

Health-Related Fitness Knowledge Development Through Project-Based Learning

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Purpose. The purpose of this study was to examine the process and outcome of an intervention using the project-based learning (PBL) model to increase students' health-related fitness (HRF) knowledge. **Method.** The participants were 185 fifth-grade students from three schools in Alabama (PBL group: $n = 109$; control group: $n = 76$). HRF knowledge was measured using a valid written test. **Results.** Using a two-level Hierarchical Linear Model (HLM) where students were nested within teachers' classrooms, the results show that controlling for "Class" there was a statistically significant difference between the two group conditions with the PBL cohort scoring 18.85% greater than the control schools at posttest. **Discussion.** The findings have shown supportive evidence as to the efficacy of a PBL-themed fitness education unit.

Keywords: curriculum; knowledge construction; physical fitness

In the most recent iteration of the national standards for physical education, a specific goal is for students to "know the implications of and the benefits from involvement in various types of physical activities" (Society of Health and Physical Educators [SHAPE America], 2014). Nevertheless, despite this priority, the studies that have investigated student knowledge would not provide resounding support for the affirmative case that students do learn important cognitive lessons in physical education. For example, the review by Keating et al. (2009) provides an executive summary, best represented by the following statement where they recognize "the lack of an adequate amount of HRF [health-related fitness] knowledge among students at all educational levels (i.e., elementary, secondary, and college)" (Keating et al., 2009, p. 333). These authors continue to suggest that these results were essentially the same as those found more than 20 years ago, indicating a persistent deficiency in fitness education.

Fitness education has become a popular curricular focus in physical education in the recent two decades mostly attributable to the steady decline in youth physical activity (Nader, Bradley, Houts, McRitchie, & O'Brien, 2008) and fitness (Welk et al., 2010). The effort to promote fitness education in schools has culminated in the release of "The Scope and Sequence of Fitness Education for PreK-16 Programs" by SHAPE America (National Association for Sport and Physical Education, 2012). By consequence, popular fitness education programs (e.g., Fitness for Life, Physical Best) and youth fitness testing batteries (e.g., FitnessGram) are now widely used by school teachers and students (Corbin et al., 2014).

Within the global content area of fitness education, fitness *knowledge* is an important correlate of youth fitness and physical activity. Indeed, a positive association between fitness knowledge and fitness/physical activity is well documented in the research literature (Ferkel, Judge, Stodden, & Griffin, 2014; Thompson & Hannon, 2012; Williams, Phelps, Laurson, Thomas, & Brown, 2013). Specifically, Williams et al. (2013) found a weak association between estimated peak oxygen uptake and a fitness knowledge exam ($r = .256$, $p = .001$), where students with higher exam scores had higher aerobic fitness after controlling for age and sex. Another study found high school students' ($n = 165$) fitness knowledge moderately

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correlated with self-reported physical activity level after experiencing the *Fitness for Life* curriculum (Thompson & Hannon, 2012). These findings were further reiterated in a review study, which also suggested the need to strengthen fitness education by improving students' fitness knowledge as well as their actual physical fitness and physical activities (Ferkel et al., 2014).

To strengthen fitness knowledge, it would seem important to heed the message from Haerens, Kirk, Cardon, and De Bourdeaudhuij (2011) who note that "the mixing of health goals with the many other goals of sport-based, multiactivity physical education programs risks undermining sustained implementation of any health-based initiatives as they were intended" (p. 327). To this end, Haerens et al. (2011) draw on the current move toward models-based practice in physical education (Metzler, 2011) to make a case for the development of a pedagogical model for Health-Based Physical Education (HBPE). Nevertheless, the HBPE model has a strong focus on valuing and enjoying an active lifestyle. What might be more appropriate is an instructional model that is grounded in the cognitive elements of health-enhancing fitness development. To this end, given the collective evidence in education supports the efficacy of the project-based learning model (PBL) in enhancing students' learning quality in comparison with other instructional methods (Thomas, 2000), this study examined its potential in engaging students in relevant and meaningful fitness content knowledge.

According to Bender (2012), PBL is "an instructional model based upon having students confront real-world issues and problems that they find meaningful, determine how to address them, and then act in a collaborative fashion to create problem solutions" (p. 1). In essence, then, PBL is a model that organizes learning around projects (Thomas, 2000). According to the definitions found in PBL handbooks for teachers, projects are complex tasks, based on challenging questions or problems that involve students in design, problem-solving, decision making, or investigative activities; give students the opportunity to work relatively autonomously over extended periods of time; and culminate in realistic products or presentations (Thomas, Mergendoller, & Michaelson, 1999).

Collective evidence in education supports the efficacy of the PBL approach in enhancing students' learning quality in comparison with other instructional methods (Thomas, 2000). For example, Boaler (2002) found that students who received PBL instruction for three years demonstrated improved students' mathematics skills and knowledge, while the Cognition and Technology Group at Vanderbilt University (1992) showed superior problem solving and planning abilities compared with students who received traditional instructions. Besides enhanced learning achievement, PBL was also found to foster positive attitude toward math while reducing anxiety (Boaler, 2002). Similar evidence from science education (Robinson, 2013) or STEM (science, technology, engineering, and math) education (Cho & Brown, 2013) is also documented in the research literature.

While its efficacy in classroom-based studies has reported positive outcomes, research evidence based on PBL intervention studies in physical education is rare. Indeed, only the study by Gubacs (2004) has provided insight into the appropriateness of PBL in this content area. In that study, Gubacs (2004) concluded that PBL was an appropriate model to integrate modern technology into physical education teacher education programs. Nonetheless, with its focus on active, hands-on learning experiences in carefully designed projects, PBL might well be a suitable avenue through which to educate students with respect to fitness knowledge (Coyne, Hollas, & Potter, 2016). By consequence, the purpose of this study was to examine the outcome of an intervention using the project-based learning (PBL) model to increase students' health-related fitness (HRF) knowledge.

Method

Participants

The participants in this study were 222 fifth-grade students, with 130 (51 girls, 79 boys, average age 10.7) being recruited from three physical education classes in an elementary school in rural Alabama and 92 (40 girls, 52 boys, average age 10.5) from two classes in each of two similar control schools within the same school district. The experimental school enrolled 472 students, of whom 16% received free/reduced school meals and 89% had English as their first language. Students had physical education five days a week for 30 min each day. The two control schools were similar to the experimental school in terms of enrollment size (465 and 450) and socioeconomic/ethnic status. Informed consent was obtained from all participants and their parents before the beginning of data collection and the research protocol was approved by the Institutional Review Board for Human Subjects Research at the lead researcher's university. Each of the schools was graded as achieving the same 7 out of 10 items on the "Environments that Support Physical Activity Scale" (Young et al., 2007). Details about those environmental characteristics at these three schools are shown in Table 1.

In terms of their physical education before this study, all three schools followed very similar protocols. Each school employed one certified specialist physical education teacher as well as one aide. Given the state requirement for daily physical education in Alabama, the staff at each school would receive two intact homeroom classes of between 24–28 students each for a 30-minute period, resulting in a typical class size of between 50 and 60 students. All three schools were well resourced with ample outdoor play spaces, moderately sized indoor activity areas, and sufficient equipment to provide each student with their own piece of equipment during skills-based lessons.

The instructional program across all three schools was also similar. All instruction was provided by a specialist teacher, with the aide acting as a resource mostly with respect to class management (e.g., gathering students

Table 1 Schools' Support of Physical Activity

Items	Response
Daily physical education required for all students	Yes
All physical education instructors are certified as physical education specialists	Yes
Facilities are adequate to teach the district's physical education curriculum	Yes
Lack of funding for physical education is not a concern of teachers	Yes
Fitness testing is required	Yes
Intramural sports program is available	Yes
Students have access to areas for free play	Yes
Physical education classes have no more than 30 students per teacher	No
Late/activity bus is available at least once per week	No
Interscholastic sports program is available	No

from classrooms, managing equipment, and attending to administrative details during Sport Education seasons). Each school conducted two to four seasons of Sport Education across the year, with these being interspersed with more direct instruction on shorter units focused on the development of specific motor skills such as striking (both long and short handled implements), kicking and punting, and track and field events. In addition, each school allocated one day per week to health-related fitness, with names such as "Workout Wednesday" (intervention school) or "Fitness Friday" and "Monday Madness" (control schools). During these lessons, students could choose to select from (or participate through) a number of fitness stations, that covered the components of cardiorespiratory endurance (e.g., step-ups, rope jumping, running), muscular strength and endurance (e.g., push-ups, individual weight lifting), flexibility (e.g., stretching and yoga stations), and core strength (e.g., planks, curl ups). The presentation of HRF knowledge during these fitness lessons could best be described as ad hoc, with most instruction focusing on the matching of exercises to the appropriate fitness component. There was little formal deliberate teaching during these fitness days.

The Project as Intervention

Within this case, the "project" was for students to plan a series of exercise stations within their school that would build three fitness trails (one aerobic, one muscular strength/endurance, and one core strength and flexibility). The project extended across one 9-week school term, with two of the five classes each week dedicated to the project while the other three classes focused on motor-skill based instruction. The lead researcher and the physical education teacher at the experimental school planned the 18-lesson unit, with the teacher providing the in-class fitness education to the students, and facilitating students' process of designing and planning the fitness trails. An instructional framework was established as a guide before the start of the project, with the teacher and researcher meeting following each lesson to make more specific plans based upon the students' responses, given

that they were provided with significant opportunities for autonomy in designing the stations and the trails.

Figure 1 shows the progression of the project with the essential "problems" embedded within the different stages. The first five lessons of the unit concentrated on the teaching of health-related fitness concepts, with each lesson focusing on one particular fitness component (cardiorespiratory endurance, muscular strength, muscular endurance, and flexibility) or the development of core strength. The activities within these lessons included both participation in fitness activities, as well as the completion of worksheets. These lessons were followed by two lessons where the students made decisions about the number of stations, and their location within the school grounds. The next five lessons focused on planning the activities and exercises at each station, with each group having to be particularly cognizant of the order of stations as they relate to the principles of overload and progression. Once the stations and activities were finalized, the students then spent three lessons on itemizing the equipment and materials needed to construct the stations. This was followed by three lessons where the students were involved in the creation of videos demonstrating the exercises appropriate for each station based upon the HRF knowledge they had learned in class. The recorded videos were uploaded to the YouTube that were accessible on mobile devices through Quick Response (QR) codes as well as the URL, which were disseminated both in class as presentations and after school for fitness promotion purpose (e.g., informing parents and teachers). Finally, the students, with assistance from contracted construction staff and parents, physically built the various stations of the trails with the financial aid through a health promotion grant.

In their paper that distinguished PBL from busywork, Larmer and Mergendoller (2010) list seven essential elements of meaningful projects. These include (a) a need to know, (b) a driving question, (c) student voice and choice, (d) 21st century skills, (e) inquiry and innovation, (f) feedback and revision, and (g) a publicly presented project. Table 2 shows how each of these elements was accounted for in the current study to ensure the project was meaningful to the learners.

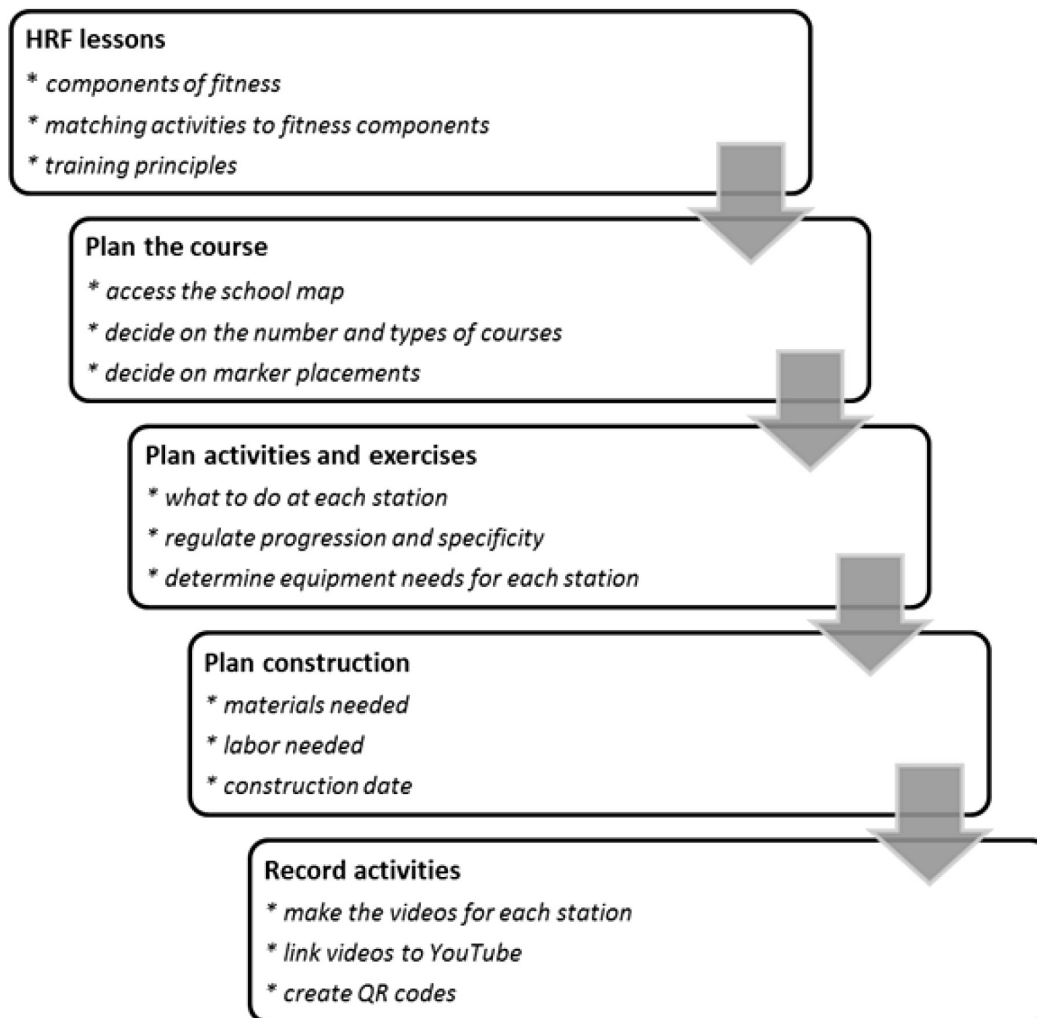


Figure 1 — Progression of the project

Table 2 The Seven Elements of Designing Meaningful Projects

Element of PBL	Application in this study
A need to know	The entry event was a visit from the funding sponsor of the project, explaining how they were excited that the students would be developing a fitness trail.
A driving question	How are we (you) going to design 3 fitness trails that are exciting for students, teachers and parents to use? What information do we need to make sure we produce the best final product?
Student voice and choice	Students were able to decide on what fitness stations they would create, the location of the stations, what exercises to include, and the allocation of roles within their teams.
21st Century Skills	Collaboration within and between teams was central to the project. Students worked in design teams, meeting and presenting their work continuously across the unit. Critical thinking and technology skills were also essential to success.
Inquiry and innovation	As students began to design their trails and station, new questions were raised and investigated. Examples in this case related mostly to the fitness concepts of progression, overload and specificity.
Feedback and revision	Teams critiqued others' station designs, and other students and teachers within the school were asked to provide feedback.
A publicly presented project	The fitness trails represent a permanent artifact for public use within the school. The creation of video links to smartphones of sample exercises for each station enhanced the public nature of the students' work.

To confirm the fidelity of implementation of the project, all lessons were recorded on digital video. From these records, two sport pedagogy researchers independent of the project were asked to assess six, 20-minute lesson segments with respect to evidence of the seven elements described in Table 2. Two of these segments were from the initial lessons where the project was being introduced and beginning planning and instruction took place. An additional two segments were from lessons where students were planning and trialing their stations, while the final two were from the latter stages of the project where the students were consolidating their finished products and were preparing their video records for the QR codes. Both evaluators agreed that these segments were in 100% compliance with the criteria defined as project-based learning.

Instruments

Fitness Knowledge Test. Before instruction, all students completed a validated, grade appropriate test of health-related fitness knowledge (Chen, Chen, Sun, & Zhu, 2013; Zhu, Safrit, & Cohen, 1999). This test has 11 multiple choice questions sought to determine students' knowledge of four areas of fitness: (i) FITT (frequency, intensity, type, and time) principles, (ii) training principles of overload, progression, and specificity, (iii) health-related fitness components, and (iv) parts of a workout (e.g., warm-up, cool down). The test has two equivalent forms (form A vs. form B). Students at the experimental school and one of the control schools completed version A test, while those in the second control school completed version B of this test. At the completion of the project, all students completed the same test as pretest.

Data Analysis

A two-level Hierarchical Linear Model (HLM) examined the effectiveness of the PBL unit on the fitness knowledge of students, where students were nested within teachers' classrooms. This study was considered a multilevel design due to the nesting of the unit of analysis (students) within the experimental unit (class within school). Using HLM is only warranted when a true nesting effect occurs despite using a multilevel design. To examine the nesting effect, an intraclass correlation coefficient (ICC) measured the amount of variance in student level posttest OC scores attributed to the class.

Results

Fitness Knowledge

The Unconditional Nested Model. Although the results of the unconditional nested model failed to detect any statistically significant variability in *Post Scores*, $p = .12$, the random between-*Classes* effect achieved an ICC of 0.29 [95% CI, 0.13–0.54]. In other words, *Classes* accounted for 29% of the *Post Score* variance and an Akaike's Information Criterion (AIC) of 1538.16. Table 3 presents the estimates of covariance parameters.

The Level I Conditional Model. In the Level I Conditional model, we added *Condition* (PBL intervention vs. control) and *Pretest HRF knowledge score* to the prior model. Results indicated, both the *Condition* and the Interaction between *Condition* and *Pretest HRF knowledge score* were significant predictors of the *Posttest HRF knowledge score*. The *Intervention* group

Table 3 Estimates of Covariance Parameters

Parameter	Estimate	s.e.	Wald Z	p	95% Confidence Interval	
					Lower Bound	Upper Bound
Residual	219.58	23.27	9.44	.00	178.39	270.27
Intercept [subject = Class] Variance	93.23	58.72	1.59	.12	27.13	320.40

Note. Dependent variable is the post-test score.

Table 4 Estimates of Fixed Effects on HRF Knowledge ^a

Parameter	Estimate	s.e.	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	60.87	1.52	181.00	40.15	.00	57.87	63.86
PBL condition	18.15	1.97	181.00	9.20	.00	14.25	22.04
Control condition	.00 ^b	.00	.	.	.	.	.
Pretest HRF knowledge	-.02	.11	181.00	-.14	.89	-.23	.20
PBL * Pretest	.56	.14	181.00	4.14	.00	.30	.83
Control * Pretest	0 ^b	0	.	.	.	.	.

Notes.

a. Dependent Variable: Post-test HRF knowledge.

b. This parameter is set to zero because it is redundant.

achieved greater *Posttest HRF knowledge scores* ($M = 79.02$) [95% CI, 76.52–81.51] than the *Control* group ($M = 60.86$) [95% CI, 57.87–63.86] while controlling for the within and between *Class* variance. On the average, for every single percent increase on the *Pre-Score*, the *Intervention* group's *Post-Score* increased by slightly more than a half-percent (0.56). Both the AIC (1477.54) and Residual (173.33) reflected lower values indicating that the addition of the Level I variables substantially improved the model. The estimates for the fixed effects are presented in Table 4.

The Level II Conditional Model. Lastly we included the *Class* and *Pretest HRF knowledge score* as a Level II variable, which failed to achieve any statistically significant improvement in the model, $p = .86$.

Discussion

This study evaluated the outcome of a fitness education unit based on the PBL approach. The unit proved to be effective in enhancing students' fitness knowledge. The structure of the project involved a form of content-embedded accountability, which refers to the idea that much of the accountability for student performance during the managerial and instructional tasks was tied intimately to the goal of the unit (that is, the development of a trail that was the students' legacy to the school). This form of accountability is evident in other novel curriculum models such as Sport Education, which all serve to provide a more authentic experience to students.

In addition, the PBL pedagogical model offered coherent educational experiences with an emphasis on fitness education. Such structured education is believed to be conducive to solving real-world problems (Cho & Brown, 2013). Building fitness trails is indeed a novel, creative, and educational meaningful project that enabled the students to apply the HRF knowledge into practice which bears high relevancy to the healthful-living.

With specific respect to knowledge, the students gained HRF knowledge as a result of the PBL fitness education, with students in the PBL group demonstrating significant increases in overall HRF knowledge score in comparison with the students in the control schools. Previous research has pointed out the importance of fitness education, due to the fact that it is a pressing concern to promote youth fitness and physical activity (Nader et al., 2008; Welk et al., 2010) and that HRF knowledge is a positive correlate of fitness or physical activity (Ferkel et al., 2014; Thompson & Hannon, 2012; Williams et al., 2013). Furthermore, systematic evidence also showed the ubiquitous deficiency in HRF knowledge in students of all age groups (Ferkel et al., 2014; Keating et al., 2009). Without adequate knowledge about HRF, it is unlikely that students will have the desire, motivation, and competence to exercise regularly and scientifically, especially in the long-run. On the other hand, knowing how to self-design an exercise program according to the FITT principles and training principles (i.e., specificity, overload, progression,

and variation), students will have a fundamental knowledge repertoire for adopting and maintaining behaviors that lead to increased physical activity and fitness.

The findings from the current study demonstrated that purposeful fitness education based on the PBL pedagogical model is capable of enhancing students' essential knowledge about HRF. They support the utility of the PBL model in physical education. This is an innovative finding and carries encouraging messages to physical education professionals. While the PBL model has been accepted as a legitimate and useful instructional approach in other disciplines such as education and STEM (Boaler, 2002; Cho & Brown, 2013; Robinson, 2013; Thomas, 2000), its use in physical education is still at infancy. Limited empirical evidence is available to support the utility of the PBL model in physical education. The findings from this study advocate the PBL model as an alternative approach to teaching meaningful physical education, fitness education in particular, to elementary school children. Future evidence on the efficacy of PBL-themed fitness education on other outcomes such as fitness, physical activity, and motor skills is warranted.

Strength and Limitations

This is the first study that has applied the PBL model in physical education based intervention research. The research on PBL has been mostly based in the classroom education settings. This study has several strengths. First, it is an intervention study following a quasi-experimental research design. The environmental conditions of the experimental and control groups were similarly matched. The HRF knowledge achievement discrepancy between the PBL and control classes over time was evident as result of this design. Second, the manipulation of the intervention was informed by the latest PBL research and practice. Key principles of the PBL were followed to design a coherent fitness education unit and the essential elements of designing meaningful projects were addressed before the intervention. One limitation of the study is that we did not measure behavior changes as result of this PBL intervention. Future research is encouraged to examine the potential of PBL-themed fitness education in promoting youth physical activity and physical fitness. The other limitation lies in the nature of the PBL. Despite the positive results shown in this study, developing and implementing the full version of PBL model is uneasy. Its disadvantages are well-documented in research and should be well-informed to professionals who endeavor to use the pedagogical model in their work.

The third limitation of this study was an examination of how the students responded to the PBL approach. That is, there were no measures of how the program of action developed across the unit, nor any measures of student engagement, enjoyment of interest. Future work examining PBL might seek to get further "inside" the teaching/learning aspects of the model through the use of qualitative tools including observations, interviews and critical incident analysis.

Conclusions

The findings from this study have shown supportive evidence as to the efficacy of the unit. Students significantly gained HRF knowledge through their PBL experiences. Fitness education in school is crucial to fitness development and physical activity promotion in youth. Some effective fitness education approaches have been implemented in schools (e.g., Fitness for Life), but alternative models that stress both achievement and experiential learning are needed. As evaluated in the current study, the PBL model appeared to be efficacious model in enhancing students' HRF knowledge. Utilizing this model to deliver high quality fitness education in physical education is promising and viable. The learning coming off this pedagogical model may help schools to educate and foster healthier and more active student bodies and cultures.

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