Project-Based Learning
An Integrated Science, Technology, Engineering, and Mathematics (STEM) Approach

Robert M. Capraro
Texas A&M University

and

Scott W. Slough (Eds)
Texas A&M University

This edited volume presents an original approach to Science, Technology, Engineering, and Mathematics (STEM) centric Project-based Learning (PBL). We define PBL as an "ill defined task with a well-defined outcome," which is consistent with our engineering design philosophy and the accountability highlighted in a standards-based environment. We emphasize a backward design that is initiated by well-defined outcomes tied to local, state, or national standards that provide teachers with a framework guiding students' design, solving, or completion of ill-defined tasks. These tasks are well suited to our integrated approach because tasks typically require students to incorporate skills and knowledge from multiple domains rather than simply single school-based subjects. This book was designed for middle and secondary teachers who want to improve engagement and provide contextualized learning for their students. However, the nature and scope of the content covered in the 13 chapters are appropriate for engaging preservice teachers in thinking collaboratively and focusing on integrating the content as well as for advanced graduate methods courses.
Project-Based Learning
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Robert M. Capraro
Texas A&M University

Scott W. Slough
Texas A&M University

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The actual doing of Project-Based Learning (PBL) within STEM (science, technology, engineering, mathematics) classrooms at the secondary level is the primary focus of this book. However, that does not explain why a group of faculty and graduate students here at Texas A&M University have gotten involved in PBL. We deeply and strongly believe that it is possible to have both equity and excellence in all of our schools, regardless of who the students are who attend these schools. By equity, we mean schools that do not have achievement gaps based on race, ethnicity, language or culture, ability, income level, or gender, and by excellence, we mean that virtually all children can reach high standards. While this is not true for the majority of schools nationwide or statewide in Texas, we know from widespread research (Elmore & Burney, 1997; Scheurich & Skrla, 2001; Scheurich & Skrla, 2003) that it is possible to create high performing schools for any group of children.

Furthermore, we also deeply and strongly believe that the quality of our schools, i.e., the equity and the excellence that exists in our schools, is the work and responsibility of the adults who run the schools (teachers, school leaders, etc.) and the adults in the communities served by the schools (parents, grandparents, business people, other community members, etc.). In contrast, we do not believe in blaming the students, though they certainly must be skillfully taught by us adults to take personal responsibility for their learning and school behavior. Nonetheless, it is the adults who plan, organize, teach, and lead the schools, and thus it is the responsibility of the adults to create schools that are successful with ALL children.

Developing practical, workable, applicable, powerful classroom tools to accomplish equity and excellence in all of our schools is what got us into PBL. Accordingly, we are particularly interested in those tools that can reduce the achievement gaps for those student groups on the bottom side of that gap by driving up achievement for those student groups. In other words, we are interested in developing and implementing classroom tools that significantly improve learning for the lower scoring student groups, while also being of positive benefit to higher scoring students. In our view, the research clearly supports PBL as such a tool (Barron, Schwartz, Vye, Moore, Petrosino, Zech, Bransford and The Cognition and Technology Group at Vanderbilt, 1998; Blumfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991; Schneider, Krajcik, Marx, & Soloway, 2002).

Traditionally, when math or science courses are taught in secondary schools, they are taught almost exclusively through abstract thought. That is, students are taught formulas or laws, and then the students are tested on those formulas or laws. The real world connections or importance of those formulas or laws are rarely taught, and even when they are included, they are generally just mentioned in the textbook.
or by the teacher. These real world connections are rarely at the center of teaching and learning.

The result of this abstract textbook approach is that students must memorize these formulas or laws without ever understanding their connection to the real world or their application to the “engineered” world in which we live. In fact, they have no idea that those formulas and laws are a basis for all of the many technologies students like so much, such as cell phones, ipods, computers, automobiles, television, cable services, wireless, etc. Indeed, students appear to love the array of technology that science, math, and their integration through engineering has created without having any clear sense that it was those abstract formulas and laws that made these technologies possible.

The point, then, of PBL is to reverse this relationship: engage students in real world projects through which they learn those math and science formulas and laws upon which our world is now increasingly built. No matter whether schools have low achieving students or high achieving students, a high percentage of students find working with real world projects to be exciting, engaging, fun, satisfying, and meaningful. And, the research indicates (Schneider, Krajcik, Marx, & Soloway, 2002) that through this method, they learn at a deeper level (not learning at a deeper level is one of the weaknesses of our educational system nationally [Dart, Burnett, Boulton-Lewis, Campbell, Smith, & McCrindle, 1999; Tobin & Gallagher, 1987]) than they learn with our traditional teaching methods. Thus, we see PBL as one of those powerful tools that we educators can use in our classrooms to increase both equity and excellence throughout U.S. education.

Another reason we are engaged in this work is STEM. We believe that a curriculum revolution is just beginning in our educational system. When one of us (Scheurich) went to high school, the primary second language to learn was Latin so Scheurich had four years of Latin. Decades ago, Latin mostly disappeared from the U.S. curriculum. Even earlier, high school diplomas were not common, but now of course, they are required, and some postsecondary education is increasingly being seen as necessary for everyone. Consequently, our educational system is always evolving, and now we are starting another such evolution—the necessity to be STEM educated.

The curriculum revolution we see is that science and math will increasingly be taught in an integrated fashion along with technology, just as it is used in the real world, and that engineering will become a common course of study at the high school and maybe even the middle school levels. In other words, just like Latin left the standard curriculum offerings, engineering is entering the curriculum. This will happen here, there, and yonder over the next decade or so until it has become standard for secondary education.

Certainly, one reason this is happening is the national paranoia about our economy, which is deeply dependent on engineering, being superseded by other national economies, like those of China and India. Currently, very few high school students graduate with the idea of becoming an engineer on their minds, even though the field of engineering is where many of the best paying and most satisfying jobs exist. We simply do not currently have an educational system that
poses engineering as a paramount choice for college or university study, though we
certainly ought to be communicating this to our secondary students.

A larger and more important reason this curriculum revolution will happen is the
role of STEM—science, technology, engineering, mathematics—in our world. The
rate of technological innovation and change has been tremendous over the past ten
years, but this rapid increase will only continue. Ten years ago, cell phones and the
internet were not large; now they are world altering. The next ten will only bring
much more. In other words, the way we live our daily lives will be more and more
deeply inside of or interactive with technology. Some philosophers are even now
discussing that what a human being is will become some sort of dynamic integration
of ourselves with technology or, more accurately, with STEM. That is, our being as
humans will include our integration with technology. This may seem farfetched to
some, but how does your world operate differently with ipods, cell phones, and the
internet. These have certainly changed how and how much we communicate with
others, and the way we communicate with others is certainly central to our being as
humans. This may sound like star wars, but we would simply say it is tomorrow, or,
if we look from the viewpoint of 50 years ago, it is today. Thus, the STEM
curriculum revolution is but one part of the larger, worldwide momentum of
technological change or the human built world.

As a final note, we want to point out that Texas is seemingly at the forefront of
this revolution in many different ways, including ongoing work on creating
engineering as a high school subject. Our part of this effort is what is called Texas
STEM Centers. Two years ago, some creative, visionary people at the Texas
Education Agency (TEA) and others at the Texas High School Project (THSP, one
of many projects of the Communities Foundation of Texas, a private non-profit
started largely on Gates money) to create several STEM Centers across Texas.
Each of these had to be partnerships among universities, school districts, private
business, workforce organizations, and public institutions, like science museums,
and several of these Centers are located primarily in universities.

The goal of this effort was to bring together key players to promote STEM
education. In addition, these Centers are obligated to develop as self-sustaining
after the state funding is gone. While starting one of these Centers from the bare
ground and while building these complex partnerships with this array of
organizations, all of whom have different discourses and different discourse
methods, has sometimes been a difficult struggle, we at our Texas A&M University-
based STEM Center are strongly committed to the original TEA-THSP vision for
building STEM education, and this book is an important element of our effort to
build this future.

Finally, we return to our beginning. Equity and excellence in ALL of our
schools with ALL of our children is our vision, our goal, and our challenge. We
strongly believe this is possible. We strongly believe that an equitable democracy
requires it. We strongly believe that we, as educators, have the responsibility to
make this happen. We are working on the dream, and we hope you are, too. And, it
is our belief that this book will provide you with some key tools for working on the
dream with us.
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James Joseph Scheurich  
Department of Educational Administration & Human Resource Development  
Texas A&M University

Kristin Higgins  
Department of Educational Administration & Human Resource Development  
Texas A&M University
INTRODUCTION

Science, Technology, Engineering, and Mathematics (STEM) Project-Based Learning (PBL) integrates engineering design-principles with the K-16 curriculum. This infusion of design principles enhances real-world applicability and helps to prepare students for post-secondary education, with an emphasis on making connections to what STEM professionals actually do on their job.

This book discusses STEM PBL and establishes a set of expectations for implementing PBL in the K-16 classroom. Readers may want to skim chapters, reading those chapters that hold promise to answer questions they already have and reserving some chapters for questions they encounter as they implement PBL in their own classroom. As an edited book, it has some overlap that should provide context within each discrete chapter but hopefully no redundancy. This brief chapter will outline some of the vocabulary, discuss the basic tenets of STEM PBL, and familiarize readers with what to expect from implementing PBL in their school.

CHAPTER OUTCOMES

When you complete this chapter you should better understand:
- the nature of PBL
- STEM PBL concepts and terminology

When you complete this chapter you should be able to:
- communicate using STEM PBL terms
- explain the basic tenets of STEM PBL
- make informed decisions about which chapters to read first

OVERVIEW OF STEM PBL

Why PBL?

Project-Based Learning has been around for many years, and it has been undertaken in medicine, engineering, education, economics, and business. Project-Based Learning is often shortened to PBL, but this acronym is often confused with
problem-based learning. The two terms are not synonymous. In this book, the authors endeavour to keep problem-based learning in lower case to help the reader differentiate the two. PBL is broader and often composed of several problems students will need to solve. PBL provides the contextualized, authentic experiences necessary for students to scaffold learning and build meaningfully powerful, STEM concepts supported by language arts, social studies, and art. PBL is both challenging and motivating. PBL requires students to think critically and analytically and enhances higher-order thinking skills. PBL requires collaboration, peer communication, problem-solving, and self-directed learning. PBL adds rigor for all students.

Why STEM?

The idea of PBL is not new; however, what is new is the emphasis on STEM education and a focus to link secondary education with post-secondary practices. It is common in post-secondary institutions for students to be required to work in groups to solve complex problems situated within larger projects. Although problems and projects do not necessitate convergent solutions, students are required to explain their solutions and be able to justify the suitability of a proposed solution to the specifications of the PBL. Commonly, this process has been termed problem-solving and is often expected to be taught in mathematics or engineering classes. However, STEM professionals all engage in complex problem-solving and in most cases, there are multiple possible solutions, each with strengths and limitations. Therefore, it is important for secondary students to develop the broad knowledge that allows them to be successful on high-stakes tests but to also develop the depth of knowledge that allows them to reflect on strengths and weaknesses of their solutions. The process develops critical thinkers who will be more likely to succeed in post secondary institutions where these skills are essential.

An additional advantage to integrating STEM and PBL is the inclusion of authentic tasks (often the construction of an artifact) and vocabulary through the inclusion of design briefs. After identifying the learning goals, the teacher develops expectations for the authentic task to be completed or artifact to be constructed along with the necessary constraints to establish boundaries for the learning. The constraints are often included in the design brief and are the most basic of requirements often considered essential. Therefore, not meeting the constraints would indicate an inadmissible attempt. The design brief contains both the constraints and the criteria informed by knowing exactly which objectives or standards students will be expected to master. The criteria are measurable. These criteria help students know how they are progressing on the tasks and it is these criteria that inform assessment. In fact, it is the criteria that form the basics of all assessments used throughout the PBL.
OVERVIEW OF PBL

Why Now?

We define STEM PBL as a well-defined outcome with an ill-defined task. Well-defined outcomes include clear expectations for learning connected to local, state, and national standards and clearly-defined expectations and constraints for the completion of the task. The ill-defined task requires multiple solutions, which are often constrained by the teachers so that simplistic or trivial solutions are not possible. STEM PBLs engage students in authentic tasks that result in specific learning, essential in the current standards-based educational model, while connecting K-12 education and post-secondary education and addressing the future workplace learning needs.

Building a Common Language

It is important to understand what is meant by somewhat common terms in relation to PBL. For example, brainstorming is commonly used to signify simply generating ideas and not engaging in the evaluation of any particular one. In addition, PBL brainstorming is used as a pedagogical technique to establish teams and encourage a common focus. It is during brainstorming sessions that teams develop shared knowledge and a group dynamic that will serve as the incubator for their work together and eventually will lead to the groups’ solution. The term relevance has to have many meanings: the usefulness of the education to life-long learning, meaningfulness to self, importance to society, real-world applicability, and finally, the formation of moral decision-making. In PBL, relevance is not an oversimplification of these ideas, just a prioritization that is used to align learning with formal standards or student expectations. So in PBL educators talk about educationally relevant, and it is this educational relevance that facilitates the development of rigorous and challenging experiences for students.

An important factor when considering PBL is that of the interdependent nexus of learning objectives, assessment, and student learning. It is common to refer to student objectives. The phrase “student objectives” has come to be interpreted in behavioristic terms. STEM PBL would be considered polar opposite to behavioristic paradigms of teaching and learning, therefore, educators use the term student expectations or SEs. The term SEs is not laden with prior notions but still conveys the message that teachers must use some form of national or state standard, objective, learning goal, or performance expectation in order to align teaching, learning, and assessment in this era of accountability. So rather than be stereotyped into a specific paradigm, the perspective of this book is to accommodate many views, and regardless of personal perspective, one can fit those views for describing what students will learn into PBL.

Given the importance of establishing SEs, it is essential also to use some form of assessment to determine the extent to which students master the learning goals. PBL is well suited to rubric assessment but NOT to the exclusion of other forms of assessment. It is important to have a mix of assessments and to build student experience with as many forms as possible.
Many schools that adopt PBL also establish a professional learning community (PLC). A PLC can be an important and very productive school-based initiative that provides for and sustains PBL. The formation of a PLC facilitates discussion about roles and responsibilities, establishes group norms, and sets expectations for everyone involved in the PLC. Often PLCs have stakeholders from across the continuum but it is just as common for school-based PLCs to have representation from a more limited set of stakeholders.

The Flow of the Book

The book contains chapters that address major topics specific to STEM PBL, including special education and a focus on the personal perspective of implementing PBL as a school-wide initiative. The succeeding chapters address the Who, What, Where, and When of Implementing PBL, a discussion about making the decision to explore PBL in addition to present practices. The Theoretical Basis for PBL explores the theory behind PBL, its reasons for success, and an understanding of when it does not work. Design Principles make thinking visible, facilitate metacognition, and develop collaborative learning settings. In Integrating Content through STEM PBL, the interrelated and interdependent nature of PBL is discussed along with enlisting collaborator assistance as teachers move along the continuum from partial to full implementation.

The book is designed to provide a modern STEM approach to PBL that is informed by research. It covers the typical major topics but also includes a historical perspective, a modern perspective on assessment that works in symbiosis with high-stakes testing, and insights into the formation of PLCs and their impact on sustaining school change. It is not written as a prescription or novel in the hope that readers select chapters as they journey from dabbling in PBL to its mastery. Because the book was not intended to be read sequentially but by individual need, the overlap in content is purposeful and intended to assist the reader in making transitions and connections between and among the chapters.

Vocabulary for Reading the Book

**Constraint.** Parameters established as part of the project to structure the deliverables of a PBL event. Constraints are placed on the design process and the product. Constraint is not synonymous with criteria. A constraint could be that a presentation must include research and contain a marketing component that lasts no more than three minutes, no two puzzle pieces can be the same, the boat must float two minutes, or materials cannot be cut. All constraints must be met to have an admissible project.

**Criteria.** Items written to support specificity that can be ranked or demonstrate the continuum between expert and novice knowledge of the learning outcome. Generally, it is these criteria that function as part of the assessment component.
Designer-defined criteria are used to select among plausible designs and may include wow factor, personal insights, complexity, novelty, or cost.

Design Brief. The parameters for a project-based lesson. The design brief contains the constraints, establishes criteria, may or may not establish evaluation standards, clearly communicates the deliverables, and outlines the conditions under which the project-based inquiry occurs.

Problem-based learning. Problem-based learning for the purposes here is the use of a problem statement that both guides the learning and any resultant activities to explore the topic. Generally, problem-based learning is context rich but textually and informationally impoverished. The focus of the learning is on individual and groups to (a) clearly identify what information they need to solve the problem and (b) identify suitable resources and sources of information.

Professional Learning Community (PLC). Communities of practitioners, students, administrators, community stakeholders, and district personnel whose mission is to facilitate the teaching and learning process where the goals are to establish common language, expectations, and standards and to facilitate increased student outcomes. It is also not uncommon to have a more limited set of stakeholders depending on the level of district commitment.

Project-Based Learning (PBL). A well-defined outcome and ill-defined task. PBL for the purposes here is the use of a project that often results in the emergence of various learning outcomes in addition to the ones anticipated. The learning is dynamic as students use various processes and methods to explore the project. The project is generally information rich but directions are kept to a minimum. The richness of the information is often directly related to the quality of the learning and level of student engagement. The information is often multifaceted and includes background information, graphs, pictures, specifications, generalized and specific outcome expectations, narrative, and in many cases, formative and summative expectations.

Relevance. Refers to the real-world connections that should be fostered in each PBL; it is also associated with facilitating student development of a personal connection to the project and fosters “buy-in” for solving individual problems presented in the project.

Rubric. May be co-developed with the students before the project starts and provides clear criteria that rank the extent to which a team or individual meet the expectations. Multiple rubrics can be developed to assess cooperation, collaboration, presentation, content, completeness, language, visual appeal, and marketing. The evaluator can be the individual, peers, teacher, administrator, or external stakeholder.
Small Learning Community (SLC). Formed by ensuring that all the content area teachers (mathematics, science, social studies, reading/language arts) teach the same students and have common planning, behavior management plans, and common performance expectations. SLC affords teachers the opportunity to become better acquainted with students and improves communication among teachers about student progress on common issues.

Student Expectations (SEs). Specify learning goals where the focus is on the verbs. Clearly defined student expectations facilitate the alignment of teaching, learning, and assessment.

Robert M. Capraro
Department of Teaching, Learning and Culture,
Texas A&M University

Scott W. Slough
Department of Teaching, Learning and Culture,
Texas A&M University
INTRODUCTION
Project-Based Learning (PBL) has been a long tradition in America’s public schools, extending back to the 19th century and to the work of Francis W. Parker and John Dewey. As a method for general education, the idea of project-based classroom instruction was co-opted from agriculture and the industrial arts and, after first being applied in the elementary schools, was extended to all grade levels. Initially focused on “real-world” problems with tangible, measurable outcomes, the project method was quickly adopted and applied to any activity of interest to students, however transient and/or insignificant. Hampered by the lack of a succinct definition for the project method prevented the assessment of the successfulness, regardless, the “method” became the “current” model of instruction in all subjects for all students, often failing to meet the needs of children, teachers, or society. The project method, as a descriptive term for school practice, was replaced with child-centeredness and the activity curriculum. After a period of near obscurity, PBL has been reclaimed by educators to educate 21st-century students.

CHAPTER OUTCOMES
When you complete this chapter you should better understand:

- the origins of the idea of the Project Method
- the early applications of the Project Method
- the reasons why the Project Method failed to have a lasting influence in 20th-century education practice

When you complete this chapter you should be able to:

- explain the origins of the Project Method
- identify some of the major proponents of the Project Method
- explain how the lack of a clear definition of the Project Method contributed to its decline in the public schools
- Explain how the idea of the Project Method changed into the ideas of child-centeredness and the activity curriculum
In this chapter, the authors present (1) a brief history of the project method, both before and after Kilpatrick’s widely read and cited article and (2) some of the issues related to the application of the project method in public school classrooms. We also examine the definition of “project” and how that definition was applied to the use of the project method in the school.

When William Heard Kilpatrick published “The Project Method” in the Teachers College Record in September of 1918, he started the piece saying, “The word ‘project’ is perhaps the latest arrival to knock for admittance at the door of educational terminology” (p. 319). He also posed the following two questions:

. . . is there behind the proposed term . . . a valid notion or concept which proposes to render appreciable service in educational thinking? Second, if we grant the foregoing, does the term “project” fitly designate the waiting concept? (p. 319)

Kilpatrick (1918) encompassed the whole range of issues related to the “project method,” both its history and application to practice. Over the next five years, many authors offered definitions and explanations for the project method and how it should be enacted in schools. However, the definitions were diverse enough to encompass almost any instruction and failed to give teachers specific criteria against which they could measure their practice and, in the end, satisfied neither the theorists nor the practitioners.

ORIGINS OF THE “PROJECT METHOD”

Kilpatrick (1918) readily acknowledged that he was a latecomer to the use of the term project and that he was unaware of its heritage, but he saw value in using the term:

I did not invent the term nor did I start it on its educational career. Indeed, I do not know how long it has already been in use. I did, however, consciously appropriate the word to designate the typical unit of the worthy life. (p. 320)

Noyes (1909) traced the idea of learning situated around a project to as early as 1875 with the “Swedish” or “Sloyd” system of manual training, which emphasized domestic projects for the purpose of building neatness, accuracy, carefulness, and a respect for labor in a social context. Authors from diverse disciplines used the term in agriculture, manual training (wood and metal shop), and domestic science (homemaking and cooking) classes (Horn, 1922), whereas others traced the evolution of the term and practice to John Dewey at the University of Chicago and Teachers College Columbia University. von Hofe (1916) wrote:

The sixth-grade pupils in the Horace Mann School are studying science regardless of every artificial division. The class chooses a project, something that has attracted attention and in which they are vitally interested. The teacher then presents the information to follow not the so-called logical
Although not labeling the practice as a “method,” von Hofe (1916) described a pedagogical practice that became popularized as the project method. The project method was not rote or recitative learning but learning with a purpose; it was a purposeful act directed by student and teacher interest.

A MODEL OF PEDAGOGICAL PRACTICE

Kilpatrick’s (1918) goals were to describe the pedagogical and psychological learning principles on which the idea of the project was based and to provide guidance to teachers. He wrote that behaving in a purposeful way was the basis for a worthy life:

man who is master of his fate, who with deliberate regard for a total situation forms clear and far-reaching purposes, who plans and executes with nice care the purposes so formed. A man who habitually so regulates his life with reference to worthy social aims meets at once the demands for practical efficiency and moral responsibility. (p. 322)

Kilpatrick, following the idea of Dewey and others that school is not for life but is life, continued to explain the value of a purposeful act:
LYNN M. BURLBAW, MARK J. ORTWEIN, AND J. KELTON WILLIAMS

As a purposeful act is thus the typical unit of a worthy life in a democratic society, so also should it be made the typical unit of school procedure... education based on the purposeful act prepares best for life while at the same time it constitutes the present worthy life itself. (p. 323)

Seldom in the many articles and books that followed to explain the method of the project does one find either the connection between the purposeful act (the project) and preparation for democratic life or that education is life; the first seemingly is ignored, the second seemingly is a given.

A CONCISE DEFINITION

But just what constituted a project remained, and does to this day, somewhat problematic. Despite his best efforts to establish clarity and conformity in describing the project method, Kilpatrick (1918) contributed to the uncertainty of what a “project” was when he wrote:

[T]he richness of life depends exactly on its tendency to lead one on to other like fruitful activity; that the degree of this tendency consists exactly in the educative effect of the activity involved and that we may therefore take as a criterion of the value of any activity—whether intentionally educative or not—its tendency to directly or indirectly lead the individual and others whom he touches on to other like fruitful activity. (p. 328)

In this statement, Kilpatrick did not see the activity as an end in itself but as something that contributed to a student’s growing abilities. However, his next sentences bring confusion:

It is the special duty and opportunity of the teacher to guide the pupil through his present interests and achievement into the wider interests and achievement demanded by the wider social life of the older world…Under the eye of the skillful teacher the children as an embryonic society will make increasingly finer discriminations as to what is right and proper…The teacher’s success—if we believe in democracy—will consist in gradually eliminating himself or herself from the success of the procedure. (pp. 329-330)

Kilpatrick sets the stage for the removal of the teacher from the process of choosing activities. But, according to Kilpatrick, this only occurred after the child had developed the skills and knowledge necessary to choose wisely. By the mid-1920s, student choosing had become the major criterion for selecting projects.

Parker (1922) provided the briefest definition of teaching using the project method by writing, “A pupil project is a unit of practical activity planned by the pupils [emphasis added]” (p. 335). This definition was a summary of a much longer position on project-method teaching:

The central element in project teaching is the planning by pupils of some practical activity, something to be done. Hence, a pupil-project is any unit of activity that makes the pupil responsible for such planning. It gives them
practice in devising ways and means and in selecting and rejecting the method of achieving some definite practical end. This conception conforms with the dictionary definition of a project as “something of a practical nature thrown out for the consideration of its being done”…Furthermore, it describes with considerable precision a specific type of improved teaching that has become common in progressive experimental schools since 1900. (p. 335)

Parker (1922) placed the interest and planning of action by the student as the central tenet of the project method. He defined practical as “not theoretical” but did not ground the practical in utility or social purpose beyond that desired by the student. One example was where fifth-grade students, to understand life in medieval times, constructed a castle from cardboard and wrote a play. However, Ruediger (1923) later criticized this project-method example as producing something with no inherent significance, but Parker justified his example because he believed it had high motivational value.

Kilpatrick chaired a symposium on the project method where several scholars spoke on the issue. This synergy led to a published article where his commentary has become an important component in Science, Technology, Engineering, and Mathematics (STEM) PBL:

. . . any unit of purposeful experience, any instance of purposeful activity where the dominating purpose, as an inner urge, (1) fixes the aim of the action, (2) guides its process, and (3) furnishes its drive, its inner motivation. The project thus may refer to any kind or variety of life experience which is in fact actuated by a dominating purpose. (Kilpatrick, Bagley, Bonser, Hosic, & Hatch, 1921, p. 283)

Thus, this broad definition was deemed to describe most any type of educational activity that either motivated students or that students said motivated them to learn, without concern for the social utility of the product produced, the ability of students to socially benefit from the activity, or the usefulness of the project in developing additional skills.

A PLAN FOR ALL SUBJECTS

Another difficulty adopters of the project method encountered was questions about the applicability of a method used in manual training and agriculture to non-manual (i.e., academic) subjects (Ruediger, 1923). Several authors questioned the appropriateness of the method for academic subjects. Horn’s (1922) criticism of the project method was directed at its appropriateness for academic subjects and its influence on motivation. The statement that “the most serious confusion in recent years has resulted from the teaching of those who define the ‘project’ as a wholehearted, purposeful act . . . by children” (p. 95) showed Horn’s concern about the lack of preciseness, relationship to social utility, and greater purpose. He claimed that the original purpose of the project method, social utility and the
teaching of skills for learning, had been ignored, and students’ interest and choice had become guiding principles.

Ruediger (1923) argued against using the project method for academic subjects:

The fact that the project idea in its original meaning is not applicable to the teaching of academic subjects has given rise to a number of interesting yet confusing developments. As used in agricultural education, the project has reference to the use of productive activities for teaching purposes...something of objective significance is produced. A genuine vocational activity, somewhat circumscribed perhaps, is used for educative purposes. When we come to the academic subjects, this idea of a project is not so easily realized. In reading, in arithmetic, in geography, and in history, it is not easy for the pupil to produce something of inherent significance, something that society values regardless of personal sentiment. (p. 243)

As educators struggled to adapt the project method to academic subjects, some argued that real world applicability was paramount:

The worth of such ‘projects’ [referring to traditional projects such as baking a cake, raising a plot of corn, building a bookcase] was measured by the degree to which they duplicated projects and activities found in life, by the degree to which they used the best materials and best methods, and by the degree of success that resulted. These “projects” may be defined as highly practical, problematic activities taken in their natural setting and involving the use of concrete materials, usually in a constructive way. They are to be distinguished, in general, from other school activities in that: (1) they are organized more directly about the activities of life outside the school; (2) they are more concrete; and (3) they afford a better test of working knowledge. (Horn, 1922, p. 93)

For some, urgency to define for the project method was less of an issue than the adoption of the philosophy of the project method and the focus on children’s interests. Hosic and Chase (1924), contended that there was a limit to the quantity of abstract theory teachers could assimilate and apply and that regardless of imperfections in the implementation or definition of the project method, it is a useful concept for living, learning, and teaching. They concluded by offering their own definition and parameters for which the project method could be expected to contribute results:

[T]he Project Method means providing opportunity for children to engage in living, in satisfying, worth-while enterprises—worth-while to them; it means guiding and assisting them to participate in these enterprises so that they may reap to the full the possible benefits. … The Project Method, then, is a point of view rather than a procedure. (Emphasis in original, p. 7)

A concise definition of the project method never emerged from the literature. However, a new term began to be used along with the word project, one which
might possibly have made the project clearer but which ultimately did little to clear up misunderstandings. That emerging term was problem teaching.

THE INTERSECTION OF PROJECT AND PROBLEM METHODS

Freeland (1922), once a student-teacher supervisor and principal of the teacher training school at Colorado State Teachers College, used the terms project and problem but made little distinction between them and tried to explain their relatedness by first defining the problem method and then the project:

The problem is used to appeal to and develop the child’s thought. The project may be defined in relation to the problem as something the child is interested in doing and which may involve thinking, but need not always do so. If it involves much thinking, it may contain problems. The project is different from the problem in that its essential feature is the provision of something to organize, investigate, or accomplish, rather than to stimulate thought. It may be a problem or part of a problem, and it may embrace problems. The more good problems a project affords the better it is for educational purposes. To afford something to do, the project must necessarily arise from the interests of the children. (pp. 6-7; p. 45)

The exact relationship is not clear; a project may include problems, or it may be part of a problem. Whatever label is given to the activity, the activity must arise from the interests of children.

As a pedagogical practice, Freeland (1922) saw an advantage to the project method. “The distinct advantage of the project method over the old topic or question and answer method is that it provides for continuous work on the part of the pupil rather than assignment from day to day” (p. 46). Today, STEM projects are designed so that students participate in sustained, multi-day learning activities.

Some authors, though, considered the difference between problem and project as significant. Douglass (1926) devoted separate chapters to Problem Teaching (Chapter 10, pp. 295-322) and Project Teaching (Chapter 11, pp. 324-356), making a clear distinction that projects could include problems and that problems could, at some point, become projects (pp. 324-325). Douglass, although making a distinction, saw the classification of an activity as a “problem” or a “project” as something teachers should not spend a lot of time on:

The underlying principles of procedure for problems and projects are essentially the same. Problems and projects possess very much the same values, and the merits of them as teaching procedures are based on the same psychological facts. It is not necessary or desirable even if possible, to attempt here to draw a sharp distinction between the two. (p. 324)

Although carefully defining an activity as problem or project might be possible, the classification would not guarantee quality experiences for students.
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Teachers are inclined to waste much valuable time in quibbling over what technically constitutes a project and what does not. An activity may technically constitute a project and yet be a very inferior educational activity. Merely being a project does not necessarily carry with it merit. A good problem, yes, even a good, old-fashioned, arbitrary, autocratic, daily assignment and recitation, is a much better teaching procedure than a poorly managed project. Not much good can come from merely learning the definition of a project. What is important for teachers is to appreciate the psychological principles which lie behind the project, and which account for its merit and effectiveness. (Douglass, 1926, p. 326)

A little over 20 years later, in another version of the text, Douglass and Mills (1948) devoted only 8 pages to the project method as part of a chapter about teaching units of learning and 9 pages to problem teaching as part of a chapter about questions and problems in teaching. The authors cited Douglass’s 1926 definition of project when describing a project: “The project as used in teaching is a unit of activity carried on by the learner in a natural and lifelike manner and in a spirit of purpose to accomplish a definite, attractive, and seemingly attainable goal” (Douglass, 1926, p. 325; Douglass & Mills, 1948, p. 209).

Although, early in his 1918 article, Kilpatrick emphasized the connection between a whole-hearted, purposeful activity and the social environment in which the activity takes place (p. 320), the ideas of whole-hearted and purposeful came to dominate the defining attributes of the activity.

A UNIFIED PERSPECTIVE

In 1918, Kilpatrick emphasized the importance of individualized, self-directed motivation on the part of the student in choosing the purposeful activity and said little about the role of the teacher in the selection process. By the time he wrote his 1925 book, Foundations of Method, Kilpatrick had accepted the fact that the teacher may have a role in the planning and encouragement of interest in the project:

We have, so far, not based any argument on the child’s originating or even selecting (in the sense of his deciding) what shall be done. So far, all that we have claimed will be met if the child whole-heartedly accepts and adopts the teacher’s suggestion. (p. 207)

Douglass (1926) adhered more closely to Kilpatrick’s original statement on self-selecting tasks because he included as one of the characteristics of project, “The learner approaches the task in an attitude of purposefulness; it is a self-imposed task, rather than one imposed arbitrarily by the teacher or the course of study” (p. 325). Douglass did not ignore, however, the role of the teacher in planning and assisting students in the selection and management of projects:

As in the case with any teaching procedure, the project method in itself does not provide a complete educative situation. Merely having students purposeing,
planning and executing projects may or may not be good procedure, depending upon what projects are being completed and the nature of the procedure followed. (p. 341)

THE ACCEPTANCE OF THE PROJECT METHOD

By the mid 1920s, the project method, which seemingly offered something for every student and teacher, had been used to justify the child-centered and activity movements where all curricular plans were to begin with the interests of the child. These practices were not missed by those promoting the project method, even as the idea of the project was being developed. It is important to remember that one should not assume that all interests of children were of equal value. “It is the providence of the teacher to select, stimulate, and direct activities whose worth is high in leading forward toward objectives of unquestioned value (Hosic & Chase, 1924, p. 302). The failure of a teacher to provide guidance “results in indulgence rather than direction, in a form of anarchy rather than of orderly procedure” (Kilpatrick et al., 1921, p. 302).

Years later, Hosic and Chase (1924) warned against thoughtlessly turning control of the class over to students:

First, let us observe that the project idea should not be interpreted as a doctrine of laissez faire. The fact that the project teacher invites the pupils to assume a large measure of responsibility does not mean that she turns the school over to them. Both the community and the individual are to be served. (p. 86)

However, few listened to the critics and by the late 1920s, child-centered and activity-based learning epitomized the “progressive” model of education.

CHILD-CENTEREDNESS AND THE PROJECT METHOD

The reaction to the student-centeredness of the project method began almost as it was gaining popular acceptance. Curriculum theorists and practitioners were concerned over the lack of direction and purpose of the method. Rugg and Shumaker in their 1928 work, *The Child-Centered School*, wrote, “We dare not leave longer to chance—to spontaneous, overt symptoms of interest on the part of occasional pupils—the solution to this important and difficult problem of construction of curriculum for maximum growth” (p. 118). Reflecting on the time, Tanner and Tanner (1980) wrote, “Surrounding the pupil with materials but not suggesting an end result or a plan and simply letting pupils respond according to whim, was ridiculous” (p. 295).

The project method thus led to the notion that activity on the part of students was a measure of success and critical to learning. By the 1930s, the project method was under attack by the very person who supposedly was one of the originators,
John Dewey. Dewey (1934) was concerned that teachers had abandoned their proper role in education:

> It is the business of the educator to study the tendencies of the young so as to be more consciously aware than are the children themselves what the latter need and want. Any other course transfers the responsibility of the teacher to those taught. (p. 85)

Also, by the 1930s, public schools were under scrutiny and attack for their perceived role in either not preventing the Great Depression or not “fixing” the Great Depression once it had begun thus educational innovations began to fade.

In summarizing the failure of the child-centered project method, Tanner and Tanner (1980) wrote:

> . . . experience had made it abundantly clear to many educational theorists that a curriculum based solely on the spontaneous interests of childhood was an impossibility. Such a program could have no sequence and no predetermined outcomes, not even predetermined psychological outcomes. Even a play school had to have objectives and a program that was planned to meet those objectives. Otherwise, the child might as well stay home. (pp. 296-297)

Projects, as a form of child-centeredness, again appeared on the educational scene in the late 1930s in the form of the *Building America* series sponsored by the Social Frontier group at Teachers College. Rugg (1933), also a member of the Social Frontier group at Teachers College, identified the project method as a useful method in social reconstruction at the national level. In his book, *Educational Frontier*, Kilpatrick (1933) discussed the social and educational reconstructivist movement of the 1930s. More specifically, Kilpatrick addressed the need to reform the education system to prepare students for life in contemporary society—a society that required collaborative efforts to solve problems. In this book, Kilpatrick offers a societal justification for using the project method in schools: to achieve social reconstruction.

Later, in the immediate postwar period of the late 1940s and early 1950s, in an attempt to meet the needs of a changing society where more students enrolled and graduated from high school, the project method reappeared in the form of the life-adjustment or continuing life-situations movement led by Florence Stratemeyer, also from Teachers College. Just as the project movement had been criticized for its attention to the immediate interests of children, so too was the life-situations curriculum. Stratemeyer and her colleagues acknowledged that not all children’s interests were equally valuable but that starting with the perceived needs and interests of students would better prepare them for the rapidly changing, postwar world in the U.S.

The various teaching innovations of the previous 50 or so years came under attack in the 1950s and soon disappeared from classrooms. The project method had a brief revival in the 1960s in response to the perception that education was failing the nation in science and mathematics. Educators again took an interest in the motivation of children to learn, thinking, “that the thrill of discovering scientific
concept autonomously would not only result in more effective learning but also instill in children the desire for further, more significant, discoveries” (Tanner & Tanner, 1980, p. 403). However, as Tanner and Tanner wrote, “This time the model was discipline-focused, not social-problem focused. Discover teaching was a disciplinary effort to teach children to think like scientists instead of children” (p. 403).

THE PAST AND THE FUTURE OF PROJECT LEARNING

As a popular method for general education in the early to mid 20th century, the project method borrowed its theory from agriculture and the industrial arts education and applied that theory to all subjects. However, lacking a clear definition, educational leaders and teachers often used their “definitions” to justify classroom activities driven solely by student interest, regardless of the educational value of the activity. Some (e.g., Douglass 1926, Hosic and Chase 1924) tried to prevent the overgeneralization of the term in classrooms, few practitioners listened and the focus became the interests of students. The social upheavals of the Great Depression and World War II refocused parents and leaders on societal needs rather than the wants of learners. Despite the brief activity in the later 1940s of the life-adjustment movement, the project method was thoroughly rejected by educational leaders failing to meet the needs of children, teachers, or society. In the last 10 years, augmented by research on learning and the effect of the learning environment on the learner, Kilpatrick’s goal of explaining the pedagogical and psychological principles of learning has come closer to being realized. The next chapter, the Theoretical Framework for STEM PBL, provides guidelines for implementing PBL in today’s classrooms. Although the question of applying the project method to academic subjects was never answered in the 20th century, STEM PBL illustrates that the project method is appropriate for academic subjects.

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LYNN M. BURLBAW, MARK J. ORTWEIN, AND J. KELTON WILLIAMS


Lynn M. Burlbaw  
*Teaching, Learning, and Culture*,  
Texas A & M University

Mark J. Ortwein  
*Doctoral Student*,  
Texas A & M University

J. Kelton Williams  
*American History Teacher*,  
*Bryan Independent Schools*