Rigorous Project-Based Learning
An Inquiry-Based Educational Approach

Designing Project-Based Learning Curricula:

Leveraging curriculum development for deeper and more equitable learning

Lucas Education Research
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CONTENTS

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Introduction

Project-based learning (PBL) is an inquiry-based approach that aims to engage students in challenging, active, and meaningful experiences connected to the world outside the classroom (Baines et al., 2021a). Project-based learning can improve student performance on traditional measures of academic achievement, build social and emotional learning skills, and engage students in deeper learning. This means focusing on higher-order thinking and skills that will help students succeed in college, their future careers, and their lives as active members of their communities. The alignment of PBL and deeper learning is supported by a growing body of evidence that PBL has a significant positive impact on student learning and other outcomes of deeper learning (Duke et al., 2021; Deutscher et al., 2021; Krajcik et al., 2021; Saavedra et al., 2021.) This paper will provide guidance for those who are designing curricula[1] to achieve similar goals through project-based learning.

The goal of education is not solely to prepare students to pass a test but to foster learning in a way that is transferable to their personal, cultural, academic, professional, and civic lives. PBL encourages students to develop the skills and understanding needed for the long-term retention and application of what they have learned (Strobel & van Barneveld, 2009). Importantly, deeper learning attends to he application of content knowledge and problem solving as well as the inter- and intrapersonal domains—which include communication and collaboration skills—and metacognition and learning to learn. (Huberman et al., 2014; National Research Council, 2012). Further, focusing on deeper learning means challenging students to take ownership of their work, engage in rigorous content, and develop skills and ideas that will have a positive impact on many areas of their future lives, including health and relationship outcomes and how they participate in their communities (National Research Council, 2012).

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The persistent achievement gap between groups of students in the U.S. shines a light on the need to create deeper-learning experiences for all students. Ladson-Billings (2006) reframes the achievement gap, focusing instead on the educational debt that has accumulated from decades of inequitable education for those in historically marginalized groups, such as students of color, economically disadvantaged students, and multilingual learners. In her call to action, which is all the more relevant today, Ladson-Billings argues that the societal disparities, both historic and current, require that we, as part of the education system, use our expertise to alleviate these inequities. To truly address the educational debt, equity must be an explicit priority in the design of classroom experiences and throughout the education system (Nasir, 2012; Paris & Alim, 2017).

The goals of PBL, therefore, go beyond deeper learning to providing experiences that are relevant and meaningful to each and every student[2] while supporting the development of the whole child. The whole-child approach acknowledges that supporting learning is dependent on the multidimensionality of a student's life (Darling-Hammond & Cook-Harvey,

1 While this paper is intended to provide guidance for developers who create written, full-course curriculum materials designed for use in multiple classrooms, the Design Principles and Critical Lenses can also help teachers consider their own practices. For teachers, other frameworks for implementing PBL in their classrooms can be particularly helpful alongside this paper (Boss & Larmer, 2018).

2 We use the phrase "each and every student" deliberately when we are discussing the complex set of racial, cultural, linguistic, historical, gender, community, and family identities and backgrounds represented by the students in the classroom.

2018). This means teaching and learning must focus on academic and cognitive development alongside social, emotional, and identity development. Given the learner-centered focus of PBL, it has always been uniquely positioned to advance whole-child development and educational equity; however, it has not always been explicitly part of the pedagogical approach in schools (Cheng et al., 2021).

High-quality PBL curricula, alongside sustained professional learning, supports larger-scale shifts in educational systems (Condliffe et al., 2017; Steiner et al., 2019). Carefully designed curriculum materials that embody PBL with equity at its core can support teachers in providing students with deep and equitable learning experiences. In this paper, we present guidance for how designers of curricula can create high-quality materials that engage each and every student in meaningful learning experiences that are relevant to the world beyond the classroom, affirm and sustain students' identities, and focus on the development of the whole child. While the primary goal of creating high-quality PBL curriculum materials is to provide students with engaging and effective learning experiences, it is also critical to shift teacher practices and school systems toward prioritizing deeper learning, equity, and whole-child development.

EXAMPLES OF PROJECT-BASED LEARNING CURRICULA

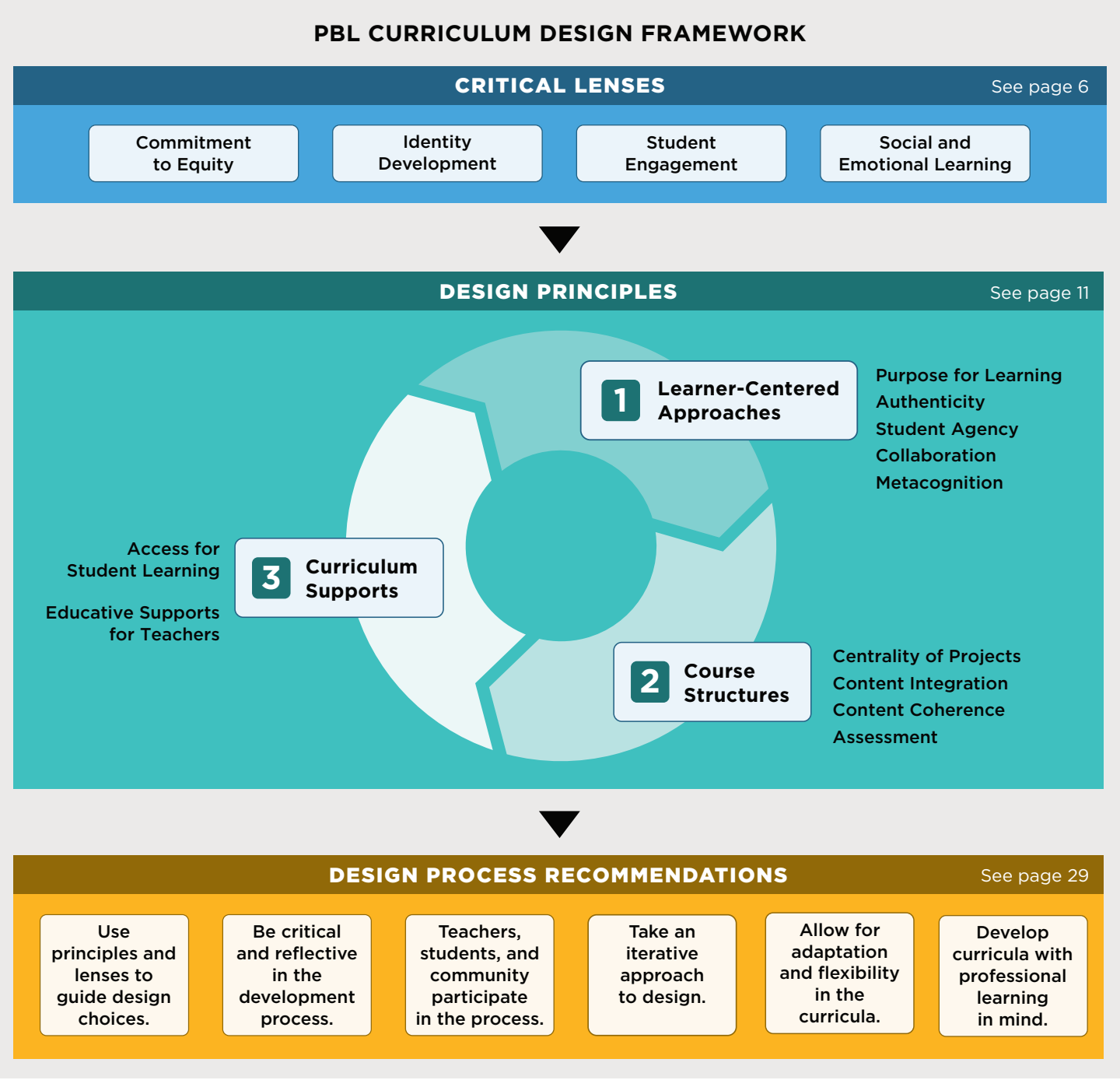
In identifying the essential features of PBL and creating the principles for curriculum design presented in this paper, the following Lucas Education Research–supported projects served as examples of PBL curricula. The research findings associated with each project show positive student outcomes in learning and engagement using rigorous methodologies. While each curriculum had a unique set of priorities and strengths, and many did not include explicit features for equity, these can illuminate how the principles of PBL curriculum design may be put into practice across a range of subjects and grade levels:

- Knowledge in Action courses in AP U.S. Government and Politics and AP Environmental Science—Two Advanced Placement courses for high schoolers codesigned by researchers at the University of Washington and high school teachers (Parker et al., 2011, 2013; Saavedra et al., 2021; Tierney et al., 2020)
- Multiple Literacies in Project-Based Learning —Science courses for third, fourth, and fifth graders that integrate math and English language arts designed by researchers at Michigan State University and the University of Michigan (Krajcik et al., 2021; Krajcik & Schneider, 2021; Miller & Krajcik, 2019)
- Learning Through Performance —A yearlong science course for sixth graders developed by researchers at Stanford University (Deutscher et al., 2021; Holthuis et al., 2018)
- Project PLACE : A Project Approach to Literacy and Civic Engagement—Second-grade curriculum integrating social studies and literacy developed by researchers at the University of Michigan and Michigan State University (Duke et al., 2021; Halvorsen et al., 2012)
- Compose Our World —Ninth-grade English language arts course developed by researchers at the University of Colorado at Boulder (Boardman et al., 2021; Garcia et al., 2020; Polman et al., 2018)

Framework for PBL Curriculum Design

Creating a PBL curriculum that allows for deep and equitable learning is a complex and challenging task. Figure 1 illustrates how the elements of this paper work together to guide the development of PBL curricula. To provide developers with guideposts that can inform design decisions, we describe a set of Design Principles that can support the creation of content-rich, student-centered experiences. These Design Principles are

FIGURE 1
Framework for PBL Curriculum Design



grouped into three categories: Learner-Centered Approaches, Course Structures, and Curriculum Supports.

We also highlight four pedagogical commitments, or Critical Lenses, for designers to consider to ensure that all students are valued, engaged, and included. These commitments provide a frame through which curriculum developers can interpret the Design Principles to ensure they are not producing or reinforcing inequities. We name these Critical Lenses both for their essential place in design and to denote the role of critique in curriculum design.

Finally, while we do not lay out a specific method for how to create PBL curricula, we do offer recommendations for the design process to support deeper learning for each and every student. As noted in Figure 1, we offer six recommendations for the design process. The first two recommendations describe the way developers can use the lenses and principles in the design process, while the other four relate to other aspects of the development process. Here, we briefly describe the first two and will revisit all six in the final section of the paper.

RECOMMENDATION 1:

Use principles and lenses to guide design choices.

To create a high-quality PBL curriculum, designers should consider and include all the principles and lenses. Without this complete set of principles and lenses, the curriculum will not fully meet the goals of PBL to engage learners equitably in deep and purposeful learning. While designers should develop their PBL curricula using all the principles and lenses, individual courses will also have their own priorities, requirements, and design features. As such, how curriculum developers incorporate the Design Principles and Critical Lenses depends on the context, including the specific needs of the targeted schools and students, with some principles more heavily featured than others.

RECOMMENDATION 2:

Be critical and reflective in the development process.

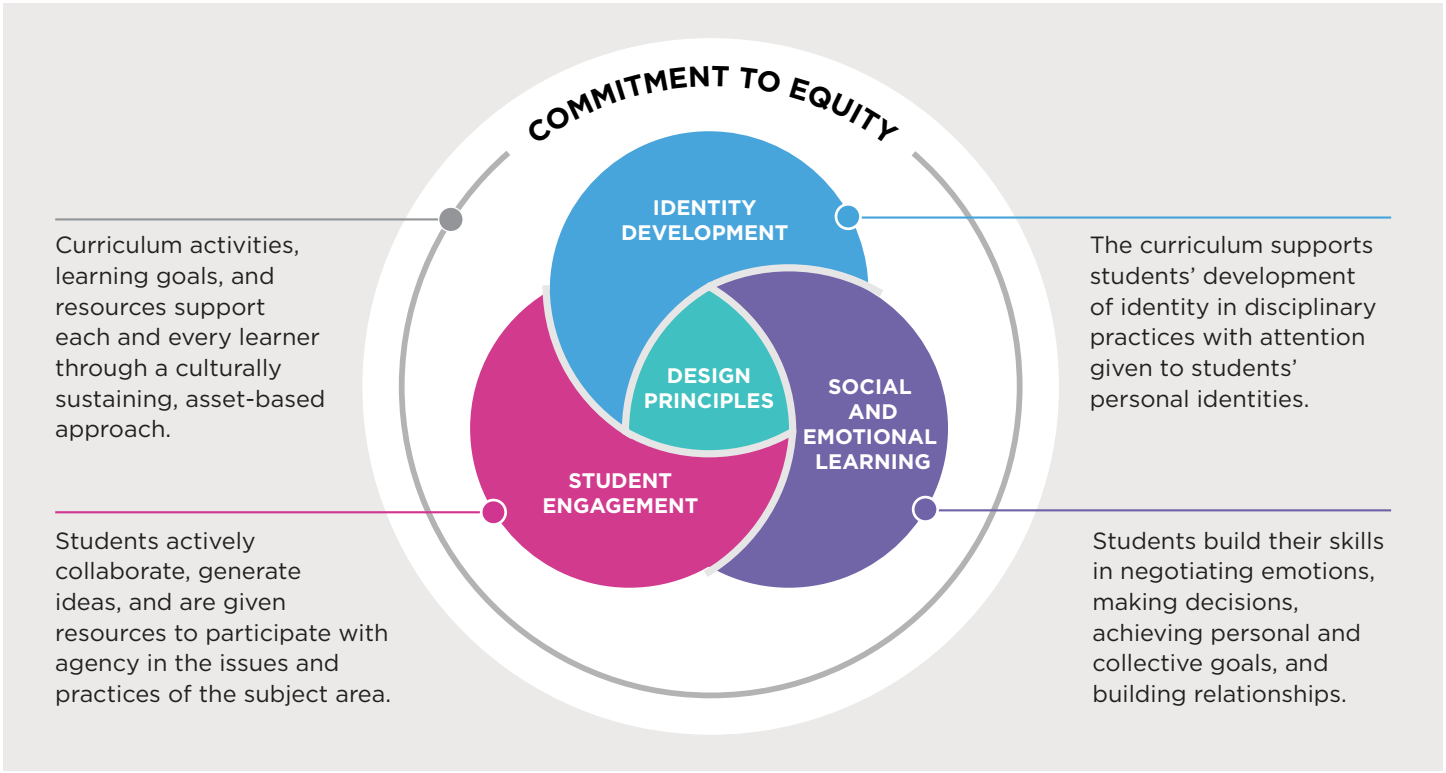
Just as a PBL curriculum asks teachers and students to be reflective of their practices, PBL curriculum designers must critically reflect on their own design process. If a curriculum is going to meet the needs of each and every student, especially those who have been historically marginalized or excluded, developers must look closely at their own existing practices in design. Criticality—which applies critical thinking to understanding the impact of power, oppression, and privilege, including through the perspectives of marginalized communities—is vital to the development of equitable curricula (Muhammad, 2018). Using criticality in the design process ensures that developers have fully considered the implications of their work on teachers who use the curriculum, students who engage with the curriculum, and communities to which those students belong. To help designers in critical reflection, including criticality, we provide examples of reflective questions in the descriptions of the Critical Lenses and Design Principles in the next two sections. Developers can ask these reflective questions at each stage of the design process and at every level (e.g., designing the whole course, each project, and each activity) to help draw out the impact of design decisions on equity and deeper learning.

Critical Lenses for PBL Curriculum Design

Designers should consider the perspectives they use as they design a curriculum for deeper learning and equitable development of the whole child. The perspectives designers use become operationalized in the developed curriculum, influencing the ways teachers implement the curriculum and, therefore, what students will experience in the classroom. To help illustrate this idea, imagine a photojournalist tasked with capturing an event. The intended audience, the photojournalist's personal style and perspective, and the context of the event all shape both the content and composition of the end results. This is similar to the work of curriculum designers, whose experiences, values, and pedagogical knowledge all influence—intentionally or not—the curriculum they create.

To ensure shared understanding of how to incorporate the Design Principles in a curriculum, we present four Critical Lenses: Commitment to Equity, Identity Development, Student Engagement, and Social and Emotional Learning (see Figure 2). These interconnected concepts and pedagogies support the development of the whole child, and we present them as a set of pedagogical commitments curriculum developers should use to create a PBL curriculum that represents the valued outcomes of the PBL approach. As illustrated in Figure 2, all of these lenses overlap and come together to define how to

FIGURE 2
Relationship of Four Critical Lenses for PBL Design



enact the Design Principles in curricula, while Commitment to Equity also encompasses the other three, representing the constant eye toward equity that should occur in PBL design.

Commitment to Equity

Equity-committed design calls upon curriculum designers, as well as teachers and the broader educational system, to embrace and enact a series of anti-oppressive, culturally sustaining, and asset-based approaches that center on students, their identities, and their experience (Gay, 2018; González et al., 2005; Nasir, 2012; Paris & Alim, 2017). These practices and approaches are a vital part of curriculum design and are interwoven into the descriptions of the other Critical Lenses and Design Principles in this paper. Because issues of equity need to be considered in nearly every aspect of education and overlap with identity, engagement, and social and emotional learning, the Commitment to Equity lens encompasses the other three lenses, as well as the Design Principles. Still, we explicitly name Commitment to Equity as a separate lens to give designers a frame to ensure that this commitment is as much a part of the design process as the other lenses and principles (see Figure 2).

Curriculum designers use criticality to examine, and where necessary challenge, the disciplinary content and pedagogical approaches they traditionally use.

It is valuable for curriculum designers to familiarize themselves with a number of approaches as they develop PBL curricula: culturally sustaining/revitalizing pedagogy (Paris & Alim, 2017), culturally responsive pedagogy (Ladson-Billings, 1994), funds of knowledge (González et al., 2005), historically responsive framework (Muhammad, 2020), culturally responsive teaching (Gay, 2018; Hammond, 2015), Indigenous and land-based perspectives (Bang et al., 2014; Barajas-López & Bang, 2018), and culturally and linguistically relevant pedagogy (Hollie, 2011). Valuing, amplifying, and celebrating students' identities and backgrounds are central to all these approaches. These include, but are not limited to, students' racial, cultural, historical, linguistic, gender, disability, community, and family identities and backgrounds.

Equity-committed PBL also includes a focus on criticality. Curriculum designers use criticality to examine, and where necessary challenge, the disciplinary content and pedagogical approaches they traditionally use. Whose stories are told? Do all students see themselves in the curriculum? Do they see positive representations of themselves and their communities? Are the teaching strategies inclusive of various ways of learning and knowing? Are students engaged in an inclusive community of learners? Where do the expectations for learning and success come from, and who are they serving? This approach nurtures teachers' and students' own abilities to identify and analyze systems of oppression and their resulting inequities and, consequently, to work to address them. Designers must consider what supportive structures for ongoing reflection a curriculum needs to facilitate this kind of teaching and learning.

Identity Development

Identity development refers to the process of people understanding who they are as they participate in the world. This process, which is ongoing as an individual changes over time, is not solely internal but also embedded in social interactions that are influenced by societal norms, stereotypes, and power relationships (Holland et al., 1998). We believe that all students' identities need to be supported as they engage in learning. PBL curricula explicitly help students link their identities to ideas and practices in specific subject areas, with the goal of creating a sense of belonging to their learning community. By

supporting students' development of identity in disciplinary practices, a key component of PBL curricula, learners are more likely to be engaged and develop positive disciplinary identities (Lo, 2017; Nasir, 2012; Nasir & Hand, 2008). This can empower students to be more agentic and to take ownership of disciplinary behaviors, dispositions, perspectives, and practices (Tierney et al., 2020). Identity development also connects to students' sense of belonging in the classroom and school communities (Flores-Gonzalez, 2002; Goodenow, 1993; Nasir et al., 2006). Identity Development as a critical lens in curriculum development embeds the perspective that high-quality instructional materials will support what students learn, who they are, and who they want to become.

Identity Development is an important lens through which to use criticality, particularly to better understand how power and oppression might impact a student's developing sense of self. The subject areas that are taught in schools are historically from a White, Western, and often male perspective, which means the content, and likely the instructional methods, requires a recentering on becoming culturally relevant and sustaining for students historically marginalized in schools (Aguirre & Zavala, 2013; Bang et al., 2018; Paris & Alim, 2017). This conflict with typical classroom culture, pedagogies, and content can trigger feelings of alienation (Brown et al., 2003; Nasir et al., 2006; Willis, 1986; Valenzuela, 1999). Curriculum designers should examine the subject-area practices and individuals portrayed as members and experts in a field. Where should designers challenge the subject-area practices? How can designers use criticality to examine and, where necessary, challenge traditional definitions and values in subject areas? Where could the curriculum elevate contributions of people of color, the role of women and gender nonbinary people, and global perspectives? How would this promote student engagement and belonging? And how might social and emotional learning skills support identity development?

Thoughtful consideration and design for identity development will allow students to build identities that link to the subject area of the course. This includes, but is not limited to, ensuring that students can see themselves within the disciplines and as disciplinary experts, engage in disciplinary practices in the classroom, transfer their learning outside the classroom, put their personal stamp on classroom products and practices, and envision their future selves in relation to the discipline.

Student Engagement

Student engagement refers to the multifaceted way in which students interact with their learning environment, including how they participate, react emotionally, and invest in their learning and school community (Fredricks et al., 2004). Engagement can be defined at multiple levels, from moment-to-moment interactions with ideas and peers to involvement with school and subject areas across classes and academic years. Higher student engagement is associated with greater academic achievement (Lei et al., 2018). As with successfully supported identity development, a high level of student engagement intersects with a student's sense of belonging in school (Appleton et al., 2008).

With the goals of deeper learning and whole-child development in mind, designers should consider whether a curriculum engages a student and, more important, how that student is engaged. On the spectrum of engagement from passive listening to actively constructing understanding, where a student falls impacts their learning at that time (Chi et al., 2018). Using the framework from Chi (2009), at the highest level of engagement—when deep learning occurs—students interact to generate ideas collaboratively. When designing a PBL curriculum, it is important to give attention to student interactions

with materials, tasks, and core ideas of a subject area. This type of engagement, called productive disciplinary engagement (PDE), connects students' activity, discourse, and learning to the practices of the discipline (Engle & Conant, 2002). Opportunities for PDE occur when students take on the problems of the discipline and have authority and agency within the classroom to actively solve those problems. Students are held accountable to others, the practices and content of the discipline, and the specific constraints of the activity. Importantly, they must be supported with the necessary resources and content knowledge (Engle, 2012). For example, in a civics class in which students are addressing a local housing issue, disciplinary engagement occurs when students have access to resources that help them explore the issue, such as materials focused on how local governments work and methods for lobbying their government.

Designing for student engagement requires curriculum developers to consider key questions. What is the right balance between student agency and alignment to the constraints of the subject-area content and practices as well as of the project (e.g., timing, defined goals, and available tools)? Should those constraints of content and subject-area practices be challenged or reimagined when they run contrary to equity goals? This requires consideration of who has historically defined the disciplinary practices students are accountable to and how identity influences student engagement (Agarwal & Sengupta-Irving, 2019). Does the curriculum, and the classroom routines and structures contained within, promote active participation through an inclusive and responsive approach? Viewing curriculum design through the lens of Student Engagement can enhance the ways that the materials, content, and student role in learning interact to provide access to deeper learning.

PBL curriculum must have clear instructional materials and support for teachers and students related to SEL goals for change to occur.

Social and Emotional Learning

Social and emotional learning (SEL) is the process of negotiating emotions, making decisions, navigating challenges, expressing empathy, achieving personal and collective goals, and establishing and maintaining relationships (Durlak, 2015; Jagers et al., 2019). SEL skills and behaviors are needed for everyday life and contribute to academic success (Durlak et al., 2011; Taylor et al., 2017). Researchers have also found that learners have "greater motivation, stronger identity development, and deeper learning" when their teachers prioritize social and emotional learning and development (National Commission on Social, Emotional, and Academic Development, 2019, p. 17).

Baines et al. (2021b) point out the importance of supporting students' SEL needs in PBL curricula, in particular because the collaborative and inquiry-based nature of PBL provides an opportunity to connect SEL and PBL. This means a PBL curriculum must have clear instructional materials and support for teachers and students related to SEL goals for change to occur (National Commission on Social, Emotional, and Academic Development, 2019). These include attention to routines, practices, and protocols that support students as they apply both knowledge and skills as they engage in projects (Baines et al., 2021b).

SEL, just like PBL, must be culturally responsive in design and implementation to recognize, affirm, and sustain students' identities. Jagers et al. (2019) refer to this as "transformative SEL" and argue that for SEL to support all students, especially those from marginalized groups, it must cultivate in students and adults "knowledge, attitudes, and skills required for critical examination and collaborative action to address root causes of inequities" (p. 163). Culturally responsive SEL within PBL is more likely to occur when a

curriculum combines PBL practices, such as collaborative learning and criticality, with the content of PBL, such as topics related to relevant social justice issues.

Curriculum developers have a number of questions to consider in this area. Are the topics providing students with opportunities to explore and celebrate their identities? Do the activities take into account the skills students need to engage with peers? How are students supported by both their teachers and their peers? Is social and emotional learning taught and implemented in a way that is culturally responsive and affirming? Are the connections between SEL skills and behaviors explicitly connected to identity development, criticality, and social justice? How is SEL taught and practiced in partnership with students' families, caregivers, and communities? What are the norms, topics, and systems students are examining? By addressing these questions, curriculum developers support the creation of collaborative, inclusive, and multicultural learning environments in which each and every student can thrive.

Photo: All4Ed

A curriculum that attends to each of the Critical Lenses can successfully support the development of the whole child.

Design Principles of PBL Curricula

The Design Principles we describe below provide guideposts for designers as they encounter choices at each stage of curriculum development. While the Critical Lenses are essential for curriculum design, they do not describe basic building blocks of a curriculum, such as designing the scope and sequence of the course, selecting pedagogical approaches, and choosing the structure and activities of a project. While we present each principle as a distinct idea, there is a significant amount of overlap between them. In addition, the description of each principle integrates ideas from the Critical Lenses, though not always with an explicit reference back to a lens.

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The Design Principles fall into three categories: Learner-Centered Approaches, Course Structures, and Curriculum Supports. The order in which we present these categories does not imply a sequence to the design process, nor does it suggest levels of priority. We begin with the Learner-Centered Approaches, which focus on how students experience the curriculum. The second category, Course Structures, contains principles concerning the scope and sequence of the content and supporting a coherent learning experience. The last category, Curriculum Supports, includes principles that help students and teachers navigate the course and their learning. We begin with a summary of the principles in the table below. We also include a design tool in the appendix that highlights ways to reflect on how each principle is applied to a curriculum, especially through the Critical Lenses.

Photo: All4Ed

A PBL curriculum that incorporates all the Design Principles will engage students in equitable, authentic, and relevant learning experiences.

TABLE 1
Design Principles of PBL Curricula

	Principle	Short Description
1	**Learner-Centered Approaches**	**How do students engage with the project and their learning? How do learners experience the project and course?**
	Purpose for Learning	Projects provide students with a reason for learning by engaging them in experiences that connect their own ideas to the project's problem or question before deeply exploring the content.
	Authenticity	Projects are relevant to students' lives, families, and communities and connect to the world outside the classroom, especially to tasks, roles, and practices of the discipline.
	Student Agency	The course design allows students to make substantive and consequential choices in their projects as well as to apply the work and learning to their daily lives.
	Collaboration	Throughout projects, students work together on problems in purposeful and supported ways and create a community of active learners that includes students and their teacher.
	Metacognition	Students have opportunities to build and use metacognitive skills to reflect on what and how they have learned, including disciplinary ideas as well as other skills and practices.
2	**Course Structures**	**How are the course content and skills chosen, designed, and organized?**
	Centrality of Projects	The projects are integral to learning by framing the entire process of and purpose for learning. A PBL course embeds all content in projects.
	Content Integration	The curriculum integrates projects with core disciplinary ideas and practices. It also specifies learning goals aligned with standards as well as other essential content, such as literacy, social and emotional learning, and equity.
	Content Coherence	The content of a PBL course is strategically sequenced to deepen understanding as students' progress through the course, revisiting and connecting ideas across projects.
	Assessment	The curriculum provides ongoing opportunities for assessing learning of disciplinary, social and emotional, and other essential skills and ideas that are performance based and authentically embedded in the work students are doing.
3	**Curriculum Supports**	**How do the materials support teachers and students?**
	Access for Student Learning	The curriculum provides appropriate scaffolds and tools to support learning, with access points for all students, including explicit framing for lessons, scaffolds for disciplinary and social and emotional learning, and multimodal content.
	Educative Supports for Teachers	The curriculum materials support teachers in deepening their disciplinary, pedagogical, and equity understanding in ways that embed the resources in a teacher's daily practice and allow teachers to effectively adapt to their own contexts and students.

1. Learner-Centered Approaches

Project-based learning that attends to the development of the whole child and deeper learning places students at the center of learning in ways that value and build upon what students know, the skills they have, and what they care about. The principles in this first category answer these questions: "How do students engage with the project and their learning?" and "How do learners experience the project and course?" The Design Principles in this category support the development of PBL curricula that are authentic to students and integrate the Critical Lenses. These principles attend to engagement, connect to students' lives, value student voice, allow students to develop fundamental cognitive skills, generate understanding collaboratively, promote independence, and support success in college, career, and life.

1A. Purpose for Learning

Providing students with a purpose for learning is fundamental to the creation of a PBL curriculum that commits to deeper learning and student engagement and is based in the science of how students learn. In "A Time for Telling," Schwartz and Bransford (1998) state that providing students a context for what they are learning, the "need to know," primes them for learning and engagement. At the beginning of a PBL unit, students discover the context for the project before any content is introduced, often through some kind of shared experience and the introduction of a problem to solve or question to answer. In this project launch, students generate their own ideas and questions on the project/topic connected to prior knowledge and drawing on racial, cultural, historical, personal, and community funds of knowledge. This launch might also introduce students to the roles they will have in the project context, giving further motivation for completing project tasks.

Providing students with a purpose for learning is fundamental to the creation of a PBL curriculum that commits to deeper learning and student engagement and is based in the science of how students learn.

Consideration of the Purpose for Learning principle extends beyond the initial engagement at the beginning of a project. The sustained inquiry process of project-based learning continues to draw on the project context, roles, and student-generated ideas and questions throughout a unit. This means that careful sequencing of activities within a project is important to provide a continued sense of purpose for learning. Lo and Tierney (2017) describe a time for telling as a challenge for "teachers to present students with information during a perfectly timed moment when it matters most to students' learning, rather than before they need to know it" (p. 65). This means the teacher provides both learning opportunities—through readings, lectures, and other sources—and learning supports when the needs arise. It is important to note this attention to sequencing highlights that the PBL approach does not stand in opposition to direct instruction, such as lectures, but students need a reason to listen to a lecture that extends beyond school and grades (Schwartz & Bransford, 1998). Providing a purpose for learning situates course content in the world outside the classroom walls and empowers students to make sense of new information and determine its value, all of which connects to the next principle, Authenticity.

PUTTING THE PRINCIPLE INTO PRACTICE: PURPOSE FOR LEARNING

In PBL, students are given ways to engage first, which situates learning in the project context. One way of doing this is by having students engage in roles within the project. In the Knowledge in Action (KIA) AP Government and Politics (Gov.) unit on the Supreme Court, students simulate landmark Supreme Court cases through two different moot courts and one mock trial. In taking on the roles of lawyers and judges, students actively engage in the practices of experts first before learning about the function of the courts in society, which sparks curiosity and a need to know so they can successfully perform in their role throughout the rest of the project.

A well-crafted driving question tied to an engaging launch can allow students to connect to their purpose for learning throughout a project. In the Multiple Literacies in PBL (ML-PBL) curriculum, a unit leads with a driving question. For example, in the third-grade unit on birds and genetics, students answer the question, "How can we help the birds near our school grow up and thrive?" Students begin the unit by observing birds near their school, gaining first-hand experience that provides motivation for learning. The progress toward the driving question along with student-generated ideas and questions are then made public on the Driving Question Board, which allows students to have an ongoing link back to the purpose.

The following questions allow designers to reflect on the ways a curriculum enacts the Purpose for Learning principle:

- In what ways does the beginning of the project engage students with a complex problem, question, or context from which students can connect to a reason for learning content, social and emotional skills, and equity practices?
- In what ways does the problem, question, or context given to engage students value and amplify the diversity of experiences and identities of the students?
- What opportunities do students have to draw on prior knowledge and their racial, cultural, historical, personal, and community funds of knowledge at the launch of and throughout the project?
- To what extent are students continuously connecting back to the problem, question, or context that gives a purpose for their learning over the course of the project?

1B. Authenticity

Authenticity connects students' learning and work to the world outside the classroom, situating learning in a way that is meaningful and relevant. When students see value in the learning due to its relevance, they are more intrinsically motivated to engage (Priniski et al., 2018; Vansteenkiste et al., 2018). Providing an authentic context for learning also supports the importance of building on existing understanding to successfully learn new knowledge (National Research Council, 2000). Finally, perceiving a PBL curriculum as relevant has been shown to increase transfer of learning and practices into students' everyday lives (Tierney et al., 2020).

In PBL curricula, authenticity has been defined in different ways, both of which are important to include. Some work focuses on authenticity as connected to subject-area expert practices, such as how scientists, politicians, journalists, etc. engage in their professions (Krajcik & Blumenfeld, 2006; Parker & Lo, 2016). Others focus on authenticity as connected to students' lives, families, communities, and values outside of school (Polman et al., 2018; Tierney et al., 2020). Both of these are vital. The experiences students have during a project involve tools, roles, tasks, practices, and processes authentic to the discipline and experts in the field. The experiences students have in PBL classrooms are

also authentic to their lives. This facet of authenticity is rooted in cultural responsiveness, which refers to the use of knowledge of students' cultures, communities, experiences, frames of reference, and performance styles to "make learning more relevant and effective" for them (Gay, 2018, p. 36). So students investigating an environmental issue can use the practices of an environmental scientist and focus on a real-world issue, such as water quality and the way it might impact their own lives or that of their community. Connecting to authentic practice in this way, in both expert practice and students' lives, tends to provide students with opportunities to critically examine and understand power, privilege, social justice, and oppression.

While many of the exemplar PBL curricula do not define authenticity to include cultural responsiveness, it is important to meet the commitments highlighted in the lenses. To do so effectively, curriculum designers have to strike a balance between what is codified and what is developed by the teacher in response to students and their local contexts. This adaptable approach requires flexible materials that support teacher choices, as will be described in the section on the final Design Principle, Educative Supports for Teachers.

PUTTING THE PRINCIPLE INTO PRACTICE: AUTHENTICITY

The curricula used as examples in this paper all emphasize the Authenticity principle and generally support disciplinary authenticity and authenticity related to students' lives. In the Civics and Goverment unit in Project PLACE, students identify a problem they want to solve at a local park or public space. Students learn about the purpose of government and engage in the practices used by community members, thoughtfully researching, writing, and presenting a proposal for their park improvements to a local official.

Similarly, in the KIA AP Environmental Science (APES) unit titled My Community Ecology, students learn about sustainable development by examining a development site in their own community using the tools and practices of ecologists. Both of these examples highlight the multiple dimensions of authenticity. The larger concepts are made directly relevant by situating them in the students' immediate surroundings, but also the work they are doing is authentic to the focal discipline.

The following questions allow designers to reflect on the ways a curriculum enacts the Authenticity principle:

- To what extent is students' perceived relevance of the projects considered in curriculum design for students across a range of communities and backgrounds?
- Do students have the opportunity to engage in authentic expert practices, such as real-world tasks, roles, tools, and/or processes?
- In what ways are approaches to authenticity rooted in students' cultures and identities in positive and affirming ways that allow students to explore their personal and disciplinary identities both within and across projects?
- To what extent are materials flexible to allow teachers to connect the learning to students' lives, families, communities, and values outside of school?
- Do students have the opportunity to critically examine and understand power, privilege, social justice, and oppression as they connect to authentic practice in the world?

1C. Student Agency

Students develop agency—that is, ownership of and engagement in their learning—when they have a voice in the content, process, value, and assessment of their learning (Calabrese Barton & Tan, 2010; Mirra & Garcia, 2020; Zeiser et al., 2018). The proper supports for student agency deepen engagement and identity development, create a space for learners to express themselves in practice, and develop student identities in the context of the discipline (Nasir, 2012; Nasir & Hand, 2008; Tierney et al., 2020). Student Agency as a PBL Design Principle can support the creation of projects that allow students to take different approaches and pathways as they engage in PBL courses and to add their own voices to the projects. Designing a curriculum that allows students to make consequential choices supports the development of key social and emotional skills, such as making decisions, navigating challenges, and setting goals.

Through opportunities for student agency, students can generate ideas, make substantive and consequential decisions related to content, and apply lessons learned through the project to their daily lives. Tierney et al. (2020) describe the iterative design of the Knowledge in Action AP Environmental Science course and how the course was redesigned for agency. Specifically, the curriculum developers redesigned the course after first-year implementation showed strong test scores but research revealed students were not engaging deeply in projects and felt pessimistic regarding a lack of agency in addressing environmental issues in the world. The revised course supports student agency and opportunities for students to transfer their learning to their everyday lives, allowing them

PUTTING THE PRINCIPLE INTO PRACTICE: STUDENT AGENCY

Student agency allows students to make substantive choices in their project and learning. In a **unit from Project Place** on economics, students are given two opportunities for making key decisions in their projects. Students first select a local cause for which they will raise money, which gives the students choice in and motivation for the goals of the project. In addition, as a means to learn about basic economics, students work as a class to select a good or service that fills an unmet need in their community and that can raise money for their cause.

In KIA APES, the curriculum focuses on students' ability to make choices in the project and have agency over their actions outside the classroom. In the **Ecologial Footprint unit**, students analyze their families' ecological footprints and create a proposal to convince their families to reduce their footprints. Finally, students reflect on how their actions have the power to add up to larger changes.

The following questions allow designers to reflect on the ways a curriculum enacts the Student Agency principle:

- What opportunities do students have to make consequential choices in how they complete project tasks to allow for student ownership and independent design?
- To what extent do projects and tasks in which students are making substantive choices include and value knowledge and experiences of each and every student's practices and ideas?
- To what extent do curriculum materials provide supports for teachers to recognize and honor all students' voices?
- What opportunities do students have to connect their work on a project to the impact that their actions can and do have on the world?
- In what ways do course materials provide explicit supports for students' social and emotional learning related to making decisions and choices in the projects?

to develop stronger identities as environmental citizens. This indicates the importance of designing opportunities for students to make consequential decisions within the projects, while also framing the application of project content, skills, and practices to their agentic actions in their daily lives. The racial, cultural, and political contexts of students' lives impact how students' experience agency beyond the classroom (Holland et al., 1998). Therefore, designers should consider how the specific contexts in which students participate, both in and outside of school, support and constrain their opportunities for agency and power.

1D. Collaboration

Collaboration is deeply embedded in project-based learning curricula. It includes group work with a shared goal and the fostering of a community of learners in which teachers and students can build on one another's ideas to advance their individual and collective understanding. Collaboration in a PBL classroom also includes opportunities for peer-to-peer feedback and co-construction of knowledge and products. These different facets of collaboration can help students develop their social and emotional skills, perform better academically, and build essential skills for college, career, and life (Barron & Darling-Hammond, 2008; Roschelle & Teasley, 1995). Collaboration can encourage community building, strengthen student relationships with peers and teachers, and enhance a sense of belonging in the classroom (Darling-Hammond et al., 2020).

Though humans are inherently social, collaboration requires a set of skills that need to be deliberately developed throughout one's life

Though humans are inherently social, collaboration requires a set of skills that need to be deliberately developed throughout one's life (Azmitia, 1996). Therefore, an equitable PBL curriculum must provide support for students to successfully navigate interpersonal dynamics and foster productive group learning. Further, if not intentionally designed and scaffolded, small-group settings can reproduce societal inequities in which students can be negatively positioned based on race, income, gender identities, and sexual preferences (Clarke, 2015; Kurth et al., 2002). For collaboration to succeed, the curriculum should include explicit structures and routines for discourse and group work that support equitable participation and identity development (Blumenfeld et al., 1996; Cohen & Lotan, 1997). In particular, for students who are still learning English or those who might need additional language development support, the inclusion of explicit ways of collaborating can boost engagement and provide opportunities to authentically engage in literacy even when English language arts is not the core subject on which the course is based (Fitzgerald, 2020). To help students collaborate and co-construct knowledge as a group, rather than simply dividing up parts of the project through cooperation, the design of the project should be at a level that requires collaboration, with tasks that have significantly complex discipline-based problems to solve (Lotan, 2003). In designing structures and roles for collaboration, all students in a group must have opportunities to grapple with the complex tasks required for mastering the learning goals. Finally, because collaboration requires sufficient time to do well, curriculum materials need to emphasize that time spent in group work and discussion is just as important as time devoted to content (Krajcik & Blumenfeld, 2006).

PUTTING THE PRINCIPLE INTO PRACTICE: COLLABORATION

PBL curricula include well-supported opportunities for collaboration throughout the project cycle. In ML-PBL, students participate in collaborative learning in pairs, small groups, and whole-class discussions. The curriculum includes teacher and student discourse moves. These scaffolds support the cognitive and linguistic demands in science learning and can support students productively working together.

To build students' capacity to work productively in groups, the Learning Through Performance (LTP) course begins with a short introductory unit focused on group work. That gives students time to recognize that all their peers have something to contribute and to reflect on the importance of roles and behavior norms in working together. Students have opportunities to practice these roles and norms. Throughout the rest of the course, as students collaborate as active learners and in creating the products for their projects, teachers review the group roles and norms.

The following questions allow designers to reflect on the ways a curriculum enacts the Collaboration principle:

- What opportunities do students have to work together on significantly complex discipline-based problems with supports that allow students to engage with disciplinary ideas and practices?
- To what extent do students have adequate group-work time to engage in interdependent learning and product or task development?
- In what ways are students building upon previous collaborative skills or experiences from project to project?
- In what ways are social and emotional learning and practices related to effective collaboration explicitly taught, supported through routines and scaffolds, and revisited throughout the course?
- To what extent is collaboration scaffolded to disrupt negative and inequitable roles and identities, including the provision of tools to confront interpersonal conflict and address race and racism in small-group settings?

1E. Metacognition

Metacognition refers to the awareness and understanding of one's own thinking and learning. While this principle is often called reflection, we call out the underlying process as it is important that the reflection be in service of metacognition. When students use metacognitive strategies, they are more engaged in both academic and nonacademic learning and achieve greater academic outcomes. For example, students can improve academic performance beyond their current ability level through the use of metacognitive strategies (McCormick et al., 2012). Further, the more learners can engage in metacognitive reflection, the better able they are to identify when they lack knowledge or skills. This allows them to advocate for help or seek out additional strategies or support, which leads to better teacher awareness of a student's learning needs.

While metacognition, including group- and self-reflection, is a common and important feature of PBL, curriculum materials often do not address the discrete skills of metacognition. There are a number of general metacognitive skills, including, but not limited to, rehearsal (e.g., planning and practice), elaboration (e.g., summarizing), and organization skills (e.g., concept mapping and planning) (Pintrich, 2002). Each of these transferable skills can be used across disciplines and to support students' development in social and emotional learning, identity development, and understanding issues of social privilege, power, and equity. For metacognitive skills to stick and students to transfer them to practice, their exposure and practice must be frequent and ongoing (Fusco & Fountain,

1992). Some strategies to promote deep metacognitive practice in the context of curriculum materials are think-alouds (verbal reports), reciprocal teaching, self-instruction, journaling, questioning, problem-solving, and concept mapping. Opportunities like these group- and self-reflection strategies are explicit components of a high-quality curriculum.

PUTTING THE PRINCIPLE INTO PRACTICE: METACOGNITION

PBL curricula rely on a number of strategies to help students build their metacognitive skills and reflect on their learning. Explicit protocols for students build routines around metacognition. In Compose Our World (COW), reflection is a key feature explicitly called out throughout the projects. Students have opportunities to reflect on their work and to reflect on their thoughts and feelings. For instance, protocols offer structured support for students to provide feedback to one another with deliberate steps for giving and receiving feedback and reflecting on peers' ideas.

Course materials can provide a structured approach to scaffolding metacognitive skills. The Individual Project Organizer provided in LTP gives students opportunities to reflect on what they have learned and connect it to their project and purpose for learning. For each project in COW, students use a journal "to build students' capacities to reflect, record ideas, analyze project content, and build a metacognitive understanding of their own learning process" (COW curriculum).

The following questions allow designers to reflect on the ways a curriculum enacts the Metacognition principle:

- To what extent are metacognitive skills outlined explicitly as content to be taught and assessed throughout the curriculum?
- To what extent are consistent tools and routines used to support metacognitive reflection in an ongoing way?
- In what ways are metacognitive skills directly connected to the content and context for learning set forth in the project (e.g., using the skill of questioning to support the inquiry process or generation of inquiry questions)?
- To what extent is metacognition used as a tool to support the development of social and emotional learning?
- Do students have the opportunity to reflect on identities, content knowledge, skills development, and their learning process?

2. Course Structures

While the previous category applies to how students experience individual projects, here we address what happens at the course level. This category of PBL Design Principles answers the question, "How are the course content and skills chosen, designed, and organized?" The principles outlined in this section are essential for a tightly designed PBL curriculum that attends to how content is approached and organized across projects in the course (i.e., the scope and sequence of content, as well as the structure of each project) and integrates the ideas of the Critical Lenses.

2A. Centrality of Projects

The Centrality of Projects principle highlights that the projects are not simply a peripheral means to assess learning or engage students; they frame the entire process and purpose of learning throughout a unit and course (Condliffe et al., 2017). Placing projects as the focus of the course means projects are the setting in which learning occurs in the course, with each activity framed by its context to the project. Parker et al. (2011) describe this as making projects the "spine of the course," which is in stark contrast to the more common instructional approach in which projects occur after lectures and tests. The authors "aimed to create a course experience where challenging projects provided the spine of the course, not the appendages; that is, the entrée, not the dessert; the main show, not the sideshow" (p. 538). Projects as the entrée provide a context and meaning for all learning that occurs. This is in contrast to "dessert" projects, in which projects, such as a poster or presentation, are a final application of learning but not the context and reason for learning. In considering the Critical Lens of Student Engagement, the projects must be sufficiently complex and open-ended to authentically solve the problems of the discipline.

PUTTING THE PRINCIPLE INTO PRACTICE: CENTRALITY OF PROJECTS

PBL curricula designed with projects at the center are often organized by and around projects. The KIA AP Gov. course is divided into five projects, each of which is a simulation that allows for the experience of the project to be central to what students are doing and learning. Project PLACE also puts projects in the foreground of learning in each of the four social studies units. Each session contributes to a project, so there is a clear motivation for the learning driven by the project. In the third-grade ML-PBL science course, the year is divided into four units, each framed by a driving question and anchored with a shared first-hand experience.

The following questions allow designers to reflect on the ways a curriculum enacts the Centrality of Projects principle:

- To what extent does learning of all content—including disciplinary concepts, skills, and social and emotional learning—occur within the context of a project?
- In what ways do students make meaningful progress throughout the unit toward the completion of their project?
- To what extent do students engage in projects throughout the course?
- To what extent does the framing around the purpose of lessons and activities rely on the project rather than needing to be done for the sake of school?

The Centrality of Projects principle describes the purpose of the project within a single unit but also the use of multiple projects across the whole course. When this principle is used across the entirety of a course, students learn little to no content in the course outside of the context of a project. In other words, nearly all content is framed within the context of the project.

2B. Content Integration

Following from the Centrality of Projects and Purpose for Learning principles, the content of the course needs to be integrated into the projects across the course. The integrated content includes opportunities for students to engage with core disciplinary ideas, thinking, and practices. Since projects provide the context for learning, the experiences students have as they participate in the projects foster understanding and develop core disciplinary ideas, practices, and thinking at a progressively deeper level than non-PBL courses (Darling-Hammond et al., 2008; Parker et al., 2013). Further, integrating rigorous disciplinary content should be done in the service of supporting students' development of identities linked to the content area by providing links between course content and students' lives and cultural practices (Nasir, 2012), as well as by setting high expectations for all students. Content for authentic projects also focuses on integrating learning across disciplines. In particular, embedding reading, writing, and speaking into PBL curriculum materials in other disciplines can improve student outcomes (Duke, 2016; Duke et al., 2021; Halvorsen et al., 2012; Li et al., 2021). To increase relevance and commitments to equity, this focus

PUTTING THE PRINCIPLE INTO PRACTICE: CONTENT INTEGRATION

ML-PBL courses strongly align with the three dimensions of the Next Generation Science Standards (Disciplinary Core Ideas, Science and Engineering Practices, and Crosscutting Concepts) with clear learning goals for lessons that tie back to the standards. In addition to science, the curriculum also integrates connections to math, literacy, social and emotional learning, and equity through explicitly stated learning goals. By calling out these interdisciplinary connections and standards, the curriculum allows teachers to better integrate explicit connections throughout the project.

Covering grade-level standards through projects requires deliberate planning. AP courses have a significant amount of content to cover for the exam. The projects in KIA AP Gov. address all the big-picture topics of the College Board's AP Gov. framework while remaining focused on building deep understanding. The purpose is not just to prepare students to pass the AP Exam but also to empower students to become civically engaged citizens.

The following questions allow designers to reflect on the ways a curriculum enacts the Content Integration principle:

- To what extent do the project tasks and experiences integrate subject-area ideas and practices as well as make connections to other subjects and foster an understanding and critique of inequities?
- In what ways does the course content honor students' diverse cultural, racial, and linguistic practices and perspectives?
- To what extent do the curriculum materials specify explicit learning goals directly related to the project that draw connections to both subject-area standards as well as literacy, SEL, and equity?
- To what extent are learning goals focused on building a deep understanding of and engagement in productive disciplinary work as well as standards?
- To what extent does the course content support learners' development of identities by linking course content to students' lives and authentic connections to the world?

on literacy also includes developing students' criticality, which builds their capacity to understand power, privilege, social justice, and oppression (Muhammad, 2020).

This principle also relates to how designers select, evaluate, and communicate the content included in a course. In creating quality, rigorous, standards-aligned curricula, designers specify deliberate learning goals for all content covered (Bransford et al., 2006; Parker & Lo, 2016). By creating these learning goals during the initial design, the curriculum designers can backward plan during development to ensure the rigor and integration of content and to communicate to those implementing the curriculum how the project covers the fundamental big ideas in a discipline (Krajcik & Shin, 2014; Wiggins & McTighe, 2005). Designers also make deliberate choices about which content is given value and ensure that the learning goals for the course do not reproduce inequities by honoring students' racial, cultural, and linguistic practices in the learning goals. Learning goals in PBL curricula focus on building deep understanding and engagement in productive disciplinary work, rather than solely focusing on standards, which can sometimes conflict with covering all the subject-area standards at a grade level. However, deliberate creation of projects with well-crafted learning goals can facilitate the process of supporting deep content learning while covering standards (Krajcik et al., 2007).

Learning goals in PBL curricula focus on building deep understanding and engagement in productive disciplinary work, rather than solely focusing on standards.

2C. Content Coherence

Building from the previous two principles, the content of the course as a whole in a PBL curriculum is coherent and strategically sequenced. To successfully understand content and skills, students need cycles of learning in which they come back to ideas, deepening and refining their conceptual understanding as well as connecting to related ideas (Schwartz & Bransford, 1998). The learning cycles not only build on subject knowledge but also include deliberate sequencing of SEL, equity, identity, and engagement goals. Using the backwards planning described in the section on the Content Integration principle, the deliberate sequencing of the learning goals within and across projects considers how students build from previous learning goals and experiences.

Parker et al. (2013) describe one aspect of the Content Coherence principle as "looping," whereby important concepts are revisited at multiple points throughout the course. Also known as spiraling content, students engage in a continuous process of connecting previous knowledge, practices, and skills into their current project. By repeatedly engaging with concepts in different project contexts, which provides a reason to learn from a variety of sources and experiences, learners are more likely to experience flexible transfer—the application of their learning to new and different situations (Parker et al., 2013; Schwartz & Bransford, 1998). This then allows them to cultivate their discipline-linked identities over the entire course (Nasir, 2012). In creating coherently sequenced content, the complexity needed for deep learning and criticality is still present. Considering ideas from multiple perspectives and understanding inequities, social justice, and issues of power are also built into the coherence of a course. Discussed in more depth in the sections on Curriculum Supports principles, the instructional materials highlight the coherence of the curriculum for teachers and students. Doing so gives teachers guideposts for exploring the complex ideas and allows students to understand how the activities all relate back to the big ideas of a unit (Krajcik et al., 2007; Reiser et al., 2017).

PUTTING THE PRINCIPLE INTO PRACTICE: CONTENT COHERENCE

In the KIA AP Gov. course, designers identified the core concepts and skills that are the foundation of the course. These core concepts (federalism, separation of powers, elections, interest groups, and civil rights) and skills (base political thinking on the constitution and appreciating the diversity of political opinions) loop within and across as students deepen their learning over not just a single project but throughout the whole course.

In ML-PBL, each unit has a science storyline document that illustrates how the project fits with the big-picture science content and how each lesson connects to core subject-area ideas and practices as well as SEL, equity, math, and literacy goals. To make this coherence visible to students, each lesson has its own driving question that directly ties back to the purpose of the project, and units provide multiple opportunities for students to discuss their progress toward answering the driving question.

The following questions allow designers to reflect on the ways a curriculum enacts the Content Coherence principle:

- To what extent are learning experiences deliberately sequenced across the course for grade-level subject-area, SEL, equity, and engagement goals?
- To what extent do cycles of learning within and between projects draw student connections to big ideas across the course and allow students to engage with ideas in different contexts, presenting ideas from a variety of sources, perspectives, and experiences?
- To what extent does the design of the coherent content maintain the degree of complexity needed for deep learning and criticality?
- In what ways do the materials make coherence visible to both teachers and students, allowing navigation of the learning cycles?
- In what ways does the curriculum support students' identities throughout the course through iterative connections to students' lives and the world and opportunities for students to make projects their own?

2D. Assessment

Assessment in PBL curricula is ongoing, authentic, and performance based. Opportunities for assessment are not exclusive to the core disciplinary content and include assessments of other valued areas, such as subject-area practices, interdisciplinary content and practices, and SEL. PBL is inherently a performance-based model in which students apply their learning to products and performances that teachers can evaluate for the purposes of feedback and student learning (Wiggins, 1989). Though this performance-based approach appears to emphasize the final summative product, frequent, formative performance-assessment opportunities allow teachers to regularly check for understanding and empower students to reflect and revise their thinking and work (Taylor & Nolen, 2008). In the highly collaborative learning environment of a PBL classroom, the design of assessments allows each individual to demonstrate understanding.

In PBL curricula, performance-based assessments are authentic, which means they are genuine, contextualized, and relevant to learners (Darling-Hammond et al., 1995). Curriculum designers embed these assessments within PBL projects rather than designate them as contrived, isolated tasks disconnected from the student's life. The opportunity to grapple with complex, realistic problems in a PBL curriculum requires the application of knowledge to a novel setting. When used properly, assessments also provide students with an opportunity for reflection, iteration, and inquiry. For teachers, authentic assessment offers information about learners' abilities and depth of knowledge to inform

instructional decisions. Authentic assessment in PBL projects includes connections to students' communities and the broader world, for example, through a presentation or submission to a diverse public audience in a related subject-area field. This then amplifies real-world connections and can reinforce identity when students see experts who "look like me" (Nasir & Saxe, 2003).

When designing PBL curricula, developers can use the authentic, performance-based assessment as the cornerstone for including the Content Integration and Content Coherence principles by backwards planning from assessments. The design of curriculum materials support teachers' evaluation of the ongoing formative performances and products with flexibility to use this information to adapt future lessons based on the outcomes of ongoing assessment. Finally, PBL designers should recognize the tensions between PBL curricula and traditional measures of accountability and, where possible, shift toward more impactful means of evaluating student learning.

PUTTING THE PRINCIPLE INTO PRACTICE: ASSESSMENT

Tangible artifact creation over the course of a project can serve as a tool for authentic, performance-based assessments. In ML-PBL, these artifacts include physical objects or drawn models, plays or short stories, and engineering solutions, presented to the community, that allow teachers to see student thinking and allow students to reflect on their learning. In the third-grade unit on motion, students design a moving toy. In preparing to do so, they draw a model of the motion of toys, which they iterate on to come up with their final design.

Similarly, the LTP curriculum emphasizes the use of the project as an embedded performance assessment, with authentic tasks for a group project and related individual tasks to assess students' understanding. For example, in a unit on energy, students work in groups to design a device that efficiently keeps something warm or heats something up, while individually students also write patent applications for the device as a summative assessment.

Project PLACE developers made community engagement central to their design. In the unit on civics and government, as noted earlier, students develop a proposal for improvements to a local park or public space, which is then presented to a local government official. This presentation to the official allows students to connect to their civic identity while providing an opportunity for them to demonstrate literacy achievement.

The following questions allow designers to reflect on the ways a curriculum enacts the Assessment principle:

- To what extent are assessments authentic with respect to alignment with the project, realistic disciplinary problems, and connections to students' communities and the broader world?
- Do students have the opportunity to engage in frequent formative assessment opportunities that generate feedback to inform teacher or student action?
- Do assessments include knowledge and skills beyond the disciplinary content, such as social and emotional skills and identity development?
- In what ways are visible and repeated structures used to engage students in metacognitive reflection on their assessments?
- To what extent are curriculum resources flexible and robust enough to allow teachers to make modifications or provide scaffolding based on formative or summative assessment data?

3. Curriculum Supports

Teaching PBL is complex. It involves deep content-area expertise, pedagogical knowledge, and a commitment to equity, which requires supportive curriculum materials. Similarly, students need supports and structures embedded in curriculum materials. This final category of PBL Design Principles answers the question, "How do the materials support teachers and students?" While the other principles can describe the experience of PBL in the classroom more broadly and independently of curriculum materials, these final two principles are unique to curriculum design.

3A. Access for Student Learning

With carefully designed materials, a PBL curriculum can promote deep learning and engagement by supporting each and every student in developing an understanding of content, ideas, and skills regardless of the learner's starting point. We highlight three ways in which this design principle can be accomplished in a PBL curriculum: (1) framing lessons and activities, (2) using appropriate scaffolds, and (3) designing learning materials to support equitable and inclusive learning.

Within a project and the course as a whole, routines and structures encourage students to create context and regularly situate students in the learning cycle, project, and connections to their lives. This concept of expansive framing for transfer (Engle, 2006; Engle et al., 2011, 2012) focuses on creating a context for learning in which students' prior knowledge is valued and applied to learning. Students use routines and structures within and across projects to create or reorient themselves to the project context, focusing on the goals of the project and questions that need answering. Included in this idea of framing is the view that each and every student has an active role within the classroom, and students can draw on their funds of knowledge from their homes and communities (Calabrese et al., 2008; Moll et al., 1992). This honors students' identities and communities while making learning relevant, applicable, and adaptable in the future.

Appropriate scaffolds and learning tools are necessary to ensure deep learning and engagement.

Appropriate scaffolds and learning tools are necessary to ensure deep learning and engagement. Teachers, peers, learning materials, and technology can provide scaffolds (Puntambekar & Hubscher, 2005), which include social interactions, structures, routines, worksheets, guiding questions, and project templates (Grant, 2002). In PBL that supports deep, equitable learning, scaffolds support disciplinary ideas and practices and other skills and aspects of learner development, such as social and emotional learning, identity, and criticality. Accompanied by high expectations, scaffolds should provide just enough support for students to reach the edge of their individual abilities and knowledge (Vygotsky, 1978). Using observation and formative assessments, teachers can determine the appropriate scaffolding for each student, thus helping students participate in activities otherwise perceived as beyond their ability (Krajcik & Shin, 2014). To allow students to still take on the majority of the cognitive work, these observations and ongoing formative assessments support teachers in deciding when to remove scaffolds. Additionally, for any course, regardless of subject area, curriculum materials need to support students' language use and learning. For non-native English speakers, supports can leverage first languages by recognizing them as assets to student thinking and by providing opportunities to engage in disciplinary thinking and practices in their native language (García, 2018).

High-quality curriculum materials provide equitable and inclusive access and include multimodal content and flexible materials. This idea is rooted in the learning sciences and the ways in which identity and context shape learning (Nasir et al., 2006). It recog-

nizes that students, regardless of their identities or backgrounds, are assets to leverage rather than deficits to fix (Banks et al., 2007). Drawing on ideas of Universal Design for Learning (Rose & Meyer, 2002), materials provide access to knowledge through different representations and allow for different means of expression. This inclusive, multimodal approach ensures equitable learning access and opportunity for each and every student.

PUTTING THE PRINCIPLE INTO PRACTICE: ACCESS FOR STUDENT LEARNING

Framing at the beginning and end of each lesson/activity situates learning explicitly within the contexts of the project, as well as within students' own ideas and lives. The KIA APES course includes framing steps for the teacher to use with students at the beginning and end of each lesson. These connect students to where they are in the learning and project cycle and allow for connections to their own lives.

COW provides student supports throughout the curriculum, including global, course-wide protocols and specific support steps within a lesson. These are explicitly called out in the teacher materials with strategies to teach each and every student so that all learners can access the content and be successful. COW used Universal Design for Learning as a guiding principle during course development to ensure that all instruction provides multiple means of representation, expression, and engagement.

The following questions allow designers to reflect on the ways a curriculum enacts the Access for Student Learning principle:

- To what extent do routines and structures encourage students to create context and situate them in the learning cycle, project, and connections to their lives?
- To what extent does the framing of lessons and activities draw on students' funds of knowledge and value cultural, racial, and linguistic identities?
- Does the curriculum offer scaffolds for disciplinary ideas and practices as well as other skills and aspects of learner development, such as social and emotional learning, identity, and criticality?
- To what extent do curriculum materials encourage modification of and adaptations to scaffolds to allow for the appropriate level of support for each learner?
- In what ways are students' language use and learning scaffolded, with a recognition of native languages as assets to student thinking?
- To what extent do curriculum materials recognize differences in how students learn, providing multimodal learning materials and viewing differences in students' means of expression as assets to leverage?

3B. Educative Supports for Teachers

PBL requires shifting teacher practice from traditional teacher-led instruction to a student-centered approach, with a learning partnership between teachers and students. Depending on an educator's existing practice, this shift might be large and require changes to content and pedagogical knowledge as well as teacher identity, beliefs, and values (Davis et al., 2017). Educative supports in curricula provide ongoing and explicit opportunities for teachers to learn within the instructional materials and can support this shift in practice (Davis et al., 2014). Educative supports embedded in curriculum materials are a part of teachers' daily practice, connect theory to practice, and improve teachers' instructional and assessment strategies (Ball & Cohen, 1996; Grossman & Thompson, 2004).

Novice and veteran teachers require support within curriculum materials to deepen their understanding in both disciplinary and pedagogical knowledge. In designing educative

curriculum materials, it is important that these resources "speak to" teachers about the ideas in a particular activity, rather than just guiding their actions (Remillard, 2000). By developing an understanding of the rationale for the features in a curriculum, teachers can make decisions on how to adapt the materials for their own classroom context—including considering students' strengths, needs, and identities—while keeping true to the pedagogical theories important to PBL. Materials can also highlight ways to modify a lesson or project. Providing an anticipatory list of what students might say or do in a specific instructional activity and how to deal with misconceptions or other challenges is one way to embed disciplinary learning for teachers (Davis & Krajcik, 2005). Educative supports can include navigation for the course structure, guides to highlight the big ideas of the unit, and materials that explain how concepts build upon one another across the course (Davis et al., 2014).

For educative materials to support the complex practice of teaching equitable PBL, they must include a broad range of pedagogical knowledge and practices. This includes, but is not limited to, student-centered learning, identity development, student engagement, equity-focus pedagogies (such as asset-based and culturally responsive), and social and emotional learning. Teachers need models and exemplars, along with supports and protocols for reflection, to aid them in understanding the pedagogical approaches and to shift their beliefs and identities toward an asset-based perspective of students at the

PUTTING THE PRINCIPLE INTO PRACTICE: EDUCATIVE SUPPORTS FOR TEACHERS

To support teachers in understanding how ideas build and the purpose for activities, ML-PBL provides a looping chart and detailed storyline document that lays out the way the content story develops for students. The storyline document connects each lesson activity to student assessments, standards, and learning goals related to literacy, math, SEL, and equity.

In the COW curriculum, each lesson includes a description of how the activities connect to PBL principles and other ideas, such as advocacy and empathy, that are connected to SEL and equity. Because of the consistent structure, teachers can connect what is happening in the classroom to their understanding of PBL instruction and the pedagogies that support it.

Finally, Project PLACE provides explanations embedded in the lesson text that act as a form of professional learning. This includes providing details about how a lesson might look, while still providing opportunities for student and teacher choice (Farmer, 2019; Halvorsen & Duke, 2017).

The following questions allow designers to reflect on the ways a curriculum enacts the Educative Supports for Teachers principle:

- Does the curriculum offer both deep-learning resources (e.g., readings) and daily activity support (e.g., anticipated misconceptions and essential background knowledge) to facilitate teachers' knowledge and skills acquisition?
- To what extent do embedded supports for teachers cover a broad range of pedagogical knowledge and practices, including identity, engagement, equity, and social and emotional learning?
- Does the curriculum provide rationales for features of the curriculum and explicit guidance on how to effectively adapt the materials to address the strengths, interests, and needs of all students?
- Are models, exemplars, or reflective exercises provided to facilitate teachers' shifts in beliefs and identities toward a student-centered, asset-based approach and a commitment to equity?
- In what ways are curriculum-based teacher supports connected to and leveraged in sustained, high-quality professional-learning opportunities?

center of learning (Davis et al., 2017). Though well-designed educative features embedded throughout the curriculum materials are vital to teachers' implementation of PBL and provide "just in time," on-demand support, they cannot stand alone. As discussed in more detail in the final recommendation in the section below on the design process, even the most effectively designed educative supports cannot replace sustained, high-quality professional-learning opportunities in which teachers are active learners in a collaborative community of practice.

Photo: All4Ed

Educative supports for teachers combined with high-quality sustained professional learning can help teachers to shift to PBL instructional practices.

Design Process Recommendations for PBL Curriculum

Understanding and applying the Design Principles and Critical Lenses is vital to creating PBL curricula, but equally as important is the process of design. In this section, we expand on the recommendations presented at the beginning of the paper. These recommendations build both from the pedagogical commitments described in the "Critical Lenses for PBL Curriculum Design" section as well as the design-based research approaches used to develop the exemplar curricula in this paper. In particular, the features of design-based implementation research (Penuel et al., 2011) and more explicitly equity-focused areas of design research—such as participatory design (Vakil et al., 2016) and community-based design (Bang et al., 2016)—are important for creating high-quality materials that elevate the ideals described in this paper. These recommendations recognize that the process of developing a curriculum is not independent from its implementation and that the process must support implementation.

RECOMMENDATION 1:

Use principles and lenses to guide design choices.

Without attention to all the lenses and principles, the curriculum would not be able to fully achieve the goals of deeper learning for all students.

In the previous sections, we describe the Design Principles and Critical Lenses curriculum designers need to consider when developing a curriculum. While we describe these lenses and principles as distinct ideas, it is important to recognize that they are interconnected and amplify each other. For example, designing for the Centrality of Projects and Content Integration principles naturally supports the Learner-Centered Approaches, especially the Purpose for Learning principle. Without attention to all the lenses and principles, the curriculum would not be able to fully achieve the goals of deeper learning for all students. More important, using the principles without the lenses would mean that the historical inequities of education and inattention to the whole child would continue to be reproduced and could do harm, especially to students from marginalized communities.

RECOMMENDATION 2:

Be critical and reflective in the development process.

We call out the importance of attuning to issues of equity within the design of PBL curricula. The Commitment to Equity lens, as well as the other three Critical Lenses identified in this paper, points the designer to view the Design Principles with a specific purpose. Put another way, the Critical Lenses require designers to reflect on this question as they use the Design Principles: "Am I using this Design Principle in the service of equity, identity, engagement, and social and emotional learning?" Designers' ability to be critical and reflective of their work, especially as it relates to understanding power and perspectives of those in historically marginalized communities (i.e., criticality), is vital to developing a PBL curriculum that supports the learning of each and every student. To help reflect and

critique at each stage of development, we provide a reflective design tool in the appendix that uses the questions posed in the "Putting Principles Into Practice" sections. This tool, which is organized around each principle, has examples of questions a designer might ask. These questions are not meant as a checklist but as a way to prompt thoughtful reflection throughout the design process.

RECOMMENDATION 3:

Teachers, students, and community participate in the process.

Designers must engage teachers, students, and their communities in the design process in ways that value their perspectives.

Designers must engage teachers, students, and their communities in the design process in ways that value their perspectives. In design teams of PBL curricula, teachers should participate as codesigners who work collaboratively with researchers and other experts. The developers of the Knowledge in Action AP Government PBL course included researchers at the University of Washington and teachers in the Bellevue School District. Having teachers as codesigners was a key principle in the initial course development (Parker et al., 2011). KIA and other PBL curricula emphasize equal participation of teachers, seeking to disrupt the often hierarchical processes involved when researchers collaborate with school districts and teachers (Adams et al., 2017). Codesign allows for effective revision of the curriculum based on teachers' implementation experiences (see the next recommendation).

Creating a curriculum that embodies the principles and lenses described, particularly in service of equity, requires understanding the perspectives of students and their communities. While rare in curriculum development, valuing student and community voices is imperative to meet the goals of equitable curricula and the pedagogical commitments described in the Critical Lenses (Cheng et al., 2021). For example, effectively connecting to students' lives requires hearing the voices of those students for whom the curriculum is designed to ensure it is authentic. And just as students who use the curriculum materials will be from a range of backgrounds, those who contribute to the design process should represent varied backgrounds too. Engaging communities during design has also been uncommon but is important for supporting equitable educational experiences that value and connect with students' identities (Bang et al., 2010). Bringing students and communities into the design process requires criticality and building trust (Bang et al., 2016; Tierney et al., 2021; Vakil et al., 2016). With the aim of educational equity, it is important to be aware of who contributes and has decision-making power in curriculum design and who is currently excluded from the process (Bang et al., 2018).

RECOMMENDATION 4:

Take an iterative approach to design.

Cycles of classroom implementation and feedback from teachers and students should inform PBL curriculum design. In many of the exemplar PBL curricula referenced in this paper, this iteration occurs over multiple years. Feedback comes from teacher codesigners as well as other pilot and field-testing classrooms and is a hallmark of the design-based implementation research approach through which these curricula were developed (Penuel et al., 2011). The cycles of revision allow the complex interplay of principles and lenses presented here to be strengthened over time. Revision based on teacher and student experience allows for multiple perspectives to emerge, thereby creating a curriculum that is engaging and equitable. The iterative process allows the curriculum to stay relevant to students' lives in the constantly changing world. Often, over the lifetime of a curriculum, materials will require revision to support new local contexts and allow for even more

adaptation and flexibility. This means that for a PBL curriculum that will be used in a wide range of classroom contexts over many years, designers should build in a process for regular revisions after the initial design phase. In all cycles of revision, designers should make sure the diversity of students and teachers giving feedback are representative of the students and teachers we hope will engage with the curriculum.

RECOMMENDATION 5:

Allow for adaptation and flexibility in the curricula.

Many of the principles and lenses described here require an approach to curriculum design and implementation that is responsive to the students' identities, strengths, and interests. This means that a teacher must be able to flexibly adapt a project or activity to local contexts and student needs. Further, because the goal of designing curriculum materials is to change instructional practices through systemic implementation, primarily at the school and district level, this same flexibility is required to address the needs of schools and districts. Rather than being a scripted lesson plan with an expectation of fidelity to what is written, the curriculum materials can provide choices for teachers and districts and guidance for productive adaptations. This requires designers to carefully consider projects and activities that teachers can more easily modify (Squire et al., 2003) and to choose texts, tools, and resources that are adaptable and do not create barriers to access.

A teacher must be able to flexibly adapt a project or activity to local contexts and student needs.

As described in the Educative Supports for Teachers principle, curriculum materials for teachers can include educative features that provide background on and rationale for content and pedagogy to allow teachers, as well as schools and districts, to make productive adaptations. Materials should also call out which elements of the curriculum are fixed and which are flexible. The ability to adapt materials while maintaining the integrity of the PBL principles and lenses requires teachers, as well as school and district leaders, to have a high level of understanding of pedagogical, equity, and disciplinary knowledge. Employing this complex set of abilities often requires support from professional-learning experiences (Beyer & Davis, 2012).

RECOMMENDATION 6.

Develop curricula with professional learning in mind.

Though a curriculum can provide high-quality instructional materials for both teachers and students, that is only part of the equation. The shift in teacher practice required for PBL that is equitable and supports whole-child development requires strong professional-learning experiences for teachers. Therefore, while not the focus of this paper, it is important that curriculum designers plan for how they will support teacher practice beyond the confines of the instructional materials. Well-designed, well-delivered, sustained professional-learning opportunities are necessary to make a curriculum come alive for teachers and support teaching practices (Schuchardt et al., 2017). If scale and more systemic uptake of PBL curricula is the goal, then schools and districts must also be able to implement these professional-learning materials developed alongside curriculum materials. For a detailed examination of the way professional learning supported teacher implementation of the KIA curriculum, see "**High-Quality Professional Learning for Project-Based Learning** ." Approaching the design process with professional learning in mind strengthens not only the professional-learning opportunities but also the teacher supports embedded in curriculum materials.

Conclusion

This paper describes the key Design Principles and Critical Lenses required to develop project-based learning curricula and makes recommendations for designing equitable, deeper-learning experiences for students. These principles, divided into three categories, describe PBL curricula that have (1) learner-centered approaches to support purposeful, authentic learning that values students' voices and encourages collaboration and reflection; (2) course structures that deeply integrate coherent and authentically assessed content in projects; and (3) curriculum supports for students and teachers to enable the deep learning and practice shifts needed. While Design Principles provide guidance for curriculum design, developers can often interpret and enact the Design Principles in a variety of ways. Therefore, the Critical Lenses align the pedagogical commitments needed to interpret the principles in a way that promotes the goal of equitable, deeper learning that attends to the development of the whole child. To further support the development of PBL curricula, we also provide recommendations on the design process. Following these recommendations will support the development of a curriculum that affirms the commitments to equity and deeper learning.

Creating a PBL curriculum that perfectly captures all aspects of each Design Principle and Critical Lens is challenging, especially when developers must also take into account specific priorities and contexts for their curriculum.

Creating a PBL curriculum that perfectly captures all aspects of each Design Principle and Critical Lens is challenging, especially when developers must also take into account specific priorities and contexts for their curriculum. For example, while the principles as described here have strong evidence that they are effective in science, English language arts, and social studies classrooms, it may be that PBL in a mathematics classroom would require somewhat different interpretations of the principles. However, regardless of its contexts, a curriculum that prioritizes deeper learning and equity must draw on all the principles and lenses as they encompass pedagogical best practices and draw on evidence of how students learn.

Designing a curriculum that embodies equity and deeper learning requires designers to push on the traditional structures of education. Indeed, one motivator for designing PBL curricula is large-scale systems change. For example, while curriculum designers may not have the power to change required content standards, they may push beyond standards by prioritizing deeper learning and whole-child development and by deemphasizing standards that are problematic and perpetuate historic inequities. We hope this paper ensures that regardless of who the curriculum designers are or their specific context for writing, there will be a shared understanding about the goals of creating PBL curricula that supports the development of all students and provides equitable experiences in deeper learning.

APPENDIX:
Tool to Guide PBL Curriculum Design

This tool is a companion to LER's white paper *Designing Project-Based Learning Curricula*. In the paper, we present a series of recommendations related to the process of creating PBL curricula. These recommendations are key to creating equitable project-based learning that engages each and every student in deep learning. This design tool is intended primarily to help developers to use the principles and lenses and to be reflective during the design process. This tool is also important to the iterative approach, which requires continuous improvement of the curriculum at all stages of development.

This tool provides reflective questions curriculum designers can use to guide and refine the development of a PBL curriculum. It is organized around the Design Principles (the basic guideposts for curriculum development). We used the Critical Lenses (Commitment to Equity, Identity Development, Student Engagement, and Social and Emotional Learning) to shape the questions themselves. The paper describes the complex interplay of the different principles and lenses and offers examples of what they look like in practice. For this reason, the tool should be used alongside the paper rather than independently.

Curriculum designers can consider the questions in this tool at each stage of the design process—when first choosing content through finalizing the materials teachers will use in their classrooms—and at every level—designing the whole course, each project, and each activity. These questions are not meant as a checklist of things to include in a PBL curriculum but allow designers to consider if the principles are fully developed and how they have integrated the lenses into the design. Therefore, the tool provides space for specific examples from the curriculum that demonstrate how the principle is put into practice, rather than an evaluation of the curriculum with a score or rubric.

1 Principles of Learner-Centered Approaches

Questions for Reflection		Evidence From Curriculum
1A.	**Purpose for Learning:** Projects provide students with a reason for learning by engaging them in experiences that connect their own ideas to the project's problem or question before deeply exploring the content.	
1A.1	In what ways does the beginning of the project engage students with a complex problem, question, or context from which students can connect to a reason for learning content, social and emotional skills, and equity practices?	
1A.2	In what ways does the problem, question, or context given to engage students value and amplify the diversity of experiences and identities of the students?	
1A.3	What opportunities do students have to draw on prior knowledge and their racial, cultural, historical, personal, and community funds of knowledge at the launch of and throughout the project?	

Questions for Reflection		Evidence From Curriculum
1A.4	To what extent are students continuously connecting back to the problem, question, or context that gives a purpose for their learning over the course of the project?	
1B.	**Authenticity:** Projects are relevant to students' lives, families, and communities and connect to the world outside the classroom, especially to tasks, roles, and practices of the discipline.	
1B.1	To what extent is students' perceived relevance of the projects considered in curriculum design for students across a range of communities and backgrounds?	
1B.2	Do students have the opportunity to engage in authentic expert practices, such as real-world tasks, roles, tools, and/or processes?	
1B.3	In what ways are approaches to authenticity rooted in students' cultures and identities in positive and affirming ways that allow students to explore their personal and disciplinary identities both within and across projects?	
1B.4	To what extent are materials flexible to allow teachers to connect the learning to students' lives, families, communities, and values outside of school?	
1B.5	Do students have the opportunity to critically examine and understand power, privilege, social justice, and oppression as they connect to authentic practice in the world?	
1C.	**Student Agency:** The course design allows students to make substantive and consequential choices in their projects as well to apply the work and learning to their daily lives.	
1C.1	What opportunities do students have to make consequential choices in how they complete project tasks to allow for student ownership and independent design?	
1C.2	To what extent do projects and tasks in which students are making substantive choices include and value knowledge and experiences of each and every student's practices and ideas?	
1C.3	To what extent do curriculum materials provide supports for teachers to recognize and honor all students' voices?	
1C.4	What opportunities do students have to connect their work on a project to the impact that their actions can and do have on the world?	
1C.5	In what ways do course materials provide explicit supports for students' social and emotional learning related to making decisions and choices in the projects?	
1D.	**Collaboration:** Throughout projects, students work together on problems in purposeful and supported ways and create a community of active learners that includes students and their teacher.	
1D.1	What opportunities do students have to work together on significantly complex discipline-based problems with supports that allow students to engage with disciplinary ideas and practices?	

Questions for Reflection		Evidence From Curriculum
1D.2	To what extent do students have adequate group-work time to engage in interdependent learning and product or task development?	
1D.3	In what ways are students building upon previous collaborative skills or experiences from project to project?	
1D.4	In what ways are social and emotional learning and practices related to effective collaboration explicitly taught, supported through routines and scaffolds, and revisited throughout the course?	
1D.5	To what extent is collaboration scaffolded to disrupt negative and inequitable roles and identities, including the provision of tools to confront interpersonal conflict and address race and racism in small-group settings?	

1E.	**Metacognition:** Students have opportunities to build and use metacognitive skills to reflect on what and how they have learned, including disciplinary ideas as well as other skills and practices.	
1E.1	To what extent are metacognitive skills outlined explicitly as content to be taught and assessed throughout the curriculum?	
1E.2	To what extent are consistent tools and routines used to support metacognitive reflection in an ongoing way?	
1E.3	In what ways are metacognitive skills directly connected to the content and context for learning set forth in the project (e.g., the use of the skill of questioning to support the inquiry process or generation of inquiry questions)?	
1E.4	To what extent is metacognition used as a tool to support the development of social and emotional learning?	
1E.5	Do students have the opportunity to reflect on identities, content knowledge, skills development, and their learning process?	

2 Principles of Course Structures

Questions for Reflection		Evidence From Curriculum
2A.	**Centrality of Projects:** The projects are integral to learning by framing the entire process of and purpose for learning. A PBL course embeds all content in projects.	
2A.1	To what extent does learning of all content—including disciplinary concepts, skills, and social and emotional learning—occur within the context of a project?	
2A.2	In what ways do students make meaningful progress throughout the unit toward the completion of their project?	
2A.3	To what extent do students engage in projects throughout the course?	
2A.4	To what extent does the framing around the purpose of lessons and activities rely on the project rather than needing to be done for the sake of school?	

Questions for Reflection		Evidence From Curriculum
2B.	**Content Integration:** The curriculum integrates projects with core disciplinary ideas and practices. It also specifies learning goals aligned with standards as well as other essential content, such as literacy, social and emotional learning, and equity.	
2B.1	To what extent do the project tasks and experiences integrate subject-area ideas and practices as well as make connections to other subjects and foster an understanding and critique of inequities?	
2B.2	In what ways does the course content honor students' diverse cultural, racial, and linguistic practices and perspectives?	
2B.3	To what extent do the curriculum materials specify explicit learning goals directly related to the project that draw connections to both subject-area standards as well as literacy, SEL, and equity?	
2B.4	To what extent are learning goals focused on building a deep understanding of and engagement in productive disciplinary work as well as standards?	
2B.5	To what extent does the course content support learners' development of identities by linking course content to students' lives and authentic connections to the world?	
2C.	**Content Coherence:** The content of a PBL course is strategically sequenced to deepen understanding as students' progress through the course, revisiting and connecting ideas across projects.	
2C.1	To what extent are learning experiences deliberately sequenced across the course for grade-level subject-area, SEL, equity, and engagement goals?	
2C.2	To what extent do cycles of learning within and between projects draw student connections to big ideas across the course and allow students to engage with ideas in different contexts, presenting ideas from a variety of sources, perspectives, and experiences?	
2C.3	To what extent does the design of the coherent content maintain the degree of complexity needed for deep learning and criticality?	
2C.4	In what ways do the materials make coherence visible to both teachers and students, allowing navigation of the learning cycles?	
2C.5	In what ways does the curriculum support students' identities throughout the course through iterative connections to students' lives and the world and opportunities for students to make projects their own?	
2D.	**Assessment:** The curriculum provides ongoing opportunities for assessing learning of disciplinary, social and emotional, and other essential skills and ideas that are performance based and authentically embedded in the work students are doing.	
2D.1	To what extent are assessments authentic with respect to alignment with the project, realistic disciplinary problems, and connections to students' communities and the broader world?	

Questions for Reflection		Evidence From Curriculum
2D.2	Do students have the opportunity to engage in frequent formative assessment opportunities that generate feedback to inform teacher or student action?	
2D.3	Do assessments include knowledge and skills beyond the disciplinary content, such as social and emotional skills and identity development?	
2D.4	In what ways are visible and repeated structures used to engage students in metacognitive reflection on their assessments?	
2D.5	To what extent are curriculum resources flexible and robust enough to allow teachers to make modifications or provide scaffolding based on formative or summative assessment data?	

3 Principles of Curriculum Supports

Questions for Reflection		Evidence From Curriculum
3A.	**Access for Student Learning:** The curriculum provides appropriate scaffolds and tools to support learning, with access points for all students, including explicit framing for lessons, scaffolds for disciplinary and social and emotional learning, and multimodal content.	
3A.1	To what extent do routines and structures encourage students to create context and situate them in the learning cycle, project, and connections to their lives?	
3A.2	To what extent does the framing of lessons and activities draw on students' funds of knowledge and value cultural, racial, and linguistic identities?	
3A.3	Does the curriculum offer scaffolds for disciplinary ideas and practices as well as other skills and aspects of learner development, such as social and emotional learning, identity, and criticality?	
3A.4	To what extent do curriculum materials encourage modification of and adaptations to scaffolds to allow for the appropriate level of support for each learner?	
3A.5	In what ways are students' language use and learning scaffolded, with a recognition of native languages as assets to student thinking?	
3A.6	To what extent do curriculum materials recognize differences in how students learn, providing multimodal learning materials and viewing differences in students' means of expression as assets to leverage?	

Questions for Reflection		Evidence From Curriculum
3B.	**Educative Supports for Teachers:** The curriculum materials support teachers in deepening their disciplinary, pedagogical, and equity understanding in ways that embed the resources in a teacher's daily practice and allow teachers to effectively adapt to their own contexts and students.	
3B.1	Does the curriculum offer both deep-learning resources (e.g., readings) and daily activity support (e.g., anticipated misconceptions and essential background knowledge) to facilitate teachers' knowledge and skills acquisition?	
3B.2	To what extent do embedded supports for teachers cover a broad range of pedagogical knowledge and practices, including identity, engagement, equity, and social and emotional learning?	
3B.3	Does the curriculum provide rationales for features of the curriculum and explicit guidance on how to effectively adapt the materials to address the strengths, interests, and needs of all students?	
3B.4	Are models, exemplars, or reflective exercises provided to facilitate teachers' shifts in beliefs and identities toward a student-centered, asset-based approach and a commitment to equity?	
3B.5	In what ways are curriculum-based teacher supports connected to and leveraged in sustained, high-quality professional-learning opportunities?	

REFERENCES

Adams, C. M., Lo, J. C., Goodell, A., & Nachtigal, S. (2017). **Shifting pedagogy in an AP U.S. Government and Politics classroom: A DBIR exploration of teacher growth**. *Teaching and Teacher Education*, *64*, 79–92.

Agarwal, P., & Sengupta-Irving, T. (2019). **Integrating power to advance the study of connective and productive disciplinary engagement in mathematics and science**. *Cognition and Instruction*, *37*(3), 349–366.

Aguirre, J. M., & del Rosario Zavala, M. (2013). **Making culturally responsive mathematics teaching explicit: A lesson analysis tool**. *Pedagogies*, *8*(2), 163–190.

Appleton, J. J., Christenson, S. L., & Furlong, M. J. (2008). **Student engagement with school: Critical conceptual and methodological issues of the construct**. *Psychology in the Schools*, *45*(5), 369–386.

Azmitia, M. (1996). Peer interactive minds: Developmental, theoretical, and methodological issues. In P. B. Baltes & U. M. Staudinger (Eds.), *Interactive minds: Life-span perspectives on the social foundation of cognition* (pp. 133–162). Cambridge University Press.

Baines, A., DeBarger, A., De Vivo, K., Warner, N., Santos, S., Brinkman, J., Udall, D., Zuckerbrod, N., Felson, K., & Urban, R. (2021a). ***Key principles for project-based learning*** [White paper]. Lucas Education Research.

Baines, A., De Vivo, K., Warner, N., DeBarger, A., Udall, D., Zuckerbrod, N., & Felson, K. (2021b). ***Why social and emotional learning is essential to project-based learning*** [White paper]. Lucas Education Research.

Ball, D. L., & Cohen, D. K. (1996). **Reform by the book: What is—or might be—the role of curriculum materials in teacher learning and instructional reform?** *Educational Researcher*, *25*(9), 6–8.

Bang, M., Curley, L., Kessel, A., Marin, A., & Suzokovich, E. (2014). **Muskrat theories, tobacco in the streets, and living Chicago as Indigenous lands**. *Environmental Education Research*, *20*(1), 37–55.

Bang, M., Faber, L., Gurneau, J., Marin, A., & Soto, C. (2016). **Community-based design research: Learning across generations and strategic transformations of institutional relations toward axiological innovations**. *Mind, Culture, and Activity*, *23*(1), 28–41.

Bang, M., Marin, A., & Medin, D. (2018). **If Indigenous peoples stand with the sciences, will scientists stand with us?** *Daedalus*, *147*(2), 148–159.

Bang, M., Medin, D., Washinawatok, K., & Chapman, S. (2010). Innovations in culturally based science education through partnerships and community. In M. Khine & I. Saleh (Eds.), *New science of learning: Cognition, computers and collaboration in education*. Springer.

Banks, J. A., Au, K. H., Ball, A. F., Bell, P., Gordon, E. W., Gutiérrez, K. D., Brice Heath, S., Lee, C. D., Lee, Y., Mahiri, J., Suad Nasir, N., Valdés, G., & Zhou, M. (2007). *Learning in and out of school in diverse environments: Life-long, life-wide, life-deep*. The LIFE Center, University of Washington, Stanford University, and SRI International; Center for Multicultural Education, University of Washington, Seattle.

Barajas-López, F., & Bang, M. (2018). **Indigenous making and sharing: Claywork in an Indigenous STEAM program**. *Equity & Excellence in Education*, *51*(1), 7–20.

Barron, B., & Darling-Hammond, L. (2008). Teaching for meaningful learning: A review of research on inquiry-based and cooperative learning. In L. Darling-Hammond, B. Barron, P. D. Pearson, A. H. Schoenfeld, E. K. Stage, T. D. Zimmerman, G. N. Cervetti, & J. L. Tilson (Eds.), *Powerful learning: What we know about teaching for understanding* (pp. 11–70). Jossey-Bass.

Beyer, C. J., & Davis, E. A. (2012). **Learning to critique and adapt science curriculum materials: Examining the development of preservice elementary teachers' pedagogical content knowledge**. *Science Education*, *96*(1), 130–157.

Blumenfeld, P. C., Marx, R. W., Soloway, E., & Krajcik, J. (1996). **Learning with peers: From small group cooperation to collaborative communities**. *Educational Researcher*, *25*(8), 37–39.

Boardman, A. G., Garcia, A., Dalton, B., Polman, J. L. (2021). *Compose our world: Project-based learning in secondary education language arts*. Teachers College Press.

Boss, S., & Larmer, J. (2018). *Project based teaching: How to create rigorous and engaging learning experiences*. ASCD; Buck Institute for Education.

Bransford, J. D., Vye, N. J., Stevens, R., Kuhl, P., Schwartz, D., Bell, P., Meltzoff, A., Barron, B., Pea, R., Reeves, B., Roschelle, J., & Sabelli, N. (2006). Learning theories and education: Toward a decade of synergy. In P. A. Alexander & P. H. Winne (Eds.), *Handbook of educational psychology* (2nd ed., pp. 209–244). Lawrence Erlbaum Associates.

Brown, M. R., Higgins, K., & Paulsen, K. (2003). **Adolescent alienation: What is it and what can educators do about it?** *Intervention in School and Clinic*, *39*(1), 3–9.

Calabrese Barton, A., & Tan, E. (2010). **We be burnin'! Agency, identity, and science learning**. *Journal of the Learning Sciences, 19*(2), 187–229.

Calabrese Barton, A. C., Tan, E., & Rivet, A. (2008). **Creating hybrid spaces for engaging school science among urban middle school girls**. *American Educational Research Journal*, *45*(1), 68–103.

Cheng, B. H., Clark, T. L., Allen, C. D., Garcia, A. G., Scipio, D., De Vivo, K., & Paulger, C. (2021). *Equity-centered project-based learning* [White paper]. Lucas Education Research.

Chi, M. T. H. (2009). **Active-constructive-interactive: A conceptual framework for differentiating learning activities**. *Topics in Cognitive Science*, *1*(1), 73–105.

Chi, M.T.H., Adams, J., Bogusch, E. B., Bruchok, C., Kang, S., Lancaster, M., Levy, R., Li, N., McEldoon, K. L., Stump, G. S., Wylie, R., Xu, D., & Yaghmourian, D. L. (2018). **Translating the ICAP theory of cognitive engagement into practice**. *Cognitive Science*, *42*(6), 1777–1832.

Clarke, S. N. (2015). The right to speak. In S. N. Clarke, L. B. Resnick, & C. S. C. Asterhan (Eds.), ***Socializing intelligence through academic talk and dialogue*** (pp. 167–180). American Educational Research Association.

Cohen, E. G., & Lotan, R. A. (1997). *Working for equity in heterogeneous classrooms: Sociological theory in practice*. Teachers College Press.

Condliffe, B., Quint, J., Visher, M. G., Bangser, M. R., Drohojowska, S., Saco, L., & Nelson, E. (2017). *Project-based learning: A literature review*. MDRC.

Darling-Hammond, L., Ancess, J., & Falk, B. (1995). *Authentic assessment in action: Studies of schools and students at work*. Teachers College Press.

Darling-Hammond, L., Barron, B., Pearson, P. D., Schoenfeld, A. H., Stage, E. K., & Zimmerman, T. (2008). *Powerful learning: What we know about teaching for understanding*. John Wiley and Sons.

Darling-Hammond, L., & Cook-Harvey, C. M. (2018). ***Educating the whole child: Improving school climate to support student success***. Learning Policy Institute.

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020.) **Implications for educational practice of the science of learning and development**. *Applied Developmental Science*, *24*(2), 97–140.

Davis, E. A., & Krajcik, J. S. (2005). **Designing educative curriculum materials to promote teacher learning**. *Educational Researcher*, *34*(3), 3–14.

Davis, E. A., Palincsar, A. S., Arias, A. M., Bismack, A. S., Marulis, L. M., & Iwashyna, S. K. (2014). **Designing educative curriculum materials: A theoretically and empirically driven process**. *Harvard Educational Review*, *84*(1), 24.

Davis, E. A., Palincsar, A. S., Smith, P. S., Arias, A. M., & Kademian, S. M. (2017). **Educative curriculum materials: Uptake, impact, and implications for research and design**. *Educational Researcher*, *46*(6), 293–304.

Deutscher, R., Holthuis, N., Maldonado, S., Pecheone, R., Schultz, S., & Chung Wei, R. (2021). ***Learning through performance: Project-based learning as a lever for engaging the Next Generation Science Standards***. Lucas Education Research.

Duke, N. K. (2016). **Project-based instruction: A great match for informational texts**. *American Educator*, *40*(3), 4–11, 42.

Duke, N. K., Halvorsen, A. L., Strachan, S. L., Kim, J., Konstantopoulos, S. (2021). **Putting PjBL to the test: The impact of project-based learning on second graders' social studies and literacy learning and motivation in low-SES school settings**. *American Educational Research Journal*, *58*(1), 160–200.

Durlak, J. A. (Ed.). (2015). *Handbook of social and emotional learning: Research and practice*. Guilford Publications.

Durlak, J. A., Weissberg, R. P., Dymnicki, A. B., Taylor, R. D., & Schellinger, K. B. (2011). **The impact of enhancing students' social and emotional learning: A meta-analysis of school-based universal interventions**. *Child Development*, *82*(1), 405–432.

Engle, R. A. (2006). **Framing interactions to foster generative learning: A situative explanation of transfer in a community of learners classroom**. *Journal of the Learning Sciences*, *15*(4), 451–498.

Engle, R. A. (2012). The productive disciplinary engagement framework: Origins, key concepts, and developments. In D. Dai (Ed.), *Design research on learning and thinking in educational settings: Enhancing intellectual growth and functioning* (pp. 170–209). Routledge.

Engle, R. A., & Conant, F. R. (2002). **Guiding principles for fostering productive disciplinary engagement: Explaining an emergent argument in a community of learners classroom**. *Cognition and Instruction*, *20*(4), 399–483.

Engle, R. A., Lam, D. P., Meyer, X. S., & Nix, S. E. (2012). **How does expansive framing promote transfer? Several proposed explanations and a research agenda for investigating them**. *Educational Psychologist*, *47*(3), 215–231.

Engle, R. A., Nguyen, P. D., & Mendelson, A. (2011). **The influence of framing on transfer: Initial evidence from a tutoring experiment**. *Instructional Science*, *39*(5), 603–628.

Farmer, S. O. (2019). ***Investigating the work of translating guidance from curriculum materials into instructional interaction*** [Unpublished doctoral dissertation]. University of Michigan.

Fitzgerald, M. (2020). **Overlapping opportunities for social-emotional and literacy learning in elementary-grade project-based instruction**. *American Journal of Education*, *126*(4), 573–601.

Flores-Gonzalez, N. (2002). *School kids/street kids: Identity development in Latino students*. Teachers College Press.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). **School engagement: Potential of the concept, state of the evidence**. *Review of Educational Research*, *74*(1), 59–109.

Fusco, E., & Fountain, G. (1992). Reflective teacher, reflective learner. In A. L. Costa, J. A. Bellanca, & R. Fogarty (Eds.), *If minds matter: A foreword to the future* (Vol. 1, pp. 239–255). IRI/21 Skyline Publishing.

Garcia, A., Guggenheim, A., Stamatis, K., & Dalton, B. (2020). **Glimmers of care: Attending to the affective everyday in ninth-grade literacy classrooms**. *Reading Research Quarterly*, *56*(2), 337–354.

García, O. (2018). Translanguaging, pedagogy and creativity. In J. Erfurt, E. Carporal, & A. Weirich (Eds.), *Éducation plurilingue et pratiques langagiéres: Hommage à Christine Hélot* (pp. 39–56). Peter Lang.

Gay, G. (2018). *Culturally responsive teaching theory, research, and practice*. Teachers College Press.

González, N., Moll, L. C., & Amanti, C. (2005). *Funds of knowledge: Theorizing practices in households, communities, and classrooms*. Lawrence Erlbaum Associates.

Goodenow, C. (1993). **The psychological sense of school membership among adolescents: Scale development and educational correlates**. *Psychology in the Schools*, *30*(1), 79–90.

Grant, M. M. (2002). **Getting a grip on project-based learning: Theory, cases and recommendations**. *Meridian: A Middle School Computer Technologies Journal*, *5*.

Grossman, P., & Thompson, C. (2004). ***Curriculum materials: Scaffolds for new teacher learning? A research report*** (Document R-04-1). Center for the Study of Teaching and Policy.

Halvorsen, A., & Duke, N. (2017, June 20). **Projects that have been put to the test**. Edutopia.

Halvorsen, A., Duke, N. K., Brugar, K. A., Block, M. K., Strachan, S. L., Berka, M. B., & Brown, J. M. (2012). Narrowing the achievement gap in second-grade social studies and content area literacy: The promise of a project-based approach. *Theory and Research in Social Education*, *40*(3), 198–229.

Hammond, Z. (2015). *Culturally responsive teaching and the brain: Promoting authentic engagement and rigor among culturally and linguistically diverse students*. Corwin.

Holland, D., Lachicotte, W., Skinner, D., & Cain, C. (1998). *Identity and agency in cultural worlds*. Harvard University Press.

Hollie, S. (2011). *Culturally and linguistically responsive teaching and learning: Classroom practices for student success*. Shell Educational Publishing.

Holthuis, N., Deutscher, R., Schultz, S., & Jamshidi, A. (2018). The new NGSS classroom: A curriculum framework for project-based science learning. *American Educator*, *42*(2), 23–27.

Huberman, M., Bitter, C., Anthony, J., & O'Day, J. (2014). The shape of deeper learning: Strategies, structures, and cultures in deeper learning network high schools (Findings from the Study of Deeper Learning Opportunities and Outcomes: Report 1). American Institutes for Research.

Jagers, R. J., Rivas-Drake, D., & Williams, B. (2019) Transformative social and emotional learning (SEL): Toward SEL in service of educational equity and excellence. *Educational Psychologist*, *54*(3), 162–184.

Krajcik, J. S., & Blumenfeld, P. C. (2006). Project-based learning. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences*. Cambridge University Press.

Krajcik, J., McNeill, K. L., & Reiser, B. J. (2007). Learning-goals-driven design model: Developing curriculum materials that align with national standards and incorporate project-based pedagogy. *Science Education*, *92*(1), 1–32.

Krajcik, J., & Schneider, B. (Eds.). (2021). *Science education through multiple literacies: Project-based learning in elementary school*. Harvard Education Press.

Krajcik, J., Schneider, B., Miller, E., Chen, I., Bradford, L., Bartz, K., Baker, Q., Palincsar, A., Peek-Brown, D., & Codere, S. (2021). *Assessing the effect of project-based learning on science learning in elementary schools* [Technical report]. Lucas Education Research.

Krajcik, J., & Shin, N. (2014). Project-based learning. In R. Sawyer (Ed.), *The Cambridge Handbook of the Learning Sciences* (pp. 275–297). Cambridge University Press.

Kurth, L. A., Anderson, C. W., & Palincsar, A. S. (2002). The case of Carla: Dilemmas of helping all students to understand science. *Science Education*, *86*(3), 287–313.

Ladson-Billings, G. (1994). *The dreamkeepers*. Jossey-Bass.

Ladson-Billings, G. (2006). From the achievement gap to the education debt: Understanding achievement in U.S. schools. *Educational Researcher*, *35*(7), 3–12.

Lei, H., Cui, Y., & Zhou, W. (2018). Relationships between student engagement and academic achievement: A meta-analysis. *Social Behavior and Personality: An International Journal*, *46*(3), 517–528.

Li, T., Miller, E., Chen, I. C., Bartz, K., Codere, S., & Krajcik, J. (2021). The relationship between teacher's support of literacy development and elementary students' modelling proficiency in project-based learning science classrooms. *Education 3-13*, *49*(3), 302–316.

Lo, J. C. (2017). Adolescents developing civic identities: Sociocultural perspectives on simulations and role-play in a civic classroom. *Theory & Research in Social Education*, *45*(2), 189–217.

Lo, J. C., & Tierney, G. (2017). Maintaining interest in politics: "Engagement first" in a U.S. high school government course. *Journal of Social Science Education*, *16*(3), 62–73.

Lotan, R. (2003). Group-worthy tasks. *Educational Leadership: Journal of the Department of Supervision and Curriculum Development, N.E.A.*, *60*(6), 72–75.

McCormick, C. B., Dimmitt, C., & Sullivan, F. R. (2012). Metacognition, learning, and instruction. In I. B. Weiner (Series Ed.), *Handbook of Psychology* (2nd ed.): *Vol. 7. Educational psychology* (pp. 69–98).

Miller, E. C., & Krajcik, J. S. (2019). Promoting deep learning through project-based learning: A design problem. *Disciplinary and Interdisciplinary Science Education Research*, *1*(1).

Mirra, N., & Garcia, A. (2020). "I hesitate but I do have hope": Youth speculative civic literacies for troubled times. *Harvard Educational Review*, *90*(2), 295–321.

Moll, L. C., Amanti, C., Neff, D., & Gonzalez, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. *Theory Into Practice*, *31*(2), 132–141.

Muhammad, G. (2020). *Cultivating genius: An equity framework for culturally and historically responsive literacy*. Scholastic.

Muhammad, G. E. (2018). A plea for identity and criticality: Reframing literacy learning standards through a four-layered equity model. *Journal of Adolescent & Adult Literacy*, *62*(2), 137–142.

Nasir, N. S. (2012). *Racialized identities: Race and achievement among African American youth*. Stanford University Press.

Nasir, N. S., & Hand, V. (2008). From the court to the classroom: Opportunities for engagement, learning, and identity in basketball and classroom mathematics. *Journal of the Learning Sciences*, *17*(2), 143–179.

Nasir, N. S., Rosebery, A. S., Warren, B., & Lee, C. D. (2006). Learning as a cultural process: Achieving equity through diversity. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 489–504). Cambridge University Press.

Nasir, N. S., & Saxe, G. B. (2003). Ethnic and academic identities: A cultural practice perspective on emerging tensions and their management in the lives of minority students. *Educational Researcher*, *32*(5), 14–18.

National Commission on Social, Emotional, and Academic Development. (2019). *From a nation at risk to a nation at hope*.

National Research Council. (2000). *How people learn: Brain, mind, experience, and school* (Expanded edition). The National Academies Press.

National Research Council. (2012). *Education for life and work: Developing transferable knowledge and skills in the 21st century*. The National Academies Press.

Paris, D., & Alim, H. S. (Eds.). (2017). *Culturally sustaining pedagogies: Teaching and learning for justice in a changing world*. Teachers College Press.

Parker, W. C., & Lo, J. C. (2016). Reinventing the high school government course: Rigor, simulations, and learning from text. *Democracy and Education*, *24*(1), 1–10.

Parker, W. C., Lo, J. C., Yeo, A. J., Valencia, S. W., Nguyen, D., Abbott, R. D., Nolen, S. B., Bransford, J. D., & Vye, N. J. (2013). Beyond breadth-speed-test: Toward deeper knowing and engagement in an advanced placement course. *American Educational Research Journal*, *50*(6), 1424–1459.

Parker, W. C., Mosborg, S., Bransford, J., Vye, N., Wilkerson, J., & Abbott, R. (2011). Rethinking advanced high school coursework: Tackling the depth/breadth tension in the AP U.S. government and politics course. *Journal of Curriculum Studies*, *43*(4), 533–559.

Penuel, W. R., Fishman, B. J., Cheng, B. H., & Sabelli, N. (2011). Organizing research and development at the intersection of learning, implementation, and design. *Educational Researcher*, *40*(7), 331–337.

Pintrich, R. (2002). The role of metacognitive knowledge in learning, teaching, and assessing. *Theory Into Practice*, *41*(4), 219–225.

Polman, J. L., Stamatis, K., Boardman, A., & Garcia, A. (2018). Authentic to whom and what? The role of authenticity in project-based learning in English language arts. In J. Kay & R. Luckin (Eds.), *Rethinking learning in the digital age: Making the learning sciences count, 13th International Conference of the Learning Sciences* (Vol. 3). International Society of the Learning Sciences.

Priniski, S., Hecht, C. A., & Harackiewicz, J. M. (2018). Making learning personally meaningful: A new framework for relevance research. *The Journal of Experimental Education*, *86*(1), 11–29.

Puntambekar, S., & Hubscher, R. (2005). Tools for scaffolding students in a complex learning environment: What have we gained and what have we missed? *Educational Psychologist*, *40*(1), 1–12.

Reiser, B. J., Novak, M., & McGill, T. A. W. (2017). Coherence from the students' perspective: Why the vision of the framework for K–12 science requires more than simply "combining" three dimensions of science learning [Paper prepared for the Board on Science Education workshop "Instructional Materials for the Next Generation Science Standards," 2017, June 27].

Remillard, J. T. (2000). Can curriculum materials support teachers' learning? Two fourth-grade teachers' use of a new mathematics text. *The Elementary School Journal*, *100*(4), 331–350.

Roschelle, J., & Teasley, S. D. (1995). The construction of shared knowledge in collaborative problem solving. In C. O'Malley (Ed.), *Computer supported collaborative learning* (NATO ASI Series F: Computer and Systems Sciences, Vol. 128, pp. 69–97). Springer Verlag.

Rose, D. H., & Meyer, A. (2002). *Teaching every student in the digital age: Universal design for learning*. Association for Supervision and Curriculum Development.

Saavedra, A., Rapaport, A., Morgan, K., Garland, M., Liu, Y., Hu, A., Hoepfner, D., & Korn, S. (2021). *Knowledge in Action efficacy study over two years* [Technical report]. Lucas Education Research.

Schuchardt, A. M., Tekkumru-Kisa, M., Schunn, C. D., Stein, M., & Reynolds, B. (2017). How much professional development is needed with educative curriculum materials? It depends upon the intended student learning outcomes. *Science Education*, *101*(6), 1015–1033.

Schwartz, D. L., & Bransford, J. D. (1998). A time for telling. *Cognition and Instruction*, *16*(4), 475–522.

Squire, K. D., MaKinster, J. G., Barnett, M., Luehmann, A. L., & Barab, S. L. (2003). Designed curriculum and local culture: Acknowledging the primacy of classroom culture. *Science Education*, *87*(4), 468.

Steiner, D., Magee, J., & Jensen, B. (2019). *High-quality curriculum and system improvement*. Learning First; Johns Hopkins Institute for Education Policy.

Strobel, J., & van Barneveld, A. (2009). When is PBL more effective? A meta-synthesis of meta-analyses comparing PBL to conventional classrooms [Abstract]. *The Interdisciplinary Journal of Problem-Based Learning*, *3*(1), 4.

Taylor, C. S., & Nolen, S. B. (2008). *Classroom assessment: Supporting teaching and learning in real classrooms*. Prentice Hall.

Taylor, R. D., Oberle, E., Durlak, J. A., & Weissberg, R. P. (2017). Promoting positive youth development through school-based social and emotional learning interventions: A meta-analysis of follow-up effects. *Child Development*, *88*(4), 1156–1171.

Tierney, G., Goodell, A., Nolen, S., Lee, N., Whitfield, L., & Abbott, R. (2020). (Re)designing for engagement in a project-based AP Environmental Sicence course. *The Journal of Experimental Education*, *88*(1), 72–102.

Tierney, G., Horstman, T., Tzou, C. (2021). Youth co-design of responsive digital badge systems: Disrupting hierarchy and empowering youth. *CoDesign: International Journal of CoCreation in Design and the Arts*, *17*(3), 313–329.

Vakil, S., McKinney de Royston, M., Nasir, N. S., & Kirshner, B. (2016). Rethinking race and power in design-based research: Reflections from the field. *Cognition and Instruction*, *34*(3), 194–209.

Valenzuela, A. (1999). *Subtractive schooling: U.S.-Mexican youth and the politics of caring*. State University of New York Press.

Vansteenkiste, M., Aelterman, N., De Muynck, G., Haerens, L., Patall, E., & Reeve, J. (2018). Fostering personal meaning and self-relevance: A self-determination theory perspective on internalization. *The Journal of Experimental Education*, *86*(1), 30–49.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Wiggins, G. (1989). A true test: Toward more authentic and equitable assessment. *Phi Delta Kappan*, *70*(9), 703–713.

Wiggins, G., & McTighe, J. (2005). *Understanding by design* (2nd ed.). Pearson.

Willis, P. (1981). *Learning to labor: How working class kids get working class jobs*. Columbia University Press.

Zeiser, K., Scholz, C., & Cirks, V. (2018). *Maximizing student agency: Implementing and measuring student-centered learning practices*. American Institutes for Research.

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