# INTEGRATIVE TECHNOLOGY-ENHANCED PHYSICAL EDUCATION: AN EXPLORATORY STUDY WITH ELEMENTARY SCHOOL STUDENTS

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Dissertation Prepared for the Degree of

DOCTOR OF PHILOSOPHY

UNIVERSITY OF NORTH TEXAS

May 2017

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Barbee, Stephanie S. *Integrative Technology-Enhanced Physical Education: An Exploratory Study with Elementary School Students*. Doctor of Philosophy (Learning Technologies), May 2017, 69 pp., 5 tables, 13 figures, references, 64 titles.

Wearable technology has made a positive impact in the consumer industry with its focus on adult fitness. Devices and applications are pervasive, inexpensive and are in high demand. Our nation struggles with obesity and health concerns related to poor fitness. However, the research on such technology has been more focused on adults. Therefore, the need to investigate wearable technology for fitness improvement with children is essential. Children lead increasingly sedentary lifestyles through TV watching, technology-use and a reduction in physical activities. Further, our society is exposed to quick food loaded with calories. These factors contribute to the growing epidemic of childhood obesity. The need to educate students early, on their ability to monitor their fitness, is the focus of this research. This dissertation investigated the impact of an integrated technology-enhanced physical education model with 127 fifth grade students over an 11-week period.  A detailed analysis, looking at theoretical perspectives across multiple data collections was conducted. This study answered the questions, 1. To what extent can students improve their performance with technology-enhanced physical education? 2. To what extent can students learn to self-monitor their performance levels? How do affective components impact teaching and learning with a technology-enhanced physical education model? Results showed that technology-enhanced physical education does improve performance measures, does improve students' ability to self-regulate and positively impacts student and teachers' affective states. However long term results were inconclusive, stimulating multiple, potential opportunities for continued research.

ACKNOWLEDGMENTS

Many deserve acknowledgement. I sincerely thank Dr. Knezek above all. He has been my mentor and guide since I started this program in 2014. His quantitative style really resonated with me, and I knew from the beginning I wanted his support as my major professor. He has provided guidance all along the way, and I am so appreciative of his support. I would like to acknowledge my other committee members, Dr. Michael Spector and Dr. Cathleen Norris. Dr. Spector was always very candid and provided the kind of support and feedback I needed to up my game. Dr. Norris was always encouraging of my research in the field of ubiquitous devices for teaching and learning and recognized the importance of analyzing secondary data. The support of my committee is so appreciated.

This dissertation would not have been possible without the partnership of Miles Bennett, Athletic Commissioner and Darren Gasper, Superintendent of Education, and the participating students and teachers from the the Sun West School Division in Rosetown, Saskatchewan, Canada. Their interest in investigating the effectiveness of the use of technology within a physical education classroom led to this collaboration. A special thanks is also in order for Ali Young, Education Account Manager for Polar Electro, Inc. and Francois Gazzano of FITSTATS Technologies, Inc.

My family has been a true force through this journey. My husband, Richard was always there as my cheerleader along with my daughters, Kate and Olivia. My father, a chemist and alumnus of UNT always kept my mind pointed in the right direction. Finally, I have to include my animals, Dazy, Atticus, Tex and Pumpkin…all who suffered from a lack of my attention over the years. I am forever grateful for their silent support.

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# CHAPTER 1

# INTRODUCTION

## Statement of the Problem

Wearable fitness trackers paired with e-health apps have grown increasingly popular. Their growing popularity is evidenced by consumer demand and suggests that these devices are producing desired results, translating into improved fitness levels for those who use them. Popular wearable fitness trackers include the Polar H7 (2016), Fitbit (2016), and Jawbone's Up (2016). E-health apps are increasingly available too and are usually paired with a wearable device or other mobile device to provide feedback. Some of these apps include FITSTATS (2016), COUCH25K (2016), and ENDOMONDO (2016) among many. In a study by Fritz, Huang, Murphy and Zimmermann (2014) of 30 adult participants who used a device for at least three months, results showed that numerical feedback through the use of wearable devices resulted in increased physical activity among participants. Specifically, "most participants reported that the use of the [wearable] device had motivated or helped them make durable changes such as walking more, taking the stairs, or standing while working rather than sitting" (p. 49). Additional studies also supported the finding that wearables and health applications increased physical activity (Barbee, 2015; Barbee & Bennett, 2016; Mercer, Li, Giangregorio, Burns, & Grindrod, 2016). In a large scale, systematic study in the Journal of the American Medical Association, Bravata et al. 2007 evaluated the literature as to the use of pedometers with physical activity and health outcomes among adults. They investigated 2246 citations; 26 studies (8 randomized controlled trials and 18 observational studies) with at total of 2,767 participants. Overall findings suggested that the use of a pedometer (similar to a wearable fitness monitor) is “associated with significant increases in physical activity and significant decreases in body mass index and blood pressure. Whether changes are durable over the long term is undetermined,” (Bravata et al, 2007, p. 2296).

Though the popularity and demand of wearable fitness devices are evident among adult users, empirical research regarding the effectiveness of wearables for fitness tracking and teaching health education to children is limited. Children suffer similarly to adults with health related issues such as obesity, sedentary lifestyles and high caloric intake. Physical activity is defined as any bodily movement produced by skeletal contraction that expends energy beyond a sedentary state (Butte, Ekelund & Westerterp (2002). Daily physical activity improves overall health including the reduction of obesity, improved cognition, and improved mental states. Seventeen-percent of children are considered obese according to a study by Ogden et al. (2016). Their report and findings were prepared from a recent analysis of the data from The National Center for Health Statistics, Center for Disease Control and Prevention (Ogden et al., 2016).

Further, the urgency to remedy obesity in children is demonstrated in our previous First Lady, Michelle Obama’s “Let’s Move” Campaign. According to Obama’s Campaign, the website states, “over the past three decades, childhood obesity rates in America have tripled, and today, nearly one in three children in America are overweight or obese” (Obama, 2016, Let’s Move). Cultural changes throughout the years have contributed to the problem. Children now are less active; they spend more time indoor with video, TV, and computers. Caloric intake is on the rise as students have access to larger portions and fast food. In many schools, physical education programs have been reduced (Fedewa & Ahn, 2011) or eliminated due to funding cuts resulting from increased pressure for schools to improve performance on standardized tests. This phenomenon is happening even though studies have shown that physical activity positively affects children's cognitive outcomes (Fedewa & Ahn, 2011). Improvements in physical activity can have far reaching consequences making this dissertation timely and relevant to address students' sedentary lifestyles, increased obesity levels, and potentially counter an increase in the consumption of high caloric foods. Therefore, providing evidence that technology can support students' physical education both systematically through sound instructional design, and affordably through current wearable technology is important.

## Purpose of Study

This study investigates an integrative technology-enhanced physical fitness model with fifth grade students. The model utilizes a wearable fitness device paired with a self-report application where students reported their individual level-of-effort and level-of-satisfaction immediately following their classroom time. Wearable technology, specifically fitness trackers and apps, are popular, accessible and affordable. They have demonstrated effectiveness with adults who wish to improve and track their fitness levels.  At this same time, childhood obesity has become widespread due to cultural changes overtime. Children with obesity become obese adults. Further, due to the pressure of high stakes testing, physical education in schools is being reduced (Hursh, 2005) and in some cases eliminated. According to Sibley and Etnier (2003), "PE programs are being cut from our schools in favor of 'core academic' subjects" (p.243). Therefore, teaching children early how to recognize, monitor and improve their fitness is essential. Continuing to use physical education to support students' overall physical health, reduce obesity and improve their cognitive health is essential. According to a study by Sibley and Etnier (2003), they reported an educationally meaningful effect size of .32 (p. 251) for a positive association with physical activity and cognition. Thus this dissertation seeks to fill an important role in the literature. This exploratory study investigated the use of a technology-enhanced physical education model with children in the fifth grade. The results of the data collection and the instructional design with its theoretical underpinnings were explored. Because school districts have limited resources from teacher training time to funding, it is imperative that adopted technology has evidence of being effective and efficient in reaching school districts' goals and improving children's health.

## Research Questions

The following questions were explored: 1. To what extent can students improve their performance measures with technology-enhanced physical education? How does behavioral theory support the results from a pre- and post-test measure comparing students taught with technology-enhanced physical education versus students who are not exposed to technology-enhanced physical education? 2) To what extent are students' self-reported data consistent with their actual performance data, and does a cognitive view support this question? 3) To what extent do the affective components of technology-enhanced physical education impact performance? How do attitudes, feelings and moods impact teaching and learning within a technology-enhanced physical education model?

## Conceptual Framework

Evidence does show that those who utilize wearable fitness trackers do improve their fitness. However, Ertmer and Newby (2013) asserted that many educators operate under a limited theoretical background. Translating theory into instructional practices and evaluation is essential for creating quality-learning programs.

The researcher sought in this study to investigate the use of wearable technology on a broader scale through behavioral, cognitive and affective lenses. Through a behavioral lens, the researcher evaluated pre and posttest measures for students who used technology-enhanced physical education compared to those who did not to determine performance outcomes based on the treatment of the technology-enhanced physical education. Through a cognitive lens, the researcher wanted to know more. The researcher wished to investigate whether students could come to learn how improved fitness felt, potentially without the aid of the wearable device. Could students *learn* from their own perceptions and internally know how it felt to be working at high levels of fitness and potentially be able to sustain that level of activity without a wearable? Learning by definition is a sustained behavior over time (Gagné,1985). Literature investigating whether improvements aided by technology could be internalized and sustained over a period of time is limited. Finally, the researcher wanted to understand affective impacts on teaching and learning and how those beliefs and attitudes changed overtime. Therefore the researcher investigated students' attitudes and behaviors immediately following the treatment and one year later to determine how and if their behaviors changed over time.

## Integrative Study

The researcher partnered with a school in Saskatchewan Canada to conduct the study. The students had been using wearable fitness devices and an application to report their subjective feelings after their P.E. classes. The school's athletic commissioner wanted to know if the investment in the technology and the app was making a difference for the students.

In order to answer questions raised by school leaders as well as other questions grounded in the literature on wearable fitness devices, the researcher investigated the use of wearables and fitness apps through three mini studies. The first study looked at these data through the behavioral lens. Simply, what were the pre- and post test results on a performance measure. Hence do the students who utilized this technology-enhanced model improve their abilities while participating in the treatment? The second study investigated the ability of students to self- monitor their results. Could students' subjective reports (their perceived satisfaction and perceived level-of-effort) correlate with what they were actually doing and how they were performing? The third study looked at their feelings, moods and attitudes during the study and one year after the study. How were their feelings and moods during the treatment and did their attitudes and feelings sustain toward physical fitness one year later? (See Appendix A).

These three mini studies are investigated with theoretical underpinnings of learning theory. The first mini study looks at the results through a behavioral lens. The second mini study considered cognitive constructs and the final mini study utilized the affective construct to investigate the results.  Because of the three perspectives, the researcher considers this study an integrative study into the affordances and limitations of technology-enhanced physical education, as is further described in Table 1.1.

Table 1.1

*Three Integrated Mini Studies to Investigate Technology-Enhanced Physical Education*

Behaviorist, Cognitivist and Affective Views of Learning Outcomes in a Technology-Enhanced Physical Education Model with Fifth Grade Students

| Theoretical Lenses | Behaviorist | Cognitivist | Affective |
|---|---|---|---|
| **Methods** ↓<br><br>Participants | N = 127<br>ExpGr n = 88 (tech enhanced phys ed)<br>Control n = 39 (traditional phys ed) | N= 32<br>A sample of the experimental group was evaluated. | N= 19 Students narrative response<br>N= 4 Teachers narrative response<br>===========<br>1-year post survey<br>N=127 (control & exp groups) |
| Materials | Polar Heart Rate Monitors/Pre-Post Test Leger 20 meter shuttle run (Beep-test), pre and post hand grip and sit and reach | Polar Heart Rate Monitors plus FIT stats Self Reporting/Reflection application | Teacher and student reflective narratives<br><br>1-year post survey with 6 Likert-scale questions |
| Questions/Hypothesis | **Question:** Can technology-enhanced physical education improve performance on post-test for subjects who utilize the technology?<br>**Hypothesis:**<br>Behavioral constructs will provide support for this outcome and will help to validate the study as a reliable instructional method for behavior change. | **Question:** Can students accurately reflect on their performance thorough a self-report application (FIT STATS, 2016) compared to empirically collected data from Polar, 2016 wearables and how Cognitivist views support this outcome.<br>**Hypothesis:**<br>The results will show that students can successfully and accurately pair their self-response data with their actual performance data. Further their accuracy for correlation will improve over time. This positive correlation would support a Cognitivist and framework for learning. | **Question:** Do attitudes, moods, and beliefs (affective components) impact teaching and learning?<br>**Hypothesis:**<br>Positive attitudes, moods and beliefs will facilitate learning with a technology-enhanced physical education model. Creating an instructional design that supports positive affective components will increase the degree of learning. This positive outcome would support the benefits of affective components in learning outcomes. |
| Analysis | This analysis evaluated how Behavioral theory supported a technology-enhanced physical education model. | The analysis utilized SPSS to evaluate the correlation and linear regression of self-reports with actual performance measures. | The entirety of the data along with reflective interviews from teachers and students were analyzed to evaluate the affective components of instructional design. |

This dissertation examines data obtained in a semester long study of a technology-enhanced physical education model. The study investigated the use of wearable fitness trackers paired with a self-reflection application among 127 fifth-graders in a physical education classroom. The conceptual framework for the purposes of this dissertation is a blend of behavioral, cognitive and affective factors. It is holistic perspective focused on individual learners, specifically 5th graders, and includes the analysis of multiple data sets viewed through multiples lenses to create a composite view of the affordances and limitations of a technology-enhanced physical education model.

First students were evaluated on pre- and post-test measures to determine if the technology-enhanced physical education made an impact on post-test results for a common fitness measure, the 20-meter shuttle run (Leger, Mercier, Gadoury & Lambert, 1988). Behaviorist theory supports this outcome and will be discussed further as an important consideration in the development of the instructional design of technology-enhanced teaching and learning.

In addition to the improvement on post-test measures, the data were further investigated to determine to what extent students made cognitive adjustments in their ability to accurately self-regulate their performance. Students' accuracy in correlating their actual performance with self-reflective responses was investigated to determine if students became more accurate across events, and over time with more exposure to the use of the technology. As students used the technology-enhanced physical education model more, to what extent did they improve at rating their satisfaction and level-of-effort? Each student participated in approximately fifteen events over the 11-week period. Events are defined as a P.E. session in which the students were utilizing the technology-enhanced physical education. Teachers chose games and activities that would promote movement during the event/session. Each session was approximately 30-40 minutes in length. Some students completed more events and some completed fewer, but the average number of sessions was 15 sessions.  Cognitive theory was the conceptual framework used to guide the investigation of this outcome.

Finally, students and teachers provided post narratives about their perceptions of their use of technology-enhanced fitness model. Students' attitudes, beliefs, feelings and moods are an important consideration in the instructional design to facilitate learning. Self-efficacy improves self-regulation through students' increased use of metacognitive strategies (Pajares & Schunk, 2011). In addition to this qualitative data, the students from both the experimental and control groups were surveyed one-year later to determine if attitudes, moods and beliefs related to daily exercise and fitness were different among groups after a substantial elapse of time.

## Research Method

A secondary data analysis was conducted on data obtained by a school division in Saskatchewan Canada to evaluate student performance outcomes and self-reported perceptions within the context of the learning theories. Technology-enhanced physical education is defined for this research study as the use of a wearable fitness device paired with a student self-report app. As students participated and were active within 70% + of their maximum heart zone for a period of ten minutes or more, they were awarded digital badges for participation (POLAR, 2015). See Figure 1.1.

Immediately following their participation, students' self-reported two measures: level-of-effort on a scale of 0-10 and level-of-satisfaction on a scale of 1 to 5 (FITSTATS, 2015). See Figure 1.2.


*Figure 1.1.* Polar dashboard screenshot.

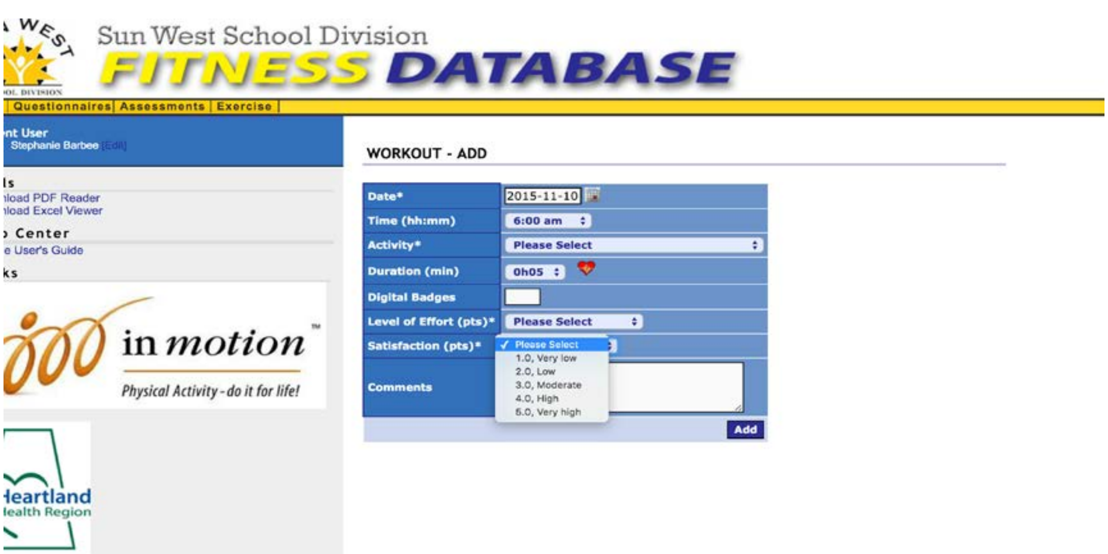


*Figure 1.2.* Satisfaction screenshot.

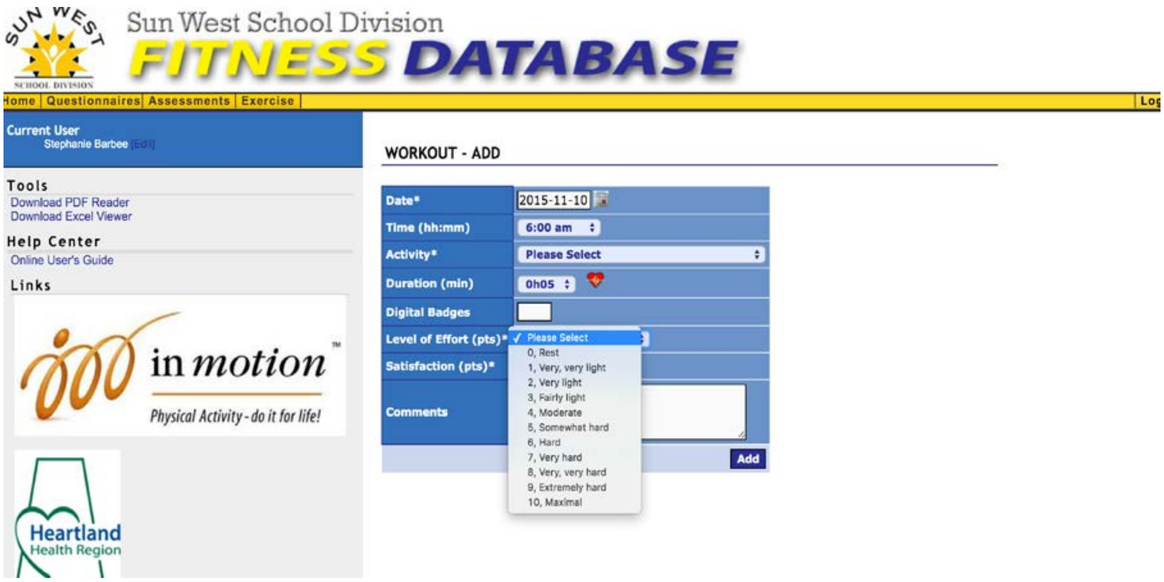

*Figure 1.3.* Screenshot from FITSTATS showing self-report measures

One hundred twenty-seven students and six teachers participated in the study. The data collection took place in Saskatchewan Canada with fifth grade students during the first semester of 2015. Eighty-eight students received the treatment and participated in using a technology-enhanced physical education model to improve fitness levels. Thirty-nine students acted as the control group and did not receive technology-enhanced physical education. Both groups received the same physical education curriculum. The study ran for 11-weeks and students participated in approximately 15 sessions. Each class period was 30-40 minutes long. The researcher provided directions to the athletic commissioner on the process for the study (See Appendix A). While the commissioner chose the schools, he reported to the researcher that the demographics were similar. There were 6 classes involved in the study. The first two classes were within the same school (school #1) and they were told they would receive digital badges and incentives if end-of-study goals were met. The next two groups were from school #2. They were told they would receive daily digital badges during their performance. School #3 represented the two classes of control. These students did not receive the technology-enhanced physical education during the study period. However all teachers were instructed to begin the study and teach the same curriculum at concurrent times. The athletic commissioner supervised the teachers and conducted the pre and posttest measures among all students; he met with teachers weekly to ensure the use of the technology and provided support for technical issues that might involve failed batteries, broken bands and technology concerns. It is important to note that conditions and curriculum were the same for both experimental and control groups. The only differences in the groups were the implementation of the technology-enhanced component. The commissioner oversaw and ensured the stability of the environments. Therefore all groups were receiving the same instruction on fitness and heart rate monitoring and the importance of physical fitness, but only four classes were receiving the technology-enhanced physical education. For the groups receiving the technology-enhanced physical education, those students were instructed to score their level-of-effort and their level-of-satisfaction immediately following their physical education time. The first two schools had access to multiple tablets within the physical education classroom so that students could input their self reported data immediately following the class period. However, school #2 with the other experimental groups were limited on their technology access. So students would report at different times, such as during a following class period or the next day. It is important to note that the students who did not receive the technology-enhanced physical education initially (the control group) were later provided the opportunity to work with the technology-enhanced features the following semester. It was important to the researcher that all students were ultimately given access to the benefits of the technology.

The following research questions were addressed:

1. To what extent can students improve their performance outcomes with a technology-enhanced physical education model and how does behaviorist theory support the outcome?
2. To what extent are students' self-reported data consistent with their actual performance data, and how does the cognitivist theory support this question?
3. To what extent do the affective components of technology-enhanced physical education impact performance? How do attitudes, moods, and feelings impact learning?

The data were analyzed using quantitative methods with SPSS, specifically a one-way ANOVA, correlation testing and regression testing plus qualitative methods such as content analysis and sentiment analysis. The following data analysis tools were used:

- One-way analysis of variance (ANOVA) –assessment on pre- and post-results of 20 meter shuttle run to evaluate the behavioral component of the study
- Correlation testing for the cognitive component
- Regression testing for the cognitive component
- Axial coding of teacher and student responses to technology-enhanced physical education for the affective component
- One-way analysis of variance (ANOVA) assessment on the 1-year post survey of attitudes, moods and beliefs with both control and experimental to evaluate their affective responses one year later for the post-affective component

## Operational Definitions

*Technology-enhanced physical education* for the purposes of this research is the use of a wearable fitness heart monitor (Polar, 2015) paired with a self-report application (FITSTATS, 2015). Each student was assigned a numbered wearable unit that tracked their heart rates in real-time while they were wearing the devices. While the devices were in use, students had access to a display board that calculated and projected their current earned number of digital badges (Table 1.2). After each session of physical education, the students utilized tablets to rate their experience by reporting their level-of-satisfaction and their level-of-effort. Their use of the technology was hypothesized to positively impact their behavior, their cognitive state and affective states, which if verified would support the concept of the use of integrated technology-enhanced physical education.

*Maximum heart rate (MHR)* ("Target Heart Rate," 2016) is calculated by using the following formula: 220 - your age = MHR. For the purposes of this study Polar (2015) had a default setting for the fifth graders of this study resulting in an MHR of 200. Therefore an MHR of 200 was used in the study.

*Target heart rate (THR)* for this study was between 70% and 90% of the students MHR. Students earned badges (one for every ten-minutes) they were performing in at their THR.

## Delimitations

While previous research had shown that improved physical fitness improved cognition (Butte, Elelund & Westerterp, 2002; Fedwa & Ahn, 2011; Sibley & Etnier, 2003), the researcher chose to focus this study on the direct benefits of the technology for fitness improvements. To what extent did the technology improve a pre- and post- physical fitness test measure? To what extent did the technology *teach* students how to potentially self-monitor their activity levels without the aid of the technology? To what extent did affective components impact results immediately and post study? Certainly there would be an important role for others to fill by continuing this research beyond the immediate health effects – to investigate cognitive changes over time and how improved fitness impacts student cognition.

## Prospective Limitations

Several limitations were identified before initiating the study. First and foremost was that the data evaluated were secondary data, not gathered by the researcher. The degree of control over the data collection process was limited to the degree of the ability of the collectors who were the athletic commissioner and teachers within the school district. However, the athletic director was provided instructions and guidance on processes and protocols for collecting the data, which included but were not limited to the importance of randomization of the groups, establishing baselines, ensuring other variables were stable such as the assigned activities and the time of data collection across groups. Furthermore, the data collectors/teachers were advised on proper classroom procedures in which the same curriculum was to be taught among control and experimental groups. The athletic commissioner and researcher met regularly via Skype and corresponded via email to discuss the status of the study and addressed issues and concerns related to the study.

Additional limitations included a small sample size. The initial sample size was $N$ = 127; Eighty-eight fifth graders utilized the technology over a semester long period and 39 students received traditional fitness instruction. The time period of data collection was also a limitation, 11 weeks for initial data collection, as a longer duration of technology-enhanced physical education activities might be expected to produce longer lasting effects.

A further anticipated limitation was that the data used to evaluate the cognitive component would require significant data preparation and scrubbing. Two databases had to be manually matched by participant when possible and combined to create a new data set. This reduced the number of participants in this portion of the study to $n = 32$.

Finally, the limitation regarding the affective component data was that only 19 of the students and four teachers reported comments that could be used in the qualitative analysis making $n = 23$ for this investigation. It is also important to note that only one coder (the researcher) identified themes within the text among the students and teachers. Best practice is to have multiple coders to conduct the content analysis. Holstii (1969) stated that coder bias exists. One coder is a limitation and Holstii (1969) suggests that having multiple coders can help reduce bias and improve the reliability of the results.

## Significance of the Study

The researcher's hope was that this study would provide empirical and theoretical evidence to schools, school districts, physicians, communities, parents and caretakers to support the use of integrated technology-enhanced physical education to improve children's fitness and health. This dissertation sought to demonstrate that children's health is a global concern that can be potentially addressed with affordable and easy to access technology paired with instructional designs supported by learning theory. Furthermore, since research shows that physical activity improves cognition (Butte, Ekelund & Westerterp, 2002; Fedwa & Ahn, 2011; Sibley & Etnier, 2003), the researcher believed this is an important point to attempt to make, providing evidence that this type of research has potential impact that reaches far beyond the researcher's initial questions.

# CHAPTER 2

# RELATED LITERATURE

Research into wearables for fitness education and children is limited. Partly, this limitation is a result of researchers' restricted access to school systems. Privacy laws in the United States restrict research in school settings. While research in the United States is not impossible, it requires more attention toward privacy and anonymity and requires both parental and student assent as well as school and teacher support. Therefore the researcher chose to work with students from a Canadian school division. However, these results can provide a good foundation for U.S. schools to consider their options and make informed decisions regarding the implementation of a technology-enhanced physical education model.

## Current Research

In a 2014 study by Miller and Mynant, and their investigation into the use of pedometers over four weeks with forty-two middle school students showed that students attitudes about fitness improved and provided evidence for the potential of social computing systems to impact behaviors. This study focused on the social component of improving students' fitness levels. Students used pedometers and met frequently to reflect on their experiences. In addition, they logged web comments in a blog format and earned activity points they could spend on a social game. Results showed the most improved performance was for students who had the lowest initial activity. While the researchers of this study acknowledged that the month-long study was a limitation, they showed that a blended online/offline approach to improving adolescent fitness had promise. Miller (2013), in a different publication noted that, “ubiquitous computing theory from a decade ago is finally impacting people in daily life” (p. 26). Miller who studies human computer interaction (HCI) acknowledged that much improvement is needed to effectively investigate how people, specifically adults, interact with body sensors. The *quantified self* movement where people monitor personal daily habits is becoming commonplace among adults. Miller (2013) defines the *quantified self* as a “movement-in which people self-monitor as much as they can of their daily habits, moods, exertion, and food” (p. 24). He continued that now these users are taking on fitness trackers as part of their *quantified self*. Miller (2013) also asserted that longer studies are needed now to understand the components of effective integration. Miller noted we have moved from making the sensors work effectively to the need to understand why and how they can improve fitness for all.

While the *quantified self* is a phenomenon that is growing among adults with access to such technologies, some studies reported that younger people are slower to adopt this type of technology. Weiss (March 2, 2015) noted that wearable technology adoption among young adults is being adopted slowly. Based on 454 young adults at a southwestern university who responded to her survey, “more than 80 percent were familiar with wearable technology, but only 16 percent owned a device” (Weiss, March 2, 2015, p. 9). Weiss surmised that young people are still at the early-adoption stage of integrating wearables into their daily lives. For these young adults the reason for not owning a device was due to necessity, the knowledge of the device and the cost of the device. However Weiss noted that 30% of the respondents planned to buy one in the future.

Lee, Drake and Williamson (2015) noted that wearable devices are becoming part of our "technological ecosystem" (p. 46), in the way laptop computers, tablets and smart phones have. As students accumulate data from wearable trackers they become better at understanding and interpreting data. Their study showed that as students participated in different activities and monitored their heart rates, they also used their knowledge of how they felt subjectively to push themselves further. "Specifically, the students in this study were interested in identifying athletic training activities that would make them work harder" (Lee, Drake & Williamson, 2015, p.48). Their study also focused on using personal data to leverage increased interest in content areas such as math and science. The wearable devices made their learning activity more relevant as the students were learning statistics using their personal class data. They stated that the advantages of incorporating class data from wearable devices are that "1. Students can passively acquire a large amount of data and 2. Students will be intimately familiar with the activities in which the data were generated" (p. 52). This access to information, data and communications could be motivation for educators who wish to the leverage learning sciences with modern technology. Lee, Drake and Williamson (2015) also acknowledged the limitations of wearable technology within instructional designs. The limitations included having the space for data transfer and making sure existing firewalls will allow services from third parties. They noted too there are issues with privacy and the affects data sharing might have on students.

Borthwick, Anderson, Finsness and Foulger (2015) stated that "adopting wearables within educational arenas will require an understanding of change theory" (p.90). Those educators who utilize wearables to address personalized learning needs “are operating in a new educational paradigm” (p.90).

We know wearables are beginning to emerge in the K-12 environment. Current research suggested that wearable devices will have a significant impact in teaching, learning and creative inquiry within the next five years. The New Media Consortium K-12 Horizon Report (2014) stated “the number of new wearable devices in the consumer sector seems to be increasing daily, greatly outpacing the implementation of this technology in schools” (Johsnson, Adams Becker, Estrada & Freeman, 2014, p. 44). However, they noted, “that the education sector is just beginning to experiment with, develop, and implement wearable technologies.”

With these changes comes the need to carefully create instructional designs that will support the use of technology within the learning environment. According to Ertmer and Newby (2013), “The need for a bridge between basic learning research and educational practice has long been discussed” (p. 43). With the anticipated growth and proliferation of wearable devices, it is important that instructional designs to support the whole learner accompany their arrival. These designs should be grounded in learning theory, focused on a combination of behavioral, cognitive and affective outcomes.

The literature is rich with research that demonstrates the importance of instructional design to support technology adoption within schools. Design research is important to be able to integrate scientific and education values through the “active involvement of the researcher in learning and teaching” (Wang & Hannafin, 2005, p. 5). While the research and design have evolved regarding technology integration, they have had little influence on practitioners’ willingness to adopt these technologies within the classroom. Therefore, adopting technology without solid instructional design will likely result in failure across all systems, including but not limited to, teacher's lack of acceptance to adopt, students reduced interest in the technology and a failure to return on a school's investment. It is important to understand how an integrative multi-lens approach to integrating technology-enhanced physical education can assist practitioners in adopting effective technology.

## Theory to Practice

Instructional design is intended to support learning. Instructional designers are very interested in learning theories that help to define learning (Smith & Ragan, 1999). Learning as defined by Gagné (1985) is a, "change in human disposition or capability that persists over a period of time and is not simply ascribable to processes of growth" (p. 2). The following material reviews behavior theory, cognitive theory and the affective components that impact learning.

Ensuring that instructional design is grounded in theory and research is essential to ensure its success. This study examined the data of a technology-enhanced physical education model through behavioral, cognitive and affective lenses. Dewey (1900) asserted that there is a need for a middleman to help bridge the gap from psychological theory to actual practice. This task of understanding theory and psychology should not be placed upon the practitioner/teacher but what Dewey calls an "educational theorist," (p. 324). He asserted that it is this person's responsibility to bridge learning theory and practice through effective instructional design. Only then by doing so, can the practitioner deliver instruction effectively and efficiently.

While this researcher did not intend an exhaustive study of the history of theory related to instructional design, an understanding of the theories provided foundational support for the results of this study.  The study included three parts focusing the instructional designs on behaviorism, cognitivism and the affective lens; it is important to note that the researcher believes that these three designs should not be taken in isolation but taken together as a holistic and composite instructional design for teaching and learning with technology-enhanced physical education.

## Behaviorist View

Traditional behaviorism operates on a principal of stimulus-response (Skinner, 2011). Skinner asserted that operant conditioning is different than conditioned reflexes. Operant conditioning's definition asserted that when a behavior is followed by a reinforcer, it is more likely to occur again. Designs for wearable technology for fitness learning using basic behavioral pedagogy include stimulus/response, positive reinforcement, shaping and behavior modification. A student wears the device and is provided with personal metrics on his or her performance. Students are motivated by the feedback of the wearable. This immediate feedback encourages students to continue the behavior.

It is important to recognize that behaviorism, cognitivism and affective states all play a part in learning. This integrative perspective is important when teaching and learning with technology. This supposition is illustrated by Karl Popper's theory of three worlds. According to (Harlow, Cummings & Aberasturi, 2005), Popper believed in three worlds, his world #1 was the external environment and processes as they exist in nature; world #2 was our interpretation of that external environment which is subjective; and world #3 represents the products and creations such as art, language and other forms of creation. This view is supportive of an integrated process for learning. It is this researcher's opinion that Popper's worlds align with behaviorism, cognitivism and affective components for learning. While this study looked at three components it is important to understand them working as a system rather than in isolation.

Behaviorism measures learning with a change in the form or frequency of a desired observable behavior, and asserts that behaviors that are followed with reinforcements are most likely to reoccur. Mental processes are not assessed. The learner is reactive to the conditions in the environment (Ertmer & Newby, 2013). Further assumptions of the behaviorist theory relevant to instructional design include an emphasis on observable behaviors, a learner pre-assessment to determine where instruction should start and the use of reinforcement such as informative feedback to increase the behaviors. With a focus on instructional design, behavioral theories assert that the job of the teacher is to determine the cues that elicit desired behaviors, arrange opportunities for practice, and arrange the educational setting so that students can make correct responses and receive positive feedback (Ertmer & Newby, 2013).

Twenty-first century behaviorism shows that the foundational principles of behaviorism are still evident in motivating and promoting desired behaviors. Nilsen and Pavel (2013) stated in their study that, "many behavioral change interventions for health have shown positive results. However behavior change programs have not been well-integrated into the public health care system" (p.25). They stated that an expansion of behaviorism is needed when measuring behavior change in the digital world to help explain the "just-in-time dynamics" (p.

26). These new technologies provide us more information to mathematically model behavior and decision-making. The use of digital badges in the classroom (see Barbee and Bennett, 2016) are evidence that this just-in-time technology can produce more effective measurements of behavior. The technology simply reinforces Skinner's theory. Nilsen and Pavel (2013) go on to assert that technology to support behavior change in health care has far reaching implications. Through unobtrusive devices paired with proper instruction supported by behavioral theory, practitioners can optimize many health interventions improving health care for all.

Further while Nilsen and Pavel (2013) acknowledged the positive effects of behavioral theory on behavior changes, they noted that behavioral change could not account for all learning. They continued that though empirical evidence exists to support behavioral constructs for change, they acknowledged that long-term sustainable change is much more difficult to measure. "Other constructs such as motivation, stress and self-control are also drivers of behavior change," (p. 26). Cognitive function is a factor as well as context. Behavioral theory while valid, cannot account for all behavior change. The next section will discuss how cognitive theories support the instructional design for a technology-enhanced physical education model.

## Cognitivist View

Ertmer and Newby (2013) state that it is "agreed that behavioral principles cannot adequately explain the acquisition of higher level skills or those that require a greater depth of processing" (p. 49). With the cognitivist view, the focus is not on observable behavior but on constructs within the mind. Cognitivists emphasize more complex processes such as thinking, problem solving, language, the formation of concepts and the processing of information

(Snelbecker, 1983). The learning is focused on what students know and how they come to know versus what they observably do (Jonassen, 1991b). The cognitive approach focuses on mental activities and the way learners "attend to, code, transform, rehearse, store and retrieve information" (Ertmer & Newby, 2013, p. 52). Further, the learner's beliefs and attitudes are considered to be an important component of the learning (Winne, 1985).

Cognitivist theories rely on the idea of schema or preexisting knowledge in order to build a foundation on pre-existing knowledge to extend and grow knowledge to become a part of a student's memory and their permanent mental structures. However behaviorism is focused more on rote learning not linked to a person's cognitive structure, therefore the learning can be easily forgotten (McLeod, 2003). It is important to note here that the researcher sees behaviorism, cognitivism and affective components working synergistically to create knowledge and promote learning.

Cognitive principals related to instructional design include an emphasis on a student's metacognitive monitoring and self-reflection abilities and an emphasis on synthesizing information and creating learning environments that encourage students to draw from their previous knowledge/schema (Ertmer & Newby, 2013). According to Anderson (1996), cognition forms from an interplay between declarative knowledge and procedural knowledge and the ability to activate this knowledge within a learning environment.

For the purpose of this research, it was important to know if students can internalize the basic behavioral shaping strategies. Can they learn to change their behaviors without the assistance of a device? The goal for the technology-enhanced physical education is for it to impart long-term effects, improving fitness in the long run. The hope is that students can cognitively construct what target behavior feels like without the use of technology-enhanced instruction. In other words the researcher wants students to learn what enhanced fitness feels like and manage that behavior (the ability to regulate heart-rate and performance levels) without the direction of wearables or applications.

Vygotsky's (1978) zone of proximal development states that learning takes place in the area where the student is most open to receiving guidance and that once that guidance/teaching/reinforcements is made in this area, learning is likely to occur. Providing instruction in the zone of proximal development sets the learner up for higher cognitive tasks in the future. This concept is also referred to as scaffolding. It is the researcher's view that the scaffolding for this study was the behaviorist component, shaping students performance levels through badge earning. As students learned what high-levels of performance felt like internally, they could make that cognitive transition.

Teaching and learning are complex constructs that involve many facets. In addition to observable behaviors (behaviorism) and changes within the mind (cognition), affective components play a key role in instructional design. Students come to a task with beliefs, attitudes, feelings and emotions. Understanding affective components within instructional design is essential for successful integration.

## Affective View

Supporting the idea that the behaviorist, cognitivist and affective components work in combination to impact learning is the research of Jones and Issroff (2005). They stated that in the past, the trend has been to study (quite separately) the distinctions between cognitive, social and emotional development. However, Jones and Issroff (2005) note, “the distinctions have gradually been eroding,” (p. 396) and acknowledge that affective components represent a large supportive piece to cognitive theory and learning. This research shows the affective outcomes of the study and it can be observed that the positive affective statements are reflective in the positive behavioral and cognitive outcomes of this study.

Taking into account students’ attitudes and beliefs is essential to successful outcomes. The affective domain includes the way in which people to respond to situations through their feelings, beliefs, attitudes, motivations and values. The literature was explored as it related to affective components for teaching and learning. Krathwohl, Bloom, Masia (1956) asserted a taxonomy related to the affective domain. They acknowledged in their book that developing a domain for affective components in learning is much more difficult than developing the cognitive domain. Krathwohl, Bloom and Masia (1956) asserted that the difficulty in creating an affective domain arises out of the difficulty of the lack of “immediacy of results” (p. 18). While cognitive skills can show quick and immediate results on an exam, interests and attitudes develop slower and over a period of time. They continued later, that perhaps the opposite is true that attitudes are formed immediately and that cognition develops over time. Krathwohl, Bloom and Masia then asserted that perhaps both occur at the same time (p 19). It is evident from this vacillation, that creating an affective domain was a difficult task. What they do agree on is that acquiring skills at the top/highest level of each domain, both affective and cognitive domains is the most difficult. Krathwohl and team proposed a five level hierarchy for the affective domain. Progressing from lowest to most complex, these are 1. Awareness, receiving phenomenon 2. Response to phenomenon, active participation, 3. Valuing, the worth a student attaches to a task, 4. Organization, student organizes values/attitudes into his system and resolves conflicts, 5. Internalizes values, the value then is transformed into a predictable, consistent behavior. The researcher asserts that there is evidence here that behaviorism and cognitivism are blended within this hierarchy.

To measure affective outcomes, the researcher followed the experiment with open-ended questions to the students and teachers as the researcher did not want to limit comments or restrict responses in any way. Furthermore, the researcher was interested in attitudes and beliefs one-year after the experiment, and this component was analyzed with a Likert-scale instrument measuring attitudes and behaviors toward fitness. Both data collections revealed interesting information related to affective components within instructional designs.

This study analyzed the data within the context of three lenses: behavioral, cognitive and affective. The study provided a composite exploration into the affordances and limitations of an integrative-technology-enhanced physical education model.

# CHAPTER 3

# METHODOLOGY

A secondary data analysis was conducted on data obtained by a school division in Saskatchewan Canada to evaluate the theories behind the instructional design of a technology-enhanced physical education model. Technology-enhanced physical education as defined for this research is the use of a wearable fitness device that measures target heart rates paired with a self-report application.  As students participated and were active at 70% or more of their maximum heart zones for a period of ten minutes or more, they were awarded digital badges for participation (POLAR, 2016) at this intensity level. Immediately following their participation, students self-reported on two measures: level-of-effort on a scale of 0-10 and level-of-satisfaction on a scale of 1 to 5

Students were randomly assigned by class by the athletic commissioner. One hundred twenty-seven fifth grade students participated in the study. There were six classes with six teachers. Three schools were involved in the study. The researcher advised and the athletic commissioner agreed to obtain informed consents and assents by parents, teachers and students. The first school included two separate classes. These students utilized the wearable tech and were offered an additional incentive such as hats, pencils, etc. if they met a negotiated goal at the end of the study. The second school with two separate classes just earned the digital badges and finally the third school had two separate classes that represented the control groups. All groups received the same curriculum and participated in the study for the same amount of time. The study took place in fall 2015 over an 11-week period. The experimental group was comprised of 88 students and the control group included 39 students. Polar H7

Heart Rate Sensors (Polar, 2016) were utilized as the wearable device for the experimental group. Data from the wearable was captured in a display and digital badges were awarded as students participated in 70% or more of the their maximum heart rate. See Figure 3.1.

*Figure 3.1.* Screenshot from the Polar application showing number of minutes in target heart zone. Taken from: Polar (2015) application.

The students used an application through FITSTATS Technology Software Program (2015) to log self-reported data on their perceived level-of-effort and level-of-satisfaction (FITSTATS, 2015). See Figure 3.2.

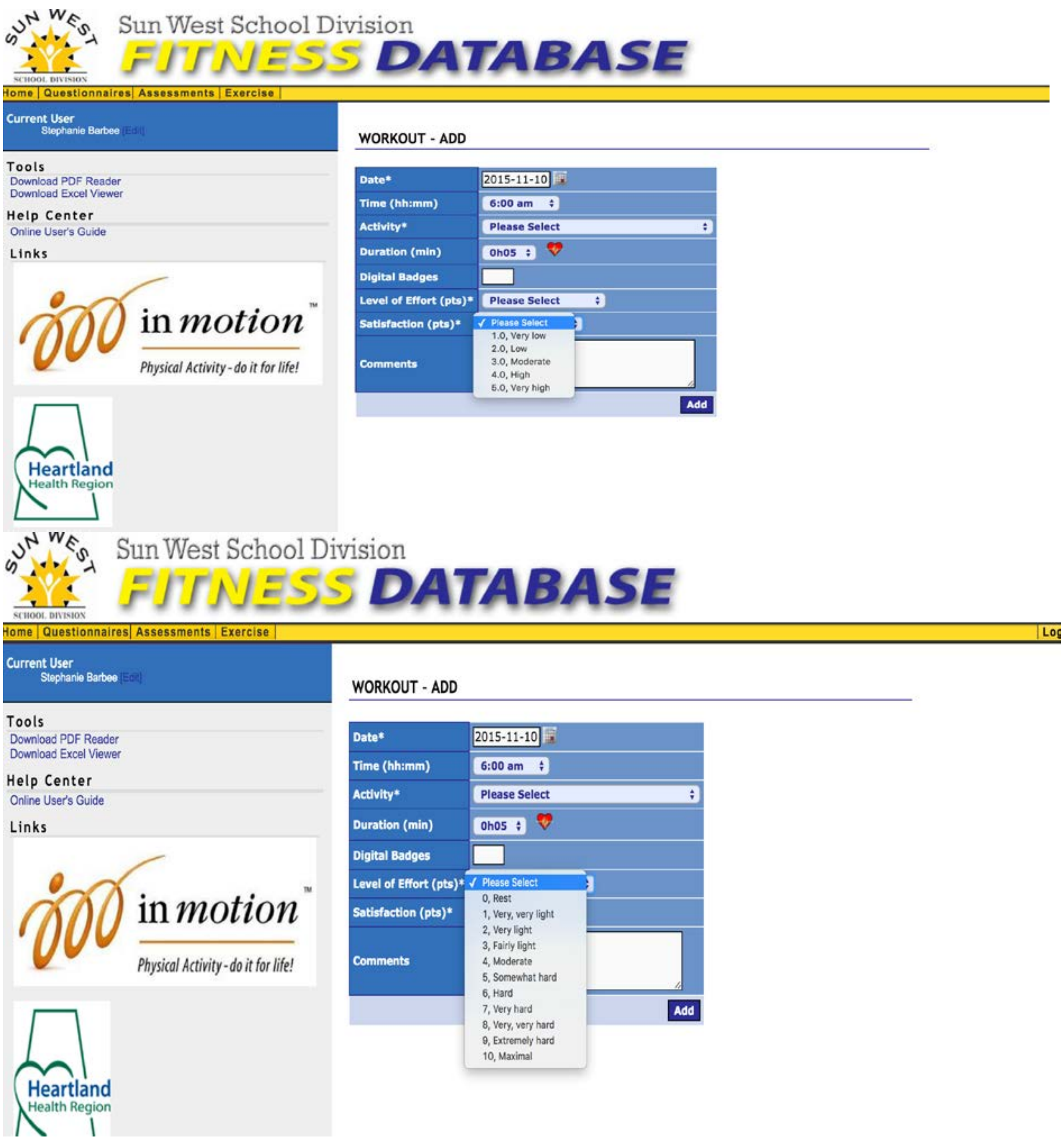

*Figure 3.2.* Screenshots from FITSTATS app where students self-reported level-of-effort and level-of satisfaction. Taken from: FITSTATS, (2015) application.

Behaviorist Methodology

The data were first analyzed reviewing pre- and post scores on a 20-meter shuttle run which is a common measure for physical fitness (Barbee & Bennett, 2016). A 20-meter shuttle run is an exercise test developed by Leger & Lambert (1982) where participants run back and forth between parallel lines positioned 20 meters apart. The students start at one line and are signaled by a beep to run 20 meters to the opposite, parallel line. The beeps gradually get faster which increases energy demand, and students are scored based on how many complete laps they ran before becoming unable to run (exhausted). Liu, Plowman & Looney (1992) tested the reliability of the 20-meter shuttle run to measure endurance and found it to be a reliable assessment.

All students, 88 in the experimental group and 39 in the control group were given baseline tests for the 20-meter shuttle run. Then, following the 11-week treatment, students were then give a post-treatment 20-meter shuttle run assessment. The experimental group ($n$ = 88) received the technology-enhanced physical education model and the control group ($n$ = 39) did not utilize the technology-enhanced model but participated in the same physical education curriculum. The experimental groups were spread over two schools and four classrooms. The first school (with two classes of students) was told that along with digital badges as an incentive, if they met a negotiated benchmark (number of badges) by the end of the study, they would receive tangible items such as hats, pens and t-shirts. The other school with the remaining two classes was told that they would receive digital badges for every ten minutes they were at 70% or above their maximum heart range. All teachers (control and experimental) were instructed by the athletic commissioner to present the same division-approved curriculum regarding measuring, monitoring and improving heart rates. The researcher worked directly with the athletic commissioner of the school division who gave instructions on procedures, protocols, and timelines. The behaviorist methodology was investigated to support behavior change and shaping with a reward structure and addressed Research Question 1: To what extent can technology-enhanced physical education improve performance on a post-test and how does the positive reinforcement of the badges support the outcome? A one-way between subjects ANOVA was conducted to compare the effect of technology-enhanced physical education on the performance outcome of a post-test (11 weeks later) 20-meter shuttle run on students with technology-enhanced physical education and those who did not receive the technology-enhanced instruction. The behaviorist model asserted that reinforcements (digital badges) will increase the desired behavior. Results are presented in chapter 4.

## Cognitive Methodology

Measuring learning from a cognitivist methodology is more complex. Cognitive learning theory does not focus on observable behaviors, but rather focuses on constructs within the mind including associations and the development of schema for learning. To measure changes in the students from a cognitivist view, a different data analysis was performed. Instead of looking at pre- and post-results on an outcome measure, the researcher investigated the correlation of the self-reported measures: level-of-effort and level-of satisfaction and compared those to actual student performance as measured by the Polar device and evidenced through badge-earning behavior (working at 70% or above maximum heart rate). 1) The researcher performed 30 separate correlation coefficient analyses within SPSS (15 for badges correlated with level-of-effort and 15 for badges correlated with level-of-satisfaction). 2) After the coefficient numbers were determined for badges/level-of-satisfaction and badges/level-of-effort, a simple regression was conducted to determine if a significant positive correlation was indicated for either condition, badge-earning with level-of-effort or badge-earning with level-of-satisfaction.

Details of data collection frequency of occurrence and rating scale options are provided in this paragraph. For every ten minutes that students were at 70% of their maximum heart rate or above, students were awarded one digital badge. These data were collected by the Polar application. At the end of the class, students utilized iPads to report their level-of-satisfaction and level-of effort within a separate software program, FITSTATS. The level-of-satisfaction rating was a Likert (1932)-scale with a rating option from 1 to 5; 1 = Very low, 2 = Low, 3 = Moderate, 4 = High and 5 = Very high. Subsequently the level-of-effort scale was a Likert-scale with a rating option of 0 – 10; 0 = Rest, 1 = Very, very light, 2 = Very light, 3 = Fairly light, 4 = Moderate, 5 = Somewhat hard, 6 = Hard, 7 = Very hard, 8 = Very, very hard, 9 = Extremely hard, 10 = Maximal. The scales were created by the program for FITSTATS. This self-reported data was correlated with the hard data retrieved from the Polar H7 devices. It is important to note that level-of-satisfaction is an affective component. This supports the idea that cognition and affect are dependent upon each other and should be carefully analyzed because of their dependent nature.

Data scrubbing processes were utilized to match the Polar, wearable data to the students' self-reported data obtained in a different database, FITSTATS. In one school, due to technology limitations, students did not have access to the self-report application immediately following the physical education session. Therefore their self-reported measures were delayed and as a result, the dates of their self-report and their actual performance could not be verified by the researcher. Because data came from two sources and then had to be hand-keyed into one master document, this reduced the sample size for this portion of the study to 32.

The following steps were used in the data scrubbing process: 1) The researcher compared Polar data to the FITSTATS data to determine the start date of the data collection process and numbered each event on each set of data to ensure an exact match of dates. 2) The researcher collapsed Polar data. Polar data was reported as number of seconds/minutes in five levels of intensity: 50-59 % of students' Maximum Heart Rate (MHR), 60-69% of MHR, 70-79% of MHR, 80-89% of MHR, and 90-100% of MHR. The researcher collapsed the data into two groups, combining the 50-59% of MHR and 60-69% of MHR into the first group to determine total minutes below 70% of MHR and then combined the 70-79% of MHR, 80-89% of MHR and 90-100% of MHR into the second group for a total number of minutes at 70% of MHR or above. Only at 70% of MHR and above do students earn badges. They must be in the 70% or greater zone for ten minutes or more to earn the digital badge. 3) The researcher then created a new spreadsheet with the cleaned and synthesized data to document the new combined data. Because of extensive data cleaning measures, only a sample of the experimental group was taken for this analysis (*n* = 32).

Correlation coefficients were calculated between badges-earned and students' perceived level-of-effort and their perceived level-of-satisfaction using the Statistical Analysis for the Social Sciences (SPSS) system. The badges-earned data was used because this value represented the total time students were at 70% or more of their MHR. These data were captured in a new spreadsheet to examine the correlation between number of badges earned and level-of-effort, as well as between badges earned and level-of-satisfaction over 15 trials.

Next a two regression analyses was performed, predicting the correlations between level-of-effort and badges earned, and level-of-satisfaction with badges earned, from the passage of time (and cumulative physical effort) across 15 trials/sessions – and evaluating the change over the course of 15 trials/sessions in the alignment of self reported perceptions of: a) level-of-effort with badges awarded and b) level-of-satisfaction with badges awarded due to participants being in the zone of >70% of maximum heart rate for at least 10 minutes.

This analysis was conceived as very important because it addresses students' ability to self-perceive their level-of-effort and satisfaction without the support of a wearable device. This analysis addressed Research Question 2: To what extent are students' self-reported data consistent with their actual performance data and how do cognitivist theories support this question? Results are presented in Chapter 4.

## Affective Methodology

To evaluate the affective components during the application of technology-enhanced physical education, the researcher investigated this construct from two perspectives. The first perspective included data collection taken immediately following the study. The researcher evaluated open-ended questions given to both students and teachers. See Figure 3.3 for a list of the questions asked.

Data were first analyzed in a qualitative content analysis through axial coding and sentiment analysis (Hoepfl, 1997). Findings are reported in Chapter 4.

The researcher found 79% positive statements toward the technology-enhanced physical education and 21% negative statements resulting from teachers' responses. Similarly the researcher found 88% positive statements toward the technology-enhanced physical education and 12% negative statements from student responses. While statements originate from the cognitive domain, sentiments originate from the affective domain. In this case statements were coded as sentiments for the purposes of this study.

**Follow-up Questions to Technology-Enhanced Physical Education, Fall 2015**

1. **Describe the benefits associated with the use of the technology-enhanced physical education model (consider both student and teacher).**
2. **Describe the barriers associated with the use of the technology-enhanced physical education model (consider both student and teacher).**
3. **Describe your experience with the application of the technology (was it easy/difficult to use, explain)**
4. **Do you have any individual success stories that you could share?**
5. **Are there other comments you would like to make regarding this project?**

*Figure 3.3.* Follow-up questions to technology-enhanced physical education.

The second data collection was taken one year after the study, during fall 2016. The researcher utilized a Likert (1932) scale instrument one year later to evaluate both experimental and control groups on their attitudes related to daily exercise and fitness. This scale was a modified scale adjusted to reflect attitudes and behaviors related to daily exercise and fitness. Originally this scale was utilized by Paman and Thompson (1988). The survey was checked for reliability and was determined to be a reliable scale. An analysis was performed on the survey items with SPSS, resulting in a reliability index of Cronbach's alpha = .78. This is deemed "respectable" according guidelines published by DeVellis (1991). A list of the items on the survey is provided in Figure 3.4.

1 Year Post-Survey on Moods, Beliefs and Attitudes Regarding Daily Fitness

1. What is your gender
    - Male
    - Female

2. I engage in physical exercise on a daily basis
    - Never
    - Sometimes
    - Usually
    - Always

3. I engage in one or more of following forms of exercise: walking, jogging/running, or weightlifting.
    - Never
    - Sometimes
    - Usually
    - Always

4. I exercise more than 3 days per week.
    - Never
    - Sometimes
    - Usually
    - Always

5. When I don't exercise, I feel guilty.
    - Never
    - Sometimes
    - Usually
    - Always

6. I sometimes feel like I don't want to exercise but go ahead and push myself anyway.
    - Never
    - Sometimes
    - Usually
    - Always

7. I will engage in other forms of exercise if I am unable to engage in my usual form of exercise.
    - Never
    - Sometimes
    - Usually
    - Always

*Figure 3.4.* 1-year post-survey on moods beliefs and attitudes regarding daily exercise (Pasman & Thompson, 1988)

The researcher utilized the open-ended questionnaire and survey data to determine how affective components (immediate and long-term) influenced learning with an integrated technology-enhanced physical education model and addressed the following research question 3: How do attitudes, feelings and moods impact teaching and learning within a technology-enhanced physical education model?

A one-way between subjects (ANOVA) was conducted to compare the differences in attitudes and beliefs related to daily exercise between the control and experimental groups one year after the treatment was given to the experimental group. Results are presented in Chapter 4.

CHAPTER 4

RESULTS

Research Questions

The following chapter addresses the results for the three research questions:

1. To what extent can technology-enhanced physical education improve performance on a post-test and how does behaviorist theory support the performance outcome?
2. To what extent are students' self-reported data consistent with their actual performance data and how do cognitivist theories support this question?
3. To what extent do attitudes, feelings and moods impact teaching and learning within a technology-enhanced physical education model?

Behaviorist View

A one-way between subjects analysis of variance (ANOVA) was conducted to measure the effect of technology-enhanced physical education. The analysis was conducted by Barbee and Bennett, 2016 to determine what effect the independent variable, technology-enhanced physical education had on students' scores on a 20-meter shuttle run under two conditions: one with technology-enhanced physical education and one without technology-enhanced physical education. There was a significant effect of the technology-enhanced physical education between the control and experimental group at the $p < .01$ level for two conditions [$F(1, 125) = 32.65$, $p = -000$]. The effect size, Cohen's $d = 1.09$ and is reported as a "large effect" according to Cohen (1988). The results of this assessment are supported through a behaviorist theory of learning. The rewards through badges shaped and improved desired behaviors in the group receiving the treatment. See Figure 4.1.

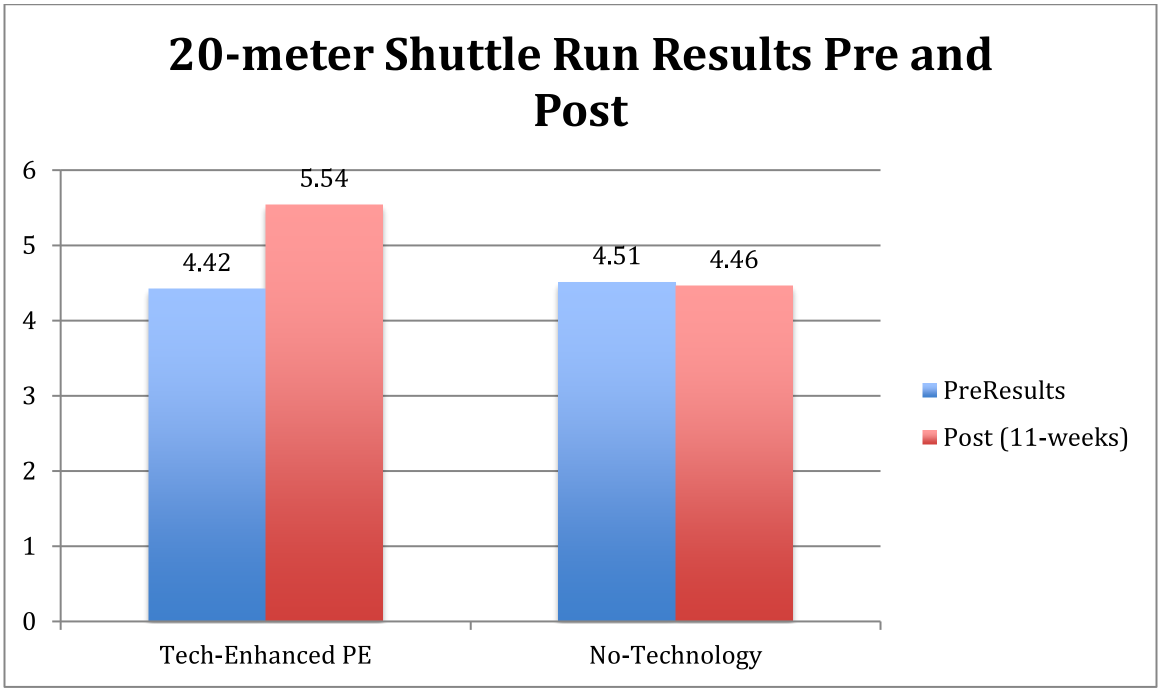


*Figure 4.1.* The mean calculations of 20-meter shuttle run results with technology-enhanced physical education and without technology enhanced physical education.

Cognitivist View

A bivariate correlation was calculated in SPSS to determine correlations between badges-earned and reported level-of-effort, and badges earned and reported level-of-satisfaction. While more precise data was acquired showing students exact number of minutes and seconds at levels at 70% or more of their target heart rates, for the correlation measure, badges were used as the outcome measure. Badges directly reflect students' time in the 70%+ zone and offer a more parsimonious analysis.

Next a simple linear regression was run using SPSS to predict the correlation coefficient calculated between badges-earned and reported-level-of effort at the end of each training trial (15 total), from sequence number in the trials (1-15). A similar regression predicting the correlation between badges-earned and reported-level of satisfaction from sequence number in the trials (1-15) was also run with SPSS. A significant ($p < .05$) progression of higher alignment between reported level-of-effort and badges earned over time was found ($F(1,13) = 13.619$, $p < .003$) with an $R^2$ of .512, indicating 51% of the degree of alignment between reported level-of-effort and badges earned could be explained just by knowing the sequence number of the physical education trial when the data were recorded. The best fit equation had participants' predicted correlation coefficient between reported level-of-effort and badges earned as equal to .480 + .018 (time) when time is measured in sessions. Therefore, participants' correlation coefficients between level-of-effort and badges earned increased .018 per session for students participating in technology-enhanced physical education. While level-of-effort degree of alignment with performance (badge-earning) increased significantly ($p < .05$) over fifteen trials; level-of-satisfaction alignment with badges earned did not.

Results showed that over fifteen sessions with technology-enhanced physical education, the correlation between badges-earned and level-of effort improves significantly. This supports the hypothesis that students' self-reported data do become consistent with their actual performance data, since the degree of level-of-effort correlation with badge-earning improves significantly ($p < .05$) over time. This result provided support that the students can potentially self regulate their physical activity even without a device. In other words, students' perceived level-of-effort becomes highly correlated with their actual performance as measured by badges-earned after 15 trials, supporting the level-of-effort construct as a reliable cognate for knowing level of physical activity (see Table 4.1 & Figure 4.2)

Table 4.1

*Correlation Coefficients for Badge Earning and Level-of-Effort and Level-of-Satisfaction*

| Event/Class Session/Trial<br><br>Fall Semester 2015<br>N=32 | Correlation Coefficient between number of earned badges (70% + MHR) and **reported Level-of-Effort** | Correlation Coefficient between number of earned badges (70% + MHR) and **reported Level-of-Satisfaction** |
|---|---|---|
| Class 1 | .49 | .57 |
| Class 2 | .4 | .44 |
| Class 3 | .57 | .52 |
| Class 4 | .51 | .58 |
| Class 5 | .56 | .6 |
| Class 6 | .67 | .67 |
| Class 7 | .62 | .54 |
| Class 8 | .74 | .53 |
| Class 9 | .59 | .39 |
| Class 10 | .82 | .77 |
| Class 11 | .7 | .54 |
| Class 12 | .66 | .7 |
| Class 13 | .65 | .52 |
| Class 14 | .61 | .57 |
| Class 15 | .82 | .68 |

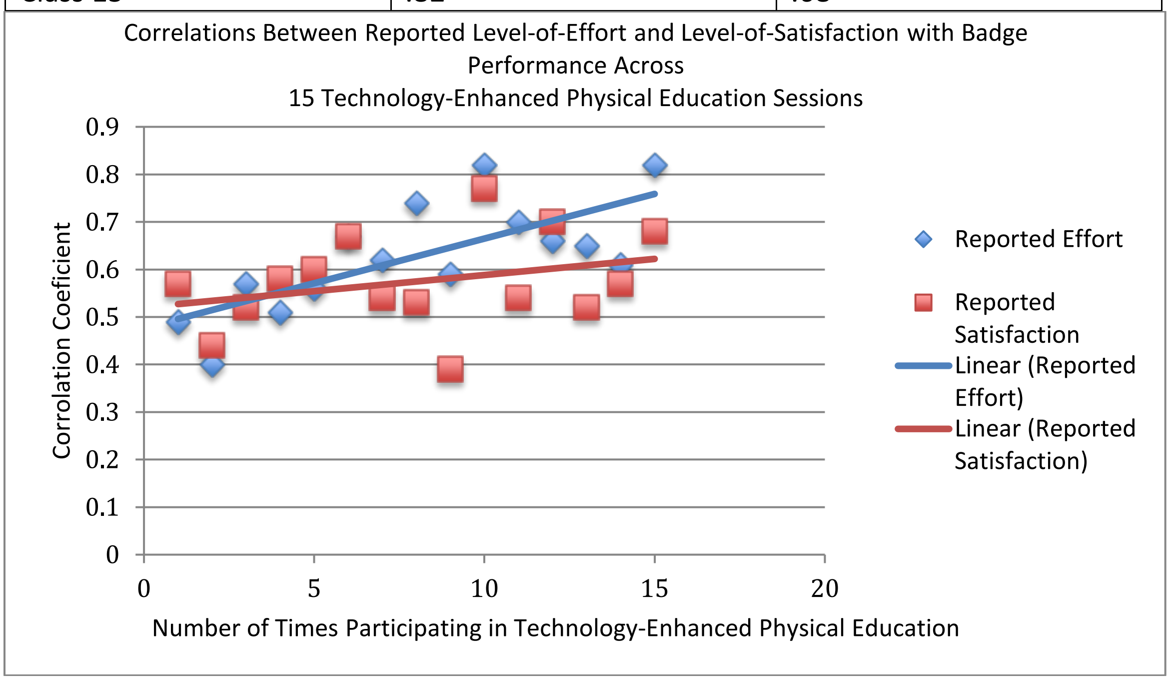


*Figure 4.2.* Changes in degree of alignment of level-of-effort and level-of-satisfaction with badges earned across 15 trials.

As illustrated in Figure 4.2, students better aligned their perceived level-of-effort with their actual performance over 15 trials, but did not convincingly ($p < .05$) align their perceived level-of-satisfaction with performance over the same fifteen physical education sessions. While levels of correlation with badges and satisfaction show positive trends on this graph, the slope of the regression line was not significantly ($p < .05$) different from zero. This provides an impetus for continued research focusing on the satisfaction construct. Perhaps with more time, the regression would prove significant. To summarize, this finding provided evidence that students can potentially self-monitor without the assistance of the technology. These results support a cognitivist framework for learning in that students can use scaffolding and schema to form constructs that allow them to perceive and complete a task without direct reinforcements.

## Affective View

A qualitative content analysis was conducted on both student and teacher data. A sentiment analysis was performed and then a breakdown of the sentiments/themes were included to give a more detailed picture of comments. For the purposes of this study, teachers' statements were assumed to represent underlying sentiments. A major finding was that the overall sentiments consisted of positive themes. See Figure 4.3. The negative themes identified were: 1. Technology issues and 2. Device issues related to putting on the equipment.

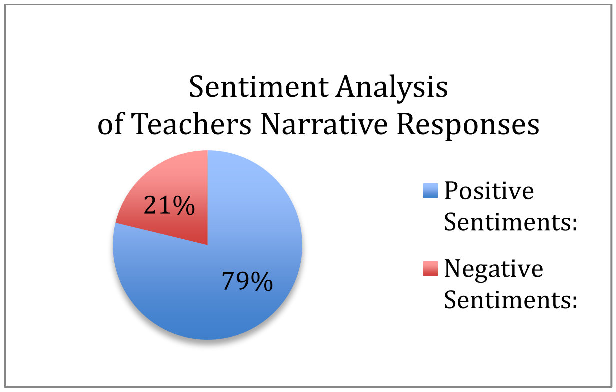


*Figure 4.3.* Overall positive sentiments from teachers with reference to technology-enhanced physical education

The positive themes were: 1. Helps students reflect 2. Helps teachers reflect and adjust instruction 3. Increased motivation in students 4. Transferring knowledge beyond school 5. Improve problem behaviors, 6. Encourage other students. See Figure 4.4.

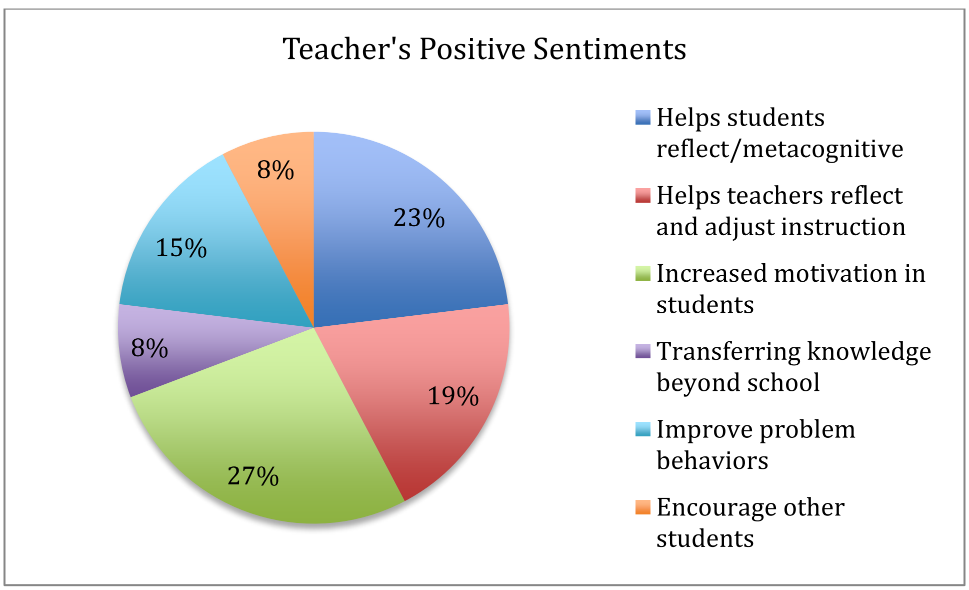


*Figure 4.4.* An analysis of teachers' positive themes

Students' statements were viewed as sentiments. The overall sentiment consisted of positive themes. See Figure 4.5. Negative themes were related to the device not fitting properly or being uncomfortable.

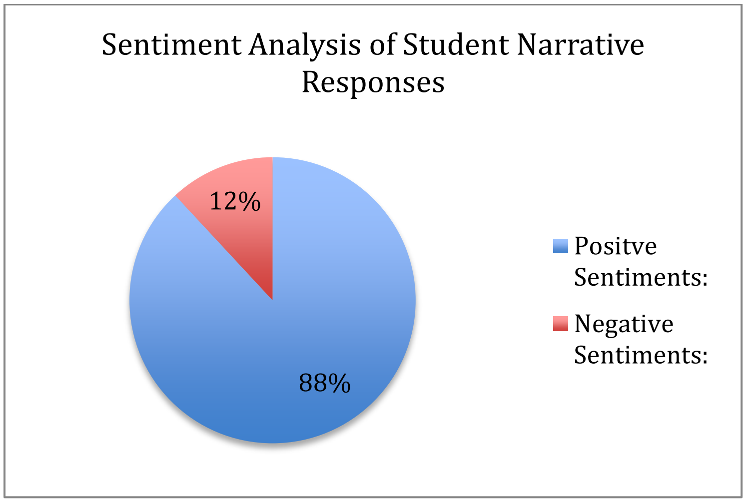


*Figure 4.5.* Overall positive sentiments from students with reference to technology-enhanced physical education.

The following positive themes were observed: 1. Work harder 2. Fun 3. Encourage peer support 4. Badges/Rewards 5. Increased fitness. See Figure 4.6.

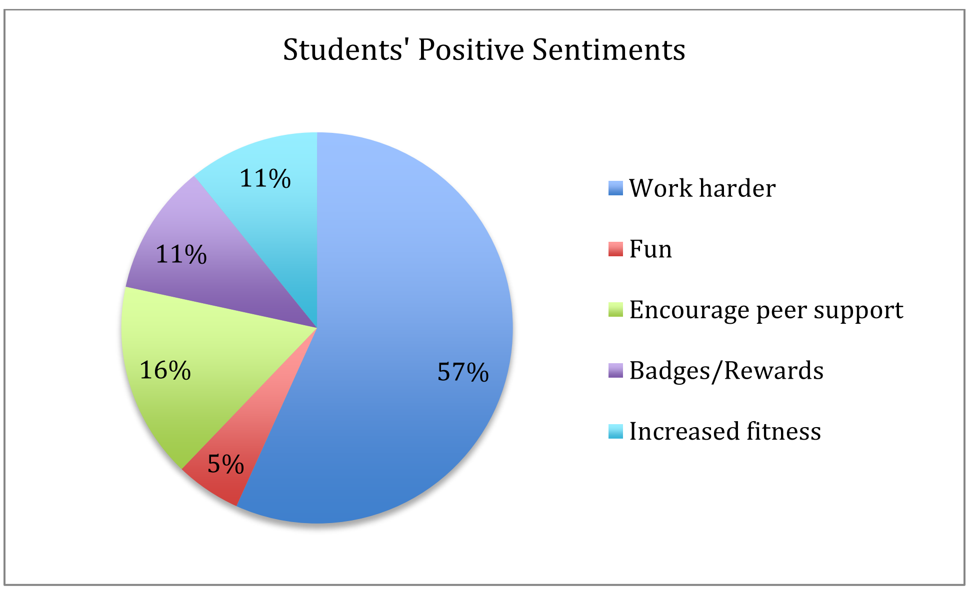


*Figure 4.6.* An analysis of students' positive themes

It is important to point out that *work harder* was the most evident theme in the students' responses and *Increased motivation in students* was the most evident theme in teachers' responses. This supports the results from the cognitivist view in that students learn to self-monitor over 11-weeks and they learned their primary learning objective, which was to "work harder." The researcher believes this "work harder" construct equates with "level-of-effort". This phenomenon also translated into improved scores on the 20-meter shuttle run as evidenced under the behaviorist methodology and results, supporting again the interdependent nature of behavior, cognition and affect in teaching and learning.

Students reported that they were more supportive of their peers rather than competitive with them (16%). At virtually the same rate (15%), teachers reported improved student behaviors. This result supports opportunities for further research. Teachers commented too that students were so excited they were reporting early to P.E. when P.E. was their first period class. The students also began to suggest alternate physical education activities, which would increase the students' heart rates. The teachers were very impressed at how motivated the students had become as a result of the integrated technology-enhanced physical education model.

From these findings it is evident that an integrated technology-enhanced physical education model can potentially improve students' abilities to perform on a post-test measure, can significantly improve students' ability to correlate their perceived effort with their actual performance and that attitudes are positively impacted by the technology enhanced physical education model.

However, the investigation into post-treatment effects was also investigated. The researcher wanted to know, did the effects of the technology-enhanced physical education sustain one year later? Were the control and experimental groups different in their attitudes and behaviors related to daily exercise one year later? Both control group and experimental group were given a seven-item survey (See Table 4.3 and Figure 3.4). A reliability analysis was performed on the items with a reliability index of Cronbach's (1951) Alpha = .78 indicating a reliable scale. See Table 4.2.

Table 4.2

*SPSS Reliability for Post- 1 Year Survey. Items Assessed as an Entire Scale*

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .777 | 6 |

Each of the items for the scale is listed in Table 4.3, with descriptive statistics showing mean and standard deviation values for each individual item within the scale. Note that only for question 2, "I engage in one/more of the following forms of exercise: walking, jogging or running," does the rating of the treatment group (mean = 2.88) emerge as more strongly in agreement with this item than the level of agreement for the control group (mean = 2.73). The fact that for five of the six items in the scale, the control group remained more positive in their ratings than the treatment group, one year after participating in integrative technology-enhanced physical education activities, is perplexing and warrants further investigation.

Table 4.3

*Descriptive Statistics for the Post, 1-Year Survey*

| | | N | Mean | Std. Deviation |
|---|---|---|---|---|
| Q1 – I engage in physical exercise on a daily basis. | 1 | 81 | 2.85 | .823 |
| | 2 | 45 | 3.09 | .793 |
| | Total | 126 | 2.94 | .817 |
| Q2 – I engage in one/more of the following forms of exercise: walking, jogging/r... | 1 | 81 | 2.88 | .842 |
| | 2 | 45 | 2.73 | .809 |
| | Total | 126 | 2.83 | .830 |
| Q3 – I exercise more than 3 days per week. | 1 | 81 | 2.96 | .914 |
| | 2 | 45 | 3.11 | .804 |
| | Total | 126 | 3.02 | .876 |
| Q4 – When I don't exercise I feel guilty. | 1 | 81 | 1.77 | .795 |
| | 2 | 45 | 2.09 | 1.041 |
| | Total | 126 | 1.88 | .900 |
| Q5 – When I feel like I don't want to exercise, I go ahead and push mysel... | 1 | 81 | 2.41 | .803 |
| | 2 | 45 | 2.53 | .786 |
| | Total | 126 | 2.45 | .796 |
| Q6 – I will engage in other forms of exercise if I am unable to engage in my usu... | 1 | 81 | 2.37 | .872 |
| | 2 | 45 | 2.53 | .894 |
| | Total | 126 | 2.43 | .880 |

Analysis of variance for the individual items showed ultimately showed no significant ($p < .05$) differences between groups (control and experimental) on individual items and the effect sizes were all $d < .20$ (Cohen's, 1988), which indicates no educationally meaningful effect (Bialo

& Sivin-Kachala, 1996). This result is evidence that the treatment did not last long term. Chapter 5 will investigate this outcome and discuss future studies and other findings. When the data were analyzed using the whole scale the results still showed no significance [F (1,124) = 1.72, p = .192]. See Table 4.4.

Table 4.4

*Survey Evaluated as One Scale Shows No Significant Differences in Overall Means*

**Descriptives**

excercise6

| | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean Lower Bound | 95% Confidence Interval for Mean Upper Bound | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|
| 1 | 81 | 2.5391 | .61366 | .06818 | 2.4034 | 2.6748 | 1.33 | 4.00 |
| 2 | 45 | 2.6815 | .52323 | .07800 | 2.5243 | 2.8387 | 1.00 | 4.00 |
| Total | 126 | 2.5899 | .58486 | .05210 | 2.4868 | 2.6931 | 1.00 | 4.00 |

**ANOVA**

excercise6

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | .586 | 1 | .586 | 1.725 | .192 |
| Within Groups | 42.172 | 124 | .340 | | |
| Total | 42.758 | 125 | | | |

In summary the results showed positive support for integrated technology-enhanced physical education. The results showed significant student improvement on pre- to post- test results for the 20-meter shuttle run. The results showed that after 15 classroom trials students' ability to align their perceived level-of-effort with their performance as measured by badge earning, improved significantly (p < .05). Furthermore, students and teachers both shared mostly positive comments related to the integrated technology-enhanced physical education model. However, the researcher found that long-term effects of the technology-enhanced physical education do not seem evident and are worthy of continued investigation as long term change is evidence of learning.

# CHAPTER 5

## SUMMARY AND DISCUSSION

The purpose of this study was to determine if integrated technology-enhanced physical education improved fitness and fitness awareness for children in a fifth grade physical education class and how instructional design supported with theory provided support for the implementation of the design. The study was conducted because of increasing childhood obesity and factors that contribute to obesity such as a sedentary lifestyle, high caloric intake and a reduction in school physical education programs. Secondarily this research can foster additional investigations related to previous research, since previous research has shown improved fitness levels resulted in improved cognition (Butte, Ekelund & Westerterp, 2002; Fedewa & Ahn, 2011; Sibley & Etnier, 2003). Finally other studies show additional benefits of wearable technologies in the classroom. These studies indicated that students could successfully leverage their personal data to study core content areas (Lee, Drake & Williamson, 2015).

Furthermore, results of this study confirmed that an existing integrated technology-enhanced physical education model can and does address current National Physical Education Standards (“National PE Standards, n.d).

> Standard 1 - The physically literate individual demonstrates competency in a variety of motor skills and movement patterns.
>
> Standard 2 -The physically literate individual applies knowledge of concepts, principles, strategies and tactics related to movement and performance.
>
> Standard 3 - The physically literate individual demonstrates the knowledge and skills to achieve and maintain health-enhancing level of physical activity and fitness.
>
> Standard 4 – The physically literate individual exhibits responsible personal and social behavior that respects self and others.

Standard 5 – The physically literate individual recognizes the value of physical activity for health, enjoyment, challenge, self-expression and/or social interaction.

This research addressed these standards and studied an instructional design implementing a technology-enhanced physical education model. However the study did not show that improvements were sustained one year later, which is a serious limitation and worthy of further research and investigation.

## Research Question 1

The first question investigated improving fitness for students participating with a technology-enhanced physical education model. The results showed significant improvement ($p < .05$) in a post 20-meter shuttle run, a common fitness measure used to measure endurance. Two parallel lines are placed 20-meters apart and students run back and forth to a series of beeps that get faster on each trial. Their score is calculated based on how many successful 20-meter shuttles they accomplished. The reinforcement of digital badges during instruction shaped and improved students' level of performance on this fitness assessment. Behaviorist theory supports this part of the design. Students learned and were motivated to improve fitness levels as a result of the technology. A future study should investigate the results of a shuttle run one year later. Did students who received the technology-enhanced physical education outperform those who did not on the 20-meter shuttle run? This warrants further investigation.

## Research Question 2

The second question relates to whether students can internalize their self-report measures and actual performance measures and gain an understanding of that correlation so that technology is not always required to achieve that level of fitness. Students showed over 15 trials that their correlation between badges-earned and level-of-effort improved significantly over time. That lends support that by trial 15 students could equate their perceived level-of-effort with their actual performance. Interestingly the level-of-satisfaction measure was not significantly correlated with actual performance over the fifteen trials. However, the trend line was positive and an investigation into improved satisfaction rates is worthy of additional research. A future study might investigate the total time students were active with the technology and correlate that measure with level-of-satisfaction. For the purposes of this study only badge-earning levels (70% or more of MHR) were evaluated and compared to the self-report measures. This effect shows that cognitive processes are at play with the improved correlation between self-reported effort and actual performance. The hope is that students come to “know” what it feels like (subjectively) to be at a recommended heart rate without the assistance of technology. This conjecture is grounds for future research.

## Research Question 3

The third research question addressed the affective elements of instructional design. From these results, it can be postulated that attitudes, beliefs and values (affective components) are very relevant and important during the instructional period. However, when instruction was removed, these values and attitudes did not endure, as evidenced by the one-year later follow up study. This result provides fuel for future research in investigating the idea that perhaps more trials (more than 15) or more time (more than 11 weeks) would help to instill the attitudes and behaviors of the students and their perceptions of the importance of daily fitness.

There are many obstacles for measuring and studying motivation and its impacts on learning (Keller, 2009). Keller notes that the unstable nature of *motivation* makes it difficult to study unlike *ability,* which is a "predictable human characteristic" (p.8). He continues that as motivation increases so does productivity but that at some point productivity declines as motivation continues leading to an anxiety-like state. He asserted that further research is needed on understanding how motivation impacts learning especially in technology-based instructional environments. Pekrun, Goetz, Titz & Perry (2002) noted that academic emotions are tied to results in the academic domain, and that emotions are intertwined with student interest and motivation and internal and external learner control, and further that emotions are a predictor of academic achievement (Pekrun, Goetz, Titz, Perry, 2002). Still further research is necessary especially in the area of how positive emotions impact teaching and learning.

## Limitations of the Study in Retrospect

There were multiple limitations to this study. First the data were secondary data and not directly obtained by the researcher. While the researcher was able to provide instructions and guidance to the data collection process, not being directly involved was a limitation. Limits of time (11-weeks) and sample size also proved to be limitations. The sample size was impacted by the data analysis that was performed. The behavioral component sample size was $n$ = 127. The cognitive component sample was $n = 32$. The Affective Component Sample 1 (comments following the study) was $n = 23$ and the follow-up post affective component was the original $n = 127$ sample.

Further limitations include the need for data cleaning and synthesizing. The technology used required two separate databases to collect data. This was not a streamlined program, but combined two technologies from two sources into one design. As a result, the data had to be synthesized to a new data set to perform the analysis. Having one database to capture both self-response measures and actual performance would eliminate this factor.

Also, because of the time limitation, it is important to acknowledge that there might be a delay in awareness of the self-regulation affordances (the cognitive component). Therefore a future study to evaluate a time-series analysis might be necessary in order to better evaluate the results.

Further, the qualitative coding results were conducted only by the primary researcher. It is important to note that this is not best practice and that qualitative coding should always be conducted by multiple coders to reduce bias and improve the integrity and reliability of the results.

When reflecting on the study, the researcher would have considered other posttest measures for the year-later study such as utilizing the 20-meter posttest to measure control and experimental groups rather than just using an attitude survey to measure post-activity performance. Some classrooms were limited with the technology for students to immediately self-report their subjective measures, resulting in delays of reporting their subjective measures. As technology has improved the data now can be more easily captured within a single database and directly paired with students' performance (time with physical activity and the wearable device) and their self-reflective reports (perceived level-of-effort and perceived level-of-satisfaction) making the process more streamlined for future investigations.

## Conclusion

Student health and fitness are of paramount importance. Increasing obesity rates are evidence that we are moving in the wrong direction. Unfortunately technology with its entertainment lure has contributed to a growing problem of childhood obesity. Certainly other factors such as increased availability of high caloric foods and a reduction in school physical education time have also contributed. Children are connected and sedentary. This research shows how technology can make a positive impact and can promote fitness rather than be a culprit. However more research is needed. Recently the World Health Organization produced its report on childhood obesity addressing "the alarming levels of childhood obesity" ("Commission presents its final report…," 2016, p.1). The report stated that overweight and obese children face many obstacles such as physical, psychological and heath consequences along with negative affects on education and these factors are likely to remain through adulthood. This poses "major health and economic consequences for them, their families and society as a whole" (Nishtar, 2016, p. 1).

While the results from this study show support for the use of integrated technology-enhanced physical education, many questions remain unanswered such as to why the results did not endure one year later? For technology-enhanced physical education to be effective it must have long-term effects. More research is needed to explore this factor.

Certainly to ensure the successful integration of wearables into the classroom, solid instructional design must be incorporated.  The designs for this research were grounded in learning theory. The quantified self, human computer interactions, and embodied cognition are current language to describe this important crossroads of technology and learning. We are just at the beginning of how wearables can impact education. In a historical overview by Vartak, Fidopiastis, Nicholson, Mikahel & Schmorrow (2008), they showed how a training system could be created to adjust content based on a learners real-time cognitive state changes as measured by wearables. Higher cognition wearables are in the future. However, learning *now* how to effectively integrate them into current teaching and learning paradigms is essential.

An additional use of personal health metrics was uncovered during the research but was not formally investigated by the researcher. However this found research certainly provides additional support to continue with use of wearables within the classroom and is worth mentioning. This model can be used to assist teachers in teaching content. Lee, Drake & Williamson (2015), explored using students' personal data to learn content related to statistics and general physical activities, and found that the use of personal data led to more positive outcomes for learning. Using students' personal, quantified data was more relevant to students and promoted student enthusiasm. To summarize, technology-enhanced physical education can lead to improved physical performance, improved attitudes toward performance, the ability to regulate heart-rate, potentially improve cognition and provides additional resources to be used to improve students' engagement toward coursework.

It is this researcher's opinion that technology-enhanced fitness is the first step into effectively integrating wearables into the classroom. Future research is warranted and is targeted to be conducted by this researcher. Potential future studies include:

- Why did the group with added value incentives (hats, pencils) not out perform students with just digital badges?
- Teachers reported improved student behavior (15%) and students reported that they encouraged their peers more during the study (16%). This is a positive result from the study and warrants further research as to use of wearables for improved classroom behaviors
- Level-of-effort was significantly correlated with badge earning over 15 trials. Does this mean that students can now monitor fitness without he aid of the wearable? This is support for further research.
- The researcher collected data on gender. Therefore investigating gender differences is a potential study.
- While level-of-satisfaction was positively trending but not significant, could a longer study show differences in satisfaction levels?
- What about correlating satisfaction levels with overall time on task, which includes those high performing periods at 70%+ of maximum heart rate but does not limit the correlation to just that time?
- The researcher has data of 5 levels of performance of target heart rates (50-60%, 60-70%, 70-80%, 80-90% & 90-100%). For the study, data was separated into heart rates

less than 70% and heart rates over 70%. This added data could provide a finer grained analysis of the results.

- Why were behaviors and attitudes not significantly different among experimental and control groups one year later? Why was the control group more positive on the items (however not significantly different)? Could a longer study have made a difference?
- Would a second 20-meter shuttle run-test one year later show differences in performance among control and treatment?
- Badges supported improvement but perhaps these can be removed as students internalize optimal performance. This is a potential future study.
- Additional studies on affect could be addressed such as having a qualitative pre-activity assessment. Qualitative measures were only gathered after the treatment was completed in this study.

In summation, it is this researcher's opinion that wearable technologies is leading edge technology that offers many opportunities for teaching and learning with a very low initial investment. Of course proper integration into the classroom is essential for effectiveness and to ensure the technology is improving students' behavioral, cognitive and affective facets. This is accomplished by focusing the instruction on the whole child. For this study we saw wearables accomplish the following: 1) Improve performance measures on a common fitness assessment 2) Improve students ability to understand/learn/self-regulate their level-of-effort with their actual performance 3) Improve student and teacher motivation. 4) Improve student behaviors and improve students feeling more supportive of their peers. For future studies wearable technology can potentially: 1) be used to collect personal data and metrics that be used to teach students course content such as measurement and statistics 2) show that improved fitness begins to change childhood obesity rates and improve children's health 3) begin to build, better, more advanced high cognition wearables that can utilize computational linguistics and machine learning to assess project group environments in real time, promoting an alternative assessment to high stakes testing and focus assessment on 21$^{st}$ century constructs. There is still so much to learn and so much information to gain. This researcher looks forward to the continued journey to investigate the affordances of wearable technologies for teaching and learning.

APPENDIX

PROCESSES FOR THE EVALUATION OF THE DATA

**SCHOOL #1**
Class #1 Experimental Group (digital badges & added incentives-pencils, cups, t-shirts)
Class #2 Experimental Group (digital badges & added incentives-pencils, cups, t-shirts)
**SCHOOL #2**
Class #1 (digital badges)
Class #2 (digital badges)
**SCHOOL #3**
Class #1 (Control)
Class #2 (Control)

| Behaviorist Lens | Cognitivist Lens | Affective Lens |
|---|---|---|
| Both control and experimental groups participated in this part of the study n=127<br><br>Classes were selected by the commissioner at random.<br><br>Control Groups: Received division curriculum and no technology-enhanced physical education.<br><br>Experimental Groups: Received technology-enhanced physical education 1-2 per week for 11 weeks total<br><br>All students were tested on the 20-meter shuttle run prior to the start of the program and baselines were evaluated (The athletic commissioner supervised all assessments). All students were tested on the 20-meter shuttle run following the study to determine outcomes of the technology enhanced physical education.<br><br>During the semester of 2015 all students participated in the same division curriculum used to teach physical fitness and heart rate monitoring. While the experimental group could evaluate themselves by the technological feedback, the control students had to manually time heart rates and learn the curriculum without the aid of the technology. | Only the experimental group was included in this evaluation. However due to technological limitations all students were not able to self-report their level-of-effort and level-of-satisfaction timely. This reduced the sample size down to n=32.<br><br>The data analysis involved data scrubbing and compiling to create a master document that included both actual performance data and self-reported data. From the data scrubbing, 15 complete sessions were evaluated with 32 students.<br><br>Fifteen separate correlation coefficient runs were conducted in SPSS to determine the correlation between badges-earned (actual performance measure) to both students' perceived level-of-effort and perceived-level-of satisfaction.<br><br>After correlation coefficients were established for each of the 15 sessions and for the correlations of badges earned to satisfaction and badges earned to effort, then a simple regression was run to determine the degree of correlation. | 2 Evaluations conducted<br><br>1. Only the experimental group was included in this evaluation. Qualitative data were obtained from 19 students and 4 teachers immediately following the study to measure their attitudes and perceptions of the technology-enhanced model.<br>2. The entire group of 127 were given Likert-scale surveys one-year later to measure the students beliefs and attitudes toward the importance of daily fitness |

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