ISSN: 2148-9955

International Journal of Research in Education and Science (IJRES)

www.ijres.net

Purposeful Movement: The Integration of Physical Activity into a Mathematics Unit

Kailey Snyder[1], Danae Dinkel[1], Connie Schaffer[1], Seth Hiveley[2], Amanda Colpitts[2]
[1]University of Nebraska
[2]Papillion La Vista Community Schools

To cite this article:

Snyder, K., Dinkel, D., Schaffer, C., Hiveley, S., & Colpitts, A. (2017). Purposeful movement: The integration of physical activity into a mathematics unit. *International Journal of Research in Education and Science (IJRES), 3*(1), 75-87.

International Journal of Research in Education and Science
Volume 3, Issue 1, Winter 2017 ISSN: 2148-9955

Purposeful Movement: The Integration of Physical Activity into a Mathematics Unit

Kailey Snyder, Danae Dinkel, Connie Schaffer, Seth Hiveley, Amanda Colpitts

Article Info

Article History

Received:
08 August 2016

Accepted:
17 November 2016

Keywords

Purposeful movement
Mathematics
Physical activity

Abstract

Classroom physical activity (PA) has been linked to a multitude of health and academic benefits. However, due to barriers such as lack of time and resources many teachers are not implementing classroom PA to the degree they would like to. One innovative solution is to integrate classroom PA into academic concepts. Based on self-determination theory, this pilot study evaluated the effectiveness of a teacher-developed purposeful movement teaching strategy on PA, on-task behavior and academic achievement. Two third grade classrooms participated in this pilot study, one acting as the comparison and the other working with the school Physical Education teacher to develop the active lessons. The evaluation consisted of accelerometers, direct observation, academic assessments and a write and draw activity to assess student perceptions. Significant improvements were found in steps achieved during math and on-task behavior. Findings reveal utilizing PA driven lessons is an effective teaching strategy.

Introduction

Children experience physical and cognitive benefits when they participate in physical activity (PA; Center of Disease Control, 2010). PA has been linked to enhanced cognitive function, improved self-esteem, reduced stress and has often been correlated to positive outcomes in school performance including improved grade point averages and standardized test scores (Kantomaa et al., 2015; Lamborne et al., 2013; Singh, Uijtdewilligen, Twisk, Van Mechelen, & Chinapaw, 2012; Taras, 2005). Additionally, positive associations between physical fitness and school performance have been found (Bass, Brown, Laurson, & Coleman, 2013; Kim et al., 2003). In regard to the physical benefits for children, PA can lead to the improvement or maintenance of a healthy weight as well as result in improved cardiovascular health, bone strength, and reduction in injury (Janssen & LeBlanc, 2010; Reiner, Niermann, Jekauc, & Woll, 2013).

Despite the many benefits associated with PA, the majority of children fall short of current PA recommendations (Griffiths et al., 2013). One possible explanation for the low levels of PA among children is a lack of PA opportunities (e.g., lack of access, unsafe neighborhoods) (Davison & Lawson, 2006). As children spend a significant amount of time at school, it represents an ideal place to enhance children's PA (Mahar, 2011). Unfortunately children are predominately sedentary during school hours with expectations to sit quietly while learning (Holt, Bartee & Heelan, 2013; Gibson et al., 2008).

Incorporating PA into academic instruction presents a possible solution to decrease sedentary time and increase PA. Several school-based interventions have shown classroom PA to be effective at improving on-task behavior, academic achievement, and children's PA levels (Katz et al., 2010; Stewart, Dennison, Kohl, & Doyle, 2004; Stylianou et al., 2016). However, due to barriers such as limited time and increasing pressure to improve academic achievement scores, PA opportunities in school continue to be a low-priority (Bartholomew & Jowers, 2011; Dinkel, Snyder, Lee & Schaffer, 2016).

To increase the amount of classroom PA and improve academic outcomes, one innovative strategy is to integrate PA directly into the teaching and learning process. Specifically, meaningful integration of movement into the learning process, purposeful movement, has yielded positive academic outcomes (Bartholomew & Jowers, 2011; Jensen, 2005). This paper begins with an overview of research on purposeful movement followed by a description of the self-determination theoretical framework used to shape this study. The development and dissemination of an intervention targeting purposeful movement strategies will then be illustrated. We conclude with recommendations for future research and the practical application of our findings for future educators.

Purposeful Movement

Purposeful movement may be an effective strategy for targeting the kinesthetic learner, considered to be the dominant learning style for the majority of primary-aged children (Tranquillo, 2008). The kinesthetic learning approach posits individuals learn best through a touch, physical movement, and hands-on approach (Gilkajani et al., 2011). Purposeful movement may also be an effective instructional strategy for students who are more visual or auditory learners. Research has shown movement stimulates brain functions responsible for maintaining attention and comprehension (Palmer & Klein, 2003). Furthermore, evidence suggests movement as simple as walking can activate excitatory brain chemicals that can improve learning and movement (Tong, Shen, Perreau, Balazs, & Cotman, 2001). Finally, PA has been linked to improved neuron connections and neurogenesis which can lead to increased cognition and information retention (Kempermann, 2002). Thus, the use of active learning techniques like purposeful movement may enhance learning experience for students with varied learning preferences.

Despite the benefits associated with purposeful movement, a recent literature review found only five studies where PA was integrated into the instruction of academic subjects (Bartholomew & Jowers, 2011; Donnelly et al., 2009; Erwin, Abel, Beighle, & Beets, 2011; Martin & Murtaugh, 2015; Oliver, Schofield, & McEvoy, 2006). The Texas I-CAN! Program is one example of this (Bartholomew & Jowers, 2011). Within this program, teachers were trained by the researchers to modify lesson plans to incorporate PA. The study found a significant increase of steps as well as improvement of on-task behavior and spelling test scores. Another study, Physical Activity Across the Curriculum (PAAC) trial (Donnelly et al., 2009), utilized a teacher training approach. This intervention involved researchers training teachers to integrate movement into learning with the primary goals of increasing PA, deterring rising student body mass index (BMI), and improving academic outcomes. A significant increase in daily PA was found. In addition, a positive relationship was found between reduction in BMI and the number of PA minutes provided to students (Donnelly et al., 2009). In regard to academic changes, after two years implementing the PAAC intervention schools reported higher standardized scores in mathematics and spelling compared to control schools. While previous studies have implemented classroom PA in multiple subjects, one common subject utilized was mathematics (Bartholomew & Jowers, 2011, Donnelly et al., 2009; Erwin et al., 2011; Martin & Murtaugh, 2015; Oliver et al., 2006). Research evaluating teachers' perceptions of classroom PA found teachers see the value of integrating movement into mathematics (Stylianou, Kulinna, & Naiman, 2015). Furthermore, mathematics may be an ideal subject for implementation as it may not take as much time to prepare active lessons compared to other subjects and teachers feel it does not detract from learning, two common barriers to integrating PA into academics (Gately, Curtis, & Hardaker, 2013).

Previous interventions utilizing purposeful movement were developed by researchers who then trained teachers to implement PA. In multiple studies, students' PA and on-task behavior improved (Katz et al., 2010; Stewart et al., 2004). This could potentially enhance health and promote a better learning environment. Despite these benefits, if teachers do not find value in purposeful movement, their use of these strategies may decrease over time (Erwin et al., 2011). Implementing PA policies may help sustain the use of purposeful movement in schools. In 2006 the state of Tennessee initiated a policy requiring 90 minutes of PA per week for elementary and secondary students. The mandate had explicit language requiring PA be utilized in some capacity during the instructional day. The year after policy implementation Tennessee's childhood obesity rate decreased from 40.9% to 39.0% (Kibbe et al., 2011). Despite this success few states have developed similar strategies often due to funding constraints or other priorities. This is in part due to the need for teacher support when developing such policies. If teachers lack motivation to adhere to a policy, its success will be hindered (Gorozidis & Papaioannou, 2014; Stylianou et al., 2015). Developing strategies to sustain purposeful movement at a school and school system level remains largely unexamined. Researchers have infrequently examined the development of purposeful movement strategies within theoretical constructs. Self-determination theory (SDT) has been utilized in-PA and also in educational settings (Edmunds et al., 2008). However to the researchers' knowledge, no previous studies have utilized SDT to develop an intervention that combines PA and education.

Self-Determination Theory

SDT is often used to frame human motivation. SDT discerns motivation as either autonomous or controlled. Autonomous motivation indicates motivation is intrinsic and reflects decisions being made out of personal interest or value. Controlled motivation involves motivation endorsed by external factors such as pressure or demand. According to SDT, individuals must be autonomously motivated to sustain long-term behavior changes, and controlled motivation is least likely to impact prolonged behavior changes (Deci & Ryan, 2008). Individuals are more autonomously motivated if three basic psychological needs are fulfilled: autonomy, competence, and relatedness. Autonomy is defined as having a sense of control or choice. Competence is defined as having the skills or knowledge needed to complete a task. Finally, relatedness involves feeling supported and having effective relationships (Deci & Ryan, 2008). Thus, individuals with strong autonomous motivation will have high levels of autonomy, competence, and relatedness. Several researchers have evaluated the effect of SDT on teachers' motivation and teaching strategies (Black & Deci, 2000; Sorebo, Halvari, Gulli, & Kristiansen, 2009; Taylor, Ntoumanis, & Standage, 2008). According to this research, teachers must feel in control of their surroundings (autonomy), masterful in the subject matter they are teaching (competence), and supported by their colleagues and administrators (relatedness).

In regard to the utilization of purposeful movement strategies, autonomous motivation may predict teachers' intentions to implement innovative instructional approaches (e.g., inquiry and interdisciplinary collaboration) such as purposeful movement (Gorozidis & Papaioannou, 2014). Research has shown intention increases the likelihood to initiate a specific behavior (Ajzen, Czasch, & Flood, 2009). Additionally if teachers participate in interventions and training due to external factors such as an incentive or administrative pressure the likelihood of their continued implementation is low (Deci & Ryan, 2010). Future interventions must consider ways to enhance teachers' autonomous motivation through fulfilling teachers' basic psychological needs (autonomy, competence, relatedness) to improve program sustainability and adherence to PA related policies. The purpose of this study was to evaluate the effectiveness of a teacher-developed purposeful movement teaching strategy guided by SDT on PA, on-task behavior and academic achievement.

Method

Study Design

This study was conducted at a medium-sized Title 1 elementary school in the Midwestern United States. Within the school 44.17% of students qualified for free/reduced meals. The predominant race/ethnicity was Caucasian (65.35%) followed by Hispanic (16.54%), African American (11.81%) and two or more races (6.3%). The intervention occurred during school hours and lasted for the duration of one mathematics unit. Two third grade classrooms were recruited to participate. One classroom served as the intervention classroom in which purposeful movement was integrated into mathematics instruction, and the other class served as the comparison classroom in which the teacher was asked to teach using typical teaching strategies. Height and weight information was collected from the school nurse who had obtained the data in the previous six months. Baseline data were collected one week prior to the mathematics unit (pre) and during the final week of the mathematics unit (post). Pre and post data collection included: PA measured via accelerometer; on-task behavior measured via direct observation; and academic achievement measured via unit testing. After the post data collection, student perceptions were measured by a write and draw activity. The study was approved by an Institutional Review Board at a university and the local school system administration.

Participants

A total of 34 third grade students, two 3rd grade classroom teachers, and one physical education (PE) teacher were eligible to participate in this pilot study. Twenty-four students returned the parental consent form, 66% (n=11) of the intervention classroom and 82% (n=13) of the comparison classroom. A majority (68%) of students were normal weight and over half (56%) were male (Table 1).

Table 1.Student demographics

Gender	n
Male	14
Female	11
BMI	
Normal	17
Overweight	3
Obese	5

Intervention

To determine which class would receive the intervention, the PE teacher spoke with the two classroom teachers to discuss who would be interested in delivering the intervention. Upon concurrence from the classroom teachers, one agreed to implement the intervention and the other consented to continue usual instruction in the comparison classroom.

The intervention classroom teacher collaborated with the PE teacher, with no input from the researchers, to develop active lessons for one mathematics unit. Prior to the start of the unit, the teachers developed daily active mathematics lessons (n=25) for the duration of the five-week unit (see appendix for example lesson). The goal of each lesson was to have students active for at least 50% of the 70-minute mathematics lesson. The activities utilized materials already available in the classroom such as white boards, markers, dice, and blocks. Prior to the start of the activities the classroom furniture was rearranged to allow for adequate space for movement. Typical activities involved incorporating exercises such as burpees, jumping jacks, and squats into the lessons. Even though the PE teacher was not physically present during the lessons, he acted as a fitness liaison during lesson development and ensured the classroom teacher knew how to direct students on proper form and technique to minimize injury risk. The comparison classroom was asked to teach the same unit utilizing typical teaching strategies.

PA Assessment

Step counts of the students were assessed using the validated Sensewear Armband Mini (Lee, Kim, Bai, Gaesser, & Welk, 2016). The mini utilizes a triaxial accelerometer to capture total number of steps. The armband was initialized with the individual student's height, weight, gender and date of birth and worn on their non-dominant arm. Research personnel visited the school each morning and afternoon of data collection to assist the students in putting on and removing the armbands. Due to unforeseen circumstances (a school field day was unexpectedly scheduled) only four days (Monday-Thursday) were analyzed from each data collection period.

On-Task Behavior Assessment

Direct observation was assessed utilizing the Behavioral Observation of Students in School (BOSS) application (Shapiro, 2003). The BOSS program measures on and off-task variables of individual student behavior. On-task variables included: active engaged time (e.g., working with a partner on an assignment, answering a teacher's question), passive engaged time (e.g., listening intently to the teacher). Off-task variables included: off-task verbal behaviors (e.g., talking out of turn), off-task passive behaviors (e.g., looking around the room for at least three consecutive seconds), and off-task motor (e.g., fidgeting, leaving desk without permission).

Six students were randomly selected from each classroom to participate in the observations. Each observation consisted of a 15-second momentary time sampling recording procedure. Research assistants observed one student for a 15-second interval, recorded the students' on- and/or off-task behavior, and then rotated to the next student for a 15-second interval. This pattern was repeated for 20 minutes. Direct observations of the same six students took place three days (Monday, Wednesday, Friday) during both pre and post intervention (Amato-Zech, Hoff, & Doepke, 2006).

The observations were conducted by three research assistants who were trained on the BOSS protocol and practiced in the classrooms prior to the start of data collection. Each day two research assistants conducted observations simultaneously for 20 minutes. A one-way random intraclass correlation (ICC) was conducted to assess agreement between the two research assistants for the pre-collection and the post-collection. A high degree of reliability was found between the research assistants. The average ICC was .996 with a 95% confidence interval from .986-.999 ($F(9,10=264.18)$, $p<.001$).

Academic Achievement Assessment

As was typical for the school's curriculum, students from both classrooms completed a Common Summative Assessment (CSA) at the end of their mathematics unit. These tests are developed at the district-level to indicate student knowledge and retention of the material. As no pre-tests were provided by the district and the teachers were not allowed to utilize CSA's as pre-tests, the classroom teachers collaborated and developed a shortened pre-test version of the CSA. Students were given 30 minutes to complete the pre-test the Friday before the mathematics unit began. Because the questions on the post-test include more components than the pre-test questions, students were given one hour on the final day of the unit to complete the CSA. Questions included both multiple choice and extended response items requiring computations.

Student Perceptions

Student perceptions of the mathematics lessons were evaluated via a write and draw activity completed at the end of the mathematics unit. On the last day of the unit both classroom teachers provided students with a blank piece of paper and asked them to "draw and write a few sentences about what you thought about the mathematics lessons." Students were given 15 minutes to complete the activity.

Data Analysis

PA

Data reduction was completed utilizing the SenseWear software to eliminate all PA activity except what was accumulated during mathematics (Lee et al., 2016). A daily mean count for steps accumulated during mathematics was calculated for the pre and post data collection. Students needed to wear the devices at least four days to be included in analysis which resulted in one student's data being excluded from the analysis. Descriptive statistics were computed and an independent t-test was utilized to compare the students' PA in the two classrooms and 2-sample independent t-tests were utilized to compare students PA pre and post intervention in each classroom.

On-Task Behavior

A multivariate analysis of covariance (MANCOVA) was conducted to determine whether the students from the intervention and comparison classrooms had significantly different levels of on and off-task behavior. The intervention and comparison classrooms served as independent variables. The dependent variable was the observed behavior. The baseline data was utilized as a covariate to control for variance in what was observed in each classroom and to ensure the behavior differences reflected the intervention and did not occur as result to confounding factors. Additionally, effect sizes were calculated using Cohen's D to determine the level of effect seen.

Academic Achievement

To score the pre and post-tests the classroom teachers developed a coding scale based on previous unit exam scores to determine a student's knowledge level. A score of 0-9 was considered a beginning score; 10-12, progressing; 13-16, proficient; and 17+, advanced. Descriptive statistics were computed to determine class mean score and then a 2-sample independent t-test was utilized to compare the student scores in the two classrooms.

Student Perceptions

In order to assess the students' draw and write activities the lead researcher qualitatively analyzed the data (Knoblauch, Baer, Laurier, Petschke, & Schnettler, 2008). The researcher became immersed in the data by reading the students' written work and analyzed their drawings. Common themes were identified and shared with a second researcher to assure bias was not influencing theme development.

Results and Discussion

Intervention

The intervention was conducted successfully and followed the timeline described previously. However, due to unforeseen circumstances the comparison classroom had a substitute teacher for the first two days of the post data collection. Additionally, the comparison classroom teacher utilized some PA in her lessons as this was a typical teaching strategy she used.

PA

Students from the intervention classroom had a significant improvement in the number of steps they accrued. From pre to post implementation, students in the intervention group recorded approximately 400 more steps per mathematics class each day t(44)=-3.779, (*p*=.0001). Students from the comparison classroom averaged approximately 160 more steps per day; however, this was not a significant difference t(13)=1.880, (*p*=.083) (Table 2).

Table 2. Average daily mathematics steps

Class	Pre	Post	t-cal	df	*p*
Intervention	643.3	1027.2	3.779	44	0.0001
Comparison	619.1	783.4	1.88	13	0.083

*Denotes significant finding

On-Task Behavior

When comparing the two classrooms during the post-data collection, a significant main effect for active engaged time (*p*=.001; ES=.92), passive engaged time (*p*=.001; ES=-.88), and off-task passive behavior (*p*=.014; ES=-.65) was found. Specifically, the intervention students exhibited significantly higher rates of active engaged time and significantly lower rates of off-task passive behavior. The comparison classroom engaged in a significantly higher amount of passive engaged time (Table 3).

Table 3. BOSS Result: Class comparison

Behavior Type	Intervention *% Observed*	Comparison *% Observed*	Effect Size
Active engaged time	78.0 (10.8)*	34.7 (7.3)	0.92
Passive engaged time	16.2 (5.8)*	44.2 (8.86)	-0.88
Off-task motor	15.6 (8.2)	25.5 (14.9)	-0.38
Off-task verbal	12.4 (5.0)	10.8 (7.37)	0.12
Off-task passive	7.29 (3.5)*	25.2 (14.4)	-0.65

*Denotes significant finding $p \leq .05$

Additionally, an analysis was conducted to assess the intervention classroom at the pre and post data collection (Table 4). The presence of a significant main effect was found for off-task passive behavior (*p*=.01; ES=.69). Although it was not found to be statistically significant active engaged time had a medium effect from pre to post (*p*=.06; SE=-.53).

Table 4. BOSS results: Intervention pre & post evaluation

Behavior Type	Pre	Post	Effect Size
Active engaged time	61.4 (15.4)	78.0 (10.8)	-0.53
Passive engaged time	24.2 (10.3)	16.3 (5.8)	0.42
Off-task verbal	12.4 (8.2)	12.4 (5.0)	0
Off-task motor	19.0 (4.9)	15.6 (8.2)	0.24
Off-task passive	16.0 (5.4)*	7.3 (3.5)	0.69

*Denotes significant finding $p \leq .05$

Academic Achievement

Prior to the intervention, there were no statistical differences in the mathematics skill level between the two classrooms (t(30) = -.616, *p*=.542). All students received scores of beginning or progressing with the exception of two students in the comparison class who received proficient scores. At the post-assessment all students received a proficient or advanced score on the final test with the exception of one student in the comparison classroom who received a progressing score. No statistically significant differences were found between the two classrooms (t(30) = -1.732, *p*=.094).

Student Perceptions

The majority of students chose to draw and write about their favorite activity and 100% of students in the intervention classroom had positive responses about the activities. As one student noted, "My favorite thing we did was the card race with shooting a hoop. I liked it because it's better than worksheets, and we can have fun and be active at the same time as learning stuff" (Figure 1). Another student reported, "My favorite game is the [Basketball] shooting game. It's fun for me because you can learn more fractions and be smarter when you grow up. It also gets your brain working on math. That's the reason why I like the [basketball] shooting [game]. Interestingly, the students in the comparison classroom also noted their favorite activities involved any time they were active in their classroom. As a reward for good behavior, the comparison students were able to do fraction bowling on the final day of the unit. Of the comparison students 53% reported this was their favorite activity of the mathematics unit. As one student wrote, "My favorite part of fractions is when we went bowling in the classroom. I liked it because it's not like ordinary bowling. We had to write down the fraction that we knocked over" (Figure 2).

Figure 1. Student perception drawing

Figure 2. Student perception drawing

Discussion

The purpose of this project was to evaluate the effectiveness of a teacher-developed purposeful movement teaching strategy on PA, on-task behavior, and academic achievement. Findings revealed PA during mathematics does not deter from satisfactory learning and retention and can increase steps, improve on-task behavior, and decrease off-task motor and passive behaviors.

In regard to the PA findings, a significant increase in steps taken during mathematics was seen for the students in the intervention classroom. These findings are analogous to previous research with classroom PA and provide justification for classroom PA as an effective means for increasing daily PA (Bartholomew & Jowers, 2011, Donnelly et al., 2009; Erwin et al., 2011; Martin & Murtaugh, 2015; Oliver et al., 2006). However, the present study is unique in its use of a teacher-developed movement curriculum. The findings of this study confirm PA levels can be increased in both teacher- and researcher driven interventions. Despite these continued positive findings few teachers are utilizing classroom PA on a regular basis (Barr-Anderson, AuYoung, Whitt-Glover, Glenn, & Yancey, 2011). Investigation into teacher perceptions suggest a need to better promote the academic and affective benefits associated with classroom PA use rather than just the physical benefits (Author et al., In Review).

The direct observation findings confirm previous research, integrating movement into academic lessons can improve the level of active engagement and deter off-task behaviors (Bartholomew & Jowers, 2011, Erwin et al., 2011; Stylianou et al., 2016). In this study, active engaged time improved significantly at the post-data collection when comparing classrooms. Research has shown active engagement results in increased learning, which is an important finding for the justification of purposeful movement lessons (Marzano & Pickering, 2013). As expected, the decrease in off-task passive behaviors was also significant. If children are spending more time actively engaged they have less opportunities to engage in off-task passive behaviors. While the impact of purposeful movement on behavior outside of the mathematics unit was not measured in our study, Mahar and colleagues (2006) found on-task behavior decreased by 3% after the use of classroom PA breaks in which teachers stopped their instruction to perform an activity. Research is needed to determine if the improvements in behavior are sustained outside of the lesson utilizing purposeful movement principles.

Although the students from both classrooms received similar scores, the lack of significant differences between classrooms in academic achievement should not be discounted. The similarity of scores confirms purposeful movement does not deter from satisfactory learning. This finding could assure teachers that incorporating PA into their curriculum as an instructional strategy will not compromise academic outcomes.

The enjoyment illustrated through the students' write and draw activity highlights students' positive perceptions of purposeful movement. Researchers have found enjoyment improves academic performance. Thus, utilizing purposeful movement could increase children's enjoyment of academic subjects and as a result may improve their academic outcomes (Pekrun, Goetz, Titz, & Perry, 2002). Research also indicates academic achievement may improve when students have high levels of self-regulated learning and motivation (Mega, Ronconi, & De Beni, 2014). The nature of the purposeful movement activities involve a significant degree of autonomy over one's own learning and as such-could also be contributing to academic achievement. More research is needed to understand purposeful movement's impact on self-regulated learning.

In regard to SDT, research has shown the three basic psychological needs (autonomy, competence, relatedness) are predictive of teachers' motivation to utilize innovative teaching strategies (Lam, Cheng, & Choy, 2010). In this intervention, purposeful movement lessons were developed solely by teachers within the participating school in order to increase teachers': sense of control (autonomy), confidence in ability to carry out the lessons (competence), and sense of support from the PE teacher (relatedness). It was hypothesized that by having the classroom and PE teacher develop the active lessons, autonomous motivation would increase. This would then enhance the degree to which activities were implemented and the sustainability of utilizing movement in the classroom. While teacher motivation was not directly measured there were a few key factors suggesting the teacher in the intervention classroom was autonomously motivated. First, there was a high level of adherence to the lessons, suggesting she felt autonomous in her teaching strategy. She utilized the active lessons every day of the unit without exception. Second, the students' improvements in on-task behavior and satisfactory learning (e.g., unit assessments) suggest she was competent in the execution of the lessons. Finally, her collaboration with the PE teacher in the development of the active lessons as well as the support provided by her school administration indicated a strong sense of relatedness. Future research should consider replication with a larger population and utilize direct measures for evaluating teacher motivation and autonomy, competence, and relatedness.

There are several limitations to be noted. First, having a substitute teacher in the comparison classroom for two days of the post-data collection may have created an atypical classroom atmosphere and skewed results. However, when comparing direct observation findings for the day with the substitute teacher no significant differences were found. Second, the comparison classroom did engage in physically active lessons on more than one occasion throughout the unit which may have muted the impact of the intervention. However, a significant difference in PA was still found, suggesting a potential of a larger difference if the comparison classroom had not utilized any PA during the mathematics unit. Third, the accelerometer measured steps instead of level of activity (i.e., light, moderate, or vigorous). Data from a wider variety of PA would have provided a more comprehensive analysis of the intervention's impact on the students' activity level. However, the use of steps is a cost-effective approach to tracking PA which can be completed with inexpensive pedometers.

Strengths of this research include the use of multiple measurement variables. Additionally, the use of a PE/classroom teacher collaboration is a unique approach with benefits not seen in typical researcher developed programming. First, both teachers had previous knowledge of the students in the project and were able to develop the program to specifically fit the needs of that classroom. Second, the teachers were easily accessible for one another throughout the school day if lesson plan questions arose. This is not always possible in typical pilot studies. Third, the teachers were able to create lesson plans within the realm of their own expertise so there were fewer concerns regarding implementation.

Conclusion

Purposeful movement may be an effective teaching strategy for improving on-task behavior and increasing PA resulting in satisfactory learning. Current and prospective teachers should be made aware of the benefits associated with purposeful movement. Pre-service teacher preparation could provide instruction on integrating purposeful movement into lesson plans regardless of academic subject to improve preservice teachers' confidence in their ability to integrate movement and have the tools and support necessary for implementation. This method of teaching has the potential for widespread benefits within the classroom, and should be considered a priority in educating future elementary teachers.

Acknowledgements

We would like to thank the school administration and students for their participation in this study.

References

Ajzen, I., Czasch, C., & Flood, M. G. (2009). From Intentions to Behavior: Implementation Intention, Commitment, and Conscientiousness. *Journal of Applied Social Psychology*, *39*(6), 1356-1372.

Amato-Zech, N. A., Hoff, K. E., & Doepke, K. J. (2006). Increasing on-task behavior in the classroom Extension of self-monitoring strategies. *Psychology in the Schools*, *43*(2), 211-221.

Barr-Anderson, D. J., AuYoung, M., Whitt-Glover, M. C., Glenn, B. A., & Yancey, A. K. (2011). Integration of Short bouts of physical activity into organizational routine: A systematic review of the literature. *American Journal of Preventive Medicine 40*(1), 76-93.

Bartholomew, J. B., & Jowers, E. M. (2011). Physically active academic lessons in elementary children. *Preventive Medicine*, *52*, S51-S54.

Bass, R. W., Brown, D. D., Laurson, K. R., & Coleman, M. M. (2013). Physical fitness and academic performance in middle school students. *Acta Paediatrica*, *102*(8), 832-837.

Black, A. E., & Deci, E. L. (2000). The effects of instructors' autonomy support and students' autonomous motivation on learning organic chemistry: A self-determination theory perspective. *Science Education*, *84*(6), 740-756.

Davison, K. K., & Lawson, C. T. (2006). Do attributes in the physical environment influence children's physical activity? A review of the literature. *International Journal of Behavioral Nutrition and Physical Activity*, *3*(1), 19.

Deci, E. L., & Ryan, R. M. (2008). Self-determination theory: A macrotheory of human motivation, development, and health. *Canadian Psychology/Psychologie canadienne*, *49*(3), 182.

Deci, E. L., & Ryan, R. M. (2010). *Self-determination*. John Wiley & Sons, Inc.

Dinkel, D., Snyder, K., Schaffer, C., & Lee, J. (In review). They just need to move: Teachers' perceptions of classroom physical activity. *Teaching and Teacher Education.*

Donnelly, J. E., Greene, J. L., Gibson, C. A., Smith, B. K., Washburn, R. A., Sullivan, D. K., & Jacobsen, D. J. (2009). Physical Activity across the Curriculum (PAAC): a randomized controlled trial to promote physical activity and diminish overweight and obesity in elementary school children. *Preventive Medicine*, *49*(4), 336-341.

Education, I. P. (2010). The Association between School-Based Physical Activity, Including Physical Education, and Academic Performance.

Edmunds, J., Ntoumanis, N., & Duda, J. L. (2008). Testing a self-determination theory-based teaching style intervention in the exercise domain. *European Journal of Social Psychology*, *38*(2), 375-388.

Erwin, H. E., Abel, M. G., Beighle, A., & Beets, M. W. (2011). Promoting children's health through physically active math classes: a pilot study. *Health Promotion Practice*, *12*(2), 244-251.

Gately, P., Curtis, C., & Hardaker, R. (2013). An evaluation in UK schools of a classroom-based physical activity programme–TAKE 10. *Â®: a qualitative analysis of the teachers' perspective. Educ Health*, *31*, 72-78.

Gibson, C. A., Smith, B. K., DuBose, K. D., Greene, J. L., Bailey, B. W., Williams, S. L., & Mayo, M. S. (2008). Physical activity across the curriculum: year one process evaluation results. *International Journal of Behavioral Nutrition and Physical Activity*, *5*(36), 1-11.

Gilakjani, A. P. (2011). Visual, auditory, kinesthetic learning styles and their impacts on English language teaching. *Journal of Studies in Education*, *2*(1), 104-113.

Gordon-Larsen, P., Nelson, M. C., & Popkin, B. M. (2004). Longitudinal physical activity and sedentary behavior trends: adolescence to adulthood. *American Journal of Preventive Medicine*, *27*(4), 277-283.

Gorozidis, G., & Papaioannou, A. G. (2014). Teachers' motivation to participate in training and to implement innovations. *Teaching and Teacher Education*, *39*, 1-11.

Griffiths, L. J., Cortina-Borja, M., Sera, F., Pouliou, T., Geraci, M., Rich, C., & Jebb, S. A. (2013). How active are our children? Findings from the Millennium Cohort Study. *BMJ Open*, *3*(8), e002893.

Holt, E., Bartee, T., & Heelan, K. (2013). Evaluation of a policy to integrate physical activity into the school day. *Journal of Physical Activity & Health*, *10*(4), 480-7.

Janssen, I., & LeBlanc, A. G. (2010). Review Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity*, *7*(40), 1-16.

Jensen, E. (1998). Teaching with the brain in mind. Alexandria, Va: Association for Supervision and Curriculum Development.

Kantomaa, M. T., Stamatakis, E., Kankaanpää, A., Kajantie, E., Taanila, A., & Tammelin, T. (2015). Associations of Physical Activity and Sedentary Behavior with Adolescent Academic Achievement. *Journal of Research on Adolescence*.

Katz, D. L., Cushman, D., Reynolds, J., Njike, V., Treu, J. A., Walker, J., & Katz, C. (2010). Putting physical activity where it fits in the school day: preliminary results of the ABC (Activity Bursts in the Classroom) for fitness program. *Preventing Chronic Disease, 7*(4), A82.

Kempermann, G. (2002). Why new neurons? Possible functions for adult hippocampal neurogenesis. *The Journal of Neuroscience*, *22*(3), 635-638.

Kibbe, D. L., Hackett, J., Hurley, M., McFarland, A., Schubert, K. G., Schultz, A., & Harris, S. (2011). Ten Years of TAKE 10!®: Integrating physical activity with academic concepts in elementary school classrooms. *Preventive Medicine*, *52*, S43-S50.

Kim, H. Y. P., Frongillo, E. A., Han, S. S., Oh, S. Y., Kim, W. K., Jang, Y. A., & Kim, S. H. (2003). Academic performance of Korean children is associated with dietary behaviours and physical status. *Asia Pacific Journal of Clinical Nutrition*, *12*(2), 186-192.

Knoblauch, H., Baer, A., Laurier, E., Petschke, S., & Schnettler, B. (2008). Visual analysis. New developments in the interpretative analysis of video and photography. *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research*, *9*(3), 1-14.

Lam, S. F., Cheng, R. W. Y., & Choy, H. C. (2010). School support and teacher motivation to implement project-based learning. *Learning and Instruction*, *20*(6), 487-497.

Lambourne, K., Hansen, D. M., Szabo, A. N., Lee, J., Herrmann, S. D., & Donnelly, J. E. (2013). Indirect and direct relations between aerobic fitness, physical activity, and academic achievement in elementary school students. *Mental Health and Physical Activity*, *6*(3), 165-171.

Lee, J. M., Kim, Y., Bai, Y., Gaesser, G. A., & Welk, G. J. (2016). Validation of the SenseWear mini armband in children during semi-structure activity settings. *Journal of Science and Medicine in Sport*, *19*(1), 41-45.

Mahar, M. T., Murphy, S. K., Rowe, D. A., Golden, J., Shields, A. T., & Raedeke, T. D. (2006). Effects of a classroom-based program on physical activity and on-task behavior. *Medicine and Science in Sports and Exercise*, *38*(12), 2006.

Mahar, M. T. (2011). Impact of short bouts of physical activity on attention-to-task in elementary school children. *Preventive Medicine*, *52*, S60-S64.

Martin, R., & Murtagh, E. M. (2015). An intervention to improve the physical activity levels of children: Design and rationale of the 'Active Classrooms' cluster randomized controlled trial. *Contemporary Clinical Trials*, *41*, 180-191.

Marzano, R. J., & Pickering, D. J. (2013). *The Highly Engaged Classroom*. Solution Tree Press.

Mega, C., Ronconi, L., & De Beni, R. (2014). What makes a good student? How emotions, self-regulated learning, and motivation contribute to academic achievement. *Journal of Educational Psychology*, *106*(1), 121.

Nces.ed.gov 2007-2008 (SOURCE: U.S. Department of Education, National Center for Education Statistics, Schools and Staffing Survey (SASS), "Public School Data File," 2007-08.

Oliver, M., Schofield, G., & McEvoy, E. (2006). An integrated curriculum approach to increasing habitual physical activity in children: a feasibility study. *The Journal of School Health*, *76*(2), 74-79.

Palmer, A., & Klein, R. (2003). Multiple roles of endorphins in morphogenesis, neuronal networking, and brain function. *Genes & Development*, *17*(12), 1429-1450.

Pekrun, R., Goetz, T., Titz, W., & Perry, R. P. (2002). Academic emotions in students' self-regulated learning and achievement: A program of qualitative and quantitative research. *Educational Psychologist*, *37*(2), 91-105.

Reiner, M., Niermann, C., Jekauc, D., & Woll, A. (2013). Long-term health benefits of physical activity–a systematic review of longitudinal studies. *BMC Public Health*, *13*(1), 813.

Shapiro, E. S. (2003). Behavioral observation of students in schools (BOSS). *Computer Software. San Antonio, TX: Psychological Corporation*.

Singh, A., Uijtdewilligen, L., Twisk, J. W., Van Mechelen, W., & Chinapaw, M. J. (2012). Physical activity and performance at school: a systematic review of the literature including a methodological quality assessment. *Archives of Pediatrics & Adolescent Medicine*, *166*(1), 49-55.

Sørebø, Ø., Halvari, H., Gulli, V. F., & Kristiansen, R. (2009). The role of self-determination theory in explaining teachers' motivation to continue to use e-learning technology. *Computers & Education*, *53*(4), 1177-1187

Stewart, J. A., Dennison, D. A., Kohl, H. W., & Doyle, J. A. (2004). Exercise level and energy expenditure in the TAKE 10!® in-class physical activity program. *Journal of School Health*, *74*(10), 397-400.

Stylianou, M., Kulinna, P. H., & Naiman, T. (2015). 'because there's nobody who can just sit that long' Teacher perceptions of classroom-based physical activity and related management issues. *European Physical Education Review*, 1356336X15613968.

Stylianou, M., Kulinna, P. H., Van Der Mars, H., Mahar, M. T., Adams, M. A., & Amazeen, E. (2016). Before-school running/walking club: Effects on student on-task behavior. *Preventive Medicine Reports*, *3*, 196-202.

Taras, H. (2005). Physical activity and student performance at school. *Journal of School Health*, *75*(6), 214-218.

Taylor, I. M., Ntoumanis, N., & Standage, M. (2008). A self-determination theory approach to understanding the antecedents of teachers' motivational strategies in physical education. *Journal of Sport & Exercise Psychology*, *30*(1), 75.

Tong, L., Shen, H., Perreau, V. M., Balazs, R., & Cotman, C. W. (2001). Effects of exercise on gene-expression profile in the rat hippocampus. *Neurobiology of Disease*, *8*(6), 1046-1056.

Tranquillo, J. (2008). AC 2008-599: Kinesthetic Learning in the Classroom. *Age*, *13*, 1.

Author Information

Kailey Snyder
University of Nebraska at Omaha
6001 Dodge St, Omaha NE 68106
Contact e-mail: *kesnyder@unomaha.edu*

Danae Dinkel
University of Nebraska at Omaha
6001 Dodge St, Omaha NE 68106

Connie Schaffer
University of Nebraska at Omaha
6001 Dodge St, Omaha NE 68106

Seth Hiveley
Papillion La Vista Community Schools
7821 Terry Dr, La Vista NE 68128

Amanda Colpitts
Papillion La Vista Community Schools
7821 Terry Dr, La Vista NE 68128

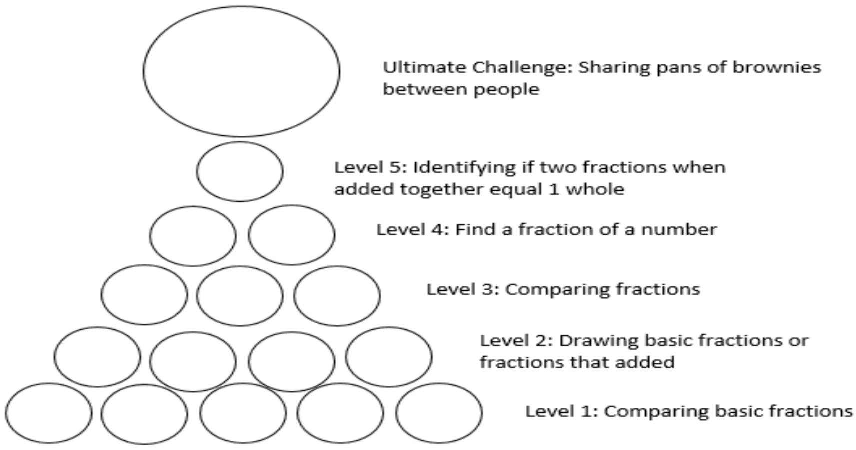
Appendix

Lesson: Fraction Pyramids

Purpose: Students will practice fraction facts with purposeful movement. Their goal is to get the question correct and/or be the first partner to answer the question correctly.

Materials:

- 15 hula hoops, arranged in a pyramid format (5 levels)
- 1 big hula hoop or small cones arranged in a circle—this is the "Ultimate Challenge Space"
- 4 exercise stations (or no exercise stations and students run 1 lap)
- 6 sets of cards that will go within the hula hoops; these will be problems that the students will answer
    - These cards can either be all the same type of problem, or each "level" can have different types of problems on the cards for the students to answer
    - Below is how we organized this game for our fraction unit



Process:

1. Students will start at a hula hoop in **Level 1**.
2. These students will flip over one question between the two of them. Students will race to be the first student to answer the question correctly.
3. The first student to answer the question correctly will "move on" to the next level, **Level 2**.
4. The student who was not the quickest will do a few things:
    a. Do the required exercises (this can either be running a lap around the gym/classroom OR doing a few exercises, such as 10 sit-ups/5 burpees/10 step-ups/etc.)
    b. Regardless of what "level" the students "got out on", they will automatically start back at **Level 1**
5. For the student who won **Level 1**, they will then move on to **Level 2**. Here, they will wait for another person to win **Level 1** and then face that student.
6. The same as **Level 1**, the student who wins will move on to **Level 3**, and the student who loses has to do the exercise and start back at **Level 1**.
7. If a student continues to win, they will continue to move on to **Level 4** and **Level 5**.
8. If a student wins the level 5 question, that student will do a few things:
    a. Put their name on the board under "Ultimate Challenger"
    b. That student will move on to the "Ultimate Challenge" area to face another student to answer the "Ultimate Question" in order to be the "Ultimate Champion"
    c. They will need to wait until another student meets them in the "Ultimate Challenge" area.
9. When there are two students in the "Ultimate Challenge" area, they will flip over one final card, and race to answer the question. The winner will then become the "Ultimate Champion", writes a tally next to their name, and continues staying in the "Ultimate Challenge" area for another challenger.
    a. The student that loses will then go do then required exercise and start back at level 1.
10. The goal for each student is to move through each level and eventually reach the "Ultimate Challenge" level, as well as review math facts/problems in an engaging and active way.

a. Students are able often motivated to do well and solve the facts/problems quicker in order to win that level

Variations of the game:

- Multiplication: 2 dice in each hula hoop. One student at a time will roll 2 dice and multiply the numbers shown on the dice. The student with the largest product will move on to the next level.
- Addition/Subtraction: 2 dice in each hula hoop. One student at a time will roll 2 dice twice. The first time the dice are rolled, those numbers create a two-digit number. The second time the 2 dice are rolled, those numbers create a two-digit number. The student then adds those numbers together. Partner two does the same by rolling the 2 dice twice and adding those two-digit numbers together. The partner with the largest sum wins. With subtraction, the students would just find the difference between the 2 two-digit numbers, and the largest difference would win.