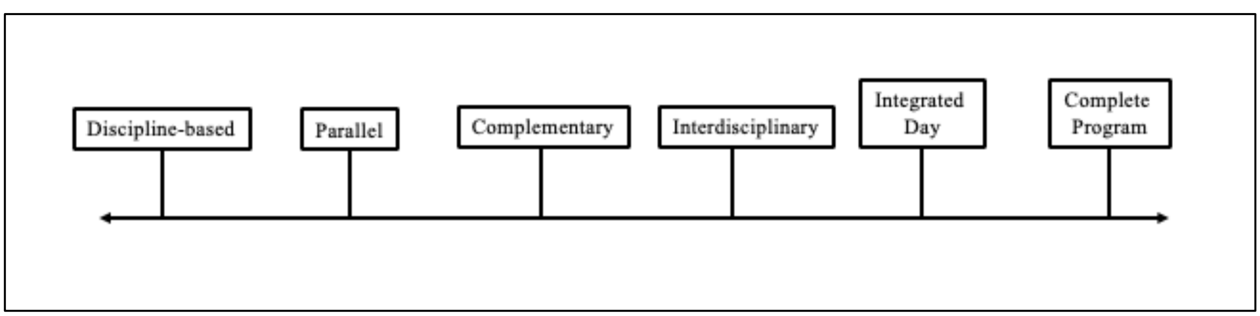
Another term frequently used in the literature is “interdisciplinary” curriculum (Jacobs, 1989). In a seminal piece titled, *Interdisciplinary Curriculum: Design and Implementation*, Jacobs (1989) defined interdisciplinary curriculum as a "curriculum approach that consciously applies methodology and language from more than one discipline to examine a central theme, issue, problem, topic, or experience" (p. 8). Echoing this definition, Drake (1998) defined interdisciplinary curriculum as interconnected subjects tied together by guiding questions or a common focus. Further, in a broad description of integrated curriculum, Fogarty (1991, 2002, 2009) asserted integrated curriculum, “…finds natural and robust ways to connect the world in search of deeper meaning and richer understanding,” and “…seeks the relatedness between and among things” (Fogarty, 2009, p. 12). Although slightly different terminology, Fogarty’s definition of “integrated curriculum” parallels Jacobs’ (1989) and Drake’s (1998) term “interdisciplinary curriculum”.

Curriculum as a Continuum

The above theorists, Jacobs (1989), Drake (1998), and Fogarty (1991, 2002, 2009), situate their curriculum models on a continuum, where the curriculum begins disjointed and progresses into more integrated forms. Jacobs’ (1989) continuum of curriculum integration consists of six approaches. It begins with “discipline-based, which is synonymous to the separate-subject approach, where each subject area is taught separately and there are no integrated components. Following the discipline-based approach, is the “parallel discipline” approach. In this approach, subjects align the sequencing of their lessons to coincide with one another. The subject content does not change, however, the order in which the content is taught changes to coordinate with another subject. Progressing into more integrative methods, the "complementary discipline" approach merges related disciplines in a unit to examine an issue where knowledge from more than one discipline can be utilized. The "interdisciplinary" approach employs each subject in the school's curriculum for a unit to address a common theme. The knowledge from each subject area supports the students in their quest to solve an issue, answer a question, or complete a project. Moving even closer to the idea of a fully integrated curriculum is the "integrated day" approach. In this one-day program, students direct exploration by investigating themes and problems relevant to them. They use knowledge across all subject areas to support their findings/solutions. Lastly, is the "complete program" approach. Like Beane's (1995, 1997) progressive curriculum integration model, Jacobs' (1989) complete program allows students to explore themes, issues, and problems every day with no subject area divisions. The curriculum is entirely directed by the students, where they can choose to investigate problems relevant to them. Figure 1 depicts Jacobs' (1989) continuum (p.14).

Figure 1

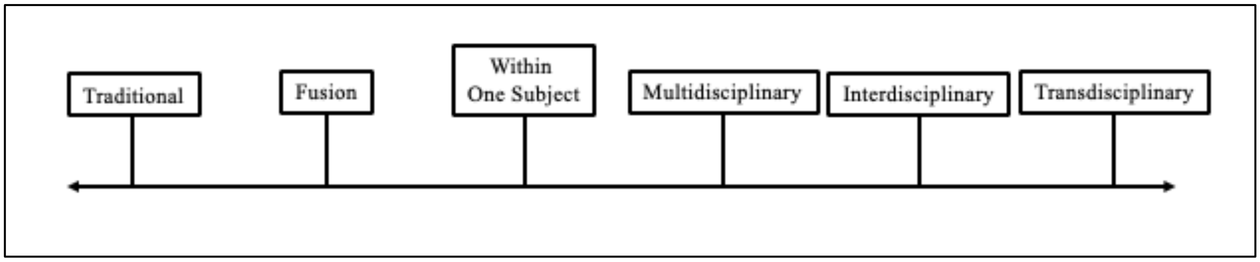
Jacobs' (1989) Curriculum Continuum



Like Jacobs' (1989) curriculum continuum, Drake's (1998, 2007) continuum consists of six unique approaches. See Figure 2 for Drake's continuum. This continuum begins with what Jacobs calls the "traditional" approach, where material is taught completely independent of one another. Next, the "fusion" approach inserts one topic into multiple subject areas. Although involved in multiple subjects, this topic is taught separately in each subject. The "within one subject" approach combines similar discipline into one subject area, "such as physics, chemistry, and biology integrated as science" (p. 20, Drake, 1998). Following within one subject is the "multidisciplinary" approach. In this approach, a theme or issue is studied at the same time in multiple subject areas. However, the theme or issue is taught separately in individual subject area classrooms. The "interdisciplinary" approach connects the subject areas beyond a theme or issue found in the multidisciplinary approach. This connection between subject areas is obvious to the students through guiding questions and cross-subject area standards – the students must use knowledge from multiple subjects to arrive at a solution. Lastly, the "transdisciplinary" approach is similar to Beane's (1997) concept of an integrated curriculum. The curriculum is guided by real world problems, not subject areas. Students address the issues at hand with knowledge across all subject areas. In addition to categorizing curriculum approaches, Drake (2007) acknowledged the challenge to both meet standards and integrate the curriculum. Drake's highly cited second edition book, *Creating Integrated Curriculum* (Drake, 1998), was revamped and aptly renamed *Creating Standards-Based Integrated Curriculum* (Drake, 2007). This work highlights the importance of intentional planning and a design-down approach to both maintain accountability and increase content relevancy through interdisciplinary curriculum.

Figure 2

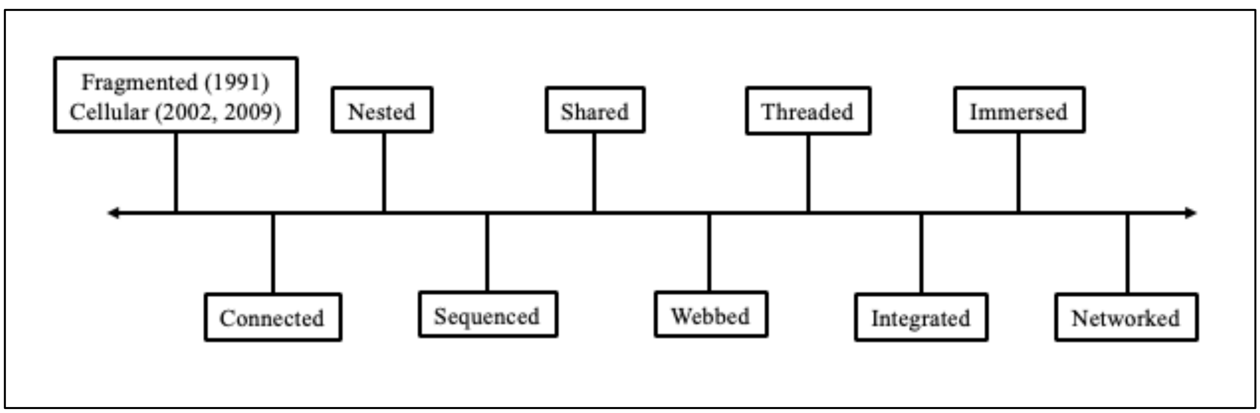
Drake's (1998, 2007) Curriculum Continuum



Fogarty (1991) noted any level of curriculum integration is a valuable beginning step toward a more integrated curriculum. With that in mind, Fogarty's (1991, 2002) curriculum integration model encompasses ten approaches. Figure 3 visually outlines Fogarty's continuum. Originally named the "fragmented" approach (1991), the first curriculum integration approach on Fogarty's continuum was renamed to the "cellular" approach (2002). The cellular approach splits the curriculum between subject areas, and each is taught independently of the others. In this approach, the curriculum is presented in a fragmented fashion with no connections made between the subjects, hence this approach's original name: "fragmented" (1991). Next, the "connected" approach explicitly connects material within one subject area. Following the connected approach is the nested approach. The "nested" approach utilizes natural connections within one subject area to reinforce material. The "sequenced" approach to curriculum integration teaches related topics at the same time but in separate subject areas. Teachers collaborate to arrange these units at the same time. Moving into a more integrated approach, the "shared" approach brings two subject areas together through a related topic. The "webbed" approach focuses on a theme across multiple subject areas. Continuing with integrating across multiple subject areas, the "threaded" approach focuses on themes or "big ideas" (p. 63, Fogarty, 1991) that transcend the subject area divisions. These big ideas, such as problem solving and conflict resolution skills, are used in each subject area. Next, the "integrated" approach rearranges the content in multiple subject areas to make connections between these interrelated concepts. A more personalized approach, the "immersed" approach to curriculum integration views concepts through the lens of one specific interest. For example, students select their reading material, artwork choices, and writing topics around one specific interest of theirs. Lastly, the "networked approach" is directed by the students. Again, like Beane's (1995, 1997) curriculum model, the students pull from the knowledge across all subject areas to answer questions, solve problems, and investigate issues related to personal interests.

Figure 3

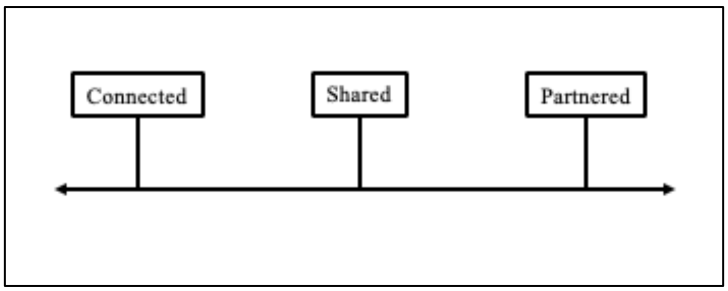
Fogarty's (1991, 2002, 2009) Curriculum Continuum



While Fogarty's continuum (1991, 2002, 2009) may encompass a wide range of curriculum integration approaches, physical education researchers found this complex continuum overwhelming (Cone, Werner, &Cone, 2009). To simplify curriculum integration for use in physical education, Cone, Werner, and Cone (2009) developed a continuum comprised of three levels: connected, shared, and partnered. Figure 4 displays these levels of integration. "Connected" integration reinforces content from one subject in another class. "Shared" integration links similar concepts and reinforces them in two or more subjects. "Partnered" integration reinforces a theme by pulling knowledge from two or more subjects. A key component of successful integration is to identify natural links across different subject areas (Hastie & Martin, 2006).

Figure 4

Cone, Werner, and Cone's (2009) Physical Education Curriculum Integration Continuum



Unlike Beane's curriculum integration peers, Beane (1997) refutes the idea of situating curriculum integration on a continuum. Beane writes,

> The misplacement of curriculum integration within a collection of interdisciplinary approaches is even more problematic when such a collection is portrayed as a continuum, thus implying that teachers moving out of the separate-subject approach might first go to a multidisciplinary one and then to integration. This might make some sense if curriculum integration was merely another way to arrange subject-area content. We have seen, however, that curriculum integration involves a very different way of thinking about curriculum than discipline-based approaches, including its theory of the organization and uses of knowledge. (p. 35)

Beane's all-or-nothing stance contrasts other experts (Drake, 1998; Fogarty, 1991, 2002, 2009; Jacobs, 1989) who view curriculum integration on a continuum.

For the sake of clarity, I will be utilizing the term “integrated curriculum” as an umbrella term that encompasses many approaches of connecting content areas. “Connected integration” will be used to describe the specific curriculum approach adopted in this dissertation.

Separate-Subject Approach

Although their curriculum approaches have a number of differences, Beane (1995, 1997), Jacobs (1989), Drake (1997), and Fogarty (1991, 2002, 2009) all recognized the shortcomings of the separate-subject approach most commonly adopted by schools. Quoting the first paragraph of Jacobs’ (1989) book illuminates how students view the separate-subject approach:

> Mike, a 2nd grader, defines mathematics as “Something you do in the morning.” Unfortunately, his statement reflects an internalization of mathematics as an experience to be absorbed from 9:45-10:30 a.m., and certainly before recess. We rarely explain to students why the school day is designed as it is. It should be no surprise that students look at arbitrary divisions for reading, math, social studies, science, art, music, and physical education and begin to define the subject areas as separate bodies of knowledge with little relationship to one another. (p. 1)

This separate-subject approach lacks unity and suggests it is the students’ responsibility to collect disconnected facts with no indications of how this knowledge can be used. In the separate-subject approach, students often ask, “Why?” as they struggle to see the real-world applications of this fragmented approach (Beane, 1995, 1997).

Life does not operate around the individual subject areas. In the real-world, knowledge is pulled from all subjects to solve problems, make decisions, and utilize in careers (Beane 1995, 1997). For this reason, it is vital to provide students with learning experiences that illustrate the interrelatedness of the subjects, and that is where integrated curriculum comes into play. Integrated curriculum has the potential to increase the relevancy of individual subject areas as students begin to discover connections and apply their knowledge (Beane, 1995, 1997; Jacobs, 1989). The flaws of the separate-subject approach coupled with the benefits of integrated learning provide support for curriculum integration.

Integrated Curriculum in the Classroom Setting

Because of the limited literature regarding integrating classroom content in physical education, I consulted research regarding integration in the classroom setting. Due to the substantial breadth and depth of this body of literature, a summary is included. Curriculum integration has implications for students and teachers. In a review of early integration efforts, Vars (1996) concluded that students achieve just as well, if not better after participating in integrated curriculums compared to the separate-subject approach. More recent studies, reviews, and meta-analyses reported similar findings (Chen & Yang, 2019; Kurt & Pehlivan, 2013), where integration improved student achievement. Teachers also reported increased student engagement in integrated units (Lam, Alviar-Martin, Adler, & Sim, 2013), and lastly, students reported improved problem-solving and teamwork skills as a result of project-based learning (Eronen, Kokko, & Sormunen, 2019). In order for integration to be done well, teachers recognized the importance of time for planning (Fu & Sibert, 2017) and support from colleagues (Brand & Triplett, 2012; Fu & Sibert, 2017). Despite the benefits of integrated instruction, teachers recognized the challenges of integration (Brand & Triplett, 2012; Kurt & Pehlivan, 2013; Lam, Alviar-Martin, Adler, & Sim, 2013; Shifflet & Hunt, 2019), specifically meeting standards, a lack of knowledge across multiple subjects, and a lack of training during their teacher preparation programs.

Integrating Movement in the Classroom Setting

Although not integration in the traditional sense, classroom teachers can incorporate movement into their lessons as a means of integrating classroom content and physical activity. Classroom learning is typically sedentary in nature. However, the addition of movement in the classroom can increase daily physical activity (Donnelly et al., 2009; Duncan, Birch, & Woodfield, 2012; Mahar et al., 2006), improve time-on-task in the classroom (Mahar et al., 2006), increase fluid intelligence (Reed et al., 2010), improve academic achievement (Donnelly, et al., 2009; Reed et al., 2010), among other things important for learning, such as increase circulation, improve episodic encoding, give students a break from learning, allow for system maturation, release noradrenaline and dopamine, and get students out of a seated position (Jensen, 2000). Due to the immense body of literature regarding movement integration in the classroom setting, this review will primarily focus on the impact of in-school interventions on physical activity levels and academic achievement.

Examining the impact of an integrated curriculum on physical activity, Oliver, Schofield, and McEvoy (2006) used a thematic approach to integrate the curriculum. Pulling from curriculum integration theory (Beane, 1995, 1997), this study connected English, social studies, mathematics, statistics, and physical education. Seventy-eight students in grades five and six wore pedometers during a three-day baseline period and a four-month intervention period. During the intervention, English, social studies, mathematics, statistics, and physical education classes all adopted the theme of a “walk around New Zealand,” where each subject area collaborated to study the history, geography, and technology of New Zealand while being physically active. Daily step averages during baseline and intervention were calculated, and data were analyzed with t-tests: comparing gender differences and comparing baseline and intervention physical activity. Baseline results showed boys were significantly more active than girls, and overall, the majority of students achieved more than 15,000 steps per day, more than the daily recommendation. Intervention results showed, again, boys were significantly more active than girls during weekdays. There was a significant decrease in steps during the intervention. However, after excluding the intervention weekends, no significant differences existed between baseline and intervention. Although this thematic, integrated unit was feasible, student physical activity did not increase as expected.

Replicating Oliver et al.'s (2006) study, Duncan et al. (2012) implemented a very similar thematic, integrated unit in the United Kingdom to investigate the impact of an integrated unit on students' physical activity and weight status. Students "traveled" across the United Kingdom by connecting the physical activity achieved in physical education to geography, science, mathematics, and technology classes. Pedometers were used to collect data one week before the intervention as a baseline measurement, during the four-week intervention, and four weeks after the intervention as a follow-up measure. Height and weight to calculate body mass index (BMI) were collected before the start of the intervention and at follow-up. Repeated measures analysis of variance was completed to analyze differences in gender, weight status, and physical activity groups. Paired samples *t*-tests analyzed BMI at baseline and follow-up, and physical activity differences at baseline, intervention, and follow-up. Results showed significant differences between steps taken at baseline and steps taken at intervention and follow-up, where students achieved more steps during the intervention and at follow-up than at baseline. There was a significant main effect for weight status, where "normal" weight students were more active than students who were "overweight/obese." However, there were no significant changes in weight status. Contrary to Oliver et al. (2006), Duncan et al. (2012) did observe significant increases in physical activity during the integrated unit. The differences in findings could be attributed to baseline physical activity differences, where Oliver et al.'s (2006) were more active at baseline than in the current study (Duncan et al., 2012); the ceiling effect could have been a contributor to the variance in results.

Also incorporating movement into the classroom, Mahar et al. (2006) examined the impact of "energizers" on daily step counts. Additionally, time-on-task was assessed, as it could be related to academic achievement. Over 12 weeks, kindergarten through fourth grade teachers in one school included ten-minute activity bursts, called energizers, into their instruction every day. Pedometers were worn daily to measure step counts, and time-on-task was measured 30 minutes before and 30 minutes after the students participated in the energizers through behavior observations by trained research assistants. Physical activity was compared between control and experimental groups. To evaluate time-on-task, a multiple baseline across classroom design was employed with four classes (two third grade and two fourth grade). One third grade and one fourth grade class began the intervention after a four-week baseline assessment, and different third and fourth grade classes began the intervention after an eight-week baseline assessment period. Independent samples *t*-test was used to compare physical activity between control and experimental groups. A two-way repeated measures analysis of variance (ANOVA) was used to analyze time-on-task for students in the four baseline classes. A final paired sample t-test analysis was conducted to compare the pre- and post-energizer time-on-task of a small sample ($n = 10$) of typically off-task students. For physical activity, results showed statistically significant differences between the daily physical activity between the experimental and control groups, where the students who participated in the energizers were more active throughout the day. For time-on-task, there was a significant interaction between time-on-task and period (baseline or intervention). From pre- to post-energizer, the increase in time-on-task was statistically significant at 8%, and this increase was amplified for typically off-task students at 20%. These findings indicated the inclusion of energizers could increase students' daily physical activity and improve students' time-on-task, which is related to academic achievement.

In a longitudinal study on a physically active school curriculum, Donnelly et al. (2009) implemented and evaluated Physical Activity Across the Curriculum (PAAC). The purpose of this study was to assess the impact of PAAC on student BMI, daily physical activity, and academic achievement. Twenty-four schools comprised of 1,527 second and third grade students participated in this three-year study. Schools were randomly assigned to experimental and control groups. Experimental group schools participated in PAAC training. Height and weight to measure body mass index (BMI) were collected at the beginning and end of each year. Physical activity was measured using accelerometers; a sub-sample of 12 students from each school wore accelerometers every spring for four days. Lastly, academic achievement was measured pre- and post-intervention using the Wechsler Individual Achievement Test-2nd Edition; a sub-sample of 575 students completed this assessment. Data were analyzed using adjusted t-tests and linear mixed models to assess changes over time. BMI results revealed no significant differences between groups from baseline to end of the intervention. However, there were significant differences in BMI based on the amount of PAAC time students received. Schools that implemented 75 minutes or more of PAAC saw smaller increases in student BMI than schools that implemented less than 75 minutes of PAAC. Additionally, students in PAAC schools achieved significantly more physical activity. Specifically, PAAC student average physical activity, weekend day physical activity, during school physical activity, and minutes of moderate-to-vigorous physical activity were greater than students in the control group. Lastly, significant improvements in academic achievement were observed in the PAAC group compared to the control group. Specifically, PAAC students' composite, reading, math, and spelling scores improved significantly more than the students in the control group. These findings suggest in-school physical activity interventions can improve student BMI and physical activity while improving academic achievement and not distracting from instruction time.

To also examine the effect of movement integration on academic achievement, Reed et al. (2010) recruited 155 third grade students to participate in a study measuring fluid intelligence and academic achievement. The students came from six in-tact classrooms; three classrooms were randomly assigned to the experimental group (n= 80), and three classrooms were randomly assigned to the control group (n = 75). Teachers with students in the experimental group received training on teaching math, language arts, and social studies with locomotor movements. The experimental group teachers implemented these active lessons 30 minutes per day, three days per week for four months. The control group teachers taught their regularly planned lessons without additional movement integration training. Participants in the experimental group wore pedometers to track physical activity during the integrated lessons. All participants completed the Previous Day Physical Activity Recall (PDPAR) during the first and last weeks of the study to assess perceptions of physical activity. Both groups of participants also completed assessments of fluid intelligence and academic achievement. Fluid intelligence was measured using the Standard Progressive Matrices (SPM) at the beginning and end of the study. Academic achievement was measured using the Palmetto Achievement Challenge Test (PACT), a state-mandated standardized test, one week after the completion of the study. Lastly, student body mass index (BMI) was collected. Data analysis included descriptive statistics to compare fluid intelligence (SPM), academic achievement (PACT), and BMI. Academic achievement scores were also analyzed using t-tests. Further, multivariate analyses (MANOVA) were employed to analyze differences in fluid intelligence, academic achievement, and BMI. When examining fluid intelligence scores, results showed total fluid intelligence was significantly higher for students in the experimental group than those in the control group. When examining academic achievement, the only significant difference found was between the groups' social studies PACT scores, where the experimental group scored significantly higher than the control group. There were no significant differences in math, English/language arts, and science PACT scores between the groups. However, for all PACTs, a higher percentage of students in the experimental group scored more proficiently and advanced than students in the control group. Physical activity measurements found students in the experimental group achieved an average of 1,146 steps, a number comparable to the recommendation for a 30-minute physical education class. PDPAR data showed no significant differences in pre- or post-intervention for students' perceptions of physical activity. Lastly, the researchers analyzed the data by splitting the participants based on BMI. BMI group designations followed the FitnessGram Healthy Fitness Zone (HFZ) thresholds. Students in the HFZ scored higher on all portions of the fluid intelligence assessment than students not in the HFZ. However, significant differences were only observed in one portion of the SPM. When comparing academic achievement PACT scores, students in the HFZ scored significantly higher than students not in the HFZ. There were no other significant differences, but a higher percentage of HFZ students scored proficient or advanced compared to non-HFZ students on all four PACT tests. These findings suggest movement integration in the classroom could benefit students' fluid intelligence and academic achievement. Further, these findings highlight the importance of physical fitness and healthy body composition.

In summary, incorporating movement into the classroom setting has shown to increase daily physical activity (Donnelly et al., 2009; Duncan et al., 2012; Mahar et al., 2006), improve on-task behaviors (Mahar et al., 2006), and improve academic achievement (Donnelly, et al., 2009; Reed et al., 2010). These studies in the classroom setting were with elementary students (Donnelly et al., 2009; Duncan et al., 2012; Mahar et al., 2006, Oliver et al., 2006, Reed et al., 2010), with intervention periods ranging from four weeks to three years. Physical activity was measured with pedometers (Duncan et al., 2012; Mahar et al., 2006; Oliver et al., 2006) and accelerometers (Donnelly et al., 2009), on-task behaviors were measured through observation (Mahar et al., 2006), and academic achievement was measured with an achievement assessment (Donnelly et al., 2009), fluid intelligence assessment (Reed et al., 2010), and state standardized tests (Reed et al., 2010).

Despite these encouraging findings, no states require schools to incorporate movement into the academic day (SHAPE America, American Heart Association, & Voices for Healthy Kids, 2016). Only 11% of school districts require movement breaks in elementary school, 8% for middle school, and 2% for high school (Centers for Disease Control and Prevention, 2016). Although few schools require movement breaks, 45% of schools utilize movement breaks throughout the day (Centers for Disease Control and Prevention, 2015).

Integrated Curriculum in Physical Education

Since combining movement and classroom content in the classroom setting has shown favorable findings, one could assume integrating classroom content into a movement-based setting, such as physical education, would result similarly. However, compared to the robust literature base of integrating movement in the classroom, empirical data regarding integrated curriculum in physical education are scarce (Marttinen, McLoughlin, Fredrick, & Novak, 2017).

Despite the scarcity of empirical articles, there are a number of practical articles providing curriculum integration strategies for physical educators (Buchanan et al., 2002; Coelho & Contreras, 2020; Cosgrove & Richards, 2019; Elliott, 2003; Fingon, 2013; Griffin & Morgan, 1998; Hollett, Sluder, Taunton, & Howard-Shaughnessy, 2016; Howard-Shaughnessy & Sluder, 2015; Kitchen & Kitchen, 2013; Sluder & Howard-Shaughnessy, 2015; Soloman & Murata, 2008; Stevens-Smith & Fones, 2003; Wachob, 2014; Wade, 2016). Articles have suggested strategies for integrating language arts (Fingon, 2013; Griffin & Morgan, 1998; Grube & Beaudet, 2005; Solomon & Murata, 2008; Wachob, 2014), mathematics (Coelho & Contreras, 2020; Kitchen & Kitchen, 2013; Wade, 2016), and science (Buchanan et al., 2002; Coelho & Contreras, 2020; Stevens-Smith & Fones, 2003) into physical education. An additional article by Cosgrove and Richards (2019) described four integration activity templates. These adaptable templates can be used to integrate any classroom content into physical education. A combination of practical suggestions with empirical findings can help physical educators implement integrated units effectively.

Integration in physical education presents both benefits and challenges (Placek & O'Sullivan, 1997). Students benefit by having the potential for increased learning, and students make connections between physical education and other subjects. Additionally, physical education can be viewed as a "real" subject and overcome the idea that physical education is just playing. Physical education teachers benefit from developing collaborative relationships with teaching colleagues. Despite the benefits, there are challenges when integrating classroom content into physical education. Administration, other teachers, and students may not be accepting of the concept. Additional knowledge, time, and resources may be needed for successful integration. Another challenge is the potential of a loss of activity time due to integrating classroom content, which brings into question the purpose of physical education. Overcoming these challenges to reap the benefits is possible; however, it takes mindful planning. For this review, the focus will be placed on external integration (Placek, 1996; Placek & O'Sullivan, 1997), which means integrating core subjects (English language arts, math, science, and social students) into physical education.

Teachers in Integrated Curriculums

In a study by Hastie (2011), a parallel curriculum was designed to connect physical education and life sciences for the 472 students in grades two through five in one school. Specifically, a Sport Education gymnastics unit was paired with a life sciences biomes unit. The purpose of this study was to describe the outcomes of this parallel curriculum. The guiding framework of this study was Ackerman's (1989) validity criteria for integrated work. These criteria sought to answer two questions: "(i) does it make intellectual sense to integrate certain parts of the curriculum? and (ii) does it make practical sense?" (p. 2) (Hastie, 2011). Further, this framework suggests that integrated work should maintain validity within, for, and beyond the paired disciplines. Should instructional time be spent on this integration? Are the topics better taught separately? Is the final product greater than the two taught individually? To address the purpose and consider Ackerman's (1989) questions, data were collected qualitatively through interviews with the teachers (physical education and life sciences). Data were analyzed inductively using constant comparison. Four themes emerged from the data: 1) excitement, 2) expanded coverage of content, 3) school commitment to innovation, and 4) the critical role of the physical education teacher. As reported in the teacher interviews, students were excited to participate. The teachers attributed the students' excitement to the use of animals in the unit and because students felt as if they were a part of something bigger. While students were excited, teachers were able to expand on the content they covered. Teachers were able to instruct in greater depth, science concepts were reinforced in physical education, and the students were introduced to concepts they usually would not have been until later in the school year. For this and other similar projects to be successful, the school and teachers needed to be committed to innovation. The teachers described challenges organizing the parallel curriculum; however, they noted how the physical education teacher was the one responsible for moving this project. Lastly, findings showed the importance of the physical education teacher's status. In this particular school, the physical education teacher was well respected by other teachers, administration, and the students. This project may have been more challenging had the physical education teacher lacked that level of respect. When analyzing the parallel curriculum's validity (Ackerman, 1989), this project met all Ackerman's criteria for validity; it was valid within, for, and beyond the disciplines.

In another study investigating teacher perspectives of integration (Chen, Cone, & Cone, 2007), the collaborative relationship between teachers in an integrated unit that paired math and physical education was explored. As identified by the authors, this study was an example of shared integration, where math was integrated into physical education, and physical education concepts were integrated into math class. The two participants were the physical education and second grade teachers. Using constructivism as the theoretical framework, an entirely qualitative study was designed. Data collection included audiotapes from two of the teachers' collaborative planning meetings, two individual interviews with each teacher, and videotapes of the integrated lessons (eight physical education lessons and three math lessons). Data were analyzed using constant comparison, and three themes emerged related to the factors that enabled successful teacher collaboration: 1) characteristics of collaborative planning processes, 2) characteristics of shared teaching responsibilities, and 3) characteristics of the teachers' personal attributes for successful collaboration. The collaborative planning process was characterized by identifying objectives, specifying content and sequence, selecting instructional strategies, and determining timelines for implementation. Characteristics of shared teaching responsibilities described how the teachers allocated the content across the two teaching settings. The math concept covered in this unit was measurement; students applied measurement skills in the gymnasium while doing locomotor movements. This measurement data was collected in the gym and analyzed in math class, where students created graphs of their measurements. The characteristics of the teachers' attributes included their previous experiences collaborating, their similar philosophies of teaching, and mutual respect for one another.

Integrated units of any kind require thoughtful planning. This was especially evident in an integrated project by Rovegno and Gregg (2007). The purpose of this paper was, first, to describe how geography was integrated into a Native American folk dancing physical education unit. A secondary purpose was to examine curriculum decisions based on Carol Cornelius' (1999) theoretical framework for respectful cultural education. When planning the 12-lesson unit, the researchers contemplated four things: "presenting culture holistically, avoiding essentializing and countering stereotypes depicting Native American cultures as dynamic, valuing diversity" (p. 209) (Rovegno & Gregg, 2007). The unit began with the students learning simple Native American dances. Next, the students designed dances using the previously learned step patterns and formations. Lastly, the unit concluded with a pow-wow. To prepare for the final pow-wow, a children's book about the significance of pow-wows was read aloud to the class, and then the students wrote a reflection paper about the story. The researchers suggested the students learned the presented material, as they were collecting evidence of learning throughout the project. However, they were unsure if the integrated unit resulted in respect for diversity and an appreciation of Native American cultures. After the unit, the researchers reflected on their teaching. Particular attention was drawn to the researchers' potential ignorance. They recognized ignorance in what they taught, the depth of the content covered, and in their omissions.

Students in Integrated Curriculums

A potential issue when integrating in physical education is the loss of activity time. Outside content could distract from student's physical activity. To address this concern, the purpose of this study was to examine the impact of a constructivist physical education curriculum on student in-class physical activity (Chen, Martin, Sun, & Ennis, 2007). A randomized controlled experimental design was employed. Thirty schools with 6,700 third, fourth, and fifth grade students participated in the study. Schools were randomly assigned to experimental and control groups. All physical education teachers were provided with training. Experimental group teachers were trained on the Be Active Kids constructivist curriculum, where health-related knowledge was integrated into physical education. Control group teachers were trained on traditional physical education teaching strategies and were given activity ideas to better develop students' skills and fitness. In-class physical activity data were collected using accelerometers. Of all the students and schools that participated in the study, 162 students from 27 schools wore accelerometers. Data were analyzed by doing a multivariate analysis of variance (MANOVA). Results revealed a statistically significant main effect by the curriculum (experimental or control) and grade, meaning students in the experimental group were more active than students in the control group. A follow-up analysis was done and found no significant differences between curriculum groups and grades, meaning students in the groups were active at similar levels in physical education class. Findings from this study showed students from both curriculum models were active. The addition of health-related knowledge in a constructivist physical education curriculum did not distract from students' in-class physical activity. Therefore, students can learn outside content in physical education without sacrificing physical activity.

While the aforementioned physical education literature addressed teacher perspectives in integrated curriculums, Chen, Cone, and Cone (2011), explored the viewpoints of students. Participants included 35 second grade students, their physical education teacher, and their classroom teacher. Twelve lesson films (eight physical education and four classroom), anecdotal records, eight student focus group interviews, one two-hour teacher interview, and related documents were collected. Data analysis involved the use of constant comparison. Anecdotal records were compared to filmed lessons, and interview transcripts and documents were also coded for themes using constant comparison. From the analysis procedures, four themes emerged: 1) applying the mathematical skills and concepts, 2) making connections between the subjects, 3) demonstrating quality movement; and 4) developing a collaborative learning community. Students utilized their knowledge and skills related to the math concepts in physical education, and students were able to make meaningful connections between the math and movement concepts as a result of this integrated unit. Despite some focus being redirected from the physical education content to the integrated aspect of this unit, teachers reported that students demonstrated quality locomotor movements in physical education. Lastly, through this integrated unit, students were provided opportunities to collaborate with their classmates, which improved their cooperative skills, as evidenced through the qualitative data.

Complementing the literature connecting physical activity and academic achievement in the classroom setting (Donnelly et al., 2009; Reed et al., 2009), Derri et al. (2010) examined the impacts of an integrated physical education curriculum on student academic achievement. Derri et al. (2010) evaluated the effect of a five-week integrated physical education and language program. Sixty-seven kindergarten students were randomly assigned to experimental and control groups. The experimental group used physical education to teach the oral and written speech program, while the control group taught the program in a traditional, non-movement-based classroom setting. Both groups were learning movement words and concepts. An instrument to measure written and oral speech was specially created for use in this study, and it was administered directly pre-intervention, directly post-intervention, and two weeks post-intervention to assess retention. Data analysis included descriptive statistics and analysis of covariance, controlling for pre-test scores because the experimental group's scores were significantly higher. Results showed the experimental group scored significantly better than the control group in all categories of analysis: written speech scores, oral speech scores, and total language scores. These findings suggest that oral and written speech are taught best in movement-based settings, such as physical education. The authors suggested future studies should examine the impact of integrating other subjects into physical education and explore the effect of integration on the motor, emotional, and social development of early childhood and elementary students.

Again, connecting classroom content and physical education, Cecchini and Carriedo (2020) explored the impact of an integrated unit connecting physical education and mathematics (i.e. single-digit subtraction). Forty-six first grade students participated in the three-week study. The control group participated in mathematics and physical education separately, and the intervention group participated in a shared (Fogarty, 1991) physical education and mathematics curriculum design. Measures included subtraction learning, physical activity, and sedentary behavior. Subtraction learning was measured using a four-minute timed subtraction test; this test was administered pre- and post-intervention. Physical activity and sedentary behavior were measured using accelerometers; participants wore accelerometers for fifteen hours, which accounted for all the mathematics and physical education instruction during the three-week study. Data were analyzed with between- and within-subject *t*-tests. Results indicated both groups significantly improved subtraction knowledge from pre- to post-test. Further, subtraction knowledge of students in the intervention group was significantly greater than students in the control group. For physical activity and sedentary behavior, there were no significant differences for students in the control group. However, students in the intervention group significantly increased physical activity and significantly decreased sedentary time. These findings suggest integrated curriculum designs can improve mathematics achievement, increase physical activity, and decrease sedentary time.

Despite the overwhelming bodies of literature regarding integrated curriculum in the classroom setting and incorporating movement in the classroom setting, the similar area of inquiry of integrating classroom content into physical education is relatively small and predominantly non-empirical. The seven data-based articles demonstrate a foundational qualitative account of the perspectives of teachers and students (Chen, Cone, & Cone, 2007; Chen, Cone, & Cone, 2011; Hastie, 2010; Rovegno & Gregg, 2007). More quantitative data are needed to explore the topic in greater detail. To address this gap, this dissertation heavily relied on quantitative measurements and analyses. Although there are only two physical education empirical articles that objectively measured academic achievement (Cecchini & Carriedo, 2020;

Derri et al., 2010), findings from the classroom literature show integrated curriculum and incorporating movement into the classroom setting improves academic performance (Chen & Yang, 2019; Donnelly, et al., 2009; Kurt & Pehlivan, 2013; Reed et al., 2010; Vars, 1996). Multiple measures of academic achievement were used in this dissertation to fill this gap in the physical education literature.

CHAPTER III

Methodology

Human Subjects Approval

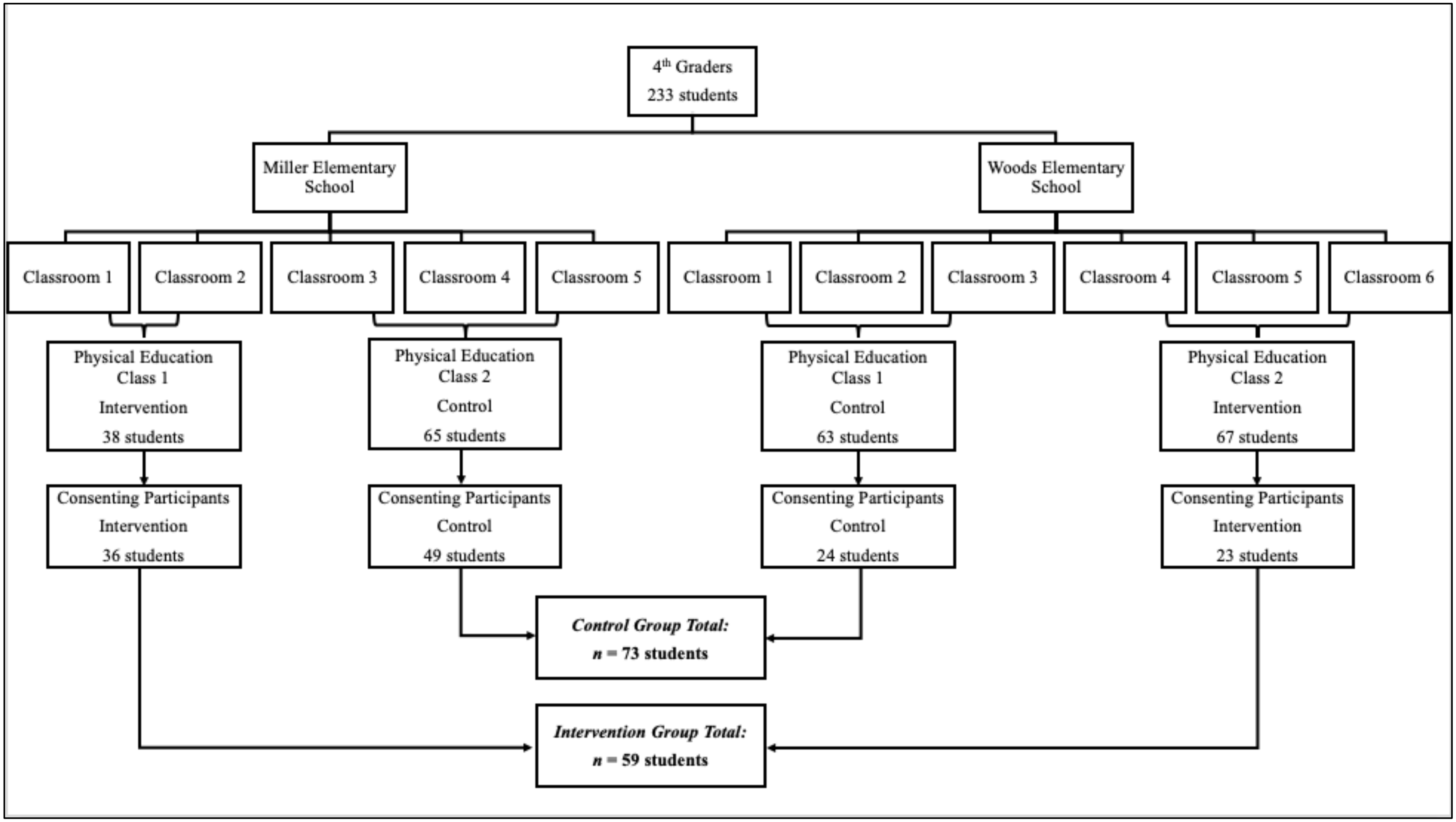
The Auburn University Institutional Review Board for Research Involving Human Subjects (IRB) approved the study plan prior to the start of the study. The full-board protocol submission (#19-387 EP 191) was approved during the time between 10/1/2019 to 9/30/2020.

Participants and Setting

Fourth grade students were recruited from two urban elementary schools in the same school district in the Southeastern United States. All 233 fourth grade students in the two schools at the start of the study were eligible to participate. The potential participant pool was comprised of students from 11 different fourth grade classrooms: five classrooms from Miller Elementary School and six classrooms from Woods Elementary School. Each school had two fourth grade physical education classes, for a total of a four physical education classes. Five fourth grade classrooms formed two physical education classes at Miller Elementary School, with two classrooms making up the first physical education class and three classrooms making up the second physical education class. Six fourth grade classrooms formed two physical education classes at Woods Elementary School, each consisting of three fourth grade classrooms. Figure 5 illustrates the schools' fourth grade populations.

Figure 5

Study Participants



Study information, parental consent forms (Appendix A), and minor assent forms (Appendix B) were sent home with the students by the physical education teachers. Those who did not consent to participate in the study still participated in physical education to adhere to state and school requirements. A total of 132 participants, 57% of the population, (57 boys, 75 girls) returned the parental consent and minor assent forms to participate in the study. From both schools combined, the intervention group consisted of 59 participants, and the control group consisted of 73 participants. Eighty-five students (36 intervention, 49 control), or 83%, from Miller Elementary School consented to participate, and 47 students (23 intervention, 24 control), or 36%, consented to participate from Woods Elementary School.

The elementary schools were purposefully selected for three main reasons: 1) the existing relationship between the physical education teachers and the university, 2) the schools resided in the same school district and housed students of the same grade levels (third-fifth grade), and 3) the diversity of the student population in the school district.

Teacher Information

As previously stated, one of the reasons the schools were selected was due to the existing relationship between the teachers and the university. Mr. Rivers and Ms. Swift were graduates of the physical education teacher education program at the university, and both taught in a neighboring school district to the university. Both teachers were considered expert teachers because of their advanced degrees and many years of experience (7-11 years).

Mr. Rivers taught at Miller Elementary School. He held a Bachelor's of Science degree in Physical Education, a Master's of Education in Physical Education, and minor in Sports Management. Mr. Rivers was in his seventh year of teaching. During this study, Mr. Rivers instructed two units in his fourth grade physical education classes: soccer and fitness. The soccer unit adopted the Sport Education model, which began with team practices and small-sided games, and then progressed to a soccer tournament and championship. The fitness unit incorporated various fitness-related tasks to help prepare the students for their fall physical fitness testing.

Ms. Swift taught at Woods Elementary School. She held a Bachelor's of Science degree in Physical Education and a Master's of Education in Physical Education. Ms. Swift was in her eleventh year of teaching. During this study, Ms. Swift instructed two units in her fourth grade physical education classes: frisbee and fitness. The frisbee unit began with simple partner-based practice activities and progressed to frisbee golf. The fitness unit incorporated various fitness-related tasks to help prepare the students for their fall fitness testing.

Design

To address the research questions in a school setting, 132 students from four intact fourth grade physical education classes from two schools participated in the study. Two physical education classes (one class from each school) made up the intervention group and received the intervention, and two physical education classes (one class from each school) served as the control group and participated in regularly planned physical education. Intact classes were assigned to intervention and control groups.

Intervention

The purpose of this intervention was to integrate mathematics into physical education using a connected integration design (Cone, Werner, & Cone, 2009). Support for the intervention used in this study was derived from the empirical results of Derri et al. (2010) and Cecchini and Carriedo (2020) in kindergarten and first grade settings. Examining the impact of integrating language studies into physical education, Derri et al. (2010) noted kindergartners who participated in the language program in physical education outperformed the kindergartners who participated in the language program in a traditional, non-movement-based setting. When describing future directions for integration work, Derri et al. (2010) suggested integrating other subjects (i.e. mathematics) into physical education. A more recent study (Cecchini & Carriedo, 2020), examined the impact of integrating mathematics, specifically single-digit subtraction, into first grade physical education. Students in the integrated intervention group improved subtraction skills more than students in the control group. This study provided evidence of a successful intervention connecting mathematics and physical education in a first grade physical education setting.

The intervention utilized four integration templates (Cosgrove & Richards, 2019). These templates outlined four activities in which classroom content can be integrated. *If – Then*, *Knowledge Tag*, *Out and Back*, and *Dice Roll and Solve* were the four activity templates. For this intervention, only mathematics content was integrated into physical education using these four templates. Prior to the start of the study, the primary investigator communicated extensively via email and in person with the fourth grade classroom teachers. During the intervention, weekly emails and meetings were held with the intervention teachers to ensure the content covered in the physical education intervention reinforced what was being taught in the mathematics lessons. Throughout the study, topics covered in the mathematics unit were equivalence, symmetry, angles, area, perimeter, and properties of quadrilaterals. The procedures of collaborating with classroom teachers and implementing the four integrated activities templates were piloted prior to this study. Table 1 provides an example of each activity template used in the study.

Table 1

Integrated Activity Template Examples, Adapted from Cosgrove & Richards (2019)

If – Then	
If	**Then**
The angle is an acute angle	Do 5 crunches
The angle is an obtuse angle	Do 5 mountain climbers
The angle is a right angle	Do 5 burpees
Knowledge Tag	
Math Task	
Identify which type of angle is pictured on the card to return to the game	
Out and Back	
Physical Education Movement Task	**Math Task**
Dribble the soccer ball	Convert the metric system measurements and order the cards from least to greatest
Dice Roll and Solve	
Physical Education Movement Task	**Math Challenge**
Frisbee passing with a partner	Solve for the perimeter and pass that many times

If – Then. In If – Then activities, the "if" related to the classroom content, and the "then" was the physical education movement response. The students responded to the classroom content (if) with a movement (then). From Cosgrove and Richards (2019):

> Taking an example that connects math with basketball, *If* the teacher displays an odd number (on a card, with their fingers, or projected on the wall), *then* the students bounce pass to a partner. *If* the teacher shows an even number, *then* the students chest pass to a partner. (p. 5)

Knowledge Tag. During Knowledge Tag designated taggers were given index cards with classroom content tasks on them. Once the tagger tagged another student, the tagged student was frozen and must complete the task on the index card to return to play, which could mean running away from taggers again or becoming the tagger themselves. For example, to reinforce types of angles, angles were drawn on the taggers' index cards. Once tagged, students had to correctly identify the type of angle to return to the game.

Out and Back. Out and Back required students to be placed into small teams for a relay-style activity. Students completed a physical education task across the length or width of the gymnasium, collected a card at the opposite end, and brought it back to their team. Classroom-related content was on each card, and each card represented "a piece of an academic puzzle" (Cosgrove & Richards, 2019, p. 6). Once all the cards were collected, the students worked together to complete the task. An example of this activity was students dribbled a soccer ball across the gym. At the other end of the gym, the students picked up an index card and brought it back to their group by dribbling. Students on each team took turns until all index cards were back at the starting point. Multiplication facts were written on the index cards, and the team had to work together to put the multiplication facts in order from lowest to highest.

Dice Roll and Solve. In Dice Roll and Solve, students solved a math problem before completing a movement task. The answer to the math problem dictated the number of repetitions the students completed of each movement. Teachers used large, insertable foam dice to implement this activity. To reinforce three-digit subtraction while practicing soccer passing, the teacher rolled the dice. Students, then, had to solve the subtraction problem on the dice. Once solved, the students passed the soccer ball with their team based on the answer to the math problem.

The physical education teachers implemented one activity per day for ten minutes for seven weeks (Week 3-Week 9). The researcher collaborated with the physical educators to create and deliver all the instructional materials needed for the ten-minute intervention activities, and the physical education teachers decided when the activities fit best in their lessons.

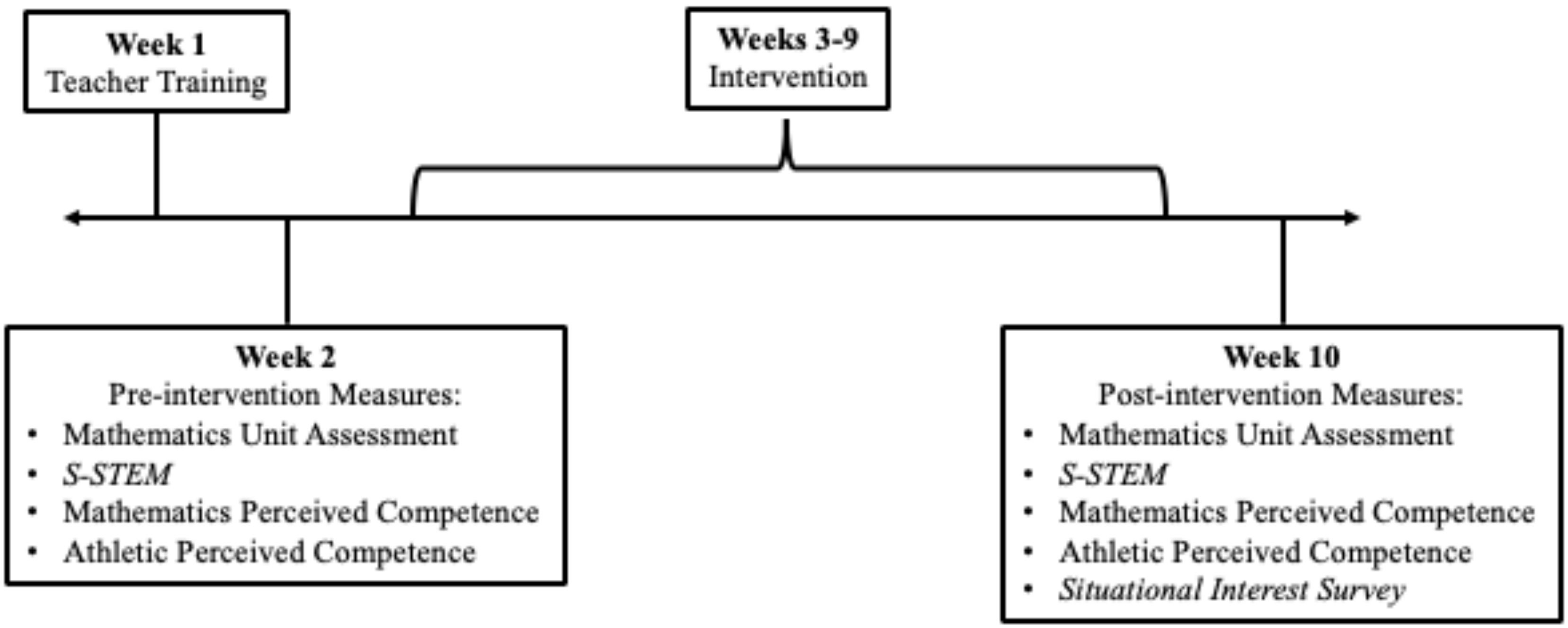
Teacher Training. The physical education teachers from both participating schools were trained in Week 1 prior to the start of the intervention. The researcher emailed the activity instructions to the teachers. Then, the researcher modeled each activity with classes not involved in the study at each school. Once comfortable, the physical education teachers taught the activities to classes not included in the study for practice, while the researcher observed. The researcher provided feedback when necessary. Additionally, the researcher was present throughout the entire intervention to ensure the fidelity of the activities.

Data Collection

Data collection included assessments of mathematics performance, mathematics attitudes, mathematics perceived competence, athletic perceived competence, and physical education interest. These data were collected pre- (Week 2) and post-intervention (Week 10) from both the intervention and control groups. Data collection instruments are included in Appendices C-G. Figure 6 displays the data collection timeline. Student demographic data (age, sex, and race) were collected from school records.

Figure 6

Data Collection Timeline



Note: Student mathematics grades and Scantron *Performance Series* scores we completed before and after the intervention. However, they are not included in this figure as they were not collected by the researcher during the study. Those data were obtained from school administration.

Mathematics Performance

A major gap in the physical education integrated curriculum literature is the lack of objective measurements of student performance. To address this gap, mathematics performance was measured three different ways: mathematics grades, a standardized mathematics assessment, and a mathematics unit assessment.

Mathematics Grades. Participants' first quarter (nine weeks) and second quarter (nine weeks) mathematics grades were collected. See Table 2 to view the school district's grading chart. First quarter grades served as the pre-intervention measure, and second quarter grades served as the post-intervention measure. Mathematics grades were obtained from school administration.

Table 2

Grading Chart

Letter Grade	Percentage
A	90-100
B	80-89
C	70-79
D	60-69
F	< 60

Standardized Mathematics Assessment. Mathematics achievement was measured with the Scantron *Performance Series* assessment. As stated on the Alabama State Department of Education's website, "Scantron *Performance Series* is a computer-adaptive, online assessment that offers educators an efficient, standards-based method to immediately diagnose student needs and inform placement and instructional strategy decisions" (Alabama State Department of

Education, 2018). Students completed the assessment twice: in the fall (August) as a baseline and in the winter (December) to measure growth. This assessment was compulsory and administered by the classroom teachers. All students in the schools completed Scantron *Performance Series* assessment, however, only consenting participants' scores were collected. *Performance Series* assessment scores were obtained from school administration.

Mathematics Unit Assessment. A mathematics unit assessment was completed pre- and post-intervention. All fourth grade students completed these assessments; however, only study participants' scores were obtained and analyzed. Topics covered in this unit were equivalence, symmetry, angles, area, perimeter, and properties of quadrilaterals. The textbook's unit assessment was used because all 11 fourth grade teachers at both schools used the same book and sequenced their instruction identically. "A" and "B" forms of the assessment were created by the primary investigator; test items were pulled directly from the unit assessment and reviewed by the fourth grade teachers. All unit topics were evaluated on both forms of the assessment, and both the "A" and "B" form consisted of 12 questions. Those who completed the "A" assessment at pre-intervention took the "B" assessment at post-intervention, and vice versa. The pre-intervention assessment (Week 2) was completed in the gymnasium during physical education, while the post-intervention assessment (Week 10) was completed in the students' regular classrooms. Form "A" can be found in Appendix C, and form "B" can be found in Appendix D.

Mathematics Attitudes

Attitudes towards mathematics were assessed using the *Student Attitudes Toward STEM (S-STEM) Survey* (Unfried, Faber, Stanhope, & Wiebe, 2015). The *S-STEM* measures student attitudes for each of the STEM (science, technology, engineering, and mathematics) subjects, and it also measures students' interest in pursuing a future career in a STEM field. Modified from 56 items (encompassing all aspects of STEM) to eight items to only address students' attitudes towards mathematics, participants completed this assessment pre- (Week 2) and post-intervention (Week 10). Possessing strong reliability at 0.85, participants responded to prompts using four- and five-point Likert scales. This assessment was completed in physical education class. See Appendix E for this instrument.

Mathematics Perceived Competence

Mathematics perceived competence was measured using the "Scholastic Competence" portion of Harter's (1985, 2012) *Self-Perception Profile for Children* (*SPPC*). The six questions addressing scholastic competence were modified to address mathematics competence by replacing the word "schoolwork" with "math." This instrument asked participants to choose between two opposite prompts. For example, "Some kids feel that they are very good at math" and "Other kids worry about whether they can do the math work assigned to them." After selecting which prompt best describes them, participants then decided if that prompt is "really true for me" or "sort of true for me." Participants completed the mathematics perceived competences assessment pre- (Week 2) and post-intervention (Week 10) in physical education class. The perceived mathematics instrument can be found in Appendix F.

Athletic Perceived Competence

Athletic perceived competence was also measured using the "Athletic Competence" portion of Harter's (1985, 2012) *Self-Perception Profile for Children* (*SPPC*). This instrument asked participants to choose between two opposite prompts. For example, "Some kids do very well at all kinds of sports" and "Other kids don't feel that they are good when it comes to sports." After selecting which prompt best describes them, participants then decide if that prompt is "really true for me" or "sort of true for me." Participants completed the athletic perceived competence assessment pre- (Week 2) and post-intervention (Week 10) on the same days as the Mathematics Perceived Competence assessment in physical education class. The Athletic Perceived Competence instrument can be found in Appendix F.

Situational Interest in Physical Education

Interest in physical education was assessed using the *Situational Interest Survey – Elementary School* (Sun, Chen, Ennis, Martin, & Shen, 2008). Participants completed this 15-item survey post-intervention (Week 10) during physical education class. Using a four-point Likert-style format, participants were asked to complete statements based on their recent experiences in physical education. For example, following the statement "My PE classes were," students chose one of the four options: "very exciting," "some exciting," "rather dull," or "very dull." Situational interest encompassed five dimensions: attention demand, challenge, enjoyment, exploration, and novelty. Each dimension was addressed with three survey questions that were randomly arranged. This survey had strong content validity, as determined by a panel of expert elementary teachers. Further, construct reliability for this survey was also strong at 0.87. The *Situational Interest Survey* used in this study is in Appendix G.

Data Analysis

Collected data were entered into a Microsoft Excel document by the researcher and two trained research assistants. All data were then transferred into IBM SPSS Version 26 for analyses. Student mathematics grades, standardized mathematics assessment, mathematics attitudes, perceived mathematics competence, and perceived athletic competence were analyzed using a mixed nested analysis of variance (ANOVA), with time (pre-/post-intervention) as the within variable, group (intervention/control) as the between variable, and school (Miller Elementary School and Woods Elementary School) as the nested variable. Physical education interest was analyzed using an independent samples *t*-test to measure differences between the control and intervention groups. All analyses included the Bonferroni adjustment to reduce the risk of Type I error.

CHAPTER IV

Results

Introduction

The purpose of this study was to examine the effects of integrating mathematics into physical education. Specific research questions addressed the impact of integrating mathematics on student mathematics performance, mathematics attitudes, mathematics perceived competence, athletic perceived competence, and situational interest in physical education. Student mathematics performance, mathematics attitudes, mathematics perceived competence, and athletic perceived competence data were analyzed using a mixed nested analysis of variance (ANOVA) design. Situational interest in physical education was analyzed using an independent samples *t*-test.

Results

Participant Demographics

One-hundred thirty-two students (n = 132) students participated in the study. Participant age, sex as assigned at birth, and race data were gathered from school records. Participants ranged in age from nine to eleven years old at the time of the study. Approximately 57% (75) of the sample were females and 43% (57) of the sample were males. Of the total sample, approximately 2% (2) were Asian, 60% (77) were Black, 14% (18) were Hispanic, and 25% (32) were White – three participants' races were not reported. Table 3 displays demographic information for the participants. Of the students from Miller Elementary school, approximately 58% (49) of the sample were females and 42% (36) of the sample were males. Approximately 2% (2) were Asian, 61% (50) were Black, 4% (3) were Hispanic, and 33% (27) were White. Table 4 displays demographic information for the Miller Elementary School participants. Of the students at Woods Elementary School, approximately 55% (26) of the sample were females and 45% (21) of the sample were males. Approximately 57% (27) were Black, 32% (15) were Hispanic, and 11% (5) were White. Table 5 displays demographic information for the Woods Elementary School participants.

Table 3

Total Sample Participant Demographics

	Female		Male	
Number of Participants	75		57	
Percentage of Sample	56.8		43.2	
	Asian	**Black**	**Hispanic**	**White**
Number of Participants	2	77	18	32
Percentage of Sample	1.6	59.7	14.0	24.8

Table 4

Miller Elementary School Participant Demographics

	Female		Male	
Number of Participants	49		36	
Percentage	57.6		42.4	
	Asian	**Black**	**Hispanic**	**White**
Number of Participants	2	50	3	27
Percentage	2.4	61.0	3.7	32.9

Table 5

Woods Elementary School Participant Demographics

	Female		Male	
Number of Participants	26		21	
Percentage	55.3		44.7	
	Asian	**Black**	**Hispanic**	**White**
Number of Participants	0	27	15	5
Percentage	0.0	57.4	31.9	10.6

Mathematics Performance

Mathematics Grades. A mixed nested ANOVA was used to determine whether mathematics quarter grades differed based on group and time, where group (intervention and control) was the between-subjects variable and time (first and second quarters) was the within-subjects variable, and school (Miller Elementary School and Woods Elementary) was the nesting variable. There was a significant difference in mathematics grades between the two schools ($F_{2, 120}$ = 13.531, $p < .001$), where about 18% of the variance can be attributed to the school (η^2 = .184). There was no significant difference in mathematics grades based on the interaction of group and time ($F_{1, 120}$ = 0.406, p = .525, η^2 = .003). Because there was no significant interaction, the main effects were examined. There was a significant difference in mathematics grades based on the group ($F_{1, 120}$ = 5.225, p = .024), where the intervention group's mathematics grades were higher than the control group's mathematics grades. About 4% of the variance in mathematics grades can be explained by the interaction (η^2 = .042). Additionally, there was a significant difference in mathematics grades in the first and second quarters ($F_{1, 120}$ = 41.728, $p < .001$), where mathematics grades were higher for the second quarter than the first. About 26% of the variance was explained by the time (first and second quarter) ($\eta^2 = .258$). See Table 4 for the descriptive statistics of mathematics grades for the groups and refer to Figure 7 for a visual depiction of mean grades.

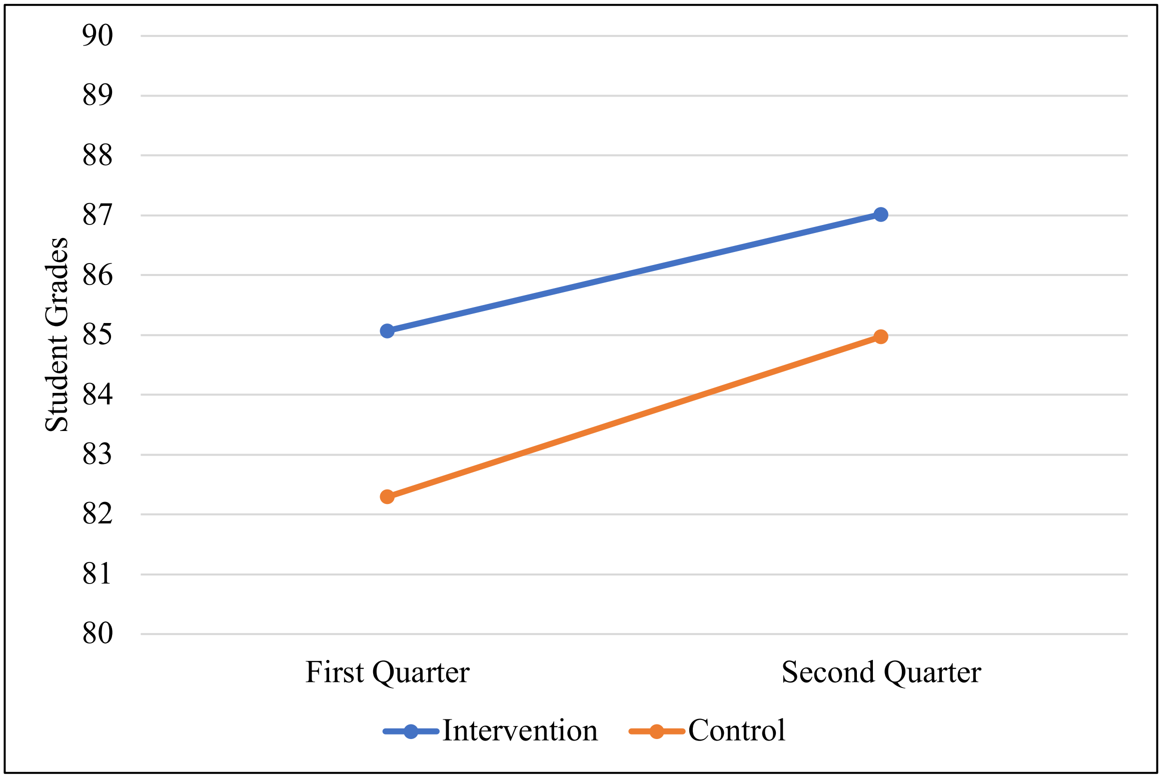
Table 6

Descriptive Statistics of Mathematics Grades

Measurement – Group	***M***	***SD***
First Quarter – Intervention	85.071	8.142
First Quarter – Control	82.294	10.494
Second Quarter – Intervention	87.018	7.735
Second Quarter – Control	84.971	9.351

Figure 7

Means of Mathematics Grades



These findings show significant differences in mathematics grades when considering the nesting variable of school, where the students at Miller Elementary School had higher grades than students at Woods Elementary School. There were no significant differences based on the interaction of group and time. However, there were significant differences in mathematics grades based on group, where the intervention group's mathematics grades were higher than the control group's mathematics grades. There were also significant differences in mathematics grades based on time, where mathematics grades in the second quarter were higher than mathematics grades in the first quarter, meaning both groups' mathematics grades improved.

Standardized Mathematics Assessment. A mixed nested ANOVA was used to determine whether standardized mathematic assessment scores differed based on group and time, where group (intervention and control) was the between-subjects variable and time (pre- and post-test) was the within-subjects variable, and school (Miller Elementary School and Woods Elementary) was the nesting variable. The standardized mathematics assessment used was the Scantron *Performance Series*. There was no significant difference in the Scantron *Performance Series* scores based on the school ($F_{2, 124}$ = .459, p = .633, η^2 = .007). There was no significant difference in Scantron *Performance Series* scores based on the interaction of group and time ($F_{1, 124}$ = .975, p = .325, η^2 = .008). Because there was no significant interaction, the main effects were examined. There was no significant difference in Scantron *Performance Series* scores based on the group ($F_{1, 124}$ = .001, p = 0.973, η^2 < .001). However, there was a significant difference in Scantron *Performance Series* scores pre- and post-test ($F_{1, 124}$ = 91.828, p < .001), where Scantron *Performance Series* scores were higher post-test than pre-test. About 43% of the variance was explained by the time of the assessment (η^2 = .425). See Table 5 for the descriptive statistics of Scantron *Performance Series* scores for the groups and refer to Figure 8 for a visual depiction of mean Scantron *Performance Series* scores.

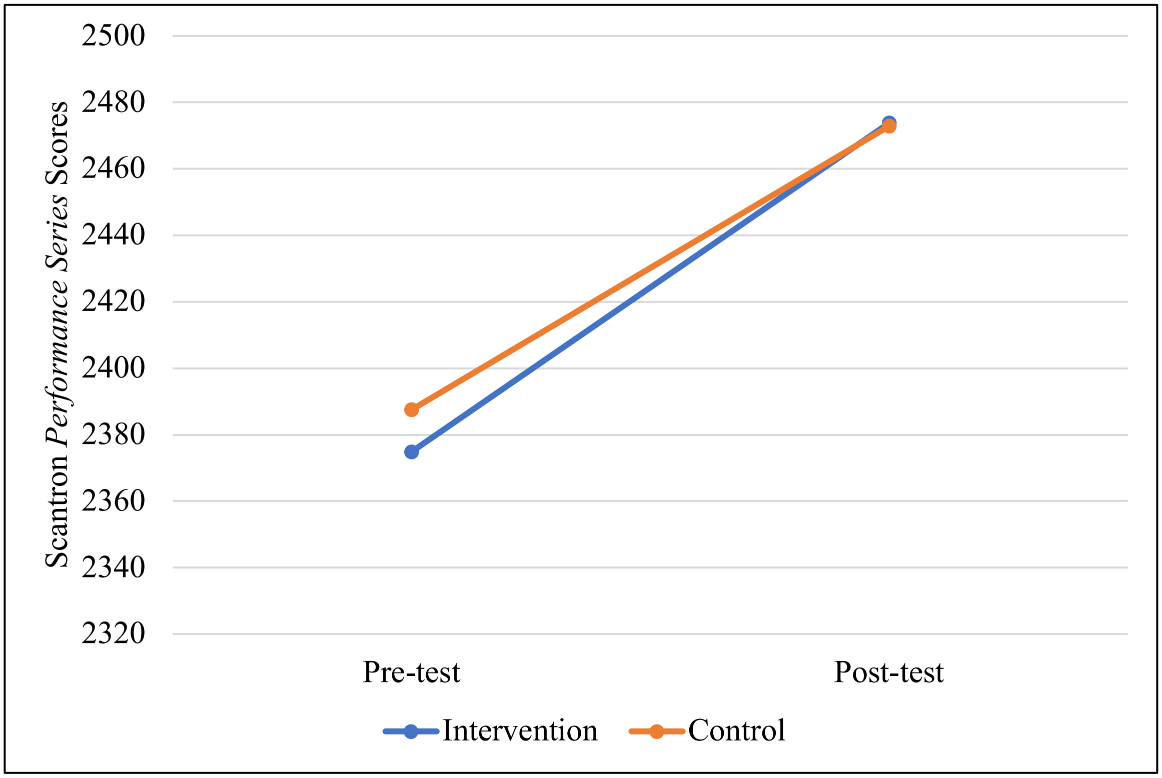
Table 7

Descriptive Statistics of Standardized Mathematics Assessment

Measurement – Group	***M***	***SD***
Scantron Pre-test – Intervention	2374.862	130.114
Scantron Pre-test – Control	2387.500	148.933
Scantron Post-test – Intervention	2473.776	129.021
Scantron Post-test – Control	2472.857	132.795

Figure 8

Mean Scores of the Standardized Mathematics Assessment



These findings show that Scantron *Performance Series* scores did not significantly differ based on the interaction of group and time. There was also no significant difference between the groups at either pre- or post-test. However, there were significant increases in Scantron *Performance Series* scores at post-test compared to pre-test, meaning both groups' Scantron *Performance Series* scores improved.

Mathematics Unit Assessment. A mixed nested ANOVA was used to determine whether mathematics unit assessment scores differed based on group and time, where group (intervention and control) was the between-subjects variable and time (pre- and post-test) was the within-subjects variable, and school (Miller Elementary School and Woods Elementary) was the nesting variable.

There was no significant difference in the mathematics unit assessment scores based on the school ($F_{2, 118}$ = 2.836, p = .063, η^2 = .046). There was a significant difference in mathematics unit assessment scores based on the interaction of group and time ($F_{1, 118}$ = 4.164, p = .044). About 3% of the variance in mathematics unit assessment scores can be explained by the interaction (η^2 = .027). To follow up on this significant interaction, simple effects analyses were completed. There was no significant difference in mathematics unit assessment scores at pre-test based on the group (t_{122} = -.404, p = .687). Yet, there was a significant difference in mathematics unit assessment at post-test based on the group (t_{128} = 2.105, p = .037). See Table 6 for the descriptive statistics of mathematics unit assessment scores for the groups and refer to Figure 9 for a visual depiction of mean unit assessment scores.

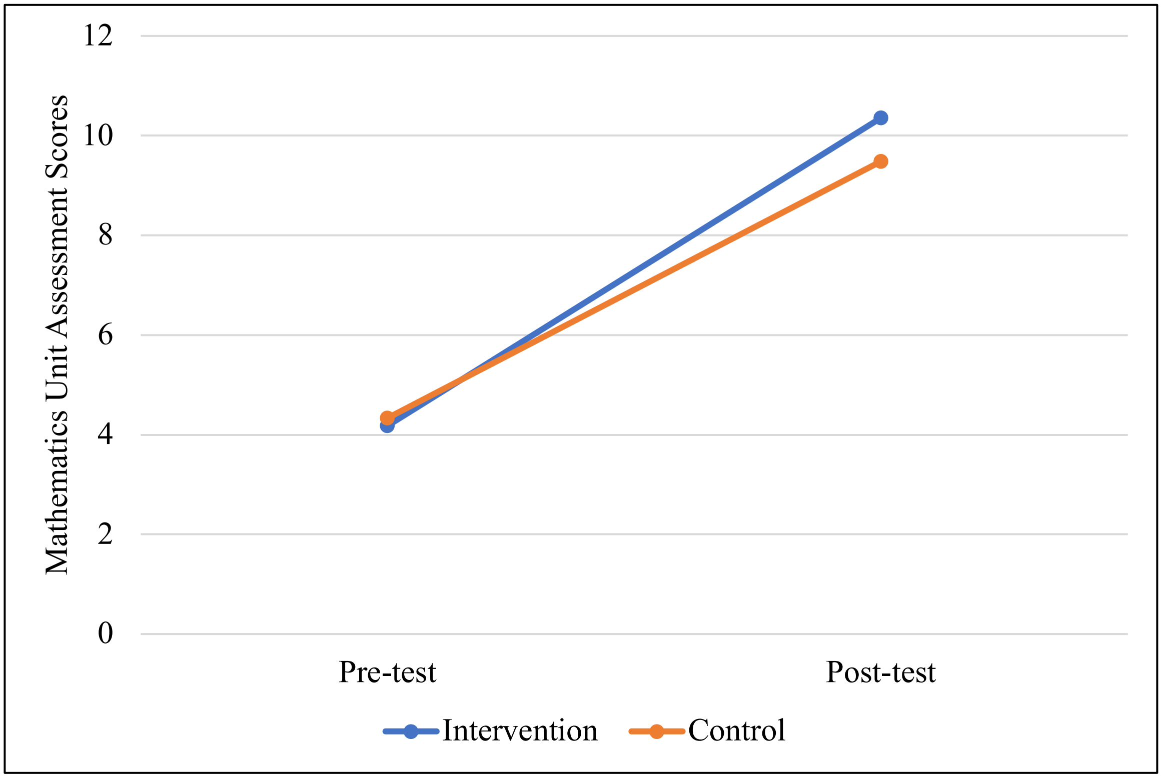
Table 8

Descriptive Statistics of Mathematics Unit Assessment

Measurement – Group	***M***	***SD***
Unit Pre-test – Intervention	4.179	2.494
Unit Pre-test – Control	4.333	2.296
Unit Post-test – Intervention	10.357	2.058
Unit Post-test – Control	9.485	2.621

Figure 9

Mean Scores of the Mathematics Unit Assessment



These findings show that mathematics unit assessment scores improved more from pre- to post-test for the students in the intervention group than the students in the control group. There were no significant differences based on the group. However, there were significant increases in mathematic unit test scores at post-test compared to pre-test, meaning both groups' mathematics unit assessment scores improved.

Mathematics Attitudes

A mixed nested ANOVA was used to determine whether mathematics attitudes differed based on group and time, where group (intervention and control) was the between-subjects variable and time (pre- and post-test) was the within-subjects variable, and school (Miller Elementary School and Woods Elementary) was the nesting variable. Mathematics attitudes were evaluated with eight questions on the *Student Attitudes Toward STEM Survey* (*S-STEM*). There was no significant difference in the S-*STEM* scores based on the school ($F_{2, 107}$ = 2.277, p = .108, η^2 = .041). There was no significant difference in *S-STEM* mathematics attitudes scores based on the interaction of group and time ($F_{1, 107}$ = 3.658, p = .058, η^2 = .033). Because there was no significant interaction, the main effects were examined. There was no significant difference in *S-STEM* mathematics attitudes scores based on the group ($F_{1, 107}$ = .082, p = .775, η^2 = .001). Further, there was not a significant difference in *S-STEM* mathematics attitudes scores at pre- and post-test ($F_{1, 107}$ = 1.244, p = .267, η^2 = .011), See Table 7 for the descriptive statistics of *S-STEM* mathematics attitudes scores for the groups and refer to Figure 10 for a visual depiction of mean *S-STEM* mathematics attitudes scores.

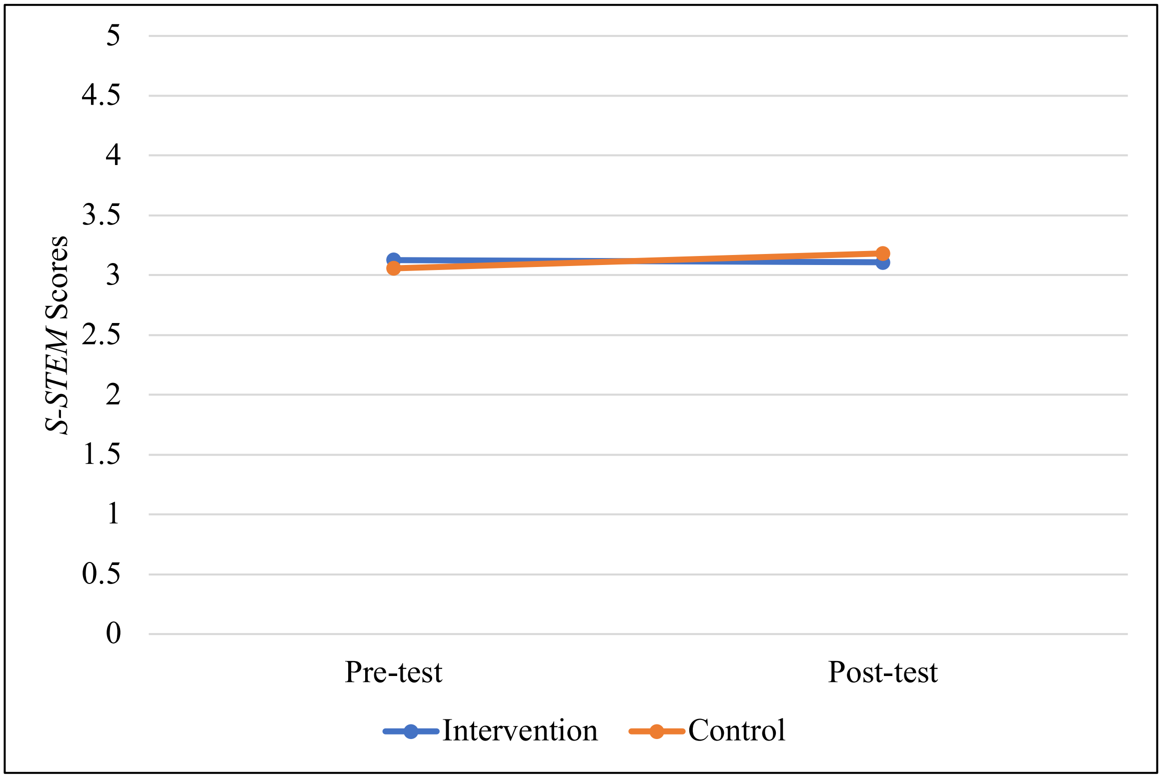
Table 9

Descriptive Statistics of Mathematics Attitudes

Measurement – Group	***M***	***SD***
Pre-test – Intervention	3.126	.391
Pre-test – Control	3.057	.468
Post-test – Intervention	3.108	.561
Post-test – Control	3.182	.382

Figure 10

Mean Scores of Mathematics Attitudes



These findings show that *S-STEM* mathematics attitudes scores did not significantly differ based on the interaction of group and time. There was also no significant difference between the groups at either pre- or post-test, and there was no significant difference in *S-STEM* scores at post-test compared to pre-test.

Mathematics Perceived Competence

A mixed nested ANOVA was used to determine whether mathematics perceived competence differed based on group and time, where group (intervention and control) was the between-subjects variable and time (pre- and post-test) was the within-subjects variable, and school (Miller Elementary School and Woods Elementary) was the nesting variable. Mathematics perceived competence was evaluated with a modified version of the scholastic portion of *Self-Perception Profile for Children (SPPC)*. There was a significant difference in the *SPPC* mathematic perceived competence scores based on the school ($F_{2, 101}$ = 3.437, p = .036), where about 6% of the variance can be attributed to the school (η^2 = .064). There was no significant difference in *SPPC* mathematic perceived competence scores based on the interaction of group and time ($F_{1, 101}$ = 2.122, p = .148, η^2 = .021). Because there was no significant interaction, the main effects were examined. There was no significant difference in *SPPC* mathematic perceived competence scores based on the group ($F_{1, 101}$ = .064, p = .801, η^2 = .001). However, there was a significant difference in *SPPC* mathematic perceived competence scores between pre- and post-test ($F_{1, 101}$ = 4.014, p = .048), where *SPPC* mathematic perceived competence scores increased from pre- to post-test. About 4% of the variance was explained by the time (pre- and post-test) (η^2 = .038). See Table 8 for the descriptive statistics of *SPPC* mathematics perceived competence scores for the groups and refer to Figure 11 for a visual depiction of mean *SPPC* mathematics perceived competence scores.

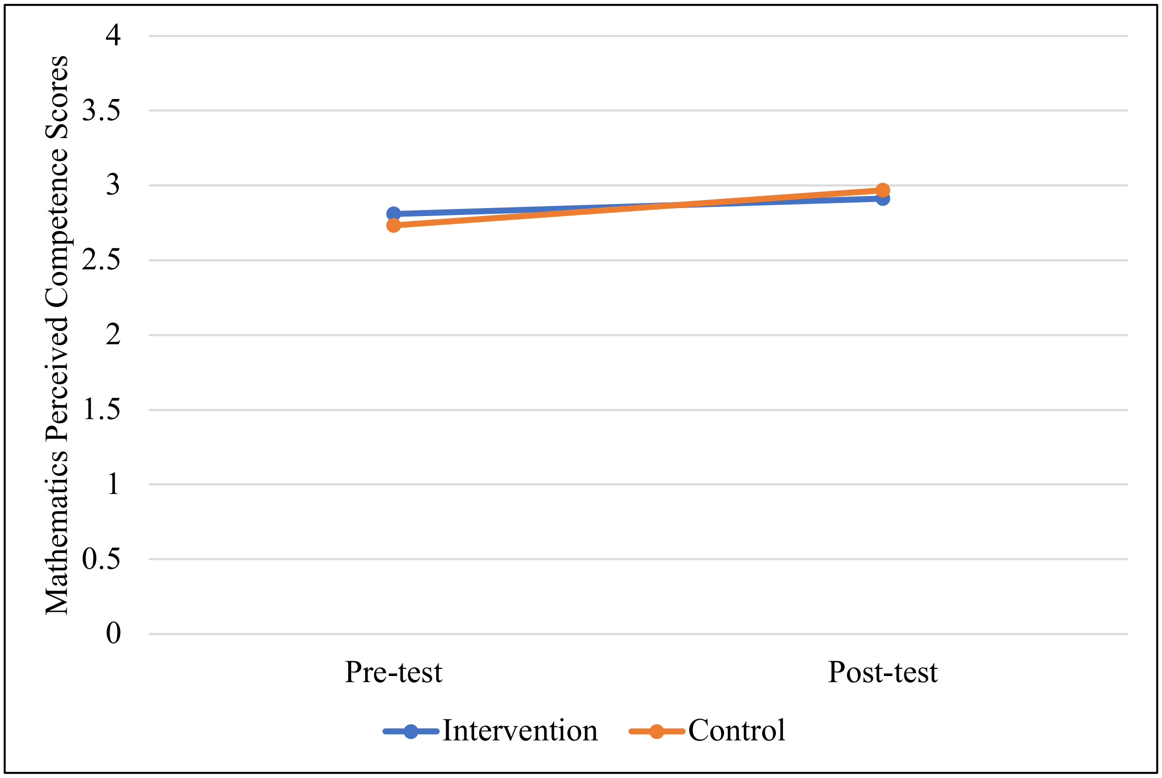
Table 10

Descriptive Statistics of SPPC Mathematics Perceived Competence

Measurement – Group	***M***	***SD***
Mathematics Pre-test – Intervention	2.809	.681
Mathematics Pre-test – Control	2.733	.626
Mathematics Post-test – Intervention	2.912	.709
Mathematics Post-test – Control	2.968	.586

Figure 11

Mean Scores of SPPC Mathematics Perceived Competence



These findings show that *SPPC* mathematic perceived competence scores did not significantly differ based on the interaction of group and time. There was also no significant difference between the groups. Lastly, there was a significant difference between pre- and post-test, where *SPPC* mathematics perceived competence increased following the intervention.

Athletic Perceived Competence

A mixed nested ANOVA was used to determine whether athletic perceived competence differed based on group and time, where group (intervention and control) was the between-subjects variable and time (pre- and post-test) was the within-subjects variable, and school (Miller Elementary School and Woods Elementary) was the nesting variable. Athletic perceived competence was evaluated with the athletic portion of the *SPPC*. There was no significant difference in the *SPPC* athletic perceived competence scores based on the school ($F_{2, 100}$ = .151, p = .860, η^2 = .003). There was no significant difference in *SPPC* athletic perceived competence scores based on the interaction of group and time ($F_{1, 100}$ = .059, p = 0.809, η^2 = .001). Because there was no significant interaction, the main effects were examined. There was no significant difference in *SPPC* athletic perceived competence scores based on the group ($F_{1, 100}$ = .014, p = 0.905, η^2 < .001). Further, there was no significant difference in *SPPC* athletic perceived competence scores between pre- and post-test ($F_{1, 100}$ = 2.163, p = .145, η^2 = .021). See Table 9 for the descriptive statistics of *SPPC* athletic perceived competence scores for the groups and refer to Figure 12 for a visual depiction of mean *SPPC* athletic perceived competence scores.

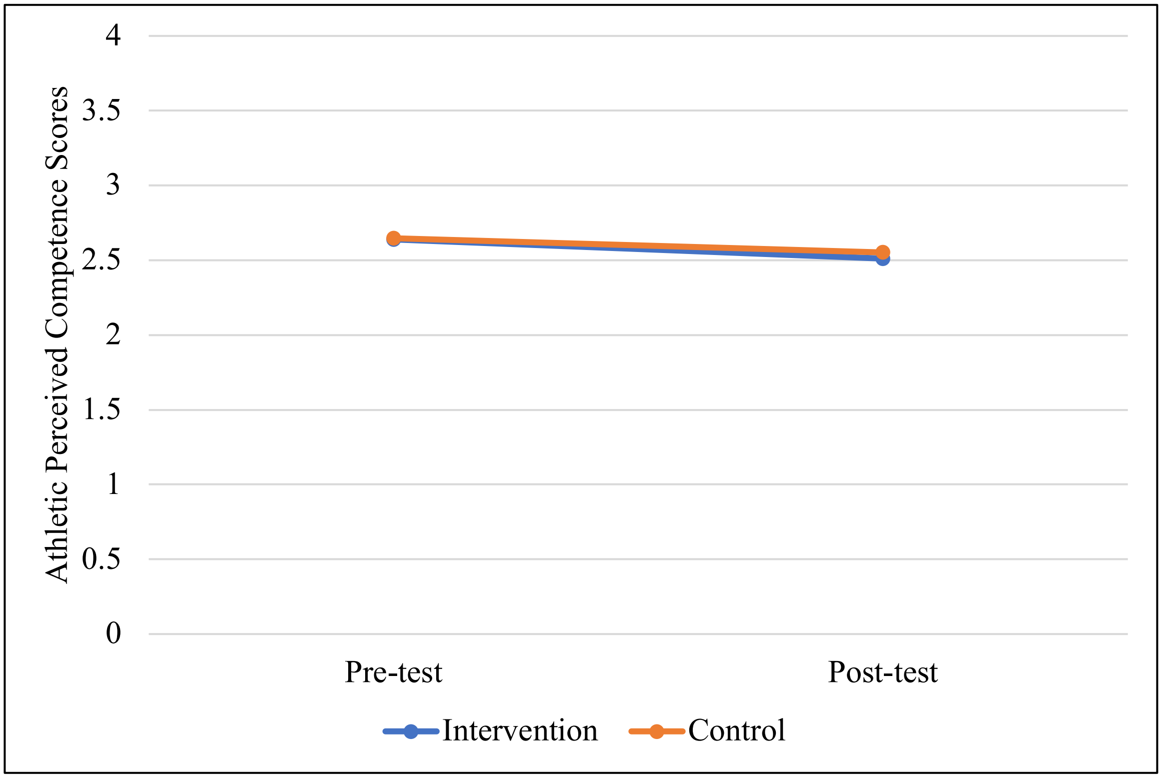
Table 9

Descriptive Statistics of SPPC Athletic Perceived Competence

Measurement – Group	***M***	***SD***
Athletic Pre-test – Intervention	2.639	.753
Athletic Pre-test – Control	2.647	.633
Athletic Post-test – Intervention	2.511	.548
Athletic Post-test – Control	2.552	.558

Figure 12

Mean Scores of SPPC Athletic Perceived Competence



These findings show that athletic perceived competence did not significantly differ based on the interaction of group and time. There was also no significant difference between the groups at either pre- or post-test. Lastly, there was no significant difference in athletic perceived competence at post-test compared to pre-test.

Situational Interest in Physical Education

An independent samples *t*-test was used to determine whether situational interest in physical education, as evaluated with the *Situational Interest Survey – Elementary School (SIS-ES)*, differed based on group (intervention and control) following the completion of the intervention. There was a significant difference in *SIS-ES* scores ($t_{109} = 2.251$, $p = .026$), where the intervention group reported greater situational interest in physical education than the control group. About 4% of the variance can be explained by the intervention ($\omega^2 = .036$). These findings show that students in the intervention group, who participated in the integrated activities, experienced greater situational interest in physical education class than the students in the control group, who did not participate in the integrated activities. Table 10 and Figure 13 display these results.

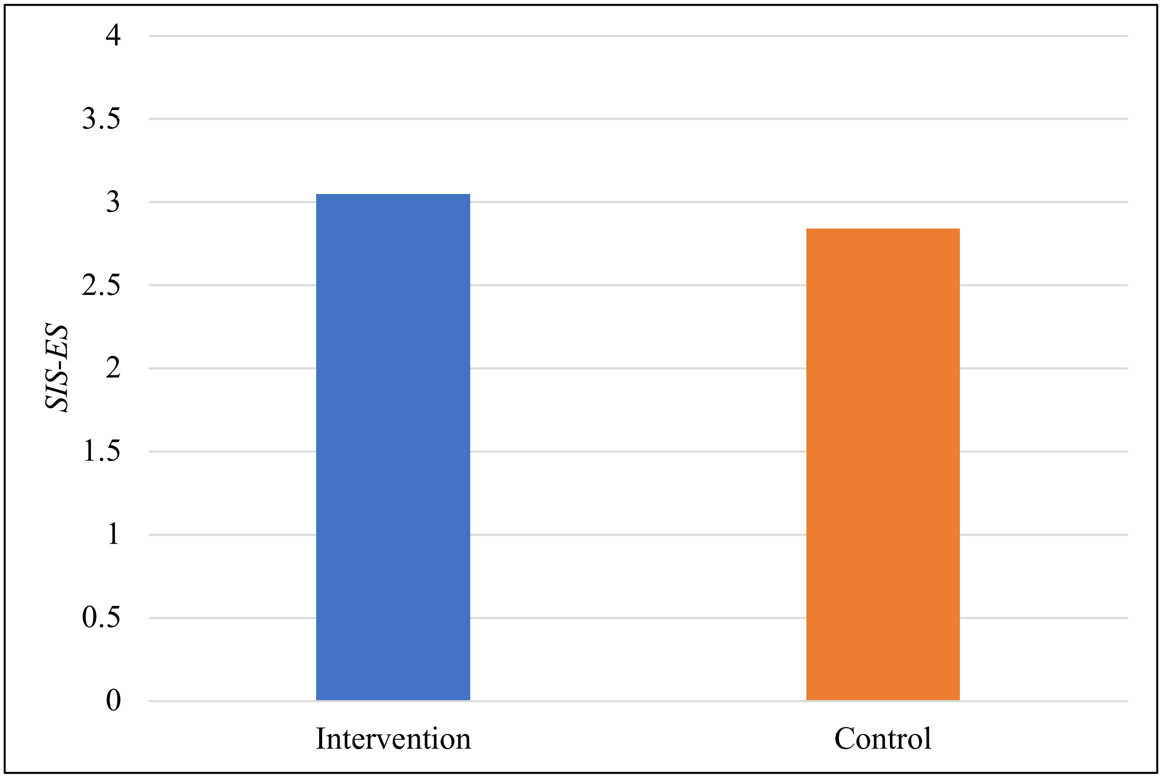
Table 12

Descriptive Statistics of Situational Interest Survey – Elementary School

Group	***M***	***SD***
Intervention	3.048	.351
Control	2.842	.568

Figure 13

Mean Scores of Situational Interest in Physical Education



There are five domains that make up situational interest: attention demand, challenge, exploration opportunity, instant enjoyment, and novelty. To analyze the effects of each domain on overall situational interest in physical education between the groups (intervention and control), independent samples *t*-test were used. There were no significant differences between the groups in the domains of attention demand (t_{114} = 1.431, p = .155, ω^2 = .009), challenge (t_{114} = .837, p = .404, ω^2 = .002), exploration opportunity (t_{113} = .717, p = .475, ω^2 = .004), and instant enjoyment (t_{115} = 1.521, p = .131, ω^2 = .011). There was a significant difference between the groups in the novelty domain (t_{113} = 3.262, p = .001). About 8% of the variance can be explained by the intervention (ω^2 = .078). Table 11 and Figure 14 display these results.

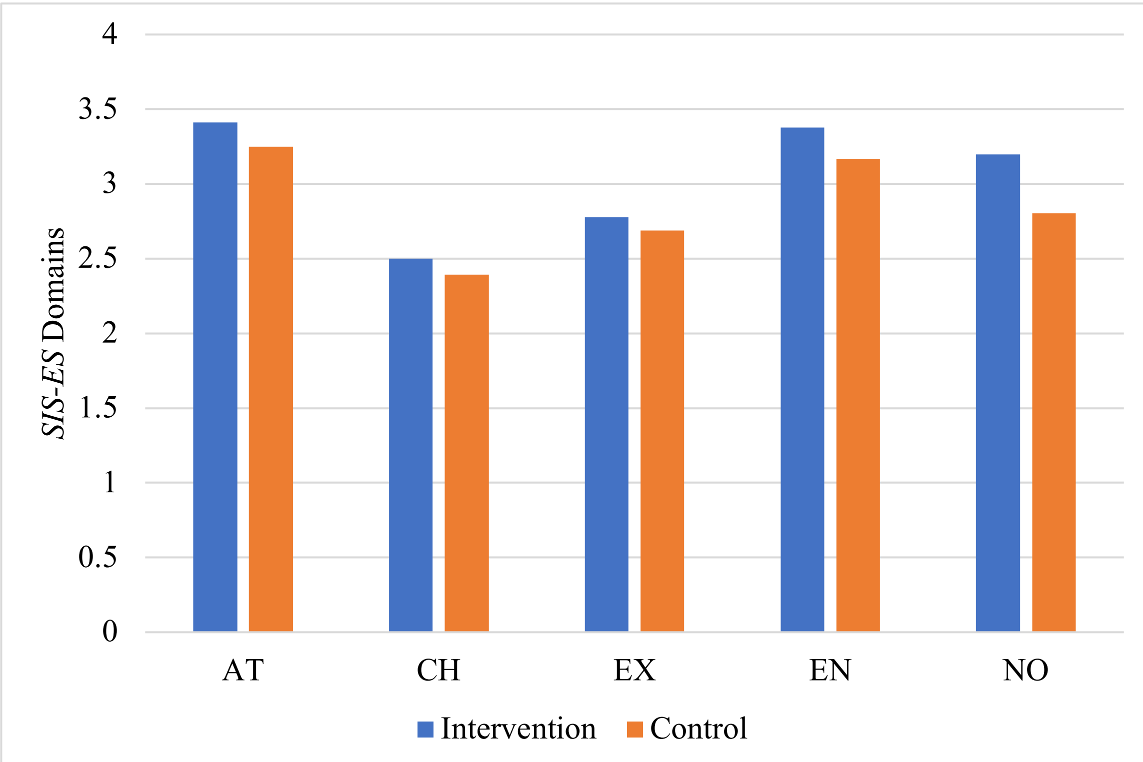
Table 13

Descriptive Statistics of the SIS-ES Domains

Intervention									
Attention Demand		Challenge		Exploration Opportunity		Instant Enjoyment		Novelty	
M	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***
3.410	.501	2.500	.624	2.778	.519	3.378	.552	3.199	.602
Control									
Attention Demand		Challenge		Exploration Opportunity		Instant Enjoyment		Novelty	
M	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***
3.250	.669	2.391	.755	2.688	.770	3.169	.858	2.804	.679

Figure 14

Mean Scores of the SIS-ES Domains (AT = attention demand, CH = challenge, EX = exploration opportunity, EN = instant enjoyment, NO = novelty)



CHAPTER V

Discussion

Introduction

The purpose of this study was to examine the effects of integrating mathematics into physical education. Specific research questions addressed integration's effect on mathematics performance, mathematics attitudes, mathematics perceived competence, athletic perceived competence, and situational interest in physical education.

Mathematics Performance

Objective measures of academic performance have been widely excluded from the literature regarding integration in physical education. To address this gap, this study sought to examine the effects of integrating mathematics into physical education on mathematics performance. Further, this study included multiple measurements of mathematics performance: mathematics grades, standardized mathematics assessment, and mathematics unit assessment. It was hypothesized that mathematics performance would improve after integrating mathematics into physical education, as there appears to be a link between movement and academic performance in both the classroom setting (Donnelly, et al., 2009; Reed et al., 2010) and physical education (Cecchini & Carriedo, 2020; Derri et al., 2010).

Across all measures of mathematics performance, students in both groups significantly improved from pre- to post-intervention. Mathematics grades significantly increased from first quarter to second quarter, Scantron *Performance Series* assessment scores significantly increased from pre-test to post-test, and mathematics unit assessment scores significantly increased from pre-test to post-test. These findings confirmed those of previous physical education integration studies (Cecchini & Carriedo, 2020; Derri et al., 2010), where all students improved over time, showing no detrimental effects of the intervention.

When considering the interaction of group (intervention and control) and time (pre- and post-intervention), significant differences were only observed in the mathematics unit assessment, where the intervention group saw significantly greater improvements from pre- to post-test compared to the control group. This significant difference mirrored previous findings (Cecchini & Carriedo, 2020; Derri et al., 2010). Derri et al. (2010) found that kindergartners who participated in a written and oral speech program in physical education outperformed their peers who were taught the same content in a traditional, classroom setting. Cecchini and Carriedo (2020) found that first graders who participated in an intervention that integrated mathematics into physical education performed better on a subtraction assessment than students in the control group.

In an attempt to explain why mathematics performance significantly differed based on the interaction of group and time on only the mathematics unit assessment, the objective measures of academic performance of previous physical education integration studies were explored (Cecchini & Carriedo, 2020; Derri et al., 2010). Previous related studies only employed one objective measurement of academic performance. Derri et al. (2010) created an assessment to measure written and oral speech, and Cecchini and Carriedo (2020) used a timed subtraction assessment to measure subtraction skills. In both studies, the content of the interventions aligned with the assessments. In the present study, mathematics grades and the Scantron *Performance Series* assessment represented global measures of mathematics performance, where the intervention covered some but not all the content related to those assessments. However, the mathematics content covered in the intervention was informed by the content taught in fourth grade mathematics during the time of the study. Therefore, the entirety of the mathematics content integrated into physical education during the intervention was evaluated on the mathematics unit assessment. While this eight-week intervention had no impact on global measures of mathematics performance, integrating mathematics into physical education improved scores on a short-term mathematics unit assessment.

Mathematics Attitudes

It was hypothesized that mathematics attitudes would improve after the completion of the intervention. The findings of the current study refuted that hypothesis, where there were no significant differences between the groups following the intervention. Although the differences were not significant, a surprising finding was mean scores of mathematics attitudes decreased slightly for the intervention group and increased slightly for the control group. The explanation to this is unknown, as this measurement tool, *Student Attitudes Toward STEM (S-STEM) Survey* (Unfried, Faber, Stanhope, & Wiebe, 2015), has never been used in physical education literature.

Mathematics Perceived Competence

It was hypothesized that mathematics perceived competence would improve after the completion of the intervention. The findings of the current study refuted that hypothesis, as there were no significant differences based on the interaction of group and time and no significant differences based on group. However, both groups saw an increase in mathematics perceived competence. This increase cannot be attributed to the intervention, but it does show the intervention did not have a negative effect on mathematics perceived competence.

Athletic Perceived Competence

It was hypothesized that athletic perceived competence would not differ between the groups after the completion of the intervention. Aside from the five- to ten-minute mathematics activities integrated into the intervention group's physical education class, the physical education content was not manipulated for either group. Therefore, it was hypothesized the intervention would not cause any differences in athletic perceived competence. The findings from this study confirmed the original hypothesis, as there were no significant differences between the control and intervention groups. Both groups saw a mean decrease in perceived athletic competence from pre- to post-test, however, this difference was not meaningful enough to be significant.

Situational Interest in Physical Education

It was hypothesized that situational interest in physical education would be greater for the students who participated in the intervention than those in the control group. The findings of this study confirmed the hypothesis. Situational interest in physical education was significantly higher in the intervention than the control group. Situational interest encompasses five domains: attention demand, challenge exploration opportunity, instant enjoyment, and novelty (Chen, Darst, & Pangrazi, 1999; Sun, Chen, Ennis, Martin, & Shen, 2008). To take a deeper look into the findings related to situational interest in physical education, the five domains were examined. Of the domains, only one, novelty, showed significant differences between the two groups. Survey responses addressing attention demand, challenge, exploration opportunity, and instant enjoyment did not significantly differ between the intervention and control groups. However, although not significant, mean scores for every domain were higher in the intervention group than the control group. Situational interest in physical education as a whole was greater for the intervention group, but this difference was predominately caused by the differences in novelty. It was expected that novelty ratings for the intervention group would be greater, as mathematics integration in physical education was foreign to the participants prior to this study.

Limitations

As with any study, this one was not without limitations. School differences and time in the field were two major limitations of this study. While recruiting participants from multiple schools was a strength because it increased the sample size and added diversity, in the case of a few measures, there was a nesting effect of school, where scores from one school were significantly different from scores from another school. This limitation was accounted for by analyzing the data with a mixed nested ANOVA. A potential cause for the nesting effect could be the demographic differences between the two schools. Although in the same school district, students at Woods Elementary School represent a lower income demographic. Additionally, more students at Woods Elementary School were English language learners, making language differences a potential barrier for students and their parents alike. This language barrier could explain the variance in the return rate of informed consents between the two schools. At Miller Elementary School, approximately 83% of the fourth grade students affirmatively consented to participating in the study. However, only approximately 36% of the fourth grade students at Woods Elementary School consented to participation. Thirteen students between the two schools requested all information and assessments translated to Spanish. One of these students was from Miller Elementary School and 12 were from Woods Elementary School. Another potential cause of the differences in consent form return rate could have been a lack of trust in the university and the researchers.

Another limitation of this study was the lack of previous work in this realm. Only seven empirical articles address integration in the physical education literature (Cecchini & Carriedo, 2020; Chen, Cone, & Cone, 2007, 2011; Chen, Martin, Sun, & Ennis, 2007; Derri et al., 2010; Hastie, 2011; Rovegno and Gregg, 2007) and those seven are vastly different in methodology, particularly the time in the field. On the shorter end, researchers examined eight (Chen et al., 2007, 2011) and 12 (Rovegno & Gregg, 2007) physical education lessons. However, other studies spent more time in the field at three weeks (Cecchini & Carriedo, 2020), five weeks (Derri et al., 2010), and six weeks (Hastie, 2011). This study was purposefully designed to be one of the longer interventions; however, more time could have been needed to see a greater impact of the intervention.

Future Directions

Future studies are needed to continue to add to the slim body of literature surrounding integration in physical education. As Derri et al. (2010) suggested after integrating language arts into physical education, future work should integrate other subjects into physical education. Hastie (2011), connected science and physical education, and Rovegno and Gregg (2007) combined physical education with social studies. Prior to the current study, Chen, Cone, and Cone (2007, 2011) and Cecchini and Carriedo (2020) were the only two studies to integrate mathematics into physical education.

In addition to further exploring integration across school subjects, future studies should examine integrating classroom content into secondary physical education. All previous studies (Cecchini & Carriedo, 2020; Chen, Cone, & Cone, 2007, 2011; Chen, Martin, Sun, & Ennis, 2007; Derri et al., 2010; Hastie, 2011; Rovegno and Gregg, 2007), including the current study, examined integration in physical education at the elementary level. Secondary students represent a novel population in terms of the effects of classroom content integration in physical education.

Lastly, future research should look to manipulate studies' timelines. Longer interventions could see greater improvements across all measures, especially global measures of academic performance. In this study, mathematics grades and a standardized mathematics assessment was used to evaluate mathematics performance globally. The eight-week timeframe of this intervention was a limiting factor in impacting those measures. In future research endeavors regarding integrated curriculum in physical education, objective measures of academic performance are suggested.

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Appendix A

Parental Permission Form

Parental Permission
for a Research Study entitled
"The Impact of Integrative Teaching in Physical Education"

Your child is being asked to take part in a research study. This research study is voluntary, meaning they do not have to take part in it. The procedures, risks, and benefits are fully described further in the consent form. The purpose of the study is to examine the effects of integrating math content into physical education. Students will participate in physical education class as normally scheduled. The researchers will be present for eight weeks. Student math grades and Scantron scores will be collected, and they will complete pre-and post-test measures that include surveys and focus group interviews. The most likely risk is discomfort during interviews when sharing their experiences in physical education. School counselors will be contacted if a student expresses feelings of discomfort. The findings from this study have the potential to improve student math grades. The alternative is to not participate in the study.

Your son or daughter is invited to participate in a research study to implement integrative teaching in physical education to observe its effect on student math grades, math test scores, math attitudes, and physical activity. The study is being conducted by Brenna Cosgrove and Dr. Sheri Brock in the Auburn University School of Kinesiology. Your child was selected as a possible participant because he/she is a fourth grade student in Opelika City School District. Since he/she is age 18 or younger we must have your permission to include him/her in the study.

What will be involved if he or she participates? If you decide to allow him or her to participate in this research study, he or she will be asked to participate in their regular physical education class. Physical education classes will be randomly assigned to groups: one group's physical education class will include brief, 10-minute activities that integrate math, and the other group will participate in physical education without the additional activity. Physical education will be taught by your child's assigned physical education teacher. In additional to participating in physical education, your child's math grades and Scantron Performance Series scores will be reported to the researchers from school personnel. Students will also be asked to complete a surveys assessing their attitudes towards math, perceived competence, situational interest, and wear an accelerometer during physical education to track their activity. Lastly, students will be randomly selected to participate in focus group interviews, where they will be asked to share their experiences in physical education. Your son/daughter's total time commitment will be approximately 50 minutes per week over the duration (8 weeks) of the study during the lessons, approximately 10 minutes to complete the survey, and approximately 80 minutes over the duration (8 weeks) of the study for the interviews.

Parent/Guardian Initials ______

AUBURN UNIVERSITY
COLLEGE OF EDUCATION
School of Kinesiology

Are there any risks or discomforts? The risks associated with participating in this study are discomfort in sharing their perceptions and experiences in physical education during focus group interviews. To minimize this discomfort, the school counselor will be notified if a student expresses feelings of discomfort. Another potential risk is breach of confidentiality. To minimize this risk, participant names will be replaced with a unique identifier that will link subject data without identifying names or identifiable data. All data collected will remain confidential and in the possession of Dr. Sheri Brock. Participation in physical activity is also a risk. To minimize this risk, the activities will be taught by the school's certified physical education teacher. In the unlikely event of an injury to your son or daughter during the research procedures, the investigators will summon help using the school's procedures. However, the investigators have no funds set aside to pay for any medical treatment that may be needed.

Are there any benefits to your son/daughter or others? If he/she participates in this study, they will have the opportunity to share their feelings about integrative teaching. Their experiences will help shape future practices in the field. Another potential benefit is an increase in student learning and retention. We cannot promise you that you will receive any or all of the benefits described.

Will you or your son/daughter receive compensation for participating? No compensation will be offered.

Are there any costs? There are no costs associated with this study.

If you (or your son/daughter) change your mind about his/her participation, he/she can be withdrawn from the study at any time. Your son's/daughter's participation is completely voluntary. If you choose to withdraw him/her, your son's/daughter's data can be withdrawn as long as it is identifiable. Your decision about whether or not to allow your son/daughter to participate or to stop participating will not jeopardize your or his/her future relations with Auburn University, the School of Kinesiology or with the researchers.

Your son's/daughter's privacy will be protected. Any information obtained in connection with this study will remain confidential. The data collected will be protected by storing them in a locked drawer or on a password-protected encrypted computer in Dr. Sheri Brock's locked office (Kinesiology Building, room 172).

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If you (or your son/daughter) have questions about this study, please ask them now or contact Brenna Cosgrove at bmc0053@auburn.edu. A copy of this document will be given to you to keep.

If you have questions about your son's/daughter's rights as a research participant, you may contact the Auburn University Office of Research Compliance or the Institutional Review Board by phone (334)-844-5966 or e-mail at IRBadmin@auburn.edu or IRBChair@auburn.edu.

HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE WHETHER OR NOT YOU WISH FOR YOUR SON OR DAUGHTER TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE INDICATES YOUR WILLINGNESS TO ALLOW HIM OR HER TO PARTICIPATE.

____________________________ ____________________________

Parent/Guardian Signature Date Investigator Obtaining Consent Date

____________________________ ____________________________

Printed Name Printed Name

____

Minor's Name

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Appendix B

Parental Permission Form – Spanish

AUBURN UNIVERSITY
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Permiso de los padres
para un estudio de investigación titulado
"El impacto de la enseñanza integradora en la educación física"

Se le pide a su hijo que participe en un estudio de investigación. Este estudio de investigación es voluntario, lo que significa que no tienen que participar en él. Los procedimientos, riesgos y beneficios se describen detalladamente en el formulario de consentimiento. El propósito del estudio es examinar los efectos de integrar el contenido matemático en la educación física. Los estudiantes participarán en la clase de educación física según lo programado normalmente. Los investigadores estarán presentes durante ocho semanas. Se recopilarán las calificaciones de matemáticas de los estudiantes y los puntajes de Scantron, y completarán las medidas previas y posteriores a la prueba que incluyen encuestas y entrevistas de grupos focales. El riesgo más probable es la incomodidad durante las entrevistas al compartir sus experiencias en educación física. Los consejeros escolares serán contactados si un estudiante expresa sentimientos de incomodidad. Los resultados de este estudio tienen el potencial de mejorar las calificaciones de matemáticas de los estudiantes. La alternativa es no participar en el estudio.

Se invita a su hijo o hija a participar en un estudio de investigación para implementar la enseñanza integral en educación física para observar su efecto en las calificaciones de matemáticas de los estudiantes, los puntajes de las pruebas de matemáticas, las actitudes de las matemáticas y la actividad física. El estudio lo llevan a cabo Brenna Cosgrove y la Dra. Sheri Brock en la Escuela de Kinesiología de la Universidad de Auburn. Su hijo fue seleccionado como posible participante porque él / ella es un estudiante de cuarto grado en el Distrito Escolar de la Ciudad de Opelika. Como él / ella tiene 18 años o menos, debemos tener su permiso para incluirlo en el estudio.

¿Qué implicará si él o ella participa? Si decide permitirle participar en este estudio de investigación, se le pedirá que participe en su clase regular de educación física. Las clases de educación física se asignarán aleatoriamente a grupos: la clase de educación física de un grupo incluirá actividades breves de 10 minutos que integran matemáticas, y el otro grupo participará en educación física sin la actividad adicional. La educación física será impartida por el maestro de educación física asignado de su hijo. Además de participar en la educación física, el personal de la escuela informará a los investigadores las calificaciones de matemáticas de su hijo y los puntajes de Scantron Performance Series. También se les pedirá a los estudiantes que completen encuestas que evalúen sus actitudes hacia las matemáticas, la competencia percibida, el interés situacional y que usen un acelerómetro durante la educación física para seguir su actividad. Por último, los estudiantes serán seleccionados al azar para participar en entrevistas de grupos focales, donde se les pedirá que compartan sus experiencias en educación física. El compromiso

Iniciales del padre / tutor ______

de tiempo total de su hijo / hija será de aproximadamente 50 minutos por semana durante la duración (8 semanas) del estudio durante las lecciones, aproximadamente 10 minutos para completar la encuesta y aproximadamente 80 minutos durante la duración (8 semanas) del estudio para las entrevistas

¿Hay algún riesgo o molestia? Los riesgos asociados con la participación en este estudio son la incomodidad de compartir sus percepciones y experiencias en educación física durante las entrevistas de grupos focales. Para minimizar esta incomodidad, se notificará al consejero escolar si un alumno expresa sentimientos de incomodidad. Otro riesgo potencial es la violación de la confidencialidad. Para minimizar este riesgo, los nombres de los participantes serán reemplazados por un identificador único que vinculará los datos del sujeto sin identificar nombres o datos identificables. Todos los datos recopilados serán confidenciales y estarán en posesión del Dr. Sheri Brock. La participación en la actividad física también es un riesgo. Para minimizar este riesgo, las actividades serán impartidas por el maestro de educación física certificado de la escuela. En el improbable caso de una lesión a su hijo o hija durante los procedimientos de investigación, el
Los investigadores solicitarán ayuda para utilizar los procedimientos de la escuela. Sin embargo, los investigadores tienen
no se reservan fondos para pagar ningún tratamiento médico que pueda ser necesario.

¿Hay algún beneficio para su hijo / hija u otros? Si él / ella participa en este estudio, tendrán la oportunidad de compartir sus sentimientos sobre la enseñanza integradora. Sus experiencias ayudarán a dar forma a futuras prácticas en el campo. Otro beneficio potencial es un aumento en el aprendizaje y la retención de los estudiantes. No podemos prometerle que recibirá alguno o todos los beneficios descritos.

¿Usted o su hijo / hija recibirán una compensación por participar? No se ofrecerá ninguna compensación.

¿Hay algún costo? No hay costos asociados con este estudio.

Si usted (o su hijo / hija) cambia de opinión acerca de su participación, puede retirarse del estudio en cualquier momento. La participación de su hijo / hija es completamente voluntaria. Si elige retirarlo, los datos de su hijo / hija se pueden retirar siempre que sean identificables. Su decisión de permitir o no que su hijo / a participe o deje de participar no pondrá en peligro sus relaciones futuras con la Universidad de Auburn, la Escuela de Kinesiología o con los investigadores.

Iniciales del padre / tutor ______

La privacidad de su hijo / hija estará protegida. Cualquier información obtenida en relación con este estudio será confidencial. Los datos recopilados se protegerán almacenándolos en un cajón cerrado o en una computadora cifrada protegida con contraseña en la oficina cerrada del Dr. Sheri Brock (Edificio Kinesiología, sala 172).

Si usted (o su hijo / hija) tiene preguntas sobre este estudio, pregúntelas ahora o comuníquese con Brenna Cosgrove a bmc0053@auburn.edu. Se le entregará una copia de este documento para que la guarde.

Si tiene preguntas sobre los derechos de su hijo / hija como participante de investigación, puede comunicarse con la Oficina de Cumplimiento de Investigación de la Universidad de Auburn o la Junta de Revisión Institucional por teléfono (334) -844-5966 o por correo electrónico a IRBadmin@auburn.edu o IRBChair@auburn.edu.

HABER LEÍDO LA INFORMACIÓN PROPORCIONADA, DEBE DECIDIR SI DESEA O NO QUE SU HIJO O HIJA PARTICIPE EN ESTE ESTUDIO DE INVESTIGACIÓN. SU FIRMA INDICA SU DISPUESTA PARA PERMITIRLE A ELLA O A ELLA PARTICIPAR.

____

Firma del Padre / Tutor   Fetcha

____

Nombre impreso

____

Nombre del menor

Iniciales del padre / tutor ______

Appendix C

Minor Assent Form

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MINOR ASSENT
for a research study entitled
"The Impact of Integrative Teaching in Physical Education"

You are invited to be in a research study to help us understand if students can learn math in physical education.

If you decide you want to be in this study, you will attend physical education class as normal. During physical education class, you will be asked to answer questions on worksheets, and you might be asked to talk with the researchers from Auburn University about how you feel about physical education class.

You can stop at any time. Just tell your parents, your teacher, or Ms. Brenna Cosgrove if you don't want to answer questions any more. No one will be angry with you if you stop.

If you have any questions about what you will do or what will happen, please ask your parents or guardian or ask Ms. Brenna Cosgrove now. If you have questions while you are in physical education class we want you to ask us.

If you have decided to help us, please sign or print your name on the line below.

Child's Signature	Printed Name	Date
Parent/Guardian Signature	Printed Name	Date
Investigator obtaining consent	Printed Name	Date

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Appendix D

Minor Assent Form – Spanish

ASESOR MENOR
para un estudio de investigación titulado
"El impacto de la enseñanza integradora en la educación física"

Lo invitamos a participar en un estudio de investigación para ayudarnos a comprender si los estudiantes pueden aprender matemáticas en educación física.

Si decide que quiere participar en este estudio, asistirá a la clase de educación física de la forma habitual. Durante la clase de educación física, se le pedirá que responda preguntas en las hojas de trabajo, y se le puede pedir que hable con los investigadores de la Universidad de Auburn sobre cómo se siente acerca de la clase de educación física.

Puedes parar en cualquier momento. Solo dígales a sus padres, a su maestra o a la Sra. Brenna Cosgrove si ya no desea responder preguntas. Nadie se enojará contigo si paras.

Si tienes alguna pregunta sobre lo que harás o lo que sucederá, pregúntale a tus padres o tutor o pregúntale a la Sra. Brenna Cosgrove ahora. Si tiene preguntas mientras está en la clase de educación física, queremos que nos haga preguntas.
Si ha decidido ayudarnos, firme o imprima su nombre en la línea a continuación.

____

Firma del niño

____

Nombre impreso Fetcha

____

Firma del Padre / Tutor

____

Nombre impreso Fetcha

Iniciales del padre / tutor ______

Appendix E

Mathematics Unit Assessment Form A

Student Name: ______________________________

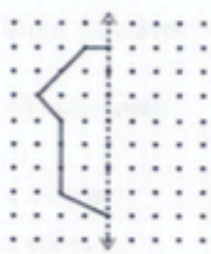
Date: ______________________________

1. Convert each unit. Write the answers below.

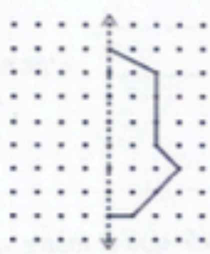
7 meters = __________ centimeters

6 centimeters = __________ millimeters

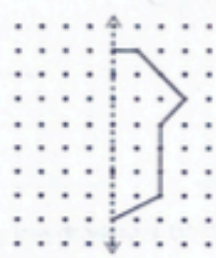
2. Which figure completes the drawing so it is symmetrical?



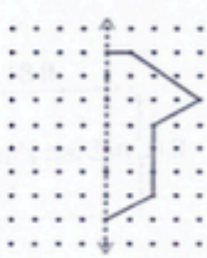
❑ A.



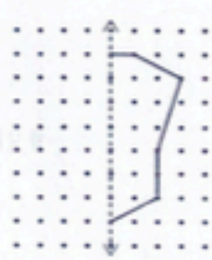
❑ B.



❑ C.



❑ D.



3. Choose the **three** true statements.

- ❑ A. An acute angle makes a square corner.
- ❑ B. A right angle is open more than an obtuse angle.
- ❑ C. All right angles have the same measure.
- ❑ D. An obtuse angle is open more than an acute angle.
- ❑ E. An acute angle is open less than a right angle.

5. Write the correct measurements.

40 millimeters   48 inches   400 centimeters   12 feet

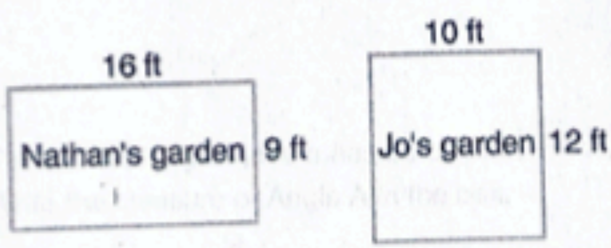
4 meters = ____________________

4 yards = ____________________

4 feet = ____________________

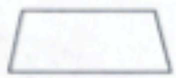
4 centimeters = ____________________

7. Which statement is true about the gardens in the drawings below?



- ❑ A. Jo's garden has a greater area than Nathan's garden.
- ❑ B. Jo's garden has a greater perimeter than Nathan's garden.
- ❑ C. They both have the same perimeter.
- ❑ D. None of the above

12. Which shapes are parallelograms?
Choose the **two** correct answers.

❑ A. 

❑ B. 

❑ C. 

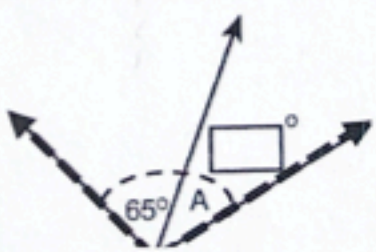
❑ D. 

---

14. Ken puts 4 pattern blocks together to make the design shown below. The small angles of each pattern block have a measure of 30 degrees. What is the measure of the large angle formed where all 4 pattern blocks join together?

______ degrees

15. The dashed angle has a measure of 110°.
Write the measure of Angle A in the box.



17. A rectangular window in Marissa's house measures 3 feet by 7 feet. What is the area of the window?

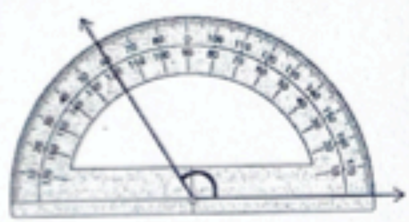
- ❑ A. 17 square feet
- ❑ B. 20 square feet
- ❑ C. 21 square feet
- ❑ D. 23 square feet

---

20. What is the measure of the angle shown?

- ❑ A. 120°
- ❑ B. 150°
- ❑ C. 30°
- ❑ D. 60°

21. What is the measure of the angle shown?
Write your answer below.



________ degrees

23. Which of the following statements are true about the figure below?

Choose the **two** correct answers.

- ☐ A. The figure has one line of symmetry.
- ☐ B. The figure has two lines of symmetry.
- ☐ C. Line *AC* is a line of symmetry.
- ☐ D. Line *AC* divides the figure in half, but is not a line of symmetry.
- ☐ E. Line *BD* does not divide the figure in half, but is a line of symmetry.

Appendix F

Mathematics Unit Assessment Form B

Student Name: ______________________________

Date: ______________________________

4. Which dashed line is a line of symmetry?

❑ A.

❑ C.

❑ B.

❑ D.

6. Certain types of bamboo can grow 3 feet in one day. How many inches is this?

❑ A. 27 inches
❑ B. 30 inches
❑ C. 33 inches
❑ D. 36 inches

8. A rectangle is 8 inches long and 4 inches wide. Which methods can be used to find the perimeter, in inches, of the rectangle? Select the **two** correct answers.

❑ A. $2 \times (8 + 4)$
❑ B. $(2 \times 8) \times (2 \times 4)$
❑ C. $(2 + 8) \times (2 + 4)$
❑ D. $8 + 4 + 8 + 4$

9. A rectangular room covers 108 square feet.
The width of the room is 9 feet. How long is the room?

- ❑ A. 9 feet
- ❑ B. 11 feet
- ❑ C. 12 feet
- ❑ D. 14 feet

10. Kaleb looks at a tennis court and uses a geometric term to describe two lines that meet to form a right angle. What term could Kaleb use?

- ❑ A. Acute angle
- ❑ B. Parallel lines
- ❑ C. Perpendicular lines
- ❑ D. Obtuse angle

11. Write each time to match the angles made by the clock hands. Use the clock to help.

2:00 9:00 1:00 5:00

30° ________

150° ________

60° ________

90° ________

13. Tyler drew a figure that has two pairs of sides equal in length, four angles formed by perpendicular lines, and two pairs of parallel sides. What geometric term best describes the figure Tyler drew?

- ❑ A. Parallelogram
- ❑ B. Rhombus
- ❑ C. Rectangle
- ❑ D. Trapezoid

16. Convert each unit. Write your answers below.

32 yards = ____________ feet

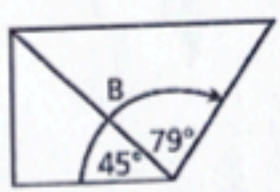
2 feet = __________ inches

18. Write the correct term for each figure. Use the terms below.

ray line line segment angle

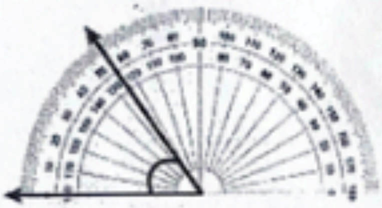
	
	
	

19. What is the measure of Angle B? Write your answer below.



________°

22. What is the measure of the angle shown?

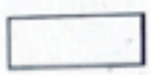


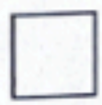
- ❑ A. 45 degrees
- ❑ B. 55 degrees
- ❑ C. 125 degrees
- ❑ D. 135 degrees

---

24. Which figures have more than one line of symmetry?
Select the **two** correct answers.

❑ A. 

❑ B. 

❑ C. 

❑ D. 

Appendix G

Student Attitudes Toward STEM (S-STEM) Survey

MISO

FRIDAY INSTITUTE FOR EDUCATIONAL INNOVATION

Golden LEAF FOUNDATION

Math

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. Math has been my worst subject.	○	○	○	○	○
2. When I'm older, I might choose a job that uses math.	○	○	○	○	○
3. Math is hard for me.	○	○	○	○	○
4. I am the type of student who does well in math.	○	○	○	○	○
5. I can understand most subjects easily, but math is difficult for me.	○	○	○	○	○
6. In the future, I could do harder math problems.	○	○	○	○	○
7. I can get good grades in math.	○	○	○	○	○
8. I am good at math.	○	○	○	○	○

Appendix H

Mathematics and Athletic Perceived Competence Assessment, adapted from the *Self-Perception Profile for Children*

Name:________________________________ Date:____________________

Directions: Put an "**X**" in the box that best describes you. Choose only one answer that is TRUE for you.

	Really true for me	Sort of true for me				Sort of true for me	Really true for me
1.	☐	☐	Some kids feel that they are very good at math	**BUT**	Other kids worry about whether they can do the math work assigned to them	☐	☐
2.	☐	☐	Some kids feel like they are just as smart as other kids their age in math	**BUT**	Other kids aren't so sure and wonder if they are as smart in math	☐	☐
3.	☐	☐	Some kids are pretty slow in finishing their math work	**BUT**	Other kids can do their math work quickly	☐	☐
4.	☐	☐	Some kids often forget what they learn in math	**BUT**	Other kids can remember math easily	☐	☐
5.	☐	☐	Some kids do very well at math	**BUT**	Other kids don't do very well at math	☐	☐

6. ☐	☐	Some kids have trouble figuring out the answers in math	**BUT**	Other kids almost always can figure out the answers in math	☐	☐
7. ☐	☐	Some kids do very well at all kinds of sports	**BUT**	Other kids don’t feel that they are good when it comes to sports	☐	☐
8. ☐	☐	Some kids wish they could be a lot better at sports	**BUT**	Other kids feel they are good enough at sports	☐	☐
9. ☐	☐	Some kids think they could do well at just about any new sports activity they haven’t tried before	**BUT**	Other kids are afraid they might not do well at sports they haven’t ever tried	☐	☐
10. ☐	☐	Some kids feel that they are better than others their age at sports	**BUT**	Other kids don’t feel they can play as well	☐	☐
11. ☐	☐	In games and sports some kids usually watch instead of play	**BUT**	Other kids usually play rather than just watch	☐	☐
12. ☐	☐	Some kids don’t do well at new outdoor games	**BUT**	Other kids are good at new games right away	☐	☐

Appendix I

Situational Interest Survey – Elementary School

Name:______________________________ Date:__________________

Situational Interest Survey

Directions: Circle the option that best completes the sentence. Choose only one answer that is TRUE for you.

1. My PE classes were

very exciting	some exciting	rather dull	very dull

2. The thinking I did in PE was

very complex	some complex	rather simple	very simple

3. My PE classes demanded me to pay

high attention	some attention	a little attention	no attention

4. My PE classes made me

very attentive	some attentive	a little attentive	not attentive

5. I did experiments in PE classes

everyday	on most days	on a few days	not once

6. My PE classes were

very unique	some unique	rather common	very simple

7. My PE classes made me think

a lot	some	a little	very little

8. My PE classes were

very enjoyable	some enjoyable	a little enjoyable	not enjoyable

9. My PE classes made me become

very curious	some curious	a little curious	not curious

10. My PE classes were

very inventive	some inventive	a little inventive	not inventive

11. My PE classes were

very new	some new	a little new	not new

12. My PE classes made me

very focused	some focused	a little focused	not focused

13. The thinking I did in PE was

very demanding	some demanding	a little demanding	not demanding

14. My PE classes were

very satisfying	some satisfying	a little satisfying	not satisfying

15. The thinking I did in PE was

very hard	some hard	a little hard	not hard