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Reimagining professional competence in physical education

Catherine D. Ennis

University of North Carolina at Greensboro, USA

Abstract

Physical educators have critical roles to play in assisting communities and schools to increase physical activity for all citizens. They can assist classroom teachers in increasing physical activity in the academic school day and can serve as school wellness directors to increase the amount of physical activity students and school staff members receive during the day. Additionally, physical educators can implement innovative approaches to physical education curricula to enhance students' opportunities to be active and to learn concepts to assist them to be physically active now and for a lifetime. When implementing evidence-based approaches to physical education, teachers need to teach the curriculum coherently and with fidelity. New programs such as Science, PE, & Me! and the Science of Healthful Living provide opportunities for students to examine the effects of exercise on their bodies in a physically active, learning-oriented approach to physical education.

Keywords

physical education; fitness; communities; schools; health

Reimagining professional competence in physical education

Academies, governments, and societies have not always acknowledged the contributions of physical activity to quality of life. Although the Greeks understood the relevance of a "sound mind in a sound body," societies have placed more value on developing the intellect, emphasizing and prioritizing the study of mathematics, history, science, and philosophy over the art and science of human movement. This is true today in many countries that often overlook the relevance, enjoyment, and science associated with physical performances.

Currently, however, health issues associated with sedentary lifestyles are causing great concern around the world (Braveman, Cubbin, Egerter, Williams, & Pamuk, 2010). As a result, politicians, physicians, government administrators, and public health officials are revisiting the role of physical education and activity in schools and communities. Chen (2013) argues that physical education and activity can act as powerful "vaccines" to improve overall public health. No longer isolated in traditional conceptualization of "health education," issues and concerns about national health are providing new opportunities for physical educators to contribute to their schools and communities.

Correspondence to: Catherine D. Ennis, Ph.D., Department of Kinesiology, University of North Carolina - Greensboro, Greensboro, NC 27412, U.S.A., c_ennis@uncg.edu, Phone: +1-336-337-6613.

Along with the emphasis on healthy nutrition, physicians, insurance providers, and health educators also are touting the role of physical activity in helping individuals maintain a healthy weight. The combined power of physical activity and healthy eating habits have the potential to limit the pervasiveness and negative impact of many sedentary and weight-related illnesses and injuries, such as Type II Diabetes, painful joints, and aching backs, as well as heart disease and many cancers (Winterfield, Shinkle, & Morandi, 2011). Along with this new push for increased personal and national wellness, is a renewed focus on opportunities for children and adults to become more physically active (U.S. Department of Health and Human Services, 2008). This interest provides many opportunities for physical education teachers to become involved in promoting physical activity as part of larger community and school health initiatives. Many of the professional competencies learned in teacher education programs are vital to these public health initiatives. Additionally, teachers will need to expand their competencies beyond teaching sports and games to embrace pedagogical competencies associated with health-related physical education (Ribeiro et al., 2010). In this paper I will discuss the changing role of physical educators in three rapidly expanding venues: community health, school wellness, and innovative, health-enhancing approaches to physical education.

The changing role of physical educators

Leading community health initiatives

Increasingly physical education teachers are viewed as key leaders of physical activity initiatives in their communities. Paid positions are frequently available for physical educators outside the school in neighborhood communities. For example, physical educators can facilitate *Get Fit* and *Healthy Eating* community fairs and events, answering questions and leading games and sport activities. In the community, their expertise is appreciated as recreational sport team coaches and as swimming, dance, and sport instructors for both mainstream and special needs populations. Although some of these are volunteer, unpaid positions, increasingly community leaders are realizing the need to engage formally trained professional, highly competent physical educators directly as community program leaders. Physical educators' competence in teaching dance, sport, exercise, and aquatics activities assure community administrators that the activities will be safe, well-managed, and provide the all important educational elements necessary to increase citizens' health by encouraging healthy family decisions (Hoffman, 2011).

Other local and national health initiatives depend on physical educators' competence and expertise to influence local practice. Physical educators are becoming directly involved in local public health campaigns to increase families' awareness of safety, health, and environmental programs. These programs provide important nutritional and physical activity information to promote physically active lifestyles and healthy eating choices. One program in the United States (U.S.) that is attracting widespread attention is the *Let's Move!* initiative, championed by First Lady Michelle Obama (Curtis, 2013). Physical educators are supporting the *Let's Move!* programs in their communities. They find full or part time work at these events in their community or city, providing physical activity and healthy eating instruction and leading community "walk, run, bike, or paddle" events. Local programs

increase awareness of organic foods, healthy meal planning, and the role of physical activity in health.

The *Let's Move!* initiative has attracted other key U.S. government agency sponsors. For example, *Let's Move!* receives financial support from the Department of Health and Human Services for healthy community projects, The Department of Agriculture for healthy eating programs, the Department of Education for school-based physical education, and the Department of the Interior to encourage family access and physical activity opportunities in the national park system and healthy eating and physical activity on cultural and tribal lands. Further, the *Let's Move!* initiatives provide financial support, advertising, and public health messages for other affiliated public and private agencies, such as *Let's Move! In Schools* (2013) and *Let's Move! Outside* (2013).

The U.S. Department of the Interior's messaging campaign, for example, encourages families to visit national parks, monuments, and museums. This agency hosts "Ready, Set, Play: National Kids to Parks Day!" National Park rangers and physical educators staff the Ready, Set, Play events in parks nationwide, providing many opportunities for physical activities and healthy lifestyle information (Let's Move Outside, 2013). Physical educators are instrumental in these public community health initiatives providing enjoyable physical activities for individuals and families who may not be able to pay fees to attend private fitness clubs. They play an essential role in addressing health issues such as obesity and sedentary lifestyle diseases.

Leading school wellness teams

Traditionally, physical educators, like most teachers, have been assigned to specific school teaching spaces where they interact with and provide instruction for students. For physical educators the gymnasium or outside fields have been designated as physical education teaching spaces. Yet, there are many large and small spaces within school buildings where physical activity can and should take place. Further, there are many times during the school day in which students and school staff can move vigorously. Whether these are interpreted as "wiggle time" for six year olds, recess, intramurals, or fitness, they provide opportunities for physical educators to take on the role of School Wellness Leader to transform the environment into a healthy, active school (Byrne, 2013).

Currently, physical educators increasingly are being asked to accept roles outside their regular physical education teaching duties. In addition to bus duty and cafeteria monitoring, they are asked to take responsibility for the school's wellness program. In this position, they can assist classroom teachers incorporate activity in their classrooms and design activity programs for students and staff during the non-academic parts of the school day.

Physical activity in the classroom (activity breaks)

Classroom teachers have long been aware of the value of physical activity breaks during the school day. Most breaks provide opportunities for students to go outside during good weather to run around and "let off some steam!" Physical educators also can be instrumental in assisting classroom teachers to infuse physical activity into their classroom lessons (Cone,

Werner, & Cone, 2009). Activity breaks (Castelli & Beighle, 2007) are short 5 to 30-minute breaks that permit time for students to engage in physical activity in the classroom. These breaks have proven effective in increasing student attention and adding activity minutes to students' school day. For example, Kahn et al. (2002) evaluated the effectiveness of school-based interventions to increase physical activity. In addition to physical education, they pointed out that inserting physically activity in normally sedentary classrooms was effective in increasing the number of minutes that school children were active during the day.

Additionally, Mahar et al. (2006) implemented the Energizers program in kindergarten through fourth grade classroom classes to examine the extent to which the program increased physical activity and on-task behavior during academic instructional time. They found that students in the Energizers program took significantly more steps during the school day than did those in the sedentary classroom (5587 to 4805 steps; Effect Size = .49). Students' on-task behavior as measured using systematic observation also improved by 8% compared with students in the control condition (ES = .60).

Currently, interdisciplinary approaches to teaching encourage all teachers to integrate relevant content from several subject areas into instructional lessons (Cone et al., 2009). For instance, teachers teaching elementary physics principles involve students in physical activity to experience the concepts of momentum, acceleration, and inertia. Physical educators can assist classroom teachers to demonstrate these scientific principles by inserting physical activity into academic lessons, offering examples of physical tasks that fit naturally into the normally sedentary classroom. Additionally, physical educators can assist students to distinguish between physical concepts, such as revolution and rotation, examine the difference in spinning actions with moment arms of different lengths, and can provide physically active tasks associated with creating and controlling power. Many of these activities can be done in the classroom, gymnasium, or laboratory. Physical educators trained in bio dynamics are tremendous resources for classroom teachers as they make physical concepts come alive for students through physical activity. The key in these initiatives is for students to have opportunities for physical activity in the classroom. They can get up and move around the classroom instead of remaining sedentary. Likewise, physical educators can teach physical education units that employ these concepts in motor skills, fitness exercises, or game play.

Some physical activity advocates argue that we can change the sedentary classroom, itself, by encouraging students to be active throughout the day. For example, John Kilbourne (2013) a physical education teacher educator at Grand Valley State University in Michigan (U.S.) created the concept of the "Activity Permissible Classroom." He solicited grant funding to purchase stability balls to use as chairs and fixed-height stand-up desks. Ninety-eight percent of students surveyed in activity permissible classrooms indicated they would like this option in every class. They reported increased ability to pay attention, take notes, engage in discussions, and take examinations when permitted to move in academic classrooms. When students had options to work at fixed-height stand-up desks, sit on fitness balls, or sit at regular chairs at a tabletop desk, they could select the alternative that was most comfortable for them. Judson (2010) reported that students expended about 50 calories an hour while standing rather than sitting at a desk. Over four to six hours, students can

expend 200–300 calories, leading over time to better weight management. Classroom teachers also are exploring a variety of seating/standing options to increase physical activity and minimize sedentary habits. Physical educators can provide support for classroom teachers interested in transitioning to more active classrooms by providing information and advocating for these opportunities with the principal and other staff members. Although assisting classroom teachers to infuse physical activity in the classroom is an important service, physical educators can dramatically impact the amount of physical activity students receive in school by becoming a School Wellness Leader.

Leading the school wellness team

When physical educators take on the role of School Wellness Leader, they can provide physical activities for classroom teachers and students throughout the school day (Rink, Hall, & Williams, 2010). The Let's Move! (2013) U.S. government-sponsored public health campaign also sponsorsLet's Move! Active Schools (2013) to support school and local community fairs and events that enhance adults and children's understanding of safe and healthy school practices. The rationale for the program states:

> As the places where kids spend a majority of their time, schools are important places for kids to experience and enjoy being active…that's why the Let's Move! Active Schools program helps schools across the country make quality physical activity a part of every kid's day. Let's Move! Active Schools provides opportunities in five key areas: (a) physical education, (b) physical activity during school, (c) physical activity before and after school, (d) family and community involvement, and (e) staff involvement (Let's Move! Active Schools website, 2013).

Physical educators participate as program leaders in their schools to involve students and staff in daily physical activity.

Derek Byrne (2013), an elementary physical educator in Washington State (U.S.) was concerned about the limited amount of physical education instruction time his students experienced during the week. As the Wellness Team Leader in his school, he started a morning jump rope program in which students could participate prior to beginning the school day. This was so successful he added a morning dance program and a Walking School Bus (2013). The Walking School Bus consists of parents who agreed to walk their children from home to school each morning, "picking up" other students along the way whose parents are unable to walk their children to school. The Walking School Bus provides a safe, adult-supervised environment that encourages students and adults to add physical activity to their day by walking rather than driving to and from school.

Byrne (2013) reported that physical activity programs in free school time were so successful he continued to add new programs that students enjoyed, including an intramural program during the lunch period. At the end of the school day, he created a variety of physical activity options for students, classroom teachers, and school staff, including a running program, a fitness program, and a Family Fun Night. Although organizing, managing, and promoting these programs required a large investment in time and energy, Byrne was able to gain the assistance of other teachers and parents to be able to run a number of programs

simultaneously. Interestingly, these programs were not limited to students, but encouraged school staff, parents, and friends of the school to participate in the organized physical activities with the children. Physical educators are contributing to physical activity in many ways in their schools, taking advantage of their skill and knowledge of physical activity and their motivation to organize formal and informal activities for their schools.

The U.S. National Association for Sport and Physical Education (NASPE; 2013) encourages physical educators to take greater roles in their schools as wellness leaders or physical activity directors. They encourage physical educators to increase their professional competencies by completing a four-hour training course that leads to certification as a Director of Physical Activity (Castelli & Beighle, 2007). Because physical educators already possess much of the physiological knowledge and skills needed to direct these activities, the training, instead, focuses on reminders and instruction in program development and organization, identifies special characteristics and fitness needs of target populations within the school (students, staff), and provides sample programs to help physical educators offer enjoyable and relevant activities for their schools.

Physical education program innovations

Certainly, physical educators have exceptionally important roles to play in the renewal and revitalization of physical education in the 21st century (Ennis, 2006). One professional competency required of all physical educators, today, is the ability to implement innovative physical education programs in public school settings. The last two decades have seen a burst of new approaches designed to enhance the quality of the physical education curriculum. Curriculum developers have responded to concerns associated with traditional multi-activity, sport-based approach to physical education by creating a range of curricular models that address new sport, fitness, and personal and social responsibility goals (e.g., Griffin & Butler, 2005; Hellison, 2011; McKenzie, Sallis, & Rosengarad, 2009; Siedentop, Hastie, and van der Mars, 2011). These models are effective because they offer physical educators a clearly defined educational structure that sequences lessons for student learning (Chen & Ennis, 2004). Two key curricular concepts that contribute to teacher competency when implementing externally designed curricula are coherence and fidelity.

Curricula coherence

James Beane (1995) explained that curricular coherence consists of four key elements that appear to enhance students' perceptions of meaning and relevance (Ennis, 2007). Curricula that are coherent contain visible links or relationships between and among content concepts that link the lesson purpose and objectives to students' everyday experiences. Students who experience "coherent" curricula readily perceive and acknowledge its immediate value and worth. The second coherence element can be found in internal sequencing that builds content understandings cumulatively within the lesson (micro sequencing), across lessons in a unit, and across units and across grades (macro sequence). Content that is sequenced effectively for learning enhances teacher competence, lifting the burden from busy teachers, while maintaining effective content and activity sequences to enhance student learning. Third, content topics and themes are selected specifically to evoke a sense of relevance within students' current social and situational context. Issues or concepts related to social

justice and critique, game tactics, or personal fitness planning, for example, can be embedded in the curriculum to enhance students' perceptions of coherence. Finally, coherent curricula provide rich, experiential opportunities for students to engage in personally relevant tasks to help them make sense of the social or scientific concepts and tasks provided. This fourth element emphasizes the student-centered focus of constructivist curricula, enhancing students' willingness to engage and participate in these programs.

It is important to remember, that while curriculum developers and teachers can strive to create coherence and implement the program coherently, students make the final judgments of curricular coherence. Students must perceive that the curriculum is meaningful and relevant and that content concepts and topics are related to each other and to valued aspects of their lives. Teacher competence when presenting externally developed curricular models hinges on both selecting a curriculum with inherent coherence and teaching the curriculum to students coherently so that they acknowledge content meaning in their lives.

Curricular fidelity

Twenty-first century teachers also require the ability to implement an externally developed curriculum with fidelity. Curricular fidelity reflects the extent to which the teacher faithfully adheres to the curriculum developers' plan when teaching the curriculum (Mowbray, Holter, Teague, & Bybee, 2003). Results confirming the effectiveness of curricula to increase student learning depend directly on the consistency with which teachers implement the new curriculum in their school/gymnasium setting. Therefore, decisions to implement a curriculum in a particular setting should be based on the generalizability of the findings to diverse school settings and student populations. In other words, the proposed implementation setting should match the critical elements that were present in the original testing environments. Researchers, therefore, should include diverse school settings and student populations with varied characteristics during the curriculum validation process to increase opportunities for generalizability to similar settings/populations in the future.

Teachers have two responsibilities when implementing an externally developed curriculum model. First, they (and their supervisors) must assess the extent to which the model can be implemented in their teaching settings. For example, the characteristics of their school environment (e.g., amount of instructional time, facilities, equipment, students, administrative support) should be sufficiently similar to the original experimental conditions for the curriculum to be taught with fidelity.

Second, when adjustments to the curriculum are required, teachers need to ensure that the goals, objectives, and lesson structures in the original model are maintained in the new setting to increase possibilities that students will learn the content to the extent proven in the original model validation. This is an underlying assumption of evidence-based practice. Although randomized controlled trial (RCT) research designs provide convincing evidence of curricular effectiveness, replication of these results requires that the curriculum be implemented in the new setting with fidelity to the original model as tested (Zhu, Ennis, & Chen, 2011). Therefore, teacher competence in implementing externally developed curricula is dependent on teacher training and teachers' ability to implement the new curriculum faithfully in their unique school environment.

In the remainder of this paper, I will discuss two new science-based approaches to elementary and middle school physical education that my curricular research team developed with large grants from the U.S. National Institutes of Health (Ennis, 2013; Sun, Chen, Zhu, & Ennis, 2012). A goal of these projects was to design curricula that were coherent and to assist teachers to develop competencies necessary to teach the programs with fidelity. Curriculum developers, teacher educators, and classroom teachers interested in assessing and promoting new approaches to physical education should explore these and other alternatives to traditional physical education.

Science, PE, & Me! Elementary physical education curriculum[1]

Science, PE, & Me! (SPEM) is a health-science (fitness) based approach to elementary physical education for 3rd–5th grade students, ages 8–11 years old (Ennis & Lindsay, 2008). The curricular design, implementation, and evaluation was funded in 2003 by a 5-year grant from the U.S. National Institutes of Health as a Science Education Partnership Award (USD $1.5 million; Ennis, PI, Chen Co-PI.). The curriculum embraces the philosophy of a sound mind in a sound body, providing a constructivist, student-centered approach to physical education. Science, PE, & Me! is based on the National Physical Education (NASPE, 2004) and Science Education (National Research Council, 2012) Content Standards and incorporates the 5Es learning cycle strategy (Mark & Cavallo, 1997) to assist teachers and students to experience the scientific inquiry process in each of the 90 lessons in the curriculum. Curricular effectiveness (i.e., student learning of fitness knowledge concepts) was tested in 30 urban elementary schools using a randomized controlled trial design (Sun et al., 2012). Developing teacher competencies to implement the curriculum effectively and with fidelity was achieved through face-to-face teacher training. Teachers were trained to use the Teachers Manual, Student Science Journals, Family Science Activity Night events, and standardized tests.

SPEM! Teachers Manual

The highly detailed SPEM! Teachers Manual serves as an essential professional development tool. It can be used to increase teacher competencies to implement the curriculum with fidelity (Ennis & Lindsay, 2008) and can replace the face-to-face teacher training, if necessary. SPEM! curricular coherence is achieved, in part, through three integrated, sequenced health-science and physical education units. Each unit focuses on one or two components of fitness: Dr. Love's Healthy Heart (cardiovascular), Mickey's Mighty Muscles (muscular strength and endurance), and Flex Coolbody's Fitness Club (flexibility and healthy nutrition) with concepts building cumulatively from lesson 1 to 90. Within each of the nine units, students participate in 10 physically active lessons in which they examine the effects of exercise on their bodies. To enhance teacher fidelity and competence, the 30–45 minute lessons are scripted to provide model lessons to facilitate teacher understanding and implementation fidelity of the fitness concepts and activities.

[1]The Science, PE, & Me! SEPA Project was funded by the National Institutes of Health through the National Center of Research Resources, Grant R25 RR015674. Content is solely the responsibility of the author and does not necessarily represent the official views of NCRR or NIH.

During the training sessions, teachers are taught to implement lesson structures faithfully to facilitate student learning. For example, each lesson begins with student-oriented key questions, such as 3rd grade questions: “Where is my heart?” (Lesson 1); “Can I exercise continuously for 10 min?” (Lesson 6). Teachers encourage students to assume the role of “junior scientists” to examine the effects of today’s lesson content on their bodies. This use of constructivist imagery is very engaging for 8–11 year old children. It places students in authentic roles as scientists and assists them to focus on the content as a legitimate and important task. Teacher-oriented information in each lesson includes one instructional objective, 3-point assessment rubric, equipment list, and safety tips for the activities. Teacher directions and sample teacher dialogue appear in different colors throughout the lesson to facilitate teacher use.

Lesson structure

The 90 Science, PE, & Me! (Ennis & Lindsay, 2008) lessons are designed with a consistent internal structure based on the 5 E’s learning cycle strategy (Mark & Cavallo, 1997) used in elementary science education to teach and reinforce the scientific inquiry process. This lesson structure is critical to lesson coherence and delivery because it creates an internal pattern repeated in each of the 90 lessons. Both teachers and students learn to rely on this structure to help them keep their place in the lesson, emphasizing specific components of the scientific inquiry process, regardless of the fitness concept or the physical activity task.

Within this strategy, each “E” is designated as an explicit segment of the lesson. Each E or lesson segment plays a key role in coherently structuring student problem solving, such as prediction, observation, data collection and analysis, and communication of findings to others, that shapes scientific inquiry. For example, lessons are introduced through the Engagement segment (warm-up) that includes both physical and cognitive activities, enhancing students’ personal interest in the topic, by presenting a grade-appropriate problem and challenging students to rely on past and present experiences necessary to predict a solution to the problem. During the Exploration lesson segment, students are physically active as they observe, monitor, and assess the effects of physical activity on their bodies, collect data documenting their own physiological changes, and work cooperatively with others who are experiencing similar physiological effects.

In the Explanation lesson segment, teachers employ constructivist-oriented strategies to assist students to work cooperatively. Students use learning strategies to explain their observations to each other, compare these results to their predictions, and propose a rationale for their findings. The Evaluation lesson segment offers structured opportunities for students to respond to teacher-posed questions, compare their findings to those presented in tables and charts, reflect on their results, and write brief responses to questions posed in their Student Science Journals.

During the Elaboration (closure) segment, teachers assist students to apply this information outside of physical education. They are encouraged to connect it meaningfully to topics discussed in other school subjects and at home as they participate in physical activity with their families. The Elaboration also includes a physically active homework assignment that assists students to apply the health-related science concepts outside of physical education.

Teachers encourage children to make the content more meaningful by sharing it with family members, testing the concepts learned in class at home. Thus, by the time families arrive at Family Science Activity Night events, they have been introduced to many of the science concepts discussed in the Science, PE, & Me! curriculum. Each lesson concludes with a preview of the content, concepts, or principles to be discussed in the next lesson. These situationally interesting lessons increase student motivation through challenging and engaging lessons (Chen, Ennis, Martin, & Sun, 2006).

Teacher resources

Teacher resources assist teachers to present the health-related science concept faithfully and accurately, increasing teacher competence and student learning (Ennis & Lindsay, 2008). Lesson resources include posters, charts, poster-size muscle puzzles/puzzle pieces, vocabulary words/definitions, the 120-page Physical Activity Directory, and task cards that teachers find useful in visually representing the concepts and principles discussed in the lesson. Created by master physical educators working with graphic designers, these resources greatly reduce teacher preparation time and facilitate student learning by providing concrete representations of concepts. Task cards are provided in multiple formats for the same task. For example, one set of resistance/toner band exercise task cards includes three cards. One card in the set includes the name of the exercise and color photographs of a child correctly performing each exercise. The second card includes the same photographs with the name and verbal description of the exercise, while the third card presents the name of the muscle or muscle group exercised and an illustration of the muscle highlighted on a picture of “Mickey,” the mighty muscle lion. This task card set provides flexibility for teachers as they present multiple perspectives on the same concept to students within different lessons, further enhancing students’ opportunities to learn.

Student Science Journals

The student Science Journals were designed to assist teachers to present and reinforce the fitness concepts and physical activity content with fidelity in a visually stimulating format (Ennis & Lindsay, 2008). Each lesson consists of a two-page journal entry created to represent a grade appropriate representation of a scientist’s laboratory journal. Graphic designers created original illustrations to clarify complex content, reinforce science-related vocabulary, and provide a reading and writing environment that heightens content value and relevance to junior scientists in physical education. Science Journal lesson entries are organized by grade so that students receive their own Science Journal for the year with the 30 lesson entries covering all three units. Journals also include extra pages for physical activity, out of class logs, test data entry, and a comprehensive vocabulary list.

Family Science Activity Nights

Family Science Activity Nights (FSAN) are after-school, evening, or weekend events in which children invite their family members to school to learn about the benefits and positive effects of exercise and healthy eating (Ennis & Lindsay, 2008). In the FSAN, teachers set up nine experiments that students have already experienced in the SPEM! lessons. Experiments focus on pulse rate and intensity (Dr. Love) muscle names and functions and resistance training principles (Mickey), and flexibility, nutrition, and caloric balance (Flex Coolbody).

Students lead their family members through the activities at each of these experiments, recording each person's data in their Family Laboratory Notebooks. We have been amazed at the very large family attendance for these events in urban elementary schools where few parents participate in Back-to-School Nights or other school events. Principals have been thrilled with opportunities to interact with family members whom they had never met prior to the FSAN. Because of the large numbers of families attending, each experiment is placed in a different area of the school. Families rotate throughout the school during the evening as they participate in each experiment.

Knowledge testing in physical education

A major focus of the academically oriented SPEM! curriculum is student learning of health-related science/fitness knowledge concepts (Zhu et al., 2009). To provide evidence to the National Institutes of Health that students were in fact learning science knowledge in physical education, we designed, standardized, and validated nine unit-specific tests to assess content in each unit at each grade. Tests items were written to reflect the Science, PE, & Me! curriculum content domains and content standards, such as fitness and science concepts, scientific inquiry process, measurement concepts, vocabulary, and concept applications in student-relevant situations. During the first three years of funding, approximately 6000 students in the experimental and control group schools completed the test items arranged in alternate test forms. Test items were evaluated based on computed difficulty and discrimination indexes. Item testing permitted us to identify 8–9 items for each unit at each grade that accurately measured students' science knowledge growth.

As a result of this research, we recommend teachers administer the 16 items pretest prior to teaching the first lesson. Immediately following unit completion, teachers administer the eight item unit and grade specific posttest. The pretest requires about 20 minutes, while students can complete the post tests in about 10 minutes. Physical educators participating in the SPEM! research downloaded links to online versions of the tests and students completed the tests on personal tablet computers or in their school's computer or media center. When they clicked "submit" the scores were sent on-line to our laboratory for analysis. We were able to return test results to teachers within two weeks after receiving posttest scores.

The Testing Manual provides a detailed description of test administration protocols, standardizing the process to increase teacher fidelity and competence in test administration. Teachers were encouraged to administer both the pre and post-tests to provide evidence of student learning in their programs. The SPEM! Testing Manual includes scoring keys for each of the tests so that teachers now can administer and score tests without participating in our research project. Additionally, the Testing Manual includes information regarding the statistical validation process for the tests and test administration protocols and a conversion table based on standardized scores, enabling teachers to convert student raw scores to a letter grade.

Does Science, PE, & Me! increase student learning?

The SPEM! curriculum was evaluated using a randomized controlled trial (RCT) in 30 urban elementary schools (student enrollment = 6500; 77% African-American). Knowledge test

results (Sun et al., 2012) indicated that students in the 15 experimental schools significantly increased their knowledge of health-related science and science inquiry (p= .001, variance explained by SPEM! R^2= .28 – .32) in each unit and in each grade when compared to students in the 15 control group schools (Chen et al., 2006; Sun et al., 2012). Specifically, in 2004 and 2005, physical educators taught all three units to 3rd–5th grade students in the 15 experimental schools. The results presented in Table 1 reflect longitudinal data, following a cohort of 3rd grade students through three years of the SPEM! program (grades 3–5) representing a successful example of evidence-based practice in elementary physical education (Sun et al., 2012). Physical education teachers played a key role in implementing this curriculum with fidelity as measured by class observations. They were able to present objective evidence to document student health-related science learning and the quality of their teaching in physically active lessons (Chen, Sun, Zhu, & Ennis, 2012). Principals and school district administrators used the results to support increases in staffing and resources for physical education programs.

The Science, PE, & Me! curriculum has been disseminated to elementary physical education teachers in the United States and is being considered by Ministries of Education in several countries. The success of this science-based physical education program laid the foundation for securing our second U.S. National Institutes of Health grant to design a middle school curriculum, entitled the Science of Healthful Living.

The Science of Healthful Living Middle School Physical Education Curriculum[2]

Similar to Science, PE, & Me!, the Science of Healthful Living curriculum is a health-science (fitness) based approach to middle school physical education for 6th–8th grade students (ages 11–14). As in the SPEM! project, the curricular design, implementation, and evaluation was funded by a 5-year grant from the U.S. National Institutes of Health as a Science Education Partnership Award (USD$1.3 million; 2011–2016; Ennis, PI., Chen Co-PI). The effectiveness of this curriculum is currently being tested in a randomized controlled trial to ensure that it meets the standards of effective evidence-based practice. The constructivist, student-centered curriculum follows the same format and structure as SPEM!, using the 5Es learning cycle strategy to assist teachers and students to use the scientific inquiry process effectively to examine the effects of exercise on their bodies.

The Science of Healthful Living curriculum integrates U.S. National Content Standards from Life Science, Physical Education, and Health Education in two, 20 lesson units: the Cardio Fitness Club (fitness and goal setting) and Healthy Lifestyles (healthy nutrition and decision making) taught to students at each grade (120 lessons). The lessons in the Teachers Manual are presented in a scripted format to provide physical education and classroom teachers with a clear understanding of each lesson and to assist them to teach the lessons with fidelity. Middle school physical educators currently are receiving extensive training to use the curriculum materials effectively with fidelity. Curriculum materials for this program

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include the detailed Teachers Manual and resources, Student Science Journals, Family Science Activity Night events, and validated, standardized knowledge tests. At the completion of this project, students will be able to progress through a carefully sequenced 3rd–8th grade, academically-oriented, fitness-based physical education curriculum.

The Science of Healthful Living curriculum is currently being tested in six public schools districts in central North Carolina (U.S.). Seventy-five middle school physical education teachers working in 24 middle schools are teaching the curriculum to 17,000 students in 6th–8th grades. Preliminary results from year 2 presented in Figure 1 indicated that in all grades, students in the 14 schools in the experimental condition increased their science knowledge significantly when compared to students in the 10 matched comparison school condition (6th grade: $t_{1,158} = 13.82$, $p = .001$, effect size (Cohen's d) = .67; 7th grade: $t_{1,188} = 12.24$, $p = .001$, effect size = .24; 8th grade: $t_{1,191} = 12.87$, $p = .001$, effect size= .50). The statistical differences are significantly meaningful for the 6th and 8th grades. Although the effect size for 7th grade is smaller, it is significant and meaningful because the study is based on true randomized sampling and condition assignment. Teachers in the experimental condition reported that the Science of Healthful Living Teachers Manual was helpful in preparing and teaching the lessons with fidelity. They document instances in which they were forced to modify the curriculum because of space, time, or equipment challenges. Further, they reported spending approximately 10–20 min. planning to teach the lessons, which they considered reasonable. Families participating in the Family Science Activity Night community events reported that these events were of high quality and helped them to understand science and physical education in a new way. We hope that by Spring 2014, the Science of Healthful Living curriculum will be available to middle school physical education teachers and their students.

Concluding comments

In the U.S., the Centers for Disease Control and Prevention and the National Institutes of Health are sounding warnings that the U.S. population is rapidly becoming overweight and obese (U.S. Department of Health and Human Services, 2008). National and local governments and medical and health sciences professionals, including physical educators, are particularly concerned about the declines in health accompanying increases in overweight and obesity. These include an increased prevalence of Type II Diabetes, joint and back stress and pain, heart disease, and cancers. These concerns are directing ever-greater attention to the role of physical education and physical activity in maintaining caloric balance necessary to sustain a healthy weight.

Physical education teachers have a central role to play as Fitness and Wellness Leaders within their schools and communities. Additionally, curriculum developers are designing innovative, coherent approaches to fitness-based physical education supported by strong evidence from randomized controlled research documenting increased student learning and physical activity in physical education. Physical education teachers are enhancing their professional competencies to teach disciplinary concepts such as those in fitness/exercise physiology and to learn new instructional strategies necessary to teach student-centered constructivist approaches to physical education. When students graduate and are on their

own (Ennis, 2010), they have learned principles associated with physical activity and nutrition they need to care for themselves and their families. The future appears bright for those in-service and pre-service teachers willing to accept the challenges to maintain and extend professional competence within an enthusiastic and energetic approach to physical education.

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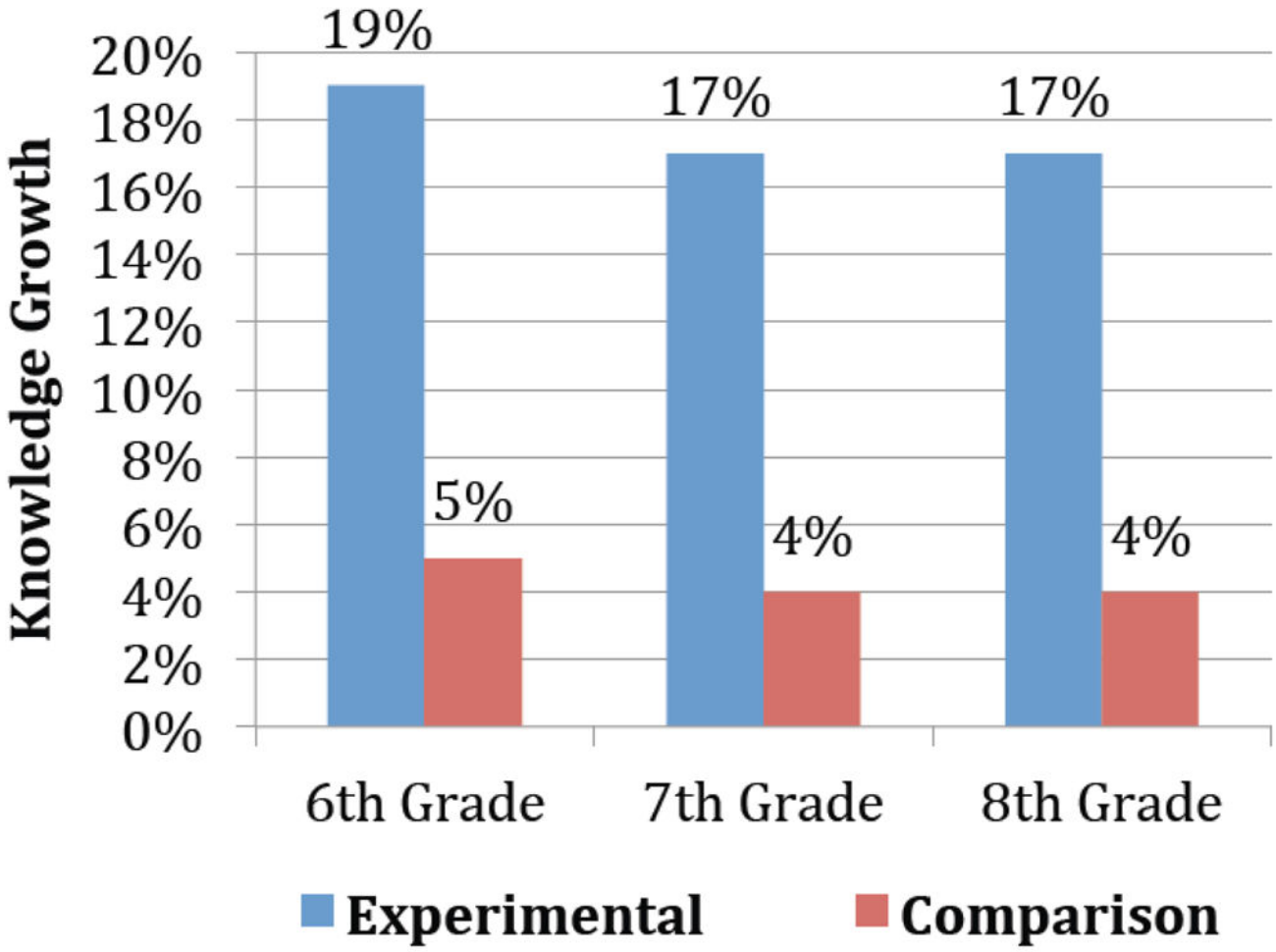

Figure 1.
Science of Healthful Living: Year 2 Preliminary Data from the Cardio Fitness Club Knowledge Test Comparison (% correct gain) between Experimental and Comparison Schools by Grade.

Table 1

Three-Year Longitudinal Knowledge Test Results from the Science PE, and Me! Curriculum Units for the Original 3rd Grade Cohort. Dr. Love's Healthy Heart Unit first taught in 2003; Data Based on % of Correct Answers on Knowledge Tests; first 3rd Grade Cohort (2003–2005).

	Y1 Pre (2003)	**Y1 Post (2003)**	**Y2 Post (2004)**	**Y3 Pre (2005)**	**Y3 Post (2005)**
Exper.	39%	76%	72%	66%	69%
Control	40%	61%	58%	60%	58%
	p=.73	*p*=.001*	*p*=.001*	*p*=.001*	*p*=.001*
Dr. Love's Healthy Heart Unit first taught in 2003; Data Based on % of Correct Answers on Knowledge Tests; first 3rd Grade Cohort (2003–2005).					
		Y2 Pre (2004)	Y2 Post (2004)	Y3 Pre (2005)	Y3 Post (2005)
Exper.		28%	58%	33%	53%
Control		26%	35%	26%	35%
		p=.114	*p*=.001*	*p*=.001*	*p*=.001*
Mickey's Mighty Muscles Unit first taught in 2004; Year 2 & 3 Data Based on % of Correct Answers on Knowledge Tests for the Original 3rd Grade Cohort (2004–2005).					
		Y2 Pre (2004)	Y2 Post (2004)	Y3 Pre (2005)	Y3 Post (2005)
Exper.		38%	60%	41%	44%
Control		32%	45%	39%	35%
		p=.001*	*p*=.001*	*p*=.251	*p*=.001*
Flex Coolbody's Fitness Club Unit first taught in 2004; Data Based on % of Correct Answers on Knowledge Tests for the Original 3rd grade Cohort (2004–1005)					

*Effect size: partial η^2 = .338; Ennis & Chen, 2006; Sun et al., 2006

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