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Curriculum Matters: Learning Science-Based Fitness Knowledge in Constructivist Physical Education

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Learning Science-Based Fitness Knowledge in Constructivist Physical Education

ABSTRACT
Teaching fitness-related knowledge has become critical in developing children's healthful living behavior. The purpose of this study was to examine the effects of a science-based, constructivist physical education curriculum on learning fitness knowledge critical to healthful living in elementary school students. The schools (N = 30) were randomly selected from one of the largest school districts in the United States and randomly assigned to treatment curriculum and control conditions. Students in third, fourth, and fifth grade (N = 5,717) were pre- and posttested on a standardized knowledge test on exercise principles and benefits in cardiorespiratory health, muscular capacity, and healthful nutrition and body flexibility. The results indicated that children in the treatment curriculum condition learned at a faster rate than their counterparts in the control condition. The results suggest that the constructivist curriculum is capable of inducing superior knowledge gain in third-, fourth-, and fifth-grade children.

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SCHOOL physical education has been considered to be a viable intervention avenue for educating young people about the benefits and principles of physically active and healthful living (Corbin, 2002). The curriculum, therefore, plays an essential role in accomplishing this goal. According to the President's Council on Physical Fitness (2009), a high-quality physical education curriculum must not only engage students in moderate or vigorous physical activity, but

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must also provide ample opportunities to learn knowledge necessary for developing and maintaining a healthful lifestyle throughout childhood and into adulthood. Scholars have developed a number of fitness education curricula (Corbin, Le Masurier, & Lambdin, 2007; Rainey & Murray, 2005) that focus on helping students learn cognitive concepts of fitness with physical activity experiences. Teaching fitness-related knowledge has become critical in developing children's healthful living behavior (Corbin et al., 2007). This intensive emphasis on learning cognitive knowledge for behavioral change appears to echo research conclusions from educational psychology (e.g., Woolfolk, 1998)—that humans control rational behavior through applying knowledge stored in their cognitive systems.

Learning cognitive knowledge in physical education is a unique experience for children. Constructivist learning theories have received much attention in educational research and have been incorporated in the process of curriculum development in many content areas. An important assumption underlying the theories is that knowledge cannot simply be transmitted from teacher to learner. Knowledge is actively constructed by individual students within the constraints of the physical and social environments where the knowledge-student interaction takes place (Alexander, 2006). Constructivist theories provide a family of alternative curriculum-design frameworks different from those from behavioral and some cognitive perspectives (e.g., information processing). They reiterate an epistemological belief that knowledge or knowing cannot exist without human construction (Alexander, 2006).

Consistent with this belief, educators have started to accept the idea that "an essential feature of learning is that it creates the Zone of Proximal Development [ZPD]; that is, learning awakens a variety of internal processes that are able to operate only when the child is interacting with people in his environment and in cooperation with his peers" (Vygotsky, 1978, p. 90). Functionally in learning, the zone of proximal development (ZPD) is defined as the distance between what a learner knows and can do and what he or she will potentially be able to know and do with help from others such as the teacher (Vygotsky, 1930–1931/1998). The concept of ZPD recognizes the critical role of social interaction in learning between the learner and knowledgeable others, such as the teacher and fellow students (Oldfather & Dahl, 1994). An effective curriculum must take into account what learners know and can do presently and what social interaction condition the curriculum will create to allow others (teachers and peers) to lead a learner through the ZPD to realize his or her potential.

The concept of ZPD has become the center of social constructivism and has provided a theoretical platform for curriculum reform and development in physical education. For example, on the basis of these social constructivist theoretical underpinnings, Ennis (2003) proposed a value-context curriculum model to describe relevant factors in the educational environment that are "directly affecting what, how, and how much students learn in physical education" (p. 114). In this model, student learning is at the center and directly influenced by the curriculum planning and teaching process. Ennis argued that teachers can enhance students' learning by carefully selecting content that is meaningful to them and by providing them with a social environment in which they can make connections between what they learn in class and their life experiences outside of class by themselves and with knowledgeable others. Ennis (2008) demonstrated in an ethnographic study that learners' prior experiences with content and their immediate social interactions during learning (teacher-student and student-student) determine the quality of learning experience and achievement. This suggests that social interaction in the learning process must be created deliberately as part of the curriculum rather than being left to chance.

Social interaction, often as a natural occurrence, is commonplace in physical education due to the fact that the content demands that students physically display their responses to learning tasks. The responses often draw peers' and teachers' attention, comments, and feedback in front of the entire class. Social interaction is a part of the learning process and potentially publicizes individual ZPDs. How to capitalize on social interactions to enhance knowledge construction remains a question for physical education researchers to answer (Hastie & Pickwell, 1996).

Among the limited scholarly attempts to articulate what a social constructivist physical education curriculum might look like, Azzarito and Ennis (2003) summarized key characteristics for curriculum designers to consider. They postulated that the goal of a social constructivist curriculum is to provide students with both physical and cognitive experiences that lead to authentic and meaningful learning achievement. In such a curriculum, teachers are facilitators and provide genuine group work (e.g., small- or large-group collaboration requiring think-pair-share with peers or activities with both individual and group responsibilities) to encourage social interaction and collaborative learning. Genuine learning tasks should help students relate the content to their previous experiences and prior knowledge on which new skills and knowledge can be constructed. Students, on the other hand, are considered active decision makers who take initiative, think carefully about the purpose of learning, and begin to possess the ownership of what they learn (Azzarito & Ennis, 2003). Azzarito and Ennis suggested that a social constructivist curriculum should help create a community of learners in which learning occurs through teacher-student and student-student interactions and connections to the real world.

Researchers must test these theoretical ideas in order to generate research-based evidence that can guide future curricular reform. The purpose of this study, therefore, is to determine effects of a curriculum designed by following social constructivist learning theory on learning fitness knowledge critical to healthful living in elementary school physical education. Specifically, we asked whether and to what extent curriculum influences elementary school students' knowledge gain in three areas important to fitness development and healthful living: cardiorespiratory health, muscular capacity, and the principle of maintaining body flexibility and good nutrition.

Method

Curriculum Development for the Treatment Condition

The curriculum for the treatment condition was designed to teach important knowledge about cardiorespiratory fitness and health, muscular capacity and fitness, and body flexibility development and nutrition for healthful living to students in grades 3–5. A curriculum writing team consisting of university researchers and expert physical education and science teachers reviewed and deliberated primary principles of constructivist learning theory in relation to the fitness content to be learned in elementary school physical education. The team determined three design guidelines.

First, all learning tasks must integrate physical and cognitive demands. Students should be physically active in exploring knowledge components. For example, in learning the concept of intensity of exercise in relation to heart-rate change, students must be engaged in physical activities that induce various physiological responses measurable by heart rate. Students must engage in cognitive tasks to predict and record heart rate, evaluate heart-rate change as evidence, and eventually determine how to select activities of appropriate intensity that will raise their heart rate into the target zone to maximize health benefits from exercise.

Second, the learning process should be centered on the principle of ZPD. The knowledge gap between the teacher (the expert) and students (novices) represents the largest distance between students' initial knowledge and the knowledge they are expected to master. Peer-teaching/learning is infused in major learning tasks in each lesson using the mechanism of think-pair-share. This mechanism allows students to interact during the entire learning process to move unconsciously among the ZPDs between peers, to actively identify the knowledge gap between prior and current knowledge, and to learn new information to fill the knowledge gap and reduce the ZPD.

Third, given the critical role that prior knowledge plays in learning new knowledge, each lesson starts with an essential question related to real-life experiences that elementary school students may face daily. For instance, a lesson may begin with a 2-minute instant activity of single jump rope (forward/backward/one foot/two feet). During the activity, the teacher directs students' attention to how their body feels (e.g., hot, sweaty, tired, out of breath), what it looks like (e.g., sweating), and what it sounds like (e.g., breathing hard). Based on the observations, the teacher leads the learners to understand the concept of physiological change due to the physical activity they have experienced.

The curriculum includes three study units: cardiorespiratory health, muscular capacity (muscular strength and endurance), and flexibility development and nutrition. The content was sequenced using the spiral sequencing structure (Gagné, Briggs, & Wager, 1992). Scientific concepts, principles, and related physical activities are repeatedly visited and revisited by students in a lesson and in multiple lessons. Important concepts can be reviewed and restudied with increased sophistication in one unit and across units, and within and across grades. Each of the three units includes 10 lessons for each of grades 3–5. The curriculum document includes, first, a teacher instructional manual that provides scripted lesson plans to guide the teacher in the concepts to be learned and activities to engage students in learning. Second, a science journal contains written assignments for students to complete along with physical activity tasks. For example, in a resistance-cord task, students explore the levels of resistance that different resistance cords give in terms of the feeling of their muscle tension and fatigue. During the exercises, they answer questions in the journal about the overload principle in relation to the level of resistance each cord gives. Third, an activity guide provides teachers with primary learning tasks and their alternatives. The alternative tasks are important in that they provide task variations for the teacher to tailor tasks according to his or her teaching context (e.g., schools with and without a gymnasium) to faithfully follow the curriculum and minimize deviation.

Consistent with constructivist theory, the content-delivery system is based on a learner-centered 5-E scientific inquiry mechanism: engagement, exploration, explanation, elaboration, and evaluation (Bybee et al., 1989). During engagement, students enter the physical education class and assume the role of a "junior scientist" (often an exercise physiologist). The teacher then involves the students instantly in an activity that includes both science knowledge and physical activity. In exploration, students predict, observe, and collect data to document how their bodies respond to physical activity. They record and document the data in their science journals in learning centers while continuing to move throughout the physical education space. During explanation, the teacher leads small- or large-group discussions where think-pair-share takes place for students to examine their data and compare them to criteria and norms included in the science journal. The evaluation component focuses students' attention on resources and assessments in the science journal entries. In this process, students compare the data they collected during exploration against a standard, such as a target heart-rate zone for optimal health benefits through exercising, to evaluate the merit of the exercise experienced. During elaboration, the students consider the real-life implications of their findings outside of class and school. They have the opportunity to discuss their findings with others and situate what they learn within a meaningful life context.

Throughout a lesson, students continuously use the science journal to document and process their responses to physical activity, discuss the meaning of their observations, and come up with conclusions. The curriculum constantly requires students to connect their physical activities to the cognitive knowledge they are expected to master. During learning, students often move, stop, think, discuss, record, calculate, conclude, and then move again. One might hypothesize that the heavy emphasis on cognition during the learning process costs precious physical activity time, which could lead to a reduction in the benefit that students ought to receive from physical education. To address this concern, the curriculum writing team used strategies such as carefully structuring journal entries, manipulating page arrangements (the left-hand page presents science vocabulary, principles, and concepts, while the right-hand page presents structured working spaces for students to answer questions, complete data observation tables, graph findings, and write science notes), recommending effective class-organization techniques for effective management of journaling, and incorporating small-group discussion with simultaneous low-intensity physical activities. These strategies seemed to work well in addressing the issue. It was found through analysis of caloric expenditure measures that students working on journals did not compromise their opportunity to engage in the moderate to vigorous physical activity that provides health benefits (Chen, Martin, Sun, & Ennis, 2007).

Research Design and Sampling

A randomized, controlled experimental design was used to determine effects of the curriculum. A total of 30 elementary schools from one of the largest multiethnic school districts in the United States were randomly selected to participate in the study. The school district was representative of the 100 largest school districts in the United States in terms of teacher-student ratio, per pupil funding, and free and reduced-price meals (FARM%). The district's means on these variables were within .5 standard deviations of the national means. During sampling, all 152 elementary schools in the district were stratified on FARM% and school performance on the state standardized science test. Schools with matching values on the stratification variables were grouped in the same sampling bracket. The procedure produced 15 brackets with four to five schools each. Two schools in each bracket were randomly selected as participating schools, one assigned to the treatment condition where the constructivist curriculum was to be implemented, the other to the control condition where a regular physical education curriculum would continue. The sampling procedure yielded 15 schools for each condition.

Treatment and control conditions. In the treatment condition, the constructivist curriculum was delivered using the 5-E system (engage, explore, explain, elaborate, and evaluate) to help children construct knowledge of physical activity principles and benefits. As described earlier, cognitive tasks were central in all lessons. Children used their individual science journals to record their experiments and measurements associated with physical activity and to write conclusions.

For comparison purposes, the curriculum in the control group served as a placebo. The control/placebo curriculum was based on national (National Association for Sport and Physical Education, 2004) and state standards. It provided students with opportunities to experience fundamental movement skills (e.g., walking, skipping, running, hopping, balancing, throwing, striking) and quasi-sport skills and games (e.g., modified soccer, basketball). As mandated by the school district, the curriculum also taught health-related fitness knowledge (e.g., the relation between heart-rate change and exercise, physical activity benefits for health) and fitness physical activities or exercises that enhance cardiorespiratory health (e.g., jumping rope, distance walking, jogging, and running), muscular strength and endurance (e.g., modified push-ups, medicine ball exercises), and body flexibility (e.g., stretching exercises). In other words, the treatment curricular content, fitness in particular, was covered in the control group, but the above fitness content was taught in a short unit in which fitness activities or exercises were experienced and children's health-related fitness was tested. Cognitive information was taught through a teacher-to-students transmission approach in which the teacher presented the information to students mostly by lecturing to them during exercises. The presentations were normally verbal without specific in-depth worksheet assignments. No lessons in the control curriculum were structured with the 5-E structure. There were no in-depth, cognitively oriented learning activities, other than lectures, aimed at promoting student knowledge such as were included in the treatment curriculum. After the short unit, fitness activities or exercises were incorporated in sport and game lessons and normally were experienced in the beginning portion of a lesson, called warm-up, to help students adjust physiologically for the upcoming sport or game content. Learning assessment was based on a variety of indicators, including daily participation, skill tests, and written tests.

The two conditions were theoretically distinct. The treatment curriculum was based on the constructivist approach in which prior knowledge, ZPD, inquiry-driven tasks, and cognitive-physical task integration were organized in the 5-E instructional system. Learning experiences were organized around individual and small-group work. The control condition was characterized by a traditional approach in which teacher-led game and sport was the major content. Fitness knowledge was learned primarily through fitness activities or exercises, while the focus was on exercising rather than cognitive understanding of exercises. Consequently, cognitive knowledge was marginalized content with few planned tasks for students. Furthermore,

Table 1. Differences between Treatment and Control Conditions

	Treatment	Control
Theoretical orientation	Constructivist	Behaviorist
Operational underpinnings	ZPD (teacher and peer) Prior knowledge Cognitive-physical task integration Experiment-inquiry driven 5-Es	Game/sport centered Teacher-led activities Direct teaching Fitness-testing related Exercise and lecture
Cognitive tasks	Major content Planned cognitive activities	Marginalized content No planned cognitive activities
Physical activity tasks	Tied into cognitive understanding Reinforcing knowledge	Independent from cognition
Learning format	Individualized Small group (think-pair-share)	Large groups

instead of individual and small groups, students participated in whole-class or large-group sport games or competitions. Table 1 describes major characteristics in the two conditions.

Teachers in the two curricular conditions participated in separate training workshops to enhance teaching effectiveness in their respective curriculum. The teachers received a 3-day, in-service training during the summer and two half-day in-service workshops during the semester. Those in the treatment condition received training specific to teaching the treatment curriculum, including its unique 5-E instructional approach. The teachers in the control condition were trained in the same format and time allotment, but the content was focused on the effectiveness of teaching the control curriculum, including class management, principles of skill development, tactical games approach, and skill and fitness assessments. The training for the control group is considered to be a placebo treatment necessary in the research design to control for noncurricular impact (such as the Hawthorne effect due to researchers' attention) on student responses in the treatment condition.

Throughout the study, teachers from both conditions were observed weekly by trained data collectors who documented the lessons in field notes. The field notes were analyzed by the researchers to monitor and determine curricular implementation fidelity of both conditions. For lessons in the treatment condition, when deviation or slippage from the lesson plans, if any, were identified, e-mail or telephone contact between the curriculum team director and the teacher was used to identify reasons for the slippage. Teachers' questions and concerns were addressed in a swift and effective manner, and suggestions were made to the teacher to remedy the slippage. For the control condition, field notes were summarized and communicated to the teacher as a form of feedback on instructional effectiveness.

Student participants. The 30 schools served 7,031 grade 3–5 students who participated in the study. Due to an approximate 19% attrition rate, the final sample included 5,717 students (48% female). They were primarily from families with lower-income socioeconomic backgrounds. Seventy-one percent were African American, 6% Caucasian American, 9% Mexican American, 2% Asian American, and 12% from other ethnic backgrounds. Missing data analysis determined that attrition was random and would not skew the data or pose threats to data integrity. The students were pre- and posttested using a standardized knowledge test that was created and validated for this study (Chen, Ennis, Martin, & Sun, 2006). During the study, students received their respective curricula in 30-minute physical education lessons twice per week. Signed consent from parents/guardians and assent from the students were secured before the pretest was administered.

Variables and measurement instrument. A set of standardized knowledge tests was integrated into the curriculum as summative assessment. One standardized test was developed for each unit in each grade. The tests were administered before and after each unit to determine students' knowledge growth. The questions covered the five specified knowledge domains taught in the curriculum: science vocabulary, exercise science principles, measurement of physiological responses to physical activity, inference of exercise intensity, and physiological benefits of exercise. To ensure that the questions truly tested the knowledge in the curriculum and were appropriate for the students in each grade, a validation examination was conducted on all the questions.

The content validity of the questions was determined by expert physical educators and science educators ($n = 7$). During the validation, the teachers were asked to rate each question on a 5-point scale for knowledge accuracy (1 = inaccurate, 5 = accurate) and language appropriateness (third-grade literacy level; 1 = inappropriate, 5 = appropriate). For inclusion in field validation testing, questions had to be rated 5 by each teacher. Questions that did not receive a rating of 5 were continually revised until a consensus (an overall 5) was reached with respect to content accuracy and grade-appropriate readability. Then the questions were field tested in a validation process to determine the index of difficulty and index of discrimination (Chen et al., 2006). Questions that met the standards of the difficulty index (.45–.55) and the discrimination index (>.40) were included in a question bank for each instructional unit (Morrow, Jackson, Disch, & Mood, 2005). Three different test forms were created for each unit to distinguish the test content between grades. Specifically, there were nine questions in each form in the cardiovascular unit, eight questions in each form in the muscular capacity unit, and 12 questions in each form in the flexibility unit. A correct answer received a point of 1, an incorrect answer 0. Thus, the total possible score for a test equaled the total number of questions.

Data collection. To ensure accuracy of data collection, we used Scantron eListent software to design the test forms and print out the forms individually for each student. The forms for each class were sealed in one manila envelope on which a written testing protocol was affixed. Pre- and posttest schedules were coordinated between the treatment and control schools so that the tests took place in the same week in matched schools in both conditions. Data were collected by physical education teachers who were trained to follow a stringent protocol for giving written tests in physical education settings to minimize threats to data reliability. Trained data collectors from the research team were present during test sessions and assisted the teachers in following the protocol by clarifying their questions about the procedure. During the test, the teacher or data collector read each question aloud to students and clarified noncontent-related questions (e.g., "Can I bubble two choices?" "No."). Immediately after the test, the teacher collected the test forms and organized them in alphabetical order by students' last name. The data collector verified students' attendance with the class roster, noted those who were absent, sealed the test forms in the original envelope, and delivered them to the research laboratory.

The in-laboratory data-collection process included four steps. First, all answered tests were catalogued by school, class, and student, and then were scanned into a spreadsheet database. Second, the data spreadsheets were converted into SPSS format and identification information and test questions were coded. Third, the student, class, and school identification information on the data spreadsheets was verified with a master roster file of participants provided by the school district to determine absentees. Finally, all verified data from each school were merged for analysis.

Data reduction. Answers to each question were coded as correct (1) or incorrect (0) based on the answer keys developed and validated by the expert group. Class means rather than individual scores were used as the unit of analysis. The unit-of-analysis issue is rooted in the possibility that the assumption of observation independence for inferential statistics is violated when the responses to the measures are autocorrelated. In school-based studies, the autocorrelation is most likely to occur within a class where students respond to the measure together. Because students experienced their respective curricula and responded to the knowledge tests in their intact classes, analyzing data using the student as the unit of analysis might run the risk of autocorrelation. Consequently, using individual students as the unit of analysis might lead to spurious results due to an inflated α rate that misdetermines the p value in inferential statistical procedures (Scariano & Davenport, 1987). In this study, the school was the sampling and intervention unit by design, but the students received the curricula and responded to the tests within their classes. Some unexpected events during the experiment occurred at the class level (e.g., unusual classroom interruptions, unusual weather) as well. Thus, the main threat to the assumption of observation independence came from class. Using class as the unit of analysis was sufficient to control for the threat.

Data analysis. Descriptive statistics were computed to provide an overall summary of students' pre- and posttest performance in three units in both groups. A series of 2 (treatment-control) $\times$ 2 (pre-post) analyses of variance (ANOVA) with repeated measures on test were performed to examine the main effect of the treatment, time, and the interactions between the two factors. We used a two-factor split-plot/mixed design, which is a combination of an independent groups ANOVA and a repeated-measures ANOVA. The within-subjects factor was knowledge test (pre-post/time) and the between-subjects factor was treatment condition (new curriculum/control). Partial eta-squared ($\eta^2 p$) was used as a measure of effect size in the analyses, and values of .02, .13, and .26 indicate small, medium, and large effect sizes, respectively (Cohen, 1992).

Results

Table 2 provides information about the number of classes in each grade. The class means for pre- and posttest scores and knowledge gain scores are reported in Table 3. The data show that the knowledge gain score means from the treatment condition were higher than those of the control group. The magnitude of the curricular (treatment) effect of each unit was calculated using Cohen's d and is reported in Table 4. The d values clearly demonstrate large effect sizes for the three treatment curriculum

Table 2. Number of Classes in Both Curriculum Conditions

	Treatment			Control		
Test	Grade 3	Grade 4	Grade 5	Grade 3	Grade 4	Grade 5
Cardiovascular fitness	30	33	39	42	41	40
Muscular fitness	31	34	36	38	38	42
Flexibility/nutrition	28	31	33	40	37	42

Note.—The differences in the numbers of classes were due to attrition. We recorded a 20% attrition rate. Over the course of the study, some schools had to increase or reduce classes during the semester to accommodate enrollment change. The number of classes might increase when overcrowded classes were split into smaller classes; the number might decrease when most students in one class left for other schools and the remaining students were combined with other classes.

units. To determine students' learning in each unit, we analyzed their performance in the three knowledge tests separately.

The Cardiovascular Fitness Unit

The repeated-measures ANOVA revealed a significant main effect for the treatment conditions, $F(1, 223) = 62.576$, $p = .001$, $\eta^2 p = .219$. The test of within-subjects effects revealed a significant effect for time, $F(1, 223) = 286.79$, $p = .001$, $\eta^2 p = .563$. In addition, the results also showed a significant effect of interaction between time and treatment, $F(1, 223) = 47.819$, $p = .001$, $\eta^2 p = .177$. Overall, the results indicate a significant difference between students' pre- and posttests: specifically, students in the treatment group learned more and at a faster rate than students in the control group.

The Muscular Fitness Unit

Similar to the cardiovascular unit, a significant main effect for the treatment was revealed by the repeated-measures ANOVA in the muscular fitness unit, $F(1, 217) = 103.715$, $p = .001$, $\eta^2 p = .323$. The test of within-subjects effects revealed a significant effect of time, $F(1, 217) = 156.2$, $p = .001$, $\eta^2 p = .419$. Additionally, the results showed a significant effect of interaction between time and treatment, $F(1, 217) = 84.291$, $p = .001$, $\eta^2 p = .280$. Taken together, the results indicate a significant difference between

Table 3. Class Means of Pretest, Posttest, and Gain Scores by Condition and Grade

	Treatment			Control		
Test	Grade 3 *M* (*SD*)	Grade 4 *M* (*SD*)	Grade 5 *M* (*SD*)	Grade 3 *M* (*SD*)	Grade 4 *M* (*SD*)	Grade 5 *M* (*SD*)
Cardiovascular fitness:						
Pretest	3.92 (1.17)	4.52 (.54)	4.20 (.54)	4.09 (.73)	4.16 (.51)	3.87 (.57)
Posttest	6.17 (.95)	6.04 (1.11)	5.33 (1.01)	4.88 (.47)	4.71 (.59)	4.53 (.58)
Muscular fitness:						
Pretest	3.83 (.54)	2.70 (.44)	3.62 (.77)	3.41 (.43)	2.54 (.43)	3.06 (.46)
Posttest	5.06 (.85)	4.46 (1.59)	4.62 (.92)	3.62 (.36)	2.73 (.57)	3.25 (.67)
Flexibility/nutrition:						
Pretest	8.26 (1.46)	6.75 (1.58)	7.69 (.96)	7.33 (1.28)	6.14 (1.23)	7.00 (1.02)
Posttest	10.71 (1.28)	9.10 (1.82)	9.31 (1.82)	8.01 (1.16)	7.15 (.74)	7.17 (.97)

Table 4. Effect Size (Cohen's *d*) by Unit and Grade

Unit	Grade 3	Grade 4	Grade 4
Cardiovascular fitness	1.72	1.50	.97
Muscular fitness	2.21	1.44	1.70
Flexibility/nutrition	2.21	1.40	1.47

Note.—An effect size of 0.2 to 0.3 might be a small effect, around 0.5 a medium effect, and 0.8 to infinity a large effect (Cohen, 1988).

students' pre- and posttests: specifically, students in the treatment group learned at a faster rate than students in the control group.

The Flexibility/Nutrition Unit

In the flexibility/nutrition unit, the repeated-measures ANOVA results show a significant main effect for the treatment, $F(1, 209) = 78.292$, $p = .001$, $\eta^2 p = .273$. In the test of within-subjects effects, the results suggest a significant main effect for time, $F(1, 209) = 194.848$, $p = .001$, $\eta^2 p = .482$. Results also revealed a significant effect for interaction between time and treatment, $F(1, 209) = 60.297$, $p = .001$, $\eta^2 p = .224$. Overall, results indicate a significant difference between students' pre- and posttests: students in the treatment group learned at a faster rate than the students in the control group.

Discussion

Evidence from the statistical analyses appears to support the notion that the curriculum worked. The analyzed data show that children given the treatment curriculum learned more and at a faster rate than their counterparts who received the control curriculum. It is also important to note that the treatment students learned the knowledge through active participation in physical activities. Given that the evidence was generated through randomized, controlled experimental research, it might be further claimed that the curriculum was the major factor for knowledge acquisition in this fitness education curriculum. The findings allow us to reason that the superior knowledge gain by the students in the treatment condition was due to the curricular and instructional components built into the curriculum. Those components included high-order knowledge-learning activities through intensive physical activity tasks, organizing learning experiences with the 5-E instructional structure, incorporating workbook assignments in every lesson to facilitate cognitive involvement in physical tasks, and using highly organized student-student social interaction structures (e.g., think-pair-share) to create effective learning communities in which ZPDs were identified and overcome with knowledge growth.

A unique indication from the evidence is that constructivist theory—the social constructivist perspective in particular—can be a viable theoretical platform for curriculum design in physical education. Previous studies (e.g., Chen, 2001, 2002; Chen & Rovegno, 2000; Darinis-Paraboschi, Lafont, & Menaut, 2005; Dyson, 2002) have considered constructivism as an instructional approach that the teacher may use to teach physical education. Dyson (2002) found that students learned more about a motor skill when they were provided with opportunities for analyzing each other's skills and providing specific feedback to their peers. Dyson (2002) argued that the cooperative learning instructional format that incorporates three tenets of constructivism—active learning, social learning, and creative learning—holds much promise for physical education. Darinis-Paraboschi and colleagues (2005) also suggested that teachers need to set up dyadic interaction within the classroom because social interaction between peers could lead to effective tactical action and decision making in a team-sport model that places much emphasis on tactical choice building in social interaction. It seems that the think-pair-share and 5-E learning strategies adopted in the treatment curriculum facilitated student-student social interaction in learning the content. Related to these findings, our results reinforce the importance of social interaction in a constructivist learning environment where creating ZPD is critical to enhancing learning.

Ennis (2008) argued that for learning to take place it is important to engage the learner in a coherent learning experience delivered by a coherent curriculum. Learning through a coherent curriculum provides a holistic knowledge construction experience more effective than a piecemeal approach that might include some constructivist ideas (Von Glasersfeld, 1995). In a coherent curriculum, the content ideas and instructional systems are integrated to promote active engagement, deep cognitive processing of information, and appreciation of ZPDs among members of the learning community.

The relationship between content topics and the instructional systems determines the coherence of a curriculum, as shown in Ennis's case study (2008). The treatment curriculum adopted scripted lesson plans as an approach to the assurance for and fidelity of content delivery. The teachers in the treatment condition were trained to follow the lesson plan script closely, sometimes verbatim, to ensure that the scientific concepts and vocabulary were precisely conveyed to the students. Through the 5-E and the peer-peer interactive structure, the students were challenged to develop a personally meaningful understanding of the knowledge and skills contained in the curriculum. In this curriculum, students were moving physically to learn cognitively. In fact, the curriculum manifested its effectiveness through providing inquiry-based content that encouraged and motivated students to internalize the knowledge and skills simultaneously demanded and supported by the curriculum.

One important tenet of constructivist theory is that knowledge and skill construction resides within individuals. External forces may influence the process of construction but will not alter the knowledge and skill repertoire unless the individual decides to internalize the new knowledge and skill components into his or her existing knowledge structure (Alexander, 2006; Von Glasersfeld, 1995). The findings of this study imply that an effective curriculum should not only be coherent for teaching, but also be meaningful for learning. The inquiry-based approach seemed to be one characteristic that distinguished the treatment curriculum from the control. The deliberate adoption of this approach appears to have assisted the internalization of knowledge and skills from an externally designed curriculum. Students in the treatment condition were constantly engaged in tasks of predicting their physiological responses to certain types of exercise or physical activity, hypothesizing what might happen as a result of physical activity, documenting and calculating information gathered during physical activity, and evaluating the information to reach conclusions that may or may not support their hypotheses.

The curricular significance of this approach lies in the fact that physically moving in the gymnasium is no longer for moving's sake or "fun" only. These movements become mini-laboratory experiences in which students explore and identify something personally meaningful. For example, they explored different tensions in color-coded resistance bands and determined the meaning of overload to themselves and in relation to important concepts of sets and repetition in developing muscular capacity for healthful living. Similarly, they explored and determined the personal meaning of range of motion in a joint during various physical activities and sport games. In this learning environment, the externally designed curriculum provided unique learning experiences that helped students internalize scientific knowledge and skills relevant to their lives in the immediate physical education setting and, speculatively speaking, relevant to their lives outside of physical education. An important implication of these findings is the possibility that an optimal ZPD may be developed externally in recognition of shared common experiences conducive to learning (Hedegaard, 2005). It could be speculated that the carefully designed spiral sequence in the treatment curriculum formed relevant scaffolds of knowledge where social interaction for learning among the students was strengthened. In other words, the externally designed curriculum can help learners determine what they can do without assistance (actual level of development) and what they can do with assistance (potential level of development), the two essential footings for the "advance of development" (Vygotsky, 1978, p. 89).

The evidence and above reasoning appear to suggest a possibility that an externally designed curriculum can be personally meaningful to students. In addition, learning can take place by constructing knowledge and skills defined by educators as "worthy" for the learner. For a long time, physical educators have noticed that students devalue physical education content because some forms of physical movement, such as competitive sports, are not perceived as personally relevant by a significant number of students (Ennis, Cothran, & Davidson, 1997). Bringing concepts relevant to everyday life into school gymnasia would strengthen the meaningfulness of content taught in classes. The findings demonstrate that blending concepts in physical activity may be a viable approach to integrated learning. The solution, based on the findings, can be designing and providing the internalization opportunities for students to develop values about physical education.

Conceptualization of learning has been changing. Although the knowledge gain documented in this study represents strong evidence of learning, learner conceptual change is increasingly considered to be the ultimate indication that learning has been accomplished (Alexander, 2006; Vosniadou, 2002). Evidence is clear that students demonstrated learning achievement in their responses to the standardized tests, but it is unclear whether the curriculum provided an experience deep enough to elicit a fundamental conceptual change in their knowledge base about fitness, benefits from physical activity, and principles guiding a sound, physically active lifestyle.

Conceptual change involves several critical steps that lead learning from a naive to a scientifically consistent conception (Vosniadou, 2002). The enduring demonstration of the latter and its application in constructing new knowledge and skills are the evidence of accomplished learning. Clearly, our data did not address this conceptualization of learning, which suggests a need for future study. Emerging studies (Bonello & Ennis, 2010) revealed that a constructivist approach heavily relying on students' connection between content and personal experience may have limitations.

For example, a student in physical education cannot see how blood transports oxygen from the cardiorespiratory system into the skeletal-muscular system, nor can that student feel the cellular respiration process of oxygenation. The physical education curriculum should be able to help the learner imagine those phenomena through kinetically responsive feelings of physical activities. Through physically experiencing bodily reaction to physical activities, the learner can overcome the enduring impact of naive conceptions and develop scientifically consistent conceptions (Bonello & Ennis, 2010).

Conclusion

This study generated convincing evidence that a constructivist physical education curriculum was able to lead elementary school students to effective knowledge construction. The superior knowledge gain in students who experienced the treatment curriculum can be attributed to the impact of the curriculum. Contributing factors include curricular coherence and the emphasis on helping students internalize the knowledge and skills in the curriculum and creating a highly learning-oriented learning community in which ZPDs can be meaningfully determined for students to enrich the learning experience. With the development of redefining learning as conceptual change in education, the evidence, based on knowledge gain determined by standardized tests, may be limiting still. Future studies incorporating conceptual change measures should be conducted to further our understanding of the power of curriculum on learning. Curriculum does matter!

Note

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