Large-scale physical education intervention: Past, present, and future

By: Darla M. Castelli and Ang Chen

Castelli, D. M., & Chen, A. (2018). Large-scale physical education intervention: Past, present, and future. *Kinesiology Review*, *7* (3), 259-265.

Abstract:

A large body of Catherine Ennis's work is focused on physical education curriculum development. Her approach to curriculum development is unique in that it is completely based on research evidence. The curricula she developed have been field-tested and the completed curriculum is supported with solid research evidence to demonstrate its efficacy in student learning and teacher ease of use. The purpose of this article is to provide an overview and explore opportunities to continue large-scale physical education curriculum intervention studies. The authors first provide a brief review of previous intervention studies by summarizing the findings and discussing implications. They then discuss potential future intervention studies by presenting several topics that are being explored by researchers in current interventions. Finally, they focus on methodology issues involved in designing effective curriculum intervention studies with the idea of adaptive designs as variations of the randomized clinical trial design.

Keywords: curriculum reform | evaluation | randomized controlled trials | team science

Article:

Emerging knowledge of most worth needs to be integrated into the praxis of our discipline through educational reform and intervention. As a curriculum theorist and researcher, Catherine Ennis contributed much knowledge and evidence that can be used to guide future work in curriculum development and curriculum research. Her scholarship not only has demonstrated what can be accomplished in theory and practice but also has established influential foundations from which future curriculum intervention research can be launched. Curriculum interventions, as a means to generate new knowledge, can bring about both behavioral and programmatic change. Understanding the ecology of physical education and the didactic interactions within the space of curriculum, scholarship is the primary path forward to curriculum innovation. Through a combination of program elements, strategies, and feedback mechanisms designed to create behavior change in a targeted population, large-scale curriculum interventions with multiple variables involving diverse communities and schools can lead to policy changes, refine educational practice, and enhance the learning environment. In other words, curriculum interventions can make a difference.

The National Institutes of Health (2018) recently asserted that "an intervention is defined as the manipulation of the subject or subject's environment for the purpose of modifying one or more health-related biomedical or behavioral processes and/or endpoints" (p. 1). There have been several physical education interventions during the past 30 years. In this paper we review health-related interventions that have taken place during physical education instruction and provide thoughts for future interventions. We attempt to center our writing on Ennis's idea of curriculum transformation as she elegantly elaborated in her last lecture (Ennis, 2017a) to highlight her emphasis that intervention *is* transformative physical education:

> Transformative PE [physical education] provides physical activity content within a nurturing and motivating environment that can change students' lives. It focuses on PE students' role in cognitive decision making, self-motivation, and their search for personal meaning that can add connection and relevance to physical activities. (p. 241)

In the following, we first provide a general review and critique of large-scale intervention studies. The review is not meant to elaborate various findings and significance but rather to lay out the landscape of this type of research in school settings. Second, we discuss future directions of intervention research to highlight areas where intervention research may enhance our collective knowledge about physical education and physical activity programming. Last, we focus on the possibility of applying adaptive randomized clinical trial (RCT) designs to aid the efficiency and efficacy of our intervention research. We believe that the information in this paper will contribute to continuing the legacy of Catherine Ennis.

The Landscape of Physical Education Intervention

From seminal research to targeted populations, there have been interventions that effectively increased physical activity of children during physical education, as well as beyond class time. Many of these interventions included nutrition and physical activity (Brown & Summerbell, 2009). This section highlights some, but not all, of the successful interventions that had a significant impact on student and teacher health-enhancing behaviors. We excluded intervention studies by Ennis and her colleagues to avoid duplications. Readers are referred to the preceding paper in this special issue of *Kinesiology Review* by Sun and Zhang. Inclusion criteria for study selection were robust scientific methodologies, evidenced-based physical education curricula, dynamic treatment plans, and the use of team science (see Brown & Summerbell, 2009, for a complete review).

The Child and Adolescent Trial for Cardiovascular Health

The Child and Adolescent Trial for Cardiovascular Health (CATCH), a 3-year RCT, was conducted in 56 intervention and 40 control schools. It was a historic first step in National Institutes for Health funding of school-based interventions that united educational and public goals (Luepker et al., 1996). Process evaluation data revealed a high investment by teachers, staff, and physical education specialists in places where certification to teach physical education content was not required, such as in California. The Eat Smart and CATCH PE curricula were compatible with the needs of elementary school children and were considered easy to implement

(Perry et al., 1997). With reductions in school-lunch fat content and increases in moderate to vigorous physical activity (MVPA) during physical education, this seminal research confirmed the feasibility, fidelity, and (eventually) sustainability of school physical activity interventions (Hoelscher et al., 2004). CATCH employed an interdisciplinary approach to deliver the Hearty Heart & Friends curriculum in third grade and the Go for Health curriculum in Grades 4 and 5. The final essential component that continues in schools today is Family Fun Nights, where themed events like Zumba, Bike & Broccoli emerge. At this event Safe Routes to School, a local Zumba instructor, and the school district's nutritional services provide opportunities for children and their families to learn about safe, active transportation; participate in physical activity; and taste fresh vegetables.

Sports, Play and Active Recreation for Kids

Initially, Sports, Play and Active Recreation for Kids (SPARK) targeted fourth- and fifth-grade students using an RCT design where students were randomly assigned to specialist-led, classroom teacher–led, or physical activity leader–led (active control) physical education conditions. The study revealed promising results of increased health-related fitness (Sallis et al., 1997). Significantly higher aerobic and muscle fitness were demonstrated in classes led by specialists, thus providing evidence that credentialed, certified professional physical educators can produce significantly better health-related fitness benefits in physical education than noncredentialed teachers or physical activity leaders. Students in the intervention conditions received approximately twice as many minutes of physical education per week as the active control group. A follow-up comparison of student academic achievement confirmed, however, that the additional time spent in physical education does not inhibit, but in fact may benefit, academic achievement (Sallis et al., 1999). A year and a half after the initial intervention, credentialed specialists were removed and there was a substantial loss in lesson quality and physical activity participation by the students (McKenzie, Sallis, Kolody, & Faucette, 1997). The results again confirmed the unique contribution of certified physical educators to the quality of physical education and student health and academic benefits. Today, SPARK remains a viable physical education program focused on increasing children's physical activity and physical fitness in many schools.

Lifestyle for Education Activity Program

CATCH and SPARK focused their interventions on elementary-school-age children but did not address a critical time when adolescent females were dropping out of physical activity participation in large numbers. The Lifestyle for Education Activity Program (LEAP), a school-based physical activity intervention targeting high school girls, included dance, aerobics, and weight training with a focus on enhancing self-efficacy through self-regulatory strategies (i.e., goal setting, time management, identifying barriers, and self-reinforcement). Intervention schools demonstrated significant increases in vigorous physical activity (Saunders, Ward, Felton, Dowda, & Pate, 2006). Dishman et al. found that enjoyment of physical activity participation (2005) and improved self-efficacy toward physical activity engagement (2004) influenced the rate and intensity of physical activity participation. Environmental factors (i.e., having a school physical activity team, family involvement, and physical activity opportunities outside of school) were also found to be influential. It was concluded that the use of a comprehensive school

physical activity program (CSPAP) approach (i.e., offering physical activity opportunities across five points of intervention of physical education, before or after school, during the school day, staff involvement, and community engagement) was likely a future direction, although not specifically expressed as such initially (Saunders et al., 2011).

Concept-Based Physical Education

Ennis's research teams at the University of Maryland and University of North Carolina at Greensboro conducted several large-scale, longitudinal curriculum intervention studies. Most noticeable are Science, PE, & Me! for elementary schools and The Science of Healthful Living for middle schools. As can be seen in Sun and Zhang (2018), the findings highlighted an original critical discovery that changing children's cognitive understanding of the mechanisms and benefits of physical activity from a scientific knowledge perspective can be a critical precursor for eventual behavior change. The findings also revealed the power of a well-designed physical education curriculum on physical activity knowledge development and behavior change. The curricula were designed following the constructivist learning theories and conceptual change models to help physical education students construct knowledge by investigating how their bodies respond to exercise with physical activity tasks. In her award-winning paper, Ennis (2015) argued that to become physically literate an individual must possess the skills and knowledge to perform individually meaningful physical activity tasks with confidence. Evidence from her intervention studies supports the proposal that the curricula can help students accomplish just that.

The CSPAP-Based Intervention Movement

Ennis had argued for a long time (see Chen, Shen, & Zhu, 2018) that the ultimate goal of physical education is to help children develop and sustain lifelong healthful lifestyles with physical activity as a major component. She agreed that implementation of a CSPAP could be a chance to transform and strengthen physical education to include mindfulness, motivation, and meaningfulness (Ennis, 2017a). CSPAP is an approach where the physical education teacher collaborates with others to provide opportunities for physical activity in schools whenever and wherever appropriate. In this context, knowledge is the foundation of this approach, as teachers must identify and select the most appropriate content and deliver the information to students situated in the school environment beyond physical education (Ennis, 1994).

CSPAP acknowledges that health benefits such as increased physical fitness and positive affect toward physical activity are gained through participation, before, during, and after school. Early indications are that a CSPAP affects the health of children and specifically at-risk children. Evidence has shown that after participation in a 36-week physical activity intervention, 217 school-age children from low-income schools had reduced LDL cholesterol (Burns, Brusseau, & Fu, 2017). Children ($N = 1{,}390$) demonstrated increased MVPA and aerobic fitness, as well as increased odds of meeting the daily physical activity recommendation of 60 minutes of participation (Brusseau, Hannon, & Burns, 2016).

Large-scale physical education interventions have been proposed and conducted. For example, from a socioecologic public health perspective, the Health Optimizing Physical Education

(HOPE) curriculum model is proposed "to help P-12 students acquire knowledge and skills for lifelong participation in the physical activity for optimal health benefits" (Metzler, McKenzie, van der Mars, Barret-Williams, & Ellis, 2013, p. 41). One advantage of the HOPE curriculum is a simultaneous focus on both the individual and the environment. To implement the strands of the HOPE curriculum requires new content and pedagogical content knowledge for the teachers (Beighle, Erwin, Castelli, & Ernst, 2009). Knowledge is the foundation of teacher expertise, as teachers must identify and select the most appropriate content and deliver this information to students situated in a given environment (Ennis, 1994).

The Healthier Children Learn Better initiative is another example. Health proxy outcomes of a standards-based physical education curriculum, such as improved physical fitness, may resonate with school administrators because healthier students are better learners (Basch, 2011). Health problems play a major obstructive role in academic learning, especially in urban, low-income schools where the clustering of health risk factors is prevalent. These factors frequently lead to school absenteeism, acute and chronic illness, and lack of self-esteem. Evidence has begun to show that participation in school physical activity could help reduce and reverse the impact of these risk factors (Janssen & LeBlanc, 2010). Basch (2011) has argued that school reforms should include CSPAP approaches to physical education and physical activity across the curriculum to improve teacher effectiveness, policy development, and opportunities to reduce the impact of health-risk factors.

CSPAP approaches also acknowledge the incremental benefits of physical activity participation and its contribution to academic learning. Some physical activity, even if not moderate or vigorous, matters to academic achievement and grades as shown in evidence comparing achievements of students enrolled in physical education with those of students who were not (Coe, Pivarnik, Womack, Reeves, & Malina, 2006). A 10-year RCT study called Fitness Improves Thinking (FITKids) offered a physical education curriculum in an after-school setting to overcome the limitations of a state mandate requiring daily physical education. Schools provided physical education class every weekday for all students, but to do so, the teachers were only able to provide 20 minutes of class time, with even less time for instruction and physical activity engagement. The FITKids program was accessible immediately after school for 2 hours with an average of 70 minutes spent in MVPA. Game-like fitness stations (e.g., partner push-ups, rock-paper-scissors-go) were used as an instant activity on arrival at the gym. The first 40 minutes were spent in MVPA and were followed by a healthy snack and health tip of the day. The remainder of the time was spent on motor-skill practice and modified game play of the sport for that instructional unit (i.e., approximately 10 lessons or 2 weeks per unit). The 9-month intervention improved aerobic fitness by an average of 4 $ml \cdot kg^{-1} \cdot min^{-1}$ over wait-list control children. An average of 70 minutes was spent in the target heart-rate zone, which proved to be a predictor of performance on Stroop color-word executive-control tasks (Castelli, Hillman, Hirsch, Hirsch, & Drollette, 2011). Furthermore, the intervention significantly enhanced cognitive performance and brain function, particularly on tasks requiring cognitive flexibility (Hillman et al., 2014). A mediating factor that was implicated in this line of research was adiposity, as the cognitive performance of 8- and 9-year-old children was differentiated by overweight and obesity classification. Mechanistically, the hippocampal region has been implicated as a facilitator of increased memory, which can enhance learning (Monti, Hillman, & Cohen, 2012).

In summary, evidence-based physical activity interventions in- and outside of physical education have multiple beneficial effects on student and teacher behavior and physical and cognitive health. At issue is reach. Despite the success stories of such interventions, there is a failure to diffuse the innovation (Glowacki, Centeio, Van Dongen, Carson, & Castelli, 2016). Since the total number of physical activity opportunities provided by a CSPAP can be predicted by a teacher's health-promotion efforts and physical activity engagement, health-promotion strategies should be part of teacher education, given the importance of physical activity participation for children's health and academic development.

Future Directions

Ennis was an optimistic, futuristic curriculum theorist. Her scholarly writings transcend curricular realities, enlighten a bright future for physical education, and encourage fellow researchers to pursue optimal outcomes of their scholarly work. She acknowledged the complexity of curriculum interventions but held a strong belief that curriculum intervention research is the only effective way to accomplish successful physical education reform (Ennis, 2013). Effective curriculum intervention should purposefully destabilize the status quo, empower teachers, change the curriculum and the environment it creates (incrementally), and produce student success. Ennis's theorizing work is consistent with the ongoing work of many curriculum scholars around the world. Next we highlight a few projects that have created or are creating a trend for future interventions. Then we discuss future directions in terms of curriculum intervention research methodology.

Community-Based Participatory Research

It is logical to acknowledge that promoting healthful and active lifestyles in children takes effort and support from all segments of a society. Stakeholders in the community have vested interests in developing a healthy generation of young Americans. In the meantime, any stakeholder can be a change agent and, as such, should have a voice in this collective effort. Community-based participatory research (CBPR) projects have created a trend to involve unconventional participants in the intervention research process. For example, the W.K. Kellogg Foundation's Community Health Scholars Program (2001) has developed a CBPR as

> a collaborative approach to research that equitably involves all partners in the research process and recognizes the unique strengths that each brings. CBPR begins with a research topic of importance to the community with the aim of combining knowledge and action for social change to improve community health and eliminate health disparities. (p. 2)

The project is not considered a new method of data collection. Instead, it represents a shift in the fundamental thinking about how to generate knowledge to inform the research community and beyond (Wallerstein, Duran, Oetzel, & Minlker, 2018). Grounded in culture-centered research methods (Dutta, Anaele, & Jones, 2013; Ennis, 1998) and reflexive practice (Muhammad et al., 2015), the project is well aligned with educational and, more specifically, physical education health-oriented goals.

CBPR uses real-world issues to develop theory and novel instructional strategies for practice. Although physical education teachers may deliver recreational, public health, or educational programs, there are common elements of effective teaching, such as the use of instructional time and the learner's application of feedback (Ennis, 2017a). Because student learning must be the priority, understanding how students mediate teacher and peer feedback and apply this information to their own behavior is paramount. CBPR interventions would consider all voices (e.g., administrators' concern about the use of instructional time, teachers' programmatic philosophies, and students' attitudes about the application of feedback), through either a direct collection of their perceptions or case studies. As such, the CBPR approach has merit in the physical education context.

Developmental Evaluations

Innovation can be chaotic and complicated (Ovens, Hopper, & Butler, 2013); however, it creates opportunities to make programmatic modifications because applying complex concepts in undefined environments has the highest potential for social change (Patton, 2010). Unlike a traditional RCT that might take years to enact and then influence curriculum, programming, and behaviors, a developmental evaluation intervention is a continuous, real-time facilitation of change. If something is ineffective and not producing the desired results, then the researcher/teacher leaders can deviate from the plan and apply new, more relevant strategies. In research supported by the J.W. McConnell Family Foundation, a practitioner-friendly developmental primer was created to introduce this process and provide tools for supporting its use in educational settings (Gamble, 2008). Compared with interventions relying on traditional formative (i.e., process) and summative program evaluations (i.e., product), a developmental evaluation intervention is highly responsive to complex situations focused on early innovations that still need to confirm feasibility and proof of concept.

Developmental evaluation is best suited for a novel and complex intervention because it might not be appropriate for all contexts and all stages of an intervention. Developmental-evaluation-based interventions could be applied to physical education when we want to understand the effects of a new curriculum. As the lessons unfold in physical education classes, there could be changes made to the instructional strategies or revised content provided to the learners. For example, if students struggle to understand the meaning of the word *calorie,* one could refer to the research Ennis and her colleagues on the formulation of mental models (Pasco & Ennis, 2015; Zhang, Chen, & Ennis, in press) and consider using a constructivist approach to teaching to enhance student learning (Zhang et al., 2014).

Interventions using approaches such as CBPR and developmental evaluations may be useful to intervene as student mental models are discovered. Such interventions have value because they provide evidence of feasibility, practicality, and validity. CBPR and developmental evaluation approaches could help proactively alleviate some challenges and reduce limitations from interventions. Interventions, mainly those not well aligned with the educational context, may face challenges from programmatic problems (e.g., ineffective teaching, a lack of resources or administrative support) or health disparities (e.g., differences in school resources and effectiveness within the same district, a clustering of health and environmental risks). An

intervention may exacerbate these issues. Although ethically intended, an intervention when conducted from a top-down organizational structure can widen the divide in racial, financial, and gender inequities. Understanding the worth of an intervention might be distorted by exploratory data suggesting that students in a given situation did not benefit from the program. Adopting CBPR and/or developmental evaluation approaches will provide opportunities for all stakeholders, especially those who are underrepresented, to have their voices heard and acted on.

A critical question for future physical education/activity interventions might be how we can increase the *reach* and *impact* of the practical instruction by some teachers and teacher educators. We argue that creating opportunities to improve the health and engagement of children lies in harnessing our entrepreneurial spirit and creative thinking, not just the survival of physical education, but more the theoretical and practical ways to meet the needs of children in culturally and economically diverse settings through learning experiences within a transformative curriculum. There are emerging approaches to intervention that should extend our scholarly thinking in such ways. These approaches are embraced by many stakeholders in- and outside schools. Among them, team-science approaches are perhaps the most relevant for physical education researchers who are interested in large-scale, high-impact curriculum intervention research.

Team Science

Team science has been defined as "scientific collaboration, i.e., research conducted by more than one individual in an interdependent fashion, including research conducted by small teams and larger groups" (Cooke & Hilton, 2015, p. 2). Team-science-based interventions rely on scholars from disparate disciplines to work simultaneously to lend their expertise to solve a single common problem that affects multiple stakeholders and societal sectors, such as physical inactivity and its consequences in children. Large-scale school program interventions often adopt this approach. For example, CATCH and SPARK used similar approaches; so did Ennis's Science, PE and Me! and The Science of Healthful Living interventions.

Using the team-science approach challenges physical education researchers to abandon the unidisciplinary approach where they work alone or with another scholar in a single discipline. Instead, educational researchers should have already begun to embrace multidisciplinary and/or interdisciplinary frameworks because transdisciplinary research has a more in-depth integration of theories, frameworks, and models that transcend any single discipline. As demonstrated in the research mentioned herein, team science has the potential to generate breakthroughs and profound knowledge that would not otherwise be possible without the collective expertise of the team. This is because, as outlined by the National Research Council's paper on team science (Cooke & Hilton, 2015), the approach permits an inclusive conceptual model for solving a problem, purposefully incorporating diverse knowledge and skill sets from member researchers and practitioners, opportunities for team members to learn together, and a network of researchers and practitioners with a common goal. These characteristics provide an environment for the team to engage in an in-depth level of collaboration and trust needed to solve large-scale problems and generate high-impact solutions.

An advantage of the approach is to allow researchers to disseminate research findings most meaningful not only to their own disciplines but also to sister disciplines. Publishing deeply integrated research findings and best practices from multiple disciplines can have a profound impact on scholarship and practice. It can lead to revolutionary changes in science, research, and practice. Most physical education researchers continue to publish primarily within our discipline. May be it is time that we acknowledge the importance and interdependence of collaboration both within and beyond our discipline of physical education. Perhaps it is the time for us to reach out and embrace research in public health and STEM (science, technology, engineering, and mathematics) education as Ennis and others have done.

Team-science approaches are not without challenges and limitations. The increased size of the research team with collaborators from different disciplines may inhibit effective communication. Different research goals and expertise mean the use of various measurement and analytic methodologies. Shared governance and research administration/management must be adopted in large-scale interventions to facilitate decision making. Science teams sometimes suffer from competing goals and thus are ineffective in addressing global problems through various theoretical positions and methodological approaches. To overcome such challenges, the team of researchers must be proactive and invest in developing procedures at the onset of the project. Irrespective of the complexities of identifying and assembling a scientific team and carrying out new methodologies, the benefits far outweigh the potential limitations. The team-science train has already left the station and we need to find a way to jump on at the next stop.

Sound Research Methods as Key for Success

Successful intervention research generates actionable findings meaningful for scholars and practitioners alike. Its success relies heavily on research teams using robust research methodologies. Conducting large-scale intervention studies in schools is full of challenges. Physical education is not a tested subject in schools and for that reason is often marginalized with limited resources and support (Ennis, 2006; Harris, 1981). It is typical that an elementary physical education teacher works in isolation and teaches multiple large classes, only seeing a particular class once or twice per week. This often affects the morale and motivation of researchers, as well as participants, in a research project. Thus, interventions are difficult to carry out in schools. In addition, robust research methodologies and current research approaches require random assignment to different treatment conditions, which may go against ethical practices that necessitate an equal opportunity for all students to benefit from new or revised programs. The randomization required in RCTs has been considered another barrier because of the difficulty in random selection and assignment of participants in school settings. In this light, it is common for educational researchers to encounter conflicts between scientific rigor and what is ethically right for children in school-based research.

There are recent developments in the research design field that address such issues. Variations of traditional designs, such as counterbalanced treatment/nontreatment sequence, staggered treatment/control sequence, and cluster randomization, have been employed in educational settings (Thomas, Nelson, & Silverman, 2015), but such strategies are limited in addressing some fundamental problems, especially those related to samples, sampling, and intervention flexibility associated with RCT designs. Most school-based intervention studies are longitudinal

and require randomization with control conditions for findings to be robust (U.S. Department of Education, 2003). Given these issues, the rigidity of RCT designs may result in a high cost of intervention implementation and data collection with results that might not be relevant (e.g., the issue of control vs. ecological validity). Scholars frequently using RCTs have begun to raise questions and solutions to address these problems.

One variation of RCT is called adaptive design, which has become a mainstream RCT method in the past decade (He, Pinheiro, & Kuznetsova, 2014). Adaptive designs were developed at the beginning of this century to address the problem of the higher failure rate of confirmatory trials in new clinical treatments (interventions). Attempts were made to pursue design solutions to allow disruption of group sequential comparison to stop a study early if the results showed efficacy or failure of a treatment and allow sample-size reestimation in terms of the interim data to either increase or decrease sample size in the midst of an experiment. After over a dozen years of examination on many issues associated with these solutions, several design models are available for researchers. Although these models were developed in medical research communities, they are appropriate and relevant for educational intervention research, as well. We now briefly discuss a few relevant ones.

The adaptive randomization design allows researchers to change the intervention randomization probabilities during an ongoing study. It is based on the assessment of the covariates' balance obtained at the prescreening stage to prospectively balance participants' (individual, class, school) profiles in different intervention (treatment) conditions while still maintaining randomization. This applies to intervention studies where multiple intervention strategies are to be assessed within a sample.

The group sequential design has a long history and is considered "gold standard" in large-scale, longitudinal intervention studies. Researchers assess interim data to monitor the efficacy of the intervention for decisions to discontinue it due to clear interim evidence either that the intervention does not work in favor of participants or that benefits are outweighed by harm. The design requires establishing appropriate analysis using repeated-measures analyses on interim data to aid decisions with Type I error well controlled. Procedures such as the error-spending function (Lan & DeMets, 1983) allow flexibility for the number and timing of interim data analyses. Specific variations from the design are available to allow for an open-end design where an end point of the intervention is difficult to determine at the planning stage, or a customized intervention that requires interim assessment on the satisfaction of specific interim (formative) goals.

Sample-size reestimation designs allow researchers to resize the sample based on emerging interim data. These designs can save resources and expedite the intervention. The designs can be applied to both blinded and unblinded RCT settings. When planning for a blinded intervention study, the researcher plans to assess key nuisance parameters (error variance for continuous data, the response rate for binary data and other data) for interim decisions on modifying sample sizes with little impact on the Type I error rate. In an unblinded study, the researcher plans to statistically test the intervention (treatment) effect interim to assess statistical power needed in the subsequent phases of the study. The results can aid in sample-size adjustment decisions.

Adaptive designs, however, are not meant to replace or eliminate the RCT design. On the contrary, they strengthen them. The rapid development of these designs has provided us with alternative ways to improve the quality and trustworthiness of our intervention research. Adopting these designs requires substantial "retooling" of our methodology knowledge and skill set (Ennis & Chen, 2014). At a time when data integrity and rigor are paramount in determining whether an intervention can and should be implemented, the stakes and benefits are high in future physical education intervention studies. Ennis had envisioned the challenges on the horizon and encouraged physical education researchers to meet the challenge of improving children's quality of life through achieving learning goals in schools (Ennis, 2017b). She set an example for physical education researchers by scaling up her research agenda in the last 20 years of her career. She would certainly be hopeful that we will continue on this path.

Epilogue

Each of us has known Cathy Ennis for a long time but in different capacities. She inspired us in so many ways. Recalling our own career paths, we feel in debt to her teaching, mentoring, encouragement, and friendship. Ennis's scholarship was rooted in physical education and in schools. Her insights, especially those about large-scale, school-based curriculum intervention studies, will continue to inspire us to pursue high-quality work in the future. We are grateful that *Kinesiology Review* is publishing this special issue to honor her legacy.

References

Basch, C. (2011). Healthier students are better learners: A missing link in school reforms to close the achievement gap. *Journal of School Health,* 81(10), 593–598. PubMed ID: 21923870 doi:10.1111/j.1746-1561.2011.00632.x Google Scholar

Beighle, A., Erwin, H., Castelli, D., & Ernst, M. (2009). Preparing physical educators for the role of physical activity director. *Journal of Physical Education, Recreation and Dance,* 80(4), 24–29. doi:10.1080/07303084.2009.10598307 Google Scholar

Brown, T., & Summerbell, C. (2009). Systematic review of school-based interventions that focus on changing dietary and physical activity levels to prevent childhood obesity: An update to the obesity guidance produced by the National Institute for Health and Clinical Excellence. *Obesity Reviews,* 10(1), 110–141. PubMed ID: 18673306 doi:10.1111/j.1467-789X.2008.00515.x Google Scholar

Brusseau, T.A., Hannon, J., & Burns, R. (2016). The effect of a comprehensive school physical activity program on physical activity and health-related fitness in children from low-income families. *Journal of Physical Activity and Health,* 13(8), 888–894. PubMed ID: 27144329 doi:10.1123/jpah.2016-0028 Link, Google Scholar

Burns, R.D., Brusseau, T.A., & Fu, Y. (2017). Influence of goal setting on physical activity and cardiorespiratory endurance in low-income children enrolled in CSPAP schools. *American Journal of Health Education,* 48(1), 32–40. doi:10.1080/19325037.2016.1250689 Google Scholar

Castelli, D.M., Hillman, C.H., Hirsch, J., Hirsch, A., & Drollette, E. (2011). FIT Kids: Time in target heart zone and cognitive performance. *Preventive Medicine,* 52, 55–59. PubMed ID: 21281671 doi:10.1016/j.ypmed.2011.01.019 Google Scholar

Chen, A., Shen, B., & Zhu, X. (2018). Curriculum intervention research as a source of knowledge of most worth. *Kinesiology Review,* 7(3). doi:10.1123/kr.2018-0023. Google Scholar

Coe, D.P., Pivarnik, J.M., Womack, C.J., Reeves, M.J., & Malina, R.M. (2006). Effect of physical education and activity levels on academic achievement in children. *Medicine & Science in Sports & Exercise,* 38(8), 1515–1519. PubMed ID: 16888468doi:10.1249/01.mss.0000227537.13175.1b Google Scholar

Cooke, N.J., & Hilton, M.L. (Eds.). (2015). *Enhancing the effectiveness of team science*. Washington, DC: National Research Council of the National Academies. http://www.nap.edu/catalog.php?record_id=19007 Google Scholar

Dishman, R.K., Motl, R.W., Saunders, R., Felton, G., Ward, D.S., Dowda, M., & Pate, R.R. (2004). Self-efficacy partially mediates the effect of a school-based physical activity intervention among adolescent girls. *Preventive Medicine,* 38(5), 628–636. PubMed ID: 15066366 doi:10.1016/j.ypmed.2003.12.007 Google Scholar

Dishman, R.K., Motl, R.W., Saunders, R., Felton, G., Ward, D.S., Dowda, M., & Pate, R.R. (2005). Enjoyment mediates effects of a school-based physical-activity intervention. *Medicine and Science in Sports and Exercise,* 37(3), 478–487. PubMed ID: 15741848 doi:10.1249/01.MSS.0000155391.62733.A7 Google Scholar

Dutta, M.J., Anaele, A., & Jones, C. (2013). Voices of hunger: Addressing health disparities through the culture-centered approach. *Journal of Communication,* 63(1), 159–180. doi:10.1111/jcom.12009 Google Scholar

Ennis, C.D. (1994). Knowledge and beliefs underlying curricular expertise. *Quest,* 46, 164–175. doi:10.1080/00336297.1994.10484118 Google Scholar

Ennis, C.D. (1998, February). *Creating a culturally relevant curriculum in physical education for disengaged girls*. Margaret Paulding Lecture presented at the annual meeting of the Eastern District of the American Alliance for Health, Physical Education, Recreation and Dance; Baltimore, MD. Google Scholar

Ennis, C.D. (2006). Curriculum: Forming and reshaping the vision of physical education in a high need, low demand world of schools. *Quest,* 58, 41–59. doi:10.1080/00336297.2006.10491871 Google Scholar

Ennis, C.D. (2013). The complexity of intervention: Implementing a curriculum in the authentic world of schools. In A. Ovens, T. Hooper, & J. Butler (Eds.), *Complexity thinking in physical education: Reframing curriculum, pedagogy and research*(pp. 14–26). New York,NY: Routledge. Google Scholar

Ennis, C.D. (2015). Knowledge, transfer, and innovation in physical literacy curricula. *Journal of Sport and Health Science,*4(2), 119–124. PubMed ID: 26558137 doi:10.1016/j.jshs.2015.03.001 Google Scholar

Ennis, C.D. (2017a). Educating students for a lifetime of physical activity: Enhancing mindfulness, motivation, and meaning. *Research Quarterly for Exercise and Sport,* 88(3), 241–250. doi:10.1080/02701367.2017.1342495 Google Scholar

Ennis, C.D. (Ed.). (2017b). *Routledge handbook of physical education pedagogies*. New York, NY: Routledge. Google Scholar

Ennis, C.D., & Chen, A. (2014, April). *Scaling research to increase funding opportunities*. Invited Invisible College presentation at the American Educational Research Association's Research on Learning and Instruction in Physical Education Special Interest Group; Philadelphia, PA. Google Scholar

Gamble, J.A.A. (2008). *A developmental evaluation primer*. Montreal, QC, Canada: JW McConnell Family Foundation. Google Scholar

Glowacki, E.M., Centeio, E.E., Van Dongen, D.J., Carson, R.L., & Castelli, D.M. (2016). Health promotion efforts as predictors of physical activity in schools: An application of the diffusion of innovations model. *Journal of School Health,* 86(6), 399–406. PubMed ID: 27122139 doi:10.1111/josh.12390 Google Scholar

Harris, D.V. (1981). Physical education: A house divided. *The Academy Papers,* 15, 32–35. Google Scholar

He, W., Pinheiro, J., & Kuznetsova, O.M. (Eds.). (2014). *Practical considerations for adaptive trial design and implementation*. New York, NY: Springer. Google Scholar

Hillman, C.H., Pontifex, M.B., Castelli, D.M., Khan, N.A., Raine, L.B., Scudder, M.R., . . . Kamijo, K. (2014). Effects of the FITKids randomized controlled trial on executive control and brain function. *Pediatrics,* 134(4), e1063–e1071. PubMed ID: 25266425 doi:10.1542/peds.2013-3219 Google Scholar

Hoelscher, D.M., Feldman, H.A., Johnson, C.C., Lytle, L.A., Osganian, S.K., Parcel, G.S., . . . Nader, P.R. (2004). School-based health education programs can be maintained over time: Results from the CATCH institutionalization study. *Preventive Medicine,* 38(5), 594–606. PubMed ID: 15066362 doi:10.1016/j.ypmed.2003.11.017 Google Scholar

Janssen, I., & LeBlanc, A.G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity,* 7(1), 40. PubMed ID: 20459784doi:10.1186/1479-5868-7-40 Google Scholar

Lan, K.K.G., & DeMets, D.L. (1983). Discrete sequential boundaries for clinical trials. *Biometrika,* 70, 659–663. doi:10.2307/2336502 Google Scholar

Luepker, R.V., Perry, C.L., McKinlay, S.M., Nader, P.R., Parcel, G.S., Stone, E.J., . . . Johnson, C.C. (1996). Outcomes of a field trial to improve children's dietary patterns and physical activity: The Child and Adolescent Trial for Cardiovascular Health (CATCH). *JAMA,* 275, 768–776. PubMed ID: 8598593 doi:10.1001/jama.1996.03530340032026 Google Scholar

McKenzie, T.L., Sallis, J.F., Kolody, B., & Faucette, F.N. (1997). Long-term effects of a physical education curriculum and staff development program: SPARK. *Research Quarterly for Exercise and Sport,* 68(4), 280–291. PubMed ID: 9421840doi:10.1080/02701367.1997.10608009 Google Scholar

Metzler, M., McKenzie, T.L., van der Mars, H., Barret-Williams, S.L., & Ellis, R. (2013). Health optimizing physical education (HOPE): A new curriculum for school programs—Part 1: Establishing the need and describing the model. *Journal of Physical Education, Recreation, & Dance,* 84(4), 41–47. doi:10.1080/07303084.2013.773826 Google Scholar

Monti, J.M., Hillman, C.H., & Cohen, N.J. (2012). Aerobic fitness enhances relational memory in preadolescent children: The FITKids randomized control trial. *Hippocampus,* 22(9), 1876–1882. PubMed ID: 22522428 doi:10.1002/hipo.22023 Google Scholar

Muhammad, M., Wallerstein, N., Sussman, A.L., Avila, M., Belone, L., & Duran, B. (2015). Reflections on researcher identity and power: The impact of positionality on community based participatory research (CBPR) processes and outcomes. *Critical Sociology,* 41(7–8), 1045–1063. PubMed ID: 27429512 doi:10.1177/0896920513516025 Google Scholar

National Institutes of Health. (2018). *NIH's definition of a clinical trial*. Bethesda, MD: Author. https://grants.nih.gov/policy/clinical-trials/definition.htm Google Scholar

Ovens, A., Hopper, T., & Butler, J. (Eds.). (2013). *Complexity thinking in physical education: Reframing curriculum, pedagogy, and research*. New York, NY: Routledge. Google Scholar

Pasco, D., & Ennis, C.D. (2015). Third grade students' mental models of energy expenditure during exercise. *Physical Education and Sport Pedagogy,* 20(2), 131–143. doi:10.1080/17408989.2013.803525 Google Scholar

Patton, M.Q. (2010). *Developmental evaluation. Applying complexity concepts to enhance innovation and use*. New York, NY: Guilford Press. Retrieved from http://tei.gwu.edu/courses_approaches.htm#developmental_evaluation Google Scholar

Perry, C.L., Seller, D.E., Johnson, C., Pederson, S., Bachman, K.J., Parcel, G.S., . . . Cook, K. (1997). The Child and Adolescent Trial for Cardiovascular Health (CATCH): Intervention, implementation, and feasibility for elementary schools in the United States. *Health Education & Behavior,* 24(6), 716–735. PubMed ID: 9408786 doi:10.1177/109019819702400607 Google Scholar

Sallis, J.F., McKenzie, T.L., Alcaraz, J.E., Kolody, B., Faucette, N., & Hovell, M.F. (1997). The effects of a 2-year physical education program (SPARK) on physical activity and fitness in elementary school students. Sports, Play and Active Recreation for Kids. *American Journal of Public Health,* 87(8), 1328–1334. PubMed ID: 9279269doi:10.2105/AJPH.87.8.1328 Google Scholar

Sallis, J.F., McKenzie, T.L., Kolody, B., Lewis, M., Marshall, S., & Rosengard, P. (1999). Effects of health-related physical education on academic achievement: Project SPARK. *Research Quarterly for Exercise and Sport,* 70(2), 127–134. PubMed ID: 10380244 doi:10.1080/02701367.1999.10608030 Google Scholar

Saunders, R.P., Pate, R.R., Dowda, M., Ward, D.S., Epping, J.N., & Dishman, R.K. (2011). Assessing sustainability of Lifestyle Education for Activity Program (LEAP). *Health Education Research,* 27(2), 319–330. PubMed ID: 22156233doi:10.1093/her/cyr111 Google Scholar

Saunders, R.P., Ward, D., Felton, G.M., Dowda, M., & Pate, R.R. (2006). Examining the link between program implementation and behavior outcomes in the Lifestyle Education for Activity Program (LEAP). *Evaluation and Program Planning,* 29(4), 352–364. PubMed ID: 17950863 doi:10.1016/j.evalprogplan.2006.08.006 Google Scholar

Sun, H., & Zhang, T. (2018). Creating powerful curricula for student learning in physical education: Contributions of Catherine D. Ennis. *Kinesiology Review,* 7(3). doi:10.1123/kr.2018-0019 Google Scholar

Thomas, J., Nelson, J., & Silverman, S. (2015). *Research methods in physical activity* (7th ed.). Champaign, IL: Human Kinetics. Google Scholar

U.S. Department of Education. (2003). *Identifying and implementing educational practices supported by rigorous evidence: A user friendly guide*. Washington, DC: Author. Google Scholar

Wallerstein, N., Duran, B., Oetzel, J., & Minlker, M. (2018). *Community-based participatory research for health*. San Francisco, CA: Jossey-Bass. Google Scholar

W.K. Kellogg Foundation Community Health Scholars Program. (2001). *Stories of impact* [brochure]. Ann Arbor: University of Michigan, School of Public Health. Community Scholars Program, National Program Office. Google Scholar

Zhang, T., Chen, A., Chen, S., Hong, D., Loflin, J., & Ennis, C.D. (2014). Constructing cardiovascular fitness knowledge in physical education. *European Physical Education Review,* 20(4), 425–443. PubMed ID: 25995702doi:10.1177/1356336X14524865 Google Scholar

Zhang, T., Chen, A., & Ennis, C. (in press). Elementary school students' naïve conceptions and misconceptions about energy in physical education context. *Sport, Education and Society*. doi:10.1080/13573322.2017.1292234 Google Scholar