

Defining High Quality PBL: A Look at the Research

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Introduction

More and more educators around the world, both in and out of the classroom, believe that Project Based Learning (PBL) is an important instructional approach that enables students to master academic skills and content knowledge, develop skills necessary for future success, and build the personal agency needed to tackle life's and the world's challenges. All students, no matter where they live or what their background, deserve access to high quality Project Based Learning.

At the same time that PBL is becoming widely used in schools and other educational settings, there is growing confusion about the definition of **high quality** Project Based Learning. There are many different varieties of PBL being practiced, and a lack of common agreement about what students should be doing, learning, and experiencing. The High Quality Project Based Learning Framework describes PBL in terms of the student experience and is intended to provide educators everywhere with a shared basis for designing and implementing good projects.

In 2016 the Buck Institute for Education received funding from the Project Management Institute Educational Foundation (PMIEF) and the William and Flora Hewlett Foundation to facilitate the development of a framework describing from a student's perspective what a high quality PBL experience should include. The process is being guided by a 27-member steering committee, backed by a 90 member advisory team. Educators and researchers from around the world serve on both bodies. The HQPBL Framework described below reflects the PBL knowledge and experiences of these individuals as well as a review of relevant educational and psychological research and theory. It has been subjected to crowd-sourced feedback and input from hundreds of others who learned about the draft framework at professional meetings or visited HQPBL.org website. The many comments and suggestions we have received, as well as continuing feedback from the steering committee and the advisory team, have been incorporated into multiple cycles of critique and revision. We want to thank the hundreds of individuals who have graciously shared their perspectives and ideas.

The High Quality Project Based Learning Framework appearing below describes six criteria that must be at least minimally present for a project to be judged "high quality." The better the implementation of these criteria, the higher quality the project. Projects that are the most memorable, and that have the greatest impact on student learning and development, will be those that fully realize each criteria.

The High Quality Project Based Learning Framework provides an essential starting point for educators, students, parents, and community members as they consider how to make classrooms and schools productive and innovative environments preparing students for adult success. At the same time, the HQPBL Framework, and the criteria it includes, is not complete. Other factors such as classroom and school culture, high quality instructional materials and practices, adequate time for teachers to learn and plan, and adaptable policies for curriculum delivery and assessment are equally important for the effectiveness of PBL. Also imperative is the fundamental belief that all students can learn, and that their voices should be heard in their own education.

Although the HQPBL Framework reflects the thinking and practice of experienced educators, it is neither idiosyncratic nor arbitrary. The criteria are grounded in educational research, and reflect current thinking about optimal student learning and preparation for adult and workplace success.¹ This white paper explores this research to clarify the criteria, describe how and why they contribute to High Quality Project Based Learning, and propose a set of terms (e.g., criteria) that can be used by the educational community and others to describe and discuss High Quality Project Based Learning.

The HQPBL Framework

The HQPBL framework contains six criteria: Intellectual Challenge and Accomplishment, Authenticity, Public Product, Collaboration, Project Management, and Reflection. Each is described below, with a brief discussion of relevant educational research and theory.

Intellectual Challenge and Accomplishment

Students learn deeply, think critically, and strive for excellence.

By definition, HQPBL is a way of learning and thinking deeply, and the intellectual demand of High Quality Project Based Learning is arguably its most fundamental feature. Drawing on John Dewey's description of the "act of thinking," HQPBL confronts students with a challenging problem, an intriguing question, or multi-sided issue.² Students are expected to take responsibility for solving the problem, answering the question, or taking a reasoned, defensible position on the issue. To accomplish this, they must first develop and exercise the specific knowledge, skills, and behaviors that define the project's learning goals. This occurs over days or weeks (or even months), as deep understanding and complex skill development require practice, and do not come quickly or effortlessly.

Structuring learning around a problem to be solved or a task to be completed has a number of advantages. When students learn something to be able to use it – rather than to simply remember it – and then use what they have learned, their learning is more meaningful and more easily remembered in the future.³ Problems, questions, and tasks focus students' attention on the information and concepts they need to understand in order to resolve the problematic situation, and provide practice in distinguishing between relevant and irrelevant

information. Such learning situations also prompt students to draw on previous learning, and connect what they already know to the new things they are learning.⁴

Although project based learning can be used to address trivial content or inessential skills, such learning can hardly be defined as high quality. High Quality Project Based Learning encourages students to dig deeply into a subject, go beyond the superficialities of a Google search, and grapple with the concepts and understandings fundamental to the subject and the discipline. HQPBL targets specific student learning outcomes -- the knowledge and success skills necessary for academic and life success -- while providing opportunities for learners to develop and practice new ways of thinking and acting.

High Quality Project Based Learning is often experienced as challenging by students. This is a good thing. Educational research has demonstrated that an appropriate degree of challenge is necessary for effective learning.⁵ Students may find themselves challenged by different aspects of the project, from the academic content or success skills they are learning, to the degree to which a project is open and evolving. When projects are less structured, students must develop their own plans and solutions, and this is more challenging than simply following a pre-ordained solution path. Such ill-structured projects provide greater opportunities for student innovation, creativity, and problem solving.

High Quality Project Based Learning is primarily a student activity. Teachers, workplace mentors, community members, and other adults, however, play an essential role in supporting student success. All learners need guidance, instruction, and feedback to deepen their knowledge and develop their skills. This is especially important for novice learners completely unfamiliar with the content, skills, and behaviors needed for successful project completion. High Quality Project Based Learning does not downplay the role of the teacher or of traditional instruction. Instead, it is a teaching strategy that organizes student learning to emphasize self-management within a collaborative learning environment, while providing integrated instruction and intellectual scaffolding. Such cognitive support occurs within the context of project activities, rather than being provided as separated instructional episodes. HQPBL classrooms also provide ample opportunities for student self-instruction and peer-instruction.⁶

HQPBL teachers know that lectures and class discussions are sometimes the best way to clarify a problematic concept or convey an important skill, and they constantly monitor student learning and the difficulties that arise during project work. This allows them to address student confusion and learning hurdles in real time. In addition, before launching a project, HQPBL teachers assess the skills and knowledge necessary for project success, and determine how to prepare students before the project begins and/or provide lessons and other scaffolds once the project starts. To use a common simile, the role of the HQPBL teacher is like that of a coach, building skills and confidence through example and instruction.

HQPBL teachers prioritize research-supported instructional practices. A high quality project that involves writing (as most do) will include proven writing instruction methods appropriate to the project topic, activities, and grade level.⁷ A HQPBL teacher, for example,

might conduct a writing lesson to solidify the literacy skills students need to compose effective letters to the editor. Similarly, in classrooms where students are learning about science concepts, HQPBL teachers will be familiar with the student misconceptions accompanying the science concept, and have research-based instructional strategies ready to counteract these misconceptions.⁸ In projects that require survey data analysis, HQPBL teachers will make sure students have the necessary math skills to make sense of the survey responses. Instruction doesn't occur for its own sake or (only) because it is dictated by standards or the syllabus; it occurs because students need it to accomplish project tasks and/or solve problems.

Just as HQPBL teachers strive to provide the highest quality project experiences coupled with research-supported instructional practices, students in a HQPBL classroom strive to complete the high quality work that demonstrates deep learning. The components of HQPBL coupled with high academic expectations create learning opportunities that support all students. It's easier for students to complete high quality work, if they understand and can visualize what quality work looks like. Creating assessment rubrics with students is one way that teachers and students can agree on what goes into excellent work. Sharing examples of high quality project work completed by previous students also provides a way to communicate high standards of accomplishment. Encouraging student critique and revision – an essential HQPBL principle that will be discussed later – also demonstrates that students can improve their work, sometimes far more than they ever imagined was possible. Teachers and students are both committed to excellence, in teaching and learning, and classroom achievement norms focus on student self-improvement toward reasonable, achievable goals.

Authenticity

Students work on projects that are meaningful and relevant to their culture, their lives, and their future.

Students often comment that High Quality Project Based Learning is “real” learning – learning that is connected to their own lives and to what happens in the world outside school. Projects designed with students in mind are foundational to culturally responsive teaching.⁹ Teachers call such learning *authentic*. Students are often more motivated by authentic projects than they are by typical school work, but the educational advantage of authentic projects is more than motivational. Research shows that authenticity not only increases motivation; it can also increase academic achievement and literacy skills.^{10 11 12 13}

In HQPBL there are a number of ways that projects are made authentic.¹⁴ First, projects can create an authentic **context** as when students create a classroom restaurant or plan and construct a miniature city. Simulations, like Model UN, or mock trials where the decision to drop an atomic bomb on Hiroshima is debated and put before a jury also create an authentic context for student learning. Although such projects require students (and adults) to suspend disbelief and liberate their imagination, the context of the project reflects thinking, decisions and actions that occur in the world outside of school. This is what makes it authentic.

Second, in HQPBL the **tasks** students complete, as well as the tools and technology they use such as measuring instruments or mapping software, can reflect the world outside of

school. Students often use tools and technology to assist with project management, presentations of learning, enhance research components of a project or facilitate communication and collaboration among student teams. Vocational-Technical Education projects are usually designed to teach students the skills, ways of thinking, and the performance standards found within a specific vocation or job. Projects often incorporate experts, mentors, or organizations from the world beyond school, and these relationships, built around task expertise and common goals, contribute to a project's authenticity. Projects often involve students conducting surveys, planning and arranging exhibitions, preparing budgets, analyzing consumer products, writing letters to the educator, or creating products to be sold to raise money for the school or a cause. These are authentic activities that occur in the world beyond school, and can be assessed using real-world standards.

Third, HQPBL projects can have a real **impact** on the world beyond school. Projects can focus on local issues such as the design of a new school garden or playground and can include the preparation of a proposal and its presentation to the school principal or the district school board. (Such projects would probably also include real world *tasks* such as surveying students about their desires for various plantings or playground designs, creating prototypes and displays, and creating a PowerPoint slide deck.) Students can also participate in citizen science projects tracking temperature or stream pollution, and submit their data to a common database. They can also organize school or community events to educate and inform others. Research suggests that projects that have an authentic impact are especially motivating, and students often choose to work on them before and after school and at recess.^{15 16 17 18}

Fourth, HQPBL can have a **personal** authenticity for students by speaking to students' personal concerns, interest, or issues in their lives. They can also provide opportunities to engage the needs, values, language, and cultural practices of students' communities and background. Community health fairs, oral and community history projects, and projects that bring a language or cultural community into the larger school community, or enable students to learn more about their background and share this with others, provide especially rich experiences.¹⁹

Finally, HQPBL is a learning environment that promotes authentic student engagement by encouraging students to make reasoned **choices** about project design and ongoing project activities. These smaller choices provide a training ground for the more significant choices they will be making later in their life. Although teachers make the final judgment about how much choice is appropriate for different students and in different projects, the general thrust in High Quality Project Based Learning is to give students as much opportunity to make choices within the project as is reasonable and manageable. This has motivational benefits, as making choices validates the basic psychological drives of autonomy and competence, contributing to intrinsic motivation.²⁰ At the same time, HQPBL teachers must be judicious in deciding which choices are meaningful, and which will contribute to project success. Choices need to be given with an eye to whether students have the knowledge necessary to make a reasonable choice, and what scaffolding and instruction will be available to backstop students if they run into difficulty. For example, middle school science projects that ask students to develop the scientific methodology

to study a phenomenon often run into trouble because students lack the basic methodological knowledge and experience to come up with a reasonable methodological plan and carry it out.²¹

Although intellectual challenge and accomplishment is the bedrock of High Quality Project Based Learning, *authenticity* is the not-so-secret ingredient that makes HQPBL different from traditional teaching, and which students often remember long after the project ends. The five types of authenticity described above can be combined in various ways, and projects that merge multiple types of authenticity are usually the most memorable to students and teachers alike.²² Interestingly, research into the factors producing adult job satisfaction and motivation echoes many of the modes of authenticity discussed above. Workers become more committed and engaged when working on tasks that make a difference or have an impact on their work or on others, require a variety of skills, and over which they have control from beginning to end.²³ The parallels between HQPBL and a satisfying work life ring true.

Public Product

Students' work is publicly displayed, discussed, and critiqued.

HQPBL classrooms are alive with student work – models, artwork, videos, and displays describing what was done and learned from a project. Whereas most school work travels no farther than the teacher's desk, HQPBL encourages students to create a product and share it with audiences beyond the classroom. Learning is not a private matter, but is shared with larger communities. These begin with peers involved in the same project who provide formative assessment on initial student products. Such formative feedback can play a powerful role in making the work better, and deepening student learning.²⁴ Later other physical and virtual groups (students, teachers, mentors, parents, and community members) can offer their own reactions and suggestions. As their products are discussed and critiqued by others, students are encouraged to do their best – nobody wants to look ill-prepared or display a second-rate product before a public audience. Making student work public ups the ante for both students and teachers.

A project product seem more consequential than private schoolwork because it is viewed, used, and appraised by others. It is not simply done “for the teacher.” It is done because it matters to someone in addition to the teacher. Public products provide platforms for discussion and critique, and give students opportunities to develop and use public speaking skills and practice thinking on their feet. The feedback and questions they receive from an audience prods them to reflect on and analyze their own thinking and learning, solidifying their learning, and making it easier to apply this learning in the future. When products are taken seriously, and considered worthy of critique and discussion, this encourages students to perceive their work as valuable, and themselves as creators who can take pride in their products and accomplishments.

The public products and the exhibitions and other events showcasing their creation make important contributions to school morale and community perceptions. By demonstrating to other students, parents, and the larger community what students know and can do, public

exhibitions of student work build support for schools and for HQPBL in general. Such exhibitions of student work not only explain what HQPBL is all about; they also engender goodwill and promote HQPBL as a powerful approach to teaching and learning.

Collaboration

Students collaborate with other students in person or online and/or receive guidance from adult mentors and experts.

A recent nationwide study asked over 400 employers about the most important skills and competencies they sought in their workers.²⁵ The ability to work effectively as a team member came in next to the top, and the importance of this skill was expected to increase over the next decade. Another survey of high level managers in American corporations reported that 9 out of 10 respondents identified teams as the key to organizational success.²⁶ In much of the modern workplace, tasks are completed by project-focused teams rather than by unconnected workers, making the ability of team members to learn from and contribute to others, a global priority.²⁷

High Quality Project Based Learning presents students with multiple tasks that are too complex to be completed efficiently by a single individual. Teamwork is the most logical way to get such tasks done. As team members are not equally adept at all tasks, productivity is increased by alternating leadership roles according to the task. For example, a team member with skills to organize a community meeting may not be the best choice for taking notes at that meeting, or writing up a report of the discussion. Effective task leadership within a group varies according to the demands of the task at hand. On effective teams, members practice the skills of leadership as well as those of supporting a leader. HQPBL provides opportunities for learners to be both leaders and followers.

Collaboration can extend beyond the classroom in projects that immerse students in the workplace, or connect with community organizations and groups. The benefits of such collaborative projects include broadening students' knowledge of the world of work and surrounding communities, and providing opportunities for students to learn new skills and perspectives. Participating businesses and community organizations benefit by grooming future potential employees and members.

There are also cognitive benefits to collaborative work, and the discussions that accompany it. Research has shown that while limited exchanges of information and explanation within a team, such as giving answers to questions, can help team members in routine, low-level learning (like math facts), more open exchange and elaborated discussion are necessary if the team interaction is to help its members master less structured tasks or achieve conceptual, deeper-level learning. Respectful collaborative team discussion, where students build upon and connect other team members' ideas, leads to better problem solving both for the team as a whole, and later, for the students who were members of those teams.²⁸

It is not collaboration, per se, that leads to positive outcomes; it is a respectful collaboration that listens to, considers, and connects ideas. Although it is difficult for many students to engage in the probing, elaborative discussion that leads to deep learning, these communication and discussion skills can be taught through instruction, modeling and role playing.²⁹ Most students will benefit from spending time learning how to be a productive group member before undertaking team tasks requiring high quality discussion and collaboration.³⁰ This is especially true on diverse teams where members differ in language background and ability, ethnicity, gender, achievement levels, and general knowledge.³¹ Giving students prepared scaffolds such as sentence stems or a list of questions to ask during a discussion, and establishing specific norms for team behavior and interaction, can make discussions more productive. Classroom norms emphasizing individual respect encourage honest communication and productive questioning.

Providing opportunities to collaborate also helps students to develop a sense of belonging, strong relationships, and a positive community that helps create more inclusive and equitable experiences.³² Further, collaborative learning is a necessary component of culturally responsive pedagogy.³³

Project Management

Students use a project management process that enables them to proceed effectively from project initiation to completion.

High Quality Project Based Learning emphasizes the importance of students thinking through what has to be done to accomplish a project, and taking an active role in planning and carrying out project activities. This intentional, decision-making role distinguishes HQPBL from more typical learning activities where teachers pre-specify what is to be done, by whom, in what manner, and in what order. In HQPBL, students have the opportunity to learn the tools and methods of project management. These important skills prepare students for the future project work on the job or in private life, such as planting gardens, planning a trip or an event, or launching marketing or political campaigns.

Project Management is the process of “applying knowledge, skills, and resources to accomplish activities that are intended to achieve a specific goal.”³⁴ In the workplace project managers break down a project into different stages and steps and guide others through the tasks necessary for completion. Such skills are worthwhile in the HQPBL classroom as well as the workplace, and there are a number of tools that were born in the workplace and have been modified for educational settings that can be used to define, plan, manage, and reflect upon projects.^{35 36} These tools and techniques enable students to effectively manage themselves and their teams through complex, multi-step projects.

According to PMIEF, in a “well-designed, effective learning project,” students are responsible for designing, managing, and evaluating their own learning.³⁷ This process is often referred to by educational researchers as self-directed learning, where students are responsible (with teacher guidance) for identifying interests, finding necessary learning resources, setting learning goals and managing their own behavior, and evaluating the results.³⁸ This process

facilitates the development of self-directed learning and self-management skills, which have been shown to be strongly associated with workplace, academic, and personal success.^{39 40 41} It should be noted, however, that although HQPBL provides a productive environment for the development of self-management and self-directed learning, not all students are initially able to take advantage of that environment, and need monitoring, scaffolding, and coaching as the project moves forward.⁴²

Design Thinking is a process approach to Project Management, and has been shown to be a useful tool for solving social and business problems, and for creating new products. According to the global design firm IDEO, the Design Thinking process includes four phases: 1) Gather Inspiration; 2) Generate ideas; 3) Make ideas tangible; and 4) Share the story.⁴³ During those phases designers determine what is really needed to solve a problem by empathizing with those affected, go through both divergent and convergent processes to conceive potential solutions, create physical prototypes reflecting promising solutions, and once the final solution is adopted, communicate a story that will inspire others toward action. As ideas and prototypes pass through these stages there is an iterative process of critique and revision, so that solutions are generated, tested, and improved as the process continues. Although not applicable in all projects, Design Thinking can be an important project management process, especially when the project goal is to innovate and create something new.

Reflection

Students reflect on their work and their learning throughout the project.

Nearly a century ago, anticipating today's interest in "metacognition," John Dewey wrote, "We do not learn from experience. We learn from reflecting on experience."⁴⁴ This is as true today as it was nearly a century ago, and it is especially true for High Quality Project Based Learning where students have to make choices about what they are going to do and how they are going to do it.⁴⁵ During High Quality Project Based Learning students reflect on the progress of project work as well as what they are learning. By articulating what they are learning, students deepen their understanding and their self-knowledge.⁴⁶ Learning becomes more efficient as students become aware of what they already know and what they need to find out.⁴⁷ Project quality improves as students learn to assess the strengths and weaknesses of their plans and products, and the assessment skills they develop will continue to be useful in future project work at home and in the workplace.⁴⁸ And by engaging in reflection now, students learn to recognize problem types, and are better able later to remember and apply what they have learned to new cognitive challenges and contexts.^{49 50}

Although most students can reflect upon what they are doing and learning, this reflection may not be very sophisticated or may not stimulate the cognitive processes needed for effective learning and remembering.⁵¹ Consequently, many students benefit from targeted guidance and examples showing how to reflect. Researchers have suggested there are four hierarchical levels, each of which provides a more adequate and sophisticated quality of reflection. The lowest level, ***description***, simply reports what was done (e.g., "I used two different websites to gather information."). The second level, ***justification***, describes what was done and why it was

done (e.g., “I used two different websites because I was looking for different opinions.”). The third level, **critique**, explains what was done, why, and evaluates the result (e.g., “I used two different websites because I was looking for different opinions, but everyone seemed to be saying the same thing.”) The final level, **discussion**, combines the previous three levels and considers what it all means, especially for future activities (e.g., “I used two different websites because I was looking for different opinions, but everyone seemed to be saying the same thing. I’m not sure that’s because everyone believes the same thing – like, killing is bad – or because I didn’t look carefully enough to find websites with a range of opinion.”).⁵²

Reflection can be encouraged and taught in a variety of ways by providing students with guiding questions to discuss, and including reflective writing or blogs within project activities. Portfolio presentations, where students describe their work and learning to others, are a natural way to encourage reflection, especially if preceded by a discussion of what constitutes a good reflection, and followed by a peer feedback session. Finally, an edited video record of project activities or group discussions can provide a powerful stimulus for joint discussion and critique.⁵³

Although John Dewey should take credit for emphasizing the importance of reflection (or the “cognitive act”) a century ago, it is another educator named John who is emphasizing the importance of reflection today.⁵⁴ After spending more than a decade reviewing thousands of studies analyzing what leads to effective learning, John Hattie summarized his findings by pointing to the importance of students becoming engaged, committed, and active learners, a process that is encouraged and guided by teachers, but fundamentally controlled by students. He advocates a “metacognitive approach to instruction” that “can help students learn to take control of their own learning by defining learning goals and monitoring their progress in achieving them. The key questions are: ‘Where are we going?’, ‘How are we going?’, and ‘Where to next?’.”⁵⁵ High Quality Project Based Learning embodies the self-managed and self-directed learning processes Hattie describes, and views students as active agents who monitor and control their learning. Their reflections on what is being planned, done, learned, and generally accomplished are essential to HQPBL.

Conclusion

High Quality Project Based Learning can be transformative for students. By presenting students with a complex mix of choice and responsibility, cognitive concepts and practical activities, within a collaborative educational environment of real-world authenticity, high quality projects engage students in learning that is deep and long-lasting. Such projects also build success skills that prepare students for the adult world and the workplace, and create confident young people who are willing and ready to take on challenges. We believe there is research evidence – and there definitely is educational theory – that argues strongly for the use of Project Based Learning with all students.^{56 57 58 59} This document has outlined the logic and research behind the HQPBL Framework. We hope educators will find it a useful guide for bringing effective Project Based Learning to all students.

Endnotes

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- ² See John Dewey, *Democracy and Education* (New York: Macmillan, 1938).
- ³ Ann L. Brown, John D. Bransford, Robert Ferrara, and Joseph Campione, “Learning, remembering and understanding,” in J. H. Flavell and E. H. Markham (Eds.), *Handbook of Child Psychology Vol. 3: Cognitive Development, 4th Edition* (New York: Wiley, 1983), 77–166.
- ⁴ Ceri B. Dean, Elizabeth Ross Hubbell, Howard Pitler, and Bj Stone, *Classroom Instruction that Works: Research-based Strategies for Increasing Student Achievement* (Alexandria, VA: ASCD, 2012).
- ⁵ John Hattie, *Visible Learning* (New York, Routledge, 2009).
- ⁶ For examples of Project Based Learning that blends student-directed activity with teacher instruction see Nell K. Duke, Anne-Lise Halvorsen, Stephanie L. Strachan, Jihyun Kim, and Spyros Konstantopoulos, “Putting PBL to the Test: The Impact of Project-based Learning on Second Grade Students’ Social Studies and Literacy Learning and Motivation,” Unpublished Manuscript (Ann Arbor: University of Michigan, 2017), Walter C. Parker, “Projects as the Spine of a Course: Designs for Deeper Learning, *Social Education* 82, no. 1 (2018), 45-48, and Joseph Polman, *Designing Project-based Science: Connecting Learners through Guided Inquiry* (New York: Teachers College Press, 2000).
- ⁷ For suggestions on including research-supported writing instruction alongside project work see the following publications from the What Works Clearinghouse: *Teaching Secondary Students to Write Effectively Practice Guide* (Washington, DC: US Department of Education, 2016), <https://ies.ed.gov/ncee/wwc/PracticeGuide/22> and *Teaching Elementary School Students to be Effective Writers* (Washington, DC: US Department of Education, 2012), <https://ies.ed.gov/ncee/wwc/PracticeGuide/17>. Also Deborah Dean, *What Works in Writing Instruction: Research and Practices* (Urbana, IL: National Council of Teachers of English, 2010), https://secure.ncte.org/library/NCTEFiles/Resources/Books/Sample/52119chap01_x.pdf.
- ⁸ For more information on pairing research-supported science instruction and high quality projects see Ann Tweed, *Designing Effective Science Instruction: What works in Science Classrooms* (Arlington, VA: NSTA Press, 2009) <http://static.nsta.org/files/pb243xweb.pdf>.
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- ¹² Daniel T. Hickey, Allison L. Moore, and James W. Pellegrino, “The Motivational and Academic Consequences of Elementary Mathematics Environments: Do Constructivist Innovations and Reforms Make a Difference, *American Educational Research Journal* 38, no. 3 (2001), 611-652.
- ¹³ Seth A. Parsons and Allison E. Ward, “The Case for Authentic Tasks in Content Literacy,” *The Reading Teacher* 64 no. 6 (March 2011), 462 – 465.
- ¹⁴ This discussion draws on the following article: Johannes Strobel, J. Wang, N. R. Weber, and Melissa Dyehouse, “The Role of Authenticity in Design-based Learning Environments: The Case of Engineering Education,” *Computers & Education* 64 (2003), 143-152.
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¹⁶ Cognition and Technology Group at Vanderbilt, "Designing Environments that Reveal, Support, and Expand our Children's Potentials," in S. Soraci & W. J. McIlvane (Eds.), *Perspectives on Fundamental Processes in Intellectual Functioning: A Survey of Research Approaches Vol. 1* (Westport, CT: Greenwood Press, 1998)

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¹⁹ Luis C. Moll, Cathy Amanti, Deborah Neff, and Norma Gonzalez, "Funds of Knowledge for Teaching: Using a Qualitative Approach to Connect Homes and Classrooms," *Theory into Practice* 31, no. 2 (1992), 132-141.

²⁰ Brophy, *Motivation*.

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