

Curriculum intervention research as a source of knowledge of most worth

By: [Ang Chen](#), Bo Shen, and Xihe Zhu

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Abstract:

A major portion of Catherine Ennis's scholarship and career was devoted to developing culturally relevant physical education curricula for K–12 students. She held a strong conviction that the efficacy of a curriculum lies in its ability to enhance students' knowledge and skills of most worth for their lives. The approach she adopted for curriculum development is an evidence-supported curriculum-design process through which a curriculum is put to the rigorous process of intervention research to determine its efficacy. In this article the authors reflect on the experiences they had with her in these curriculum interventions, share the ideas and practices in the research as Ennis envisioned, and discuss challenges and solutions in conducting large-scale, school-based curriculum intervention studies.

Keywords: Catherine Ennis | physical education | research partnership | scale-up research

Article:

A central piece of Catherine Ennis's legacy is her passion for curriculum intervention research as a viable approach to curriculum development. She constantly reminded physical education scholars and teachers that an efficacious physical education curriculum must be contextualized to benefit children in its context. Ennis considered it imperative to develop physical education curricula from which children will learn the most worthy knowledge and skills for a healthful and productive life (Ennis, 2017). As a forward-thinking curriculum theorist and researcher, Ennis spearheaded efforts to design and field-test several concept-based physical education curricula. Each is a piece of exemplary work for those who care about curriculum development. These curricula include Sport for Peace (1996–1999; Ennis et al., 1999),¹ Science, PE, and Me! (2003–2008; Chen, Martin, Sun, & Ennis, 2007; Sun, Chen, Zhu, & Ennis, 2012), Learn for Life (2005–2008; Chen, Sun, Zhu, & Ennis, 2012), and The Science of Healthful Living (2011–2016; Chen, Zhang, Wells, Schweighardt, & Ennis, 2017).

One characteristic in developing these curricula was the use of rigorous intervention research designs to field-test, revise, and finalize the curricula. This research-centered curriculum development was based on a rationale, according to Ennis, that a curriculum is effective only

when the intended audience can achieve what the curriculum intends (i.e., validity; Lucas, 2003). In other words, the efficacy of a curriculum should be tested through well-designed intervention research to ensure that students can learn and benefit from the curriculum.

The purpose of this article is to share the ideas and practices of curriculum intervention research as Catherine Ennis envisioned and directed it to be implemented. In particular, we focus on her contributions to conceptualizing and operationalizing curriculum development as intervention research, issues and solutions we experienced, and what we learned from these curriculum-development experiences. The writing is based on our collective reminiscence of Cathy Ennis as our mentor and colleague in curriculum intervention research.

Curriculum Intervention Research

According to Fraser, Richman, Galinsky, and Day (2009), an intervention can be understood as a set of strategies to make a difference. The strategies can be very simple and only work for an individual or they can be complex to address the needs of a community or a society. In this sense, institutionalized schooling can be viewed as a type of intervention whose goal is to positively affect children's development. A physical education curriculum, therefore, can be understood as such an intervention with a purpose to positively affect children's growth and development through physical activity participation.

Curriculum intervention is a "scaled" intervention where a relatively small number of teachers who receive the intervention resources and materials can influence a large number of students. In this scaled intervention, two determinants of success are transformative curriculum design (Ennis, 2017) and the fidelity of curriculum implementation (Ennis, 2011; Zhu, Ennis, Chen, 2011). These determinants have become the central focus of curriculum intervention research where evidence is collected to determine whether the curriculum goal has been accomplished. Curriculum intervention research, to a degree, is an attempt to gauge the success or failure of a scaled intervention in diverse settings, which is necessary at this point in time for physical education curriculum development (Ennis & Chen, 2014).

Curriculum research is often conducted to evaluate an existing curriculum. Large-scale curriculum intervention research to develop and evaluate a transformative curriculum is very rare in physical education. Ennis's seminal work established a benchmark through her curriculum intervention research to gain a better understanding about the evidence-based curriculum-development process. In these studies, her research team focused on three central issues in curriculum development: curriculum decision making (Ennis, 2006; Zhu et al., 2011), knowledge of most worth (Ennis, 2011), and student learning achievement (Chen et al., 2007).

Curriculum Decision Making and the Need for Intervention Research

Curriculum decision making has been driven by a few key factors. Two of the most salient ones in the literature are teachers' educational value orientations (see Chen & Zhu, 2018, and Curtner-Smith, Baxter, & May, 2018, in this issue) and educational context (Ennis, 2006). In the current educational environment, physical education curricular decisions can be made at various levels of a school, including teachers, principals, curriculum specialists in a school district's office, or a

group of professionals who may or may not work in schools. Goodlad et al. (1979) have long argued that the school curriculum decision making can be viewed from and influenced by multiple perspectives such as ideological (non-school-based experts), formal (school administration), perceived (teachers), experienced (students), and operational (observers).

Physical education curricula have been perceived as developed mostly “internally” by physical education teachers. In the United States this is explicitly acknowledged because teachers can make decisions on what to teach. Although teachers or administrators may have the authority to decide what to teach as a formal or perceived curriculum (Goodlad, 1979), in most cases the curriculum documents are developed “externally” by curriculum scholars/specialists outside of K–12 schools. These scholars often work in the field of higher education with close ties to local schools and physical education teachers. Most curricula they develop are theoretically based (Ennis, 2006) and focused on a particular curriculum model (Jewett, Bain, & Ennis, 1995). These ideological curricula are designed without a particular school or community in mind; thus, they can be considered decontextualized and their effects on student learning are usually unknown. Logically, examining the efficacy of an externally designed curriculum becomes necessary before it can be adopted by a school, a district, a state, or a nation. The examination can be regarded as intervention research.

Curriculum decision making plays an important role in intervention research in that it often affects the fidelity of curriculum implementation. The Science, PE, and Me! curriculum, for example, has scripted lesson plans for physical educators to implement in their gymnasias. Even with the scripted lesson plans, teachers could deviate teaching from the curriculum based on their personal values and beliefs about physical education (Zhu et al., 2011), thus lowering the fidelity of the curriculum implementation. For a curriculum that centers on health-related knowledge, lower fidelity is likely to be associated with lower knowledge gain (Loflin & Ennis, 2014).

Knowledge of Most Worth

A general purpose of a curriculum intervention study is to determine what knowledge, skill, and behavior are of most worth for students and the level of effectiveness with which the curriculum helps students learn the knowledge, skill, and behavior offered. These are core issues for physical education curriculum development. Ennis (2006) pointed out that physical education curricula are based on “relative values” that stakeholders of education place on the content. These values are likely to lead curriculum decision makers to adopt one of the three domain-specific curricula in physical education. Each curriculum takes a different view of “worth” of physical education content (Ennis, 2011). Recreational physical education focuses on enjoyment of participation with little opportunity for in-depth learning of knowledge, skill, and behavior as defined in the body of disciplinary knowledge. Public health physical education emphasizes receiving health benefits from physical activity and behavior change as demonstrated in physical education, such as time in workout sessions. Educational physical education takes a balanced approach (Ennis, 2011) where disciplinary knowledge, physical skills, and behavior change will be taught for students to master.

Ennis (2015) further laid out a strong rationale for focusing on cognitive knowledge in physical education. She argued that to be competently able to perform physical activity, one must possess

knowledge about skills and behavior required for participating in it. The knowledge must be both context-specific to allow students to adapt to the immediate environment to meet the needs and context-flexible to allow students to apply the knowledge in another context to continue the behavior. Knowledge to be included in a curriculum needs to be applicable, innovative, and beneficial for life. Since 2003, under Ennis's leadership in the Pedagogical Kinesiology Laboratory at the University of Maryland and later her work at the University of North Carolina at Greensboro targeted kinesiology knowledge as a primary intervention entity in several large-scale, school-based longitudinal curriculum intervention studies.

Student Learning as the Outcome

Intervention research is a type of applied research. Its goal is to help solve practical problems (Rothman & Thomas, 1994). Since the 1980s, physical education as a school subject has experienced extensive difficulties and challenges related to the value of its content and lack of support. Harris (1981) once argued that the primary reason that physical education had been marginalized was that it "failed to make a sufficient impact" and it "has not convinced the public of its worth" (p. 32). More than 3 decades later Ennis (2015) concluded that recreational physical education grounded in team/individual sports had failed to convince the public that our students had learned knowledge of most worth about human movement and that we, the professionals in the discipline, had not demonstrated student learning achievement.

Learning in physical education has long been defined from a behavioral perspective as relatively long-term observable behavior change. Operationally, learning was still is defined where the traditional curriculum is taught, manifested in improved performance in playing sports or in tests of isolated skills. It is not unusual to find that attendance and dressing out are used as indicator of achievement (Zhu, 2015). In the 2006 C.H. McCloy Research Lecture, Ennis (2007) clearly articulated the need to redefine learning in physical education from a constructivist perspective. She proposed learning as conceptual change in physical education by arguing,

In physical education, constructivism is an avenue for accessing cognitive conceptualizations of knowledge of and through the physical. It opens vantage points to a vision of a sound mind in a sound body and facilitates access to educational environments for effective delivery of physical education and physical education content. (p. 139)

In the curriculum intervention studies Ennis directed, conceptual change is the major indicator of learning. As Ennis (2007) reminded us, intervention curricula are indeed physical education curricula even though conceptual change is the learning outcome. An integrated approach is used in the curricula to provide moderate and vigorous physical activities to the learners not only as a mere benefit for health but also, more importantly, as an avenue to gain scientific knowledge about physical activity. In this curricular environment, learning achievement should be based on conceptual change demonstrated in knowledge growth, improved motivation for physical activity, and the ability to solve descriptive, relational, and reasoning problems encountered in physical movement tasks (Ennis, 2017).

Operationalizing the Interventions

Curriculum intervention studies directed by Ennis attempted to address concerns and needs derived from the three areas we just outlined: curriculum decision making, knowledge of most worth, and student learning. A central curriculum question to be addressed across these areas was the extent to which an externally designed curriculum would provide opportunities for students to learn the knowledge of most worth. Through the process of answering this central question, we were able to explore many other issues related to learning, learner motivation, curriculum organization, instructional systems, teacher perception of the curriculum, and more. Looking back, we can clearly see the four critical components that Ennis stressed as necessary for conducting curriculum intervention research: a guiding framework, innovation, rigorous research design, and funding.

A Guiding Framework

As early as the 1980s, Ennis (1986) began to pay attention to the importance of theoretical frameworks in curriculum design. Although curriculum intervention researchers should hold a neutral expectation about research outcomes, they do hope the curriculum will be successful. Conceptualizing the intervention curriculum based on a well-articulated, evidence-supported theoretical framework helps form a basis for the success. The overarching theoretical framework for our curriculum intervention research is the conceptual change learning theory. As Ennis discussed in many of her writings (e.g., Ennis, 2007), the theory has changed the way professional educators understand student learning.

The conceptual change learning theory centers on the following major tenets. Learners are not blank slates when they come into the classroom. They have developed some naïve, often scientifically incorrect, conceptions about what is to be learned. Thus, understanding these naïve conceptions (prior knowledge) is a priority of teaching. With accumulation of scientifically correct knowledge, a learner's conception begins to change. Second, when deep learning begins to take shape, naïve conceptions will be restructured to reflect scientific conceptions. Because "scientifically correct" conceptions are relative to the developmental stage of a science, educators should be sensitive about what knowledge is of most worth. Ennis recognized the issue of relativity very early based on her findings from value orientation research (see Chen & Zhu, 2018, and Curtner-Smith, Baxter, & May, 2018, in this issue) and emphasized that learning how to learn is just as important as learning the knowledge and skills.

During the change from naïve to scientific conceptions, learners endure a cognitive transition as their knowledge experiences a restructuring process. This process is characterized and observed in research as the network of information (cognitive models) being reorganized from naïve models (full of misconceptions) to synthetic models (blend of misconceptions and scientific conceptions) to scientific models (scientifically correct conceptions; Vosniadou, 1994). The knowledge-restructuring process include three stages. Information restructuring begins with the enrichment process when new information from a trusted source (e.g., teachers) begins to be assimilated into the existing knowledge repertoire. With the increase of new information, weak restructuring takes place. The naïve model begins to change because the conflicts or gaps between the old/naïve conception and the new scientific conception become so clear that the learner must either revise the naïve mental model by accepting and accommodating the new information in the knowledge repertoire or reject the new information completely to maintain the

naïve model. Research findings on conceptual change indicate that learners will revise the naïve model by creating a synthetic mental model that may allow them to explain a phenomenon using the preferred naïve conceptions with selective new information. When additional information continues to intensify the conflict and widen the gap between scientific conceptions and naïve conceptions in the synthetic mental model, the radical restructuring process begins to completely change the structure of the learner's knowledge repertoire. That is when the scientific mental model begins to hold through a careful reorganization of information. Learning, according to the conceptual change theory, is such a process of knowledge restructuring.

Although conceptual change is a process residing in an individual, its success relies on a socially supportive environment. This is particularly true for children and adolescents (Vygotsky, 1980). The core idea of Vygotsky's social constructivist learning theory is the concept of zone of proximal development (ZPD). The concept is defined as the difference (gap) between what learners can accomplish and what they are unable to accomplish without assistance from knowledgeable others. It is assumed that every learner has a ZPD. The ZPD concept highlights the necessity of a supportive learning environment where peers and knowledgeable others (e.g., teachers) can provide social support and assistance to the learner. It is essential that teachers encourage learners to identify their ZPD and guide them to bridge the gap by acquiring new knowledge through learning.

The conceptual change learning theory and social constructivism are two theoretical strands of the stem of constructivist learning theory. In Ennis's extensive writing, she and her colleagues evaluated and advocated for a curriculum that would lace together these theoretical principles to understand student conceptions of important concepts and to optimize the opportunity for students to learn in physical education. Her extensive theoretical and empirical work laid a solid foundation for the development of innovative physical education curricula (Ennis, 2007; Sun et al., 2012; Zhang, Chen, & Ennis, 2017). Her vision as a curriculum researcher guided us in several large-scale, school-based curriculum intervention studies in which innovative curricula were developed, field-tested for their efficacy, and disseminated when their positive impact on learning was established with empirical evidence.

Innovative Intervention Curricula

The central purpose of social intervention research is for researchers and stakeholders to determine whether an intervention can make a difference significant enough to benefit society (Fraser, Richman, Galinsky, & Day, 2009). Intervention research is expected to be characterized by rigorous research methods. Equally important, however, is the rigor of the intervention program (Ennis, 2006, 2015). Based on her numerous descriptive studies, especially those in urban schools where conventional team-sport-based curricula had been repeatedly regarded as detrimental (e.g., Ennis, 1996, 1998), Ennis led her research team to design and conduct three rigorous curriculum intervention studies: Sport for Peace, Science, PE, and Me!, and The Science of Healthful Living.

These curriculum intervention studies often used mixed methods with rigorous quantitative and qualitative approaches to research design, data collection, and data analysis. It is critical to point out that each included a rigorously designed intervention curriculum. These curricula share the

following characteristics.² The curricula are intensely learning oriented. The overarching approach to student learning is based on the theory of conceptual change. The entire curriculum is organized with in-depth knowledge in a broad scope and is sequenced spirally to address naïve conceptions (Vasniadou, 1994) and take advantage of useful prior knowledge (Bruner, 1960).

These curricula share the value of orientation learning process (see Chen & Zhu, 2018, and Curtner-Smith, Baxter, & May, 2018, in this issue). The orientation prioritizes the value of learning how to learn in the entire learning experience. To optimize learning, the curricula adopt a 5E instructional system where learners are guided to experience engagement, exploration/experiment, explanation, elaboration, and evaluation tasks to maximize their understanding of the concepts (Balci, Cakiroglu, & Tekkaya, 2006). The rigor of the curricula is manifested in tightly structured learning tasks based on the differentiated learning principles (Gregory & Chapman, 2013). All concepts are integrated in physical activities, and all physical activity tasks are presented in easy, average, and hard variations to accommodate different paces of learning. The rigor is also manifested in the use of student workbooks to enhance the learning experience and reinforce the learning outcome (Zhu et al., 2009). Each physical activity task is tied to a cognitive concept. Learners must complete a physical activity task and a cognitive task together. When engaged in the physical activity, learners must think about the meaning of the activity in order to complete the cognitive task after the physical activity. The cognitive tasks are structured at three cognitive levels. Descriptive tasks ask learners to provide evidence to describe physiological, psychological, perceptual, and emotional responses they experienced in the physical activity task. The relational tasks guide learners to establish a connection between what they experienced and felt about the physical activity. The reasoning tasks lead learners to reach conclusions through reasoning, which enables them to reach a cause–effect judgment about benefits or mechanisms of the physical activity they just experienced.

The rigor of the intervention curriculum is supported by a series of curriculum documents. The most important document is the teacher manual, which includes a detailed description of the national standards broken down by the curriculum, each unit, and each lesson. After presentation of the curriculum framework with a concept matrix, detailed lesson plans are written verbatim to guide teachers from the beginning to the end of a lesson. The verbatim lesson plans give teachers clear direction but allow flexibility to deliver the content following the 5E lesson structure. Each lesson also includes pages of students' workbooks to show teachers what exactly what students are supposed to experience and are expected to learn. Accompanying this are a physical activity guide and a test manual. The activity guide provides more than 100 additional physical activity tasks organized into different categories. Teachers have choices to replace the activities that they feel are irrelevant and/or too difficult to implement due to environmental constraints (space, equipment, etc.). The test manual provides test banks for assessing student knowledge growth (summative assessment) and learning progress (formative assessment based on student workbooks). Both knowledge test items and learning-progress-assessment tools (rubrics) have been developed through rigorous validation processes to ensure validity and reliability of the scores.

Because the intervention curricula are all based on theories of student-centered learning, the 5E instructional model is designed to provide students ample opportunities in each lesson to exercise independently. A major approach is to use workstations with task cards to guide the experience

of independent learning. The task cards were designed following the differentiated learning strategies (Tomlinson & Allan, 2000) that give students the choice of exercising in terms of their own sense of tolerance for physiological intensity, skill levels, and personal goals. Equally important in the curricular documents are student workbooks. In each lesson, students use a workbook to lead them in the learning process. The workbook also provides space for students to record exercise experiences and body responses that allow them to compare and share data/evidence. The workbook is a platform for students to experience self-paced learning and is intertwined with the 5E model for achievement.

A challenge in curriculum intervention is to maintain curriculum delivery quality. Intervention curricula are different from traditional curricula in either content or approach or both. Teachers who are to teach an intervention curriculum must receive high-quality professional-development workshops in which they are trained to deliver the curriculum effectively. Teacher training is the most important intervention in a curriculum intervention study. In all our curricula intervention studies, a teacher training manual was developed along with all other curricular documents. The goal was to enable each teacher to teach the intervention curriculum with acceptable implementation fidelity. Professional-development workshops were planned at the same time. The workshops usually consisted of content that would be delivered, presented on three separate days, each of which focused on different knowledge and skill sets that the teachers would need at different stages to deliver the intervention curricula effectively.

To maintain the rigor of the intervention study, professional-development manuals for teachers in the comparison (control) condition were developed, as well. Comparable professional-development workshops were provided to the teachers from the control condition as a placebo. These workshops focused on knowledge and skill sets needed to successfully teach the comparison curriculum, which was the traditional curriculum already being taught in the school.

Scaling Up Research Design for Rigor

Social intervention research requires sophisticated designs (Fraser et al, 2009; Rotham & Thomas, 1994). Curriculum intervention is a type of social intervention research that directly affects children's learning. Because of the size of the education enterprise, educational institutions and researchers often gravitate toward using research designs and methodologies that allow broad generalizability of results (U.S. Department of Education, 2003). In this regard, a preferred approach by many intervention researchers is the randomized-controlled-trial (RCT) research design. In the educational research field, however, the quantitative data-centered approach might overlook the needs of individual children, especially those who do not fit in a norm characterized by a statistically distributed pattern. In educational research, many meaningful findings have come from studies conducted using a variety of qualitative research designs (Short, 1991). These qualitative approaches can help researchers understand unique and significant cases that can contribute to a deeper understanding of education and its impact. A typical example of such a contribution is the study of the hidden curriculum (see Jewett et al., 1995). There is no doubt that each methodology has contributed and will continue to contribute to education and physical education.

As Ennis and Chen (2014) observed, physical education researchers are often inclined to use one type of research approach. This inclination likely brings them to adopt one *or* the other methodology. For a curriculum intervention study, Ennis and Chen (2014) argued that a mixed approach might be more appropriate for generating meaningful and significant findings. Educational researchers, like their counterparts in medicine, often start with small-scale case studies and then move up to large-scale trials (Ho, Peterson, & Masoudi, 2008). With growing needs to learn more and to intervene for improvement, researchers will need to broaden their inquiries to either expand the breadth or depth of knowledge or make the intervention available on a large scale. These needs present both a challenge and an opportunity for physical education researchers to “scale up” their research and scholarship.

To scale up, researchers are encouraged to consider both breadth and depth of their findings from the inception of a curriculum intervention study. It is only natural for curriculum researchers to hope that the curriculum, if proven efficacious and conducive to student learning, will be able to enhance learning achievement for every child. In this sense, generalizability (to other schools) and specificity (for individual students) of findings matter (American Educational Research Association, 2006), and a sound design can increase the likelihood of achieving the research goal of determining curriculum efficacy in terms of generalizability and specificity.

Ennis and Chen (2014) recommended specific approaches for physical education researcher to take when starting the scaling-up process. To start, researchers should be willing to keep an open mind in terms of aligning their own research topics with those that need large-scale evidence. Almost every topic we studied can be aligned with topics that need scaled-up evidence. Second, physical education researchers should be willing to retool and expand their skill set for large-scale intervention research. These skills include learning and understanding different research designs and purposes; networking with other researchers who use different methodologies; giving up the culture that prevents scaling up, such as the mentality that no funding is needed for physical education research (see “Importance of Funding” section); adjusting or even changing research focus; and accommodating different views on research rigor.

Successful scaling up can take a long time. Our own experiences in studying teacher values, curriculum efficacy in different contexts, and learning motivation and learning have gone through this process. As Chen and Ennis (2013) summarized, a few key elements can determine the outcome of a scaling-up effort. One such element is adoption of the RCT design. *RCT* is a term that many significant funding agencies use to determine the rigor of an intervention research study, often referred to as the gold-standard design for such research (Ho et al., 2008; Machin & Fayers, 2010). For a long time, physical education researchers have been struggling with several important requirements in the design, considering them too difficult to meet. For example, the unit of randomization (including sample-size issues) in relation to the unit of analysis and the meaning of control condition are but two critical ones. The rigid requirements of the RCT often prevent physical education researchers from considering using it to produce generalizable evidence to document efficacy of a curriculum.

The latest developments in RCT designs have provided many alternatives that allow flexibility in the design. These proposed changes are meant to improve the efficiency of RCTs and maintain their rigor if not improving it. A most significant alternative design is the adaptive RCT (He,

Pinheiro, & Kuznetsova, 2014). A common advantage of adaptive designs is the flexibility of sample size based on sample-size reestimation procedures in response to the interim intervention effect. Another similar advantage is to enable an analysis called optimal timing of interim analysis that could lead to various decisions to adjust the intervention for type and dosage. These are only limited examples of what adaptive RCT designs can offer. These changes are believed to lead to optimization of intervention research that benefits intervention program development more than the traditional RCT designs by leading researchers to optimal decisions at different stages of the intervention.

In summary, scaling up is a necessary step for physical education researchers to take when they need to improve the breadth and depth of the research impact of a curriculum intervention study. Scaling up requires many changes on the part of the researcher. It enables expansion of a curriculum intervention in size and depth by increasing the rigor in both directions. Alternative RCT designs such as adaptive designs can help address some challenges that physical education researchers have been facing by providing alternative design models.

Importance of Funding

Resources and support are needed to conduct large-scale, school-based, high-impact curriculum intervention research. Securing significant funding for a high-impact curriculum intervention study can ensure the rigor of the study and allow for sufficient time to examine the curriculum and its impact. Ennis and Chen (2014) laid out the needs for physical education researchers to acquire funding support from all possible sources, especially from agencies of the federal government. Because of the competitive nature of obtaining federal funding and the manner in which programs are structured and awarded, it is prudent for researchers to consider where to direct their energy and effort. Many of us choose, rightly so, to focus on publishing our current studies rather than applying for funding. Although physical education researchers have made continued contributions to the literature with high-quality research without funding, the passive culture in terms of obtaining research funding has begun to hinder the impact and influence of our findings (Ennis & Chen, 2014).

To successfully conduct large-scale, school-based curriculum intervention research, funding matters. Curriculum intervention research is very complex because the research process is both generative and responsive (Ennis, 2013). It is generative in that the process and product lead to possibilities of generating innovative curricula and pedagogy, yet it is responsive due to the fact that the intervention curriculum and the research process are constrained by the action/reaction between research requirements and a web of complex elements in school districts or schools (Ennis, 2013).

In this action and reaction, funding serves as a lubricant to enable researchers to accomplish the mission of research and opens the door for schools and teachers to experience the benefits of using evidence-guided curriculum decision making. When an RCT design is used, it creates layers of complex elements that connect research studies together for the preservation of data quality. In our curriculum interventions, we used a longitudinal repeated-measures, multilevel, multisite, controlled design. The sample components consisted of schools, teachers, students, and parents. They were sampled as cohorts at multiple levels including experimental conditions,

school academic performance levels, school socioeconomic status, teacher education values, student motivation, and learning achievement. To maximize generalizability (ecological validity), the unit of sampling was school. The school sample had to represent the 100 largest school districts in the United States for enhanced ecological validity.

Funding was obtained to support a doctoral student to work with the principal investigators for 3 months in the summer to compile, analyze, and select a school sampling pool that represented the school population. The funding permitted the researchers to assemble a curriculum-writing team to create the intervention curriculum. The team consisted of expert teachers and scientists in kinesiology. The funding supported them to work for 4 weeks during the summer to develop the curriculum documents. When the draft was completed, a small group of experts continued to work on refining the documents. In the meantime, a validation study was conducted by the assessment team in three schools to create, validate, and calibrate instruments ranging from knowledge tests to motivation assessments to accelerometers for physical activity. Over a period of 11 years, we consistently had 10–18 graduate and undergraduate students working on data collection, data transcribing, data cleaning and organization, and multiyear data matching. The outcomes are astonishingly high-quality research reports. We now know not only the efficacy of the entire intervention curriculum (see Sun, Chen, Zhu, & Ennis, 2012) but also the specific contribution of each lesson to student learning (see Zhang et al., 2014).

Physical education is a marginalized subject with limited recourses due to being a “nontested” area of study (Ennis, 2006). Curriculum reform in schools has experienced many setbacks due to lack of resources and marginalized status. Ennis (2014) envisioned that using externally designed but authentically contextualized curricula could situate the learning experience to enhance learning achievement, thus interrupting the vicious cycle of marginalization, poor curriculum, meaningless experience, and low learning outcome. But accomplishing this requires allocating resources to physical education that many local educational agencies would be reluctant to provide without evidence showing benefits to student learning and growth. Funding for curriculum intervention research often comes with support for teacher development. Using the funding wisely can not only ensure implementation fidelity but also elevate the status of physical education in schools as a subject worthy of investment. In our curriculum intervention studies, the funds supported teacher professional development, acquisition of new equipment for physical education (consistent with the intervention goals), learning assessment, and parent/guardian physical education activity nights. School administrators welcomed these initiatives and became enthusiastic partners of the research. Participating teachers felt that other teachers began to view physical education in a different light and to value the content.

Competing for research funding can be difficult and time consuming. Ennis and Chen (2014) advised that physical education researchers need, foremost, to change the passive culture in terms of seeking funding. Researchers need to be willing to change the focus of their research, position current research to match funding agencies’ priorities, and change terminology and even variables if necessary to align with those in funding announcements. Retooling research skills is very necessary to demonstrate the competence needed to conduct large-scale, school-based, high-impact intervention studies. In addition, researchers need to be willing to look at their previous research in a different light to find unique contributions and negotiate impediments in terms of funding agencies’ priorities. Finally, the ability to scale up largely depends on whether

the researcher is willing to become open-minded to issues related to research methodologies in order to adopt those we initially may not feel comfortable using. In universities, where most researchers work, an infrastructure should be in place to support researchers in the preparation of funding applications. “Use it or lose it” can apply here seamlessly, so all researchers working for universities should familiarize themselves with the available support and use that support to secure funding.

Challenges in Curriculum Intervention Research

Curriculum intervention research is a multifaceted operation with challenges in each of its dimensions (Fraser et al., 2009). In our curriculum intervention studies, we encountered numerous challenges and problems. These challenges can be summarized in five categories: teacher cooperation, parents’ impact, sampling problems, quality of (mixed) data, and partnerships with schools. We next discuss the challenges, as well as some of our solutions and what we learned from these experiences.

Teacher Cooperation

Ennis was fully aware of the strengths and weaknesses of an externally designed curriculum. She had long recognized the implementation limitations of a decontextualized curriculum (Ennis, 1992). Using dynamical systems theory, Ennis argued that a well-designed curriculum can be an “attractor,” but its power can be mediated by “constraints” in learners, teachers, and the general school environment. Ennis ranked curriculum value orientations as the strongest attractor but recognized that the curriculum could fail if the value was inconsistent with teachers’ value orientations. She cautioned us using the example of the Basic Stuff curriculum developed decades ago by National Association for Sport and Physical Education (1981), which was not well received by physical education teachers and learners.

When we were designing an intervention curriculum, the dynamical system was certainly at work. In developing our “externally designed” curriculum, Ennis involved expert physical education teachers (national board certified) in the curriculum-writing process. The teachers were invited to join our curriculum-writing team from the beginning of a project and meet with us for an extended period of time to review the curriculum framework and content matrix already developed (hence the external design). The framework and content matrix gave clear indications about the value orientations on which the curriculum would be based and the scope and sequence it would take. In the curriculum-writing process, the teachers worked with university researchers and content scientists to develop units and lesson plans. To ensure that the lessons could be taught with the highest level of fidelity, Ennis insisted that each lesson plan be written verbatim. In other words, in situations where there is no physical education specialist, the lessons can be taught by classroom teachers following the scripted lesson plans, after intensive training.

A challenge in testing curriculum efficacy is to separate the efficacy of the curriculum from the influence of the teacher. In physical education, teachers are often viewed as an inseparable part of the curriculum. This challenge often presents a problem for the ecological validity of the findings. From a research design point of view, using an RCT is the most effective way to isolate the effects from different sources influencing student learning. It is obvious that the

randomization facilitates the creation of a sample of teachers with diverse value orientations, teaching experiences, and commitment to physical education.

In sampling, we used school as the primary sampling unit with a multilevel design. We stratified the sampling pool by student scores on state standardized tests and school socioeconomic status using free and reduced-price means percentages (known as FARM%) to ensure the sample representativeness for the student population. When the sample was determined, the schools were matched in pairs in terms of the stratification variables. A further random group assignment placed each school into either the experimental or the control condition. This sampling procedure created a true random sample that included physical education teachers at different expertise levels, with different value orientations, and with different “buy-ins” with concept-based physical education. It is important that the sampling strategy provided an opportunity to test the curriculum efficacy with control over possible confounding effects from teachers (see Chen et al., 2017 for an analysis on teacher value orientation impact).

A random factor for curriculum implementation fidelity existed even for those teaching an intervention with scripted lesson plans (Zhu et al., 2011). To address the implementation fidelity issues, we provided in-depth professional-development workshops and active monitoring to earn teacher cooperation and control possible confounding effect. We provided a 2-day workshop to the teachers from both conditions each semester. For the teachers in the experimental condition, the workshops focused on teaching the experimental curriculum. For the teachers in the control condition, the workshops functioned as a placebo to control for the Hawthorne effect. With active monitoring, we sent trained graduate students to experimental schools and control schools to conduct nonparticipant fidelity-check observations by documenting information about the lesson being taught. The information became part of the data of “curriculum slippage” to examine whether a curriculum deviation occurred during instruction, where in a lesson it occurred, and for what reasons. The observers studied each lesson plan before observation and had a short conversation (informal interview) with the teacher after a lesson if a slippage did occur.

We also created and validated an instrument called the Ease of Use Inventory to collect experimental schoolteachers’ perceptions about every aspect of the intervention curriculum. The instrument permits teachers to respond to items ranging from time (in minutes) spent on lesson preparation to financial challenges, if any, of implementation. Last but not least, teachers in the experimental condition were asked to provide written feedback on the curriculum documents whenever they felt it was necessary. The feedback ranged from pointing out typos to substantial suggestions for lesson change.

These measures coupled with frequent updates on student learning (test scores provided to teachers and principals soon after a formal assessment) did earn teacher cooperation with the studies. As researchers, we felt that these measures designed by Ennis and the team were paramount in that they helped the teachers realize their beliefs based on why they chose the teaching profession in the first place, helping students learn knowledge of most worth. From a research point of view, these measures helped maintain data integrity. The teachers taught to the best of their ability. Although deviations from the curriculum and variability in student achievement occurred, the innovative curriculum design, use of an RCT, and faithful

implementation of the research plan provided valuable data with ecological validity to demonstrate the curriculum's efficacy (Sun et al., 2012).

Parents' Impact

Ennis believed that parents would determine the success or failure of educational research. They determine whether we can collect useful data through the consent process, as well as how successfully their children learn. The consent process goes beyond merely preparing the consent and assent forms for parents and their children to sign. It is a bridge-building process that helps researchers earn parent trust. Curriculum intervention research is not just a descriptive study for describing the current status—it is designed to change something. The risk of an intervention study lies in its unknown outcome. Although researchers naturally expect a positive outcome, the findings may demonstrate otherwise. It is important to disclose the uncertainty to parents to earn their support. Our solution has been to give parents detailed information about the study, including the length (a 3-year clinical trial and 2 more years of dissemination studies), the curriculum, the expectation, possible benefits, and potential risks. The consent and assent forms were in both English and Spanish to reach a diverse population. The consent rates in our studies were higher than 95%.

The intervention curricula included a deliberately designed Family Science Activity Night session. Professional development was provided to experimental schoolteachers so that they could brainstorm the best strategies to encourage parents to come to an event on physical education. The event was held to reduce parents' misconceptions related to health science. A variety of strategies were developed by teachers working in the schools. Some provided incentives with door prizes; others hosted receptions with healthy food to accommodate the interruption of dinner. All teachers started a campaign for the event very early and involved students in the process. They were convinced after the first trial that the event would be better attended when held in conjunction with other school events such as a science exhibit or before a sporting event or a concert.

Our goal was clear—physical education teaches children knowledge and skills beneficial for life. Changing parents' misconceptions should be part of the education process. The outcome, however, was mixed. The Family Science Activity Night was better attended in our elementary school study than in our middle school study, but in both cases, the parents who participated showed great interest in the content and acknowledged the worth of learning the content. Some went so far as to write to principals to highlight the “new” physical education. Some parents wrote on our evaluation form that they had never realized how useful physical education could be for life and thanked us for providing the knowledge and skills to their children. Although we did not collect data systematically from parents, this anecdotal evidence convinced us that an outreach component should be an integral part of a concept-based curriculum. It also needs to be considered as a viable variable in future curriculum intervention research.

Sampling Issues

Sampling can be considered one of the most difficult tasks in conducting an intervention study due to the nature of society-oriented goals (Fraser et al., 2009; Rothman & Thomas, 1994).

Numerous factors can affect the curriculum implementation process, but one of the most critical is the teachers' support of or resistance to the intervention (Snyder, Bolin, & Zumwalt, 1992). For a curriculum intervention study using an RCT, researchers cannot simply select the most cooperative teachers for the intervention. In our curriculum intervention studies, we faced issues of sample size and sample representativeness, as most researchers do. The sample-size issue involves adequate statistical power that directly affects the significance and meaningfulness of the findings. The sample representativeness issue is concerned with ecological validity of the findings; in our case this directly relates to the types of schools in which the findings could be of use. In other words, if the findings are promising, can most schools in the nation use the curriculum to achieve similar outcomes? Given the complex issue of the unit of analysis (Silverman & Solmon, 1998), we took care to address both the sample size and representativeness using a multilevel design based on the hierarchical linear modeling approach. This approach allowed us to use the school as the primary sampling unit based on which the statistical power analysis was conducted. It also allowed us to adequately analyze the data in a nested structure (students within classes within schools; see Chen et al., 2012).

The most challenging aspect in sampling is to recruit schools and teachers to participate in the studies and secure their commitment to continued participation for 3–5 years. Ennis led the research team to develop several strategies and worked extremely hard to recruit and retain participation. First, we used a randomized approach to developing a sampling pool that represented the 100 largest school districts in the country. In our elementary school project, the pool contained over 300 elementary schools from one very large school district. In our middle school project, the sampling pool consisted of over 100 middle schools in seven districts in a very large geographic region.

The sampling was planned during the proposal-writing stage. As soon as the study was conceptualized, Ennis began contacting districts and schools to form a university–school partnership network. She spent countless hours on the phone and on the road talking to superintendents, principals, and, most important, physical education teachers through formal presentations at principals' meetings, professional-development workshops, and informal conversations. For each of the studies, we were able to secure dozens of letters of support from superintendents, principals, and teachers to include in the proposals to funding agencies. Without this effort and school support, funding for any large-scale studies would not have been possible.

The sampling began with downloading the report-card data for all the schools in these school districts and analyzing the data using a series of statistical analyses to determine stratification variables. Aggregated data for all schools in a state or a delimited number of schools, such as the 100 largest districts in the United States, were also downloaded to establish sampling criteria against which the data from the sampling pool were compared. Based on the analysis of the stratification variables, all the schools in the sampling pool were placed in a fixed number of matching brackets for randomization (e.g., 30 brackets when 30 schools were needed as indicated by a statistical power analysis). Each bracket contained the schools with matching statistics on the stratification variables. Two schools in each bracket were then randomly selected and subsequently assigned to either the experimental or the control condition. The remaining schools in the bracket served as backup schools; in a rare case of attrition, they could be included

to continue the study without jeopardizing the quality and integrity of the data. This process usually took about 6 weeks to complete.

In the next step, Ennis led the research team to contact the schools that were sampled. A commitment to participation in the proposal-writing phase is not equal to actual participation. School administrators and teachers can move to other locations, and the new principals and teachers can decline to participate when the study is starting. When attrition happened, we moved to a backup school and started the negotiation for participation again. The processes to recruit and retain participation in schools and teachers are extremely challenging and time consuming for a large-scale, longitudinal curriculum intervention study. They demand effort, energy, stamina, and tremendous patience from the researchers.

We as researchers have learned a great deal working with Ennis on these projects, especially about inviting schools and teachers to participate in research studies. We believe that school administrators and teachers care about children deeply. They share our belief that every child deserves the best education. We learned that it is our responsibility to make it known to them that our study is for the best interest of children. We also learned that sound sampling is merely one initial step; as researchers we should build an infrastructure through which school personnel can reach us any time during and beyond a study.

Quality of (Mixed) Data

On the surface, our curriculum intervention studies relied on quantitative approaches. In actuality, however our entire design can be considered a mixed design. Compared with a single-method design, mixed methods strengthen data structure and enhance the depth and breadth of analyzing research questions (Johnson & Onwuegbuzie, 2004). We collected several major categories of outcome data, including knowledge gain, interest for learning, problem-solving skills, and amount and intensity of physical activity. Each category included multiple data points, each being longitudinal (3 years matching and 2 years matching for the dissemination study). The data points consisted of information collected using the quantitative and/or qualitative approach. The quantitative approaches are characterized by methods known to be deductive to explore intervention effects and provide generalizable appraisal of the intervention curriculum. In contrast, qualitative approaches lead to an understanding of participants' perspectives and interpretations of the content experienced.

The quantitative data points from standardized knowledge tests enabled us to assess how much students learned by comparing the knowledge gained from pre- to postintervention between the experimental and comparison conditions. In the studies, we always used a purposeful sample of six students (three boys and three girls with different body sizes) in each class for in-depth interviews to help explain how and why the knowledge was gained. Because of the RCT research design within which the qualitative data were nested, the explanation (or mechanisms) of learning can be very powerful and generalizable. By the same token, students' responses to the workbook questions were often in the form of writing (qualitative data), so we developed and validated a rubric to evaluate the responses to each question. The results, often in the form of a rank code, allowed us to further determine the importance of each question and lesson in relation

to learning achievement. The analysis helped us further determine the importance of lessons in each unit in relation to the efficacy of the intervention curriculum (Zhang et al., 2014).

Data from large-scale curriculum intervention studies tend to be very rich and diverse. Although specific aims laid out in a research proposal specify the research questions to address, researchers can often identify additional emerging questions during the research process. Our curriculum intervention studies are no exception. Our data encompass a large spectrum of areas of research—learning, learner motivation, in-class physical activity, after-school behaviors, teacher value orientation (as a control variable), curriculum design, implementation fidelity, instructional resources, and assessment issues. As Ennis conceptualized, all these data can support research on important topics in physical education from either a cross-sectional (year-by-year) or a longitudinal (years consecutively) perspective. We have published the data since 2003 and are still working on the dissemination of other important findings.

The experience of working with Dr. Ennis on these curriculum intervention studies has made it clear to us that research methods are tools to address research questions. It is the questions that should drive the choice of methods, rather than the other way around. For years, Ennis insisted that our graduate students master both qualitative and quantitative research methodologies. She crafted a graduate student training program for students to receive a certificate in statistics and a qualitative methods course package consisting of three courses. This intensive training in research methods has enabled us to establish and sustain a competent research team that can use techniques from both families of research methods complementarily.

The central issue in data use is data validity and reliability. In our curriculum intervention studies, establishing the evidence for validity/reliability and trustworthiness has been a paramount task and a top priority. Ennis insisted that all instruments and techniques used in our research must possess at least adequate evidence for validity and reliability. Normally, validation processes started in the pilot year before the experiment began. Validations were conducted with content validity, construct validity, trustworthiness, and reading levels on all knowledge tests, all paper-and-pencil (now Internet-based) instruments, interview questions, field-observation note-taking guides, and workbook-grading rubrics. In addition, intra- and interobserver reliabilities were established and checked periodically throughout the data-collection and -analysis periods over the years. Clear data-collection protocols and data-handling procedures were established and enforced in our research lab with clear personal accountability. Data collectors were trained to write research methodology memos to record unusual events in schools that might affect data quality. Data-sharing policies were established in the lab so that graduate students would work on separate topics with little or no data overlapping. These data-management measures and practices have helped maintain data integrity and quality throughout the years. They certainly have enhanced the validity of the data and led to strong confidence in the findings we publish.

Partnerships With Schools

Curriculum intervention research is in the best interest of schools rather than that of the researchers. A long-term collaborative relationship with local schools and school districts is necessary to develop, nurture, and grow a positive partnership. From the section of this paper on sampling, it is evident that physical education researchers need to invest much effort in

establishing this partnership if they are to help school physical education through research. Needless to say, securing funding for a large-scale curriculum intervention study demands such a partnership to gain meaningful and generalizable evidence. We have learned through working with Dr. Ennis that forming a constructive partnership with schools requires setting up a research lab for teachers, acknowledging incremental curriculum change as healthy and positive, and providing continuous support to teachers even after the research is over. All these requirements are connected.

Our Pedagogical Kinesiology Laboratory has long been a productive research lab. It is also a lab that provides service and support to teachers. Ennis saw these as parallel and related missions of a pedagogy research lab. The lab should not only lead the field with quality research but also provide tangible support and service to schools. For many years, the lab has partnered with many school districts to support curriculum development, learning assessment, and professional development. This support and service helped us earn trust from the teachers and schools and establish a healthy partnership with them.

Ennis cautioned us that we as researchers should be committed to curriculum improvement but also understand curriculum as an incremental process. This is important for those who conduct curriculum intervention research. In many cases, the content of choice can regress back to the traditional curriculum that was prevalently taught before the intervention due to many factors at work in a complex web of influence (Ennis, 2013). This is because

as the curriculum cascades through the various levels of schools and society, it encounters stabilizing agents in other systems that resist adaptations and attempt to return the system to a state of stability. The system may return to the previous status quo or restabilize at a new point that accepts some, but rarely all, of the innovations. (Ennis, 2013, p. 24)

Thus, we need to be patient and accept curriculum slippage during curriculum interventions with a belief that the intervention has provided the teachers a repertoire of strategies and tools to reengage in the change that the intervention had brought to them.

Our lab has embraced this belief and continued to provide support after intervention as the key for restabilizing the intervention curriculum to increase the chance of its sustainability. Ennis noticed that, in our elementary school intervention, some teachers continued the curriculum after the intervention even when new administrators in an experimental district withdrew their support. Recently we also noticed that three experimental schools and one dissemination school in our middle school intervention study continued teaching the experimental curriculum after the study was officially closed. The lab has maintained our partnership with all districts that have been involved in the studies. Six of the seven partnership school districts have agreed to partner with our lab again in our proposed high school physical education curriculum intervention study.

Closing: What We Have Learned From Catherine Ennis's Legacy

Catherine Ennis established herself as a giant curriculum theorist and a pioneer in physical education curriculum intervention research. Through working with her, we learned that

curriculum change must be based on research evidence and that producing high-quality evidence is a crucial responsibility of curriculum researchers. We also learned that it may not be enough to document learning achievement; we must ask the fundamental question “What knowledge is of the most worth?” again and again. Only after we can answer this question can we become convinced that our curriculum has provided adequate and relevant knowledge and skills to the learners for a lifelong benefit (Ennis, 2017). Finally, we have learned that the strongest indicator of success in physical education is when our students becoming lifelong learners who are able to define and acquire the knowledge and skills of the most worth with a deep understanding of kinesiological science that enhances their quality of living (today) and quality of life (throughout the life span).

Notes

1. This and others cited in this sentence are representative publications from each curriculum research project. These articles may not represent the full scope of each project.
2. The characteristics described do not include those in Sport for Peace. We were not able to locate the curriculum documents at the time of this writing.

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