Rethinking Assessment: Using Project-Based Learning to Assess Student Learning

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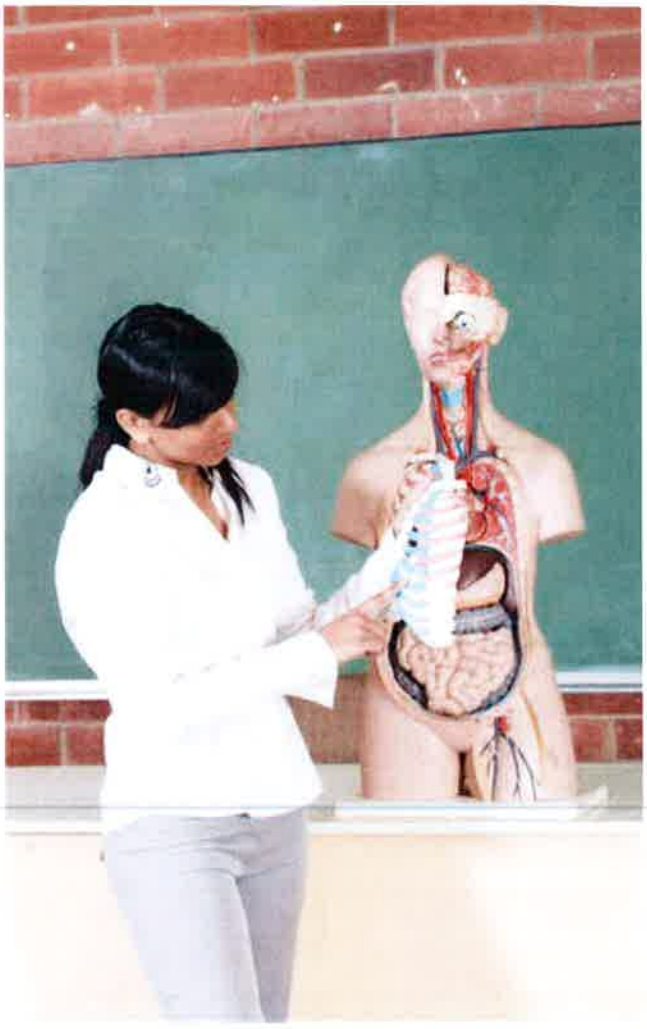
Ms. Terrle, a fifth grade teacher, is teaching about the circulatory system. She shows a video that explains how the heart pumps blood through the body. She introduces the vocabulary words students will see in their text: blood vessels, veins, arteries, capillaries. She asks students to look the words up in the glossary and write the words and definitions in their science journals. Ms. Terrle has students work in pairs to read chapter 6 in their science books to learn about the circulatory system. Students then complete a worksheet answering comprehension questions about the text. Finally, she assesses students' learning by administering a test with multiple-choice questions, a diagram that students must label, and a short essay in which they describe what they know about the circulatory system.

Across the hall, Ms. Magby's fifth grade students are also learning about the circulatory system. She begins by having students measure their pulse before and after doing a series of exercises. Then, she has them discuss the data with one another to investigate why their heart rate increases with their activity level. Next, her students read articles about celebrities with heart conditions. As they read and discuss the articles, students post questions on a bulletin board for the class to investigate later. The students are then challenged with an engineering task based on a real-world case study of a child with a hole in their heart. Students must work as biomedical engineers to design a working model of a circulatory system to understand the child's condition and find out which parts of the body might not be getting enough circulation. They enter the classroom each morning excited to learn! Throughout the planning and construction process, students conduct gallery walks and provide feedback to each other. They also receive feedback from Ms. Magby who uses checklists and rubrics to assess student progress. After testing and redesigning their model, students write a reflection about how their model addresses the case study and connects to the circulatory system.



In which of these classrooms does the most authentic learning take place? Which one provides a more motivating experience? Which classroom provides a well-rounded picture of student understanding of the content? The description of Ms. Magby's classroom is one where project-based learning (PBL) is being implemented--students are engaged, motivated, and learning! As educators who, like Ms. Magby, have seen many academic and motivational benefits to students engaged in PBL, the authors of this paper want to encourage educators to incorporate this approach to teaching and learning in their own classrooms. The purpose of this article is to provide an overview of PBL, describe its benefits for students, and help educators think about ways to implement PBL while using PBL as a tool for assessing student understanding. In the following pages we first describe PBL, synthesizing definitions from the literature. We then discuss the ways PBL benefits students, discussing both cognitive and motivational benefits. Next, we address the teacher's role and provide examples of how educators can implement PBL in their classrooms. Finally, we share how teachers can assess PBL through the

development of rubrics and the use of formative and post assessments.

What is Project-Based Learning?

Project-based learning, or PBL, is a type of performance task, where students are asked to complete an open-ended, long term project around specific content area standards. The National Education Association (2014) describes the PBL approach as being developed by John Dewey in the early 1900s. It was originally known as the "learning by doing" method. More modern PBL requires students to learn by doing as well as to develop skills and knowledge through engagement with projects that investigate real-world problems, working to answer questions relevant to student lives, or thinking through authentic challenges (Bell, 2010). Using projects to teach allows students to apply content rather than memorize and recall information for a test. It provides opportunities for students to focus on learning goals, solve meaningful problems, practice sustained inquiry, engage in learning for authentic purposes and produce for authentic audiences (Bell, 2010). PBL creates an enriching environment where students are engaged in meaningful learning, while teachers capture data on student knowledge and understanding.

PBL is also a way educators can assess students authentically. Since the implementation of the No Child Left Behind Act in 2002, there has been an ever-increasing focus on assessing students through standardized testing. However, there are many issues with relying solely on this type of assessment to understand student achievement. For example, "multiple choice tests do not reflect the nature of performance in the real world, which rarely presents people with structured choices" (Darling-Hammond & Adamson, 2010, p. 3). Darling-Hammond (2014) urged teachers to move toward assessments that improve learning. Specifically, she encouraged educators to question the current forms of assessment and ask: "How can we engage students in assessments that measure higher order thinking and performance skills—and use these to transform practice? How can these assessments be used to help students become independent learners, and help teachers learn about how their students learn?" (Darling-Hammond, 2014, p. 12). Engaging in the authentic assessments, such as those implemented through PBL, is one way teachers can address the concerns of assessments.

Authentic assessment involves real world tasks, can be collaborative and co-constructed, allows for multiple products and artifacts, and can involve digital modes of assessment (Barber, King, & Buchanan, 2015). They are meaningful for students and require multiple modes of evaluation of their knowledge (Frey, Schmitt, & Allen, 2012). Student understanding is analyzed and tracked throughout each stage in an authentic assessment; and the criteria for success are continuously communicated to the students (Frey et al., 2012). From an engagement standpoint, authentic assessments, like those used in PBL, are "interesting, require complex thought, and require high levels of student participation" (Frey et al., 2012, p. 13).

Using authentic assessments is not a new idea in education reform. Creating a robust assessment such as a performance task or project creates curricular planning that is guided by "the overall purposes and goals of the instruction, not by miscellaneous content coverage pressures or test items" (Brophy, 2000, p.13). PBL offers an approach to assessment that requires students to explore and discover content using critical thinking and real-world problem solving skills. Because hands-on projects require higher order thinking, teachers can assess a student's understanding and application of the material. The result is a project that students have had ownership of and an opportunity for teachers to assess student-driven goals and gain insight into students' critical thinking. Researchers have shown that students who have opportunities to engage in learning such as PBL have higher academic achievement including better scores on standardized assessments and retention of knowledge than peers who have not had exposure to such instruction (Karacalli & Korur, 2014). Teachers that integrate PBL into their curriculum can assess a fuller picture of the student that goes beyond traditional formal assessment methods.

How does Project-Based Learning Benefit Students?

Collin, a student in Ms. Magby's class, rolled his eyes and let out a grunt of annoyance when Ms. Magby initially explained that students would be working on a project with their peers. Due to being retained in the first and then again in the third grade Collin is two years older than his peers. He is on a second grade reading level and to distract his classmates from his academic struggles he often engages in disruptive behavior. Knowing that Collin would initially resist having to work in groups, Ms. Magby encouraged Collin to brainstorm independently about how to address the case study before helping him select a group that would help him be successful. As Collin began sharing his thinking with his group, he became a leader among his peers. He also began to see how the circulatory system works because he was able to experiment with how the heart pumps blood throughout the body. One day, as he and his group were discussing how to fix a circulation problem in the leg of their model, - one of the straws kept closing up - Collin came up with an idea. His grandfather had a stint put in his leg which

helped hold one of his veins open. Collin suggested placing a tiny paperclip into the straw to hold it open. His group loved the idea, and best of all, it worked. As Collin's understanding grew, so did his confidence. This new role among his classmates made Collin want to go to school, and the real world context of the case study gave the project new weight.

As can be seen in the case study example above, the benefits to students who engage in PBL are countless! This approach to learning provides a space for students to use real-world problem solving skills, make connections to their lives, develop independence, and apply knowledge in ways that take advantage of their exploratory nature. The project Ms. Magby implemented required that her students use critical thinking skills to create working models and evaluate the work of their peers. Ms. Magby was able to collect data throughout the project by examining the feedback students provided to their peers and the reflections they wrote. Ms. Magby's students, including Collin, were engaged and excited about the material. They were given a sense of ownership by thinking through an authentic task. Trusting students to complete projects like this one boosts engagement and comprehension of material (Bell, 2010). It has also been shown to increase motivation and time on-task, as well as improve student learning outcomes (Ilter, 2014), as it did with Collin. Bell (2010), highlights additional benefits to students who engage in PBL, including increased independence, accountability to others (e.g., peers), and increased proficiency with twenty-first century skills such as negotiation.

PBL allows students to feel a sense of agency and take ownership of their education by promoting "learner-driven learning, catering to the needs and interests of the [individual] students" (Newell, 2003, p. 8). Moreover, it helps students develop life-long learning skills such as collaboration and responsibility (Bell, 2010; Newell, 2003). PBL increases student motivation by providing opportunities for students to write for authentic audiences and purposes (Bell, 2010; Tobias, Campbell, & Greco, 2015). It also creates space for students to make choices and learn about topics they are interested. In fact, Gallavan (2009) reported that students in elementary school describe any assignment resembling PBL as their "most satisfying and rewarding moments in school" (p. 86). By implementing PBL, education centers on the learner and their interests, instead of the instructor and assessments, making learning meaningful to students.

What is the Teacher's Role in Project-Based Learning?

Teachers who use PBL often act as a support and guide, coaching students through the project. The instructor role-shift can serve as a motivator for students. Moreover, research has shown that teachers who apply PBL in their classrooms find it "professionally transformative" (Colley, 2008, p. 28). When PBL is used as an approach to teaching and learning, classrooms transform into laboratories where teachers can become excited about learning alongside their students. In this way, the role of the teacher in PBL is that of consultant, facilitator, as well as learners themselves (Colley, 2008; Wray, 1999). When teachers are excited about learning and engage in the learning process themselves students become more enthusiastic about content as well (Newell, 2003). Ms. Magby facilitated instruction as she guided students through thinking about the challenges they ran into while designing their models—she asked questions such as, "How are you using the design process to help you solve this problem?" and "What are the most important things to consider when thinking about how you will repair this child's heart?"

When serving as a facilitator and guide, teachers must also plan student-led assessments throughout the process. This helps students take ownership in their project and allows the teacher to ensure that students are on track in completing the assignment. Similarly, teachers can develop checkpoints for students to use as confirmation they are making progress. Also, teachers will want to pay close attention to student collaboration efforts. Creating diverse groups helps students become more independent and can help facilitate cooperative collaboration (Bell, 2010; Hopper, 2014; Wray, 1999).

How Can Educators Implement Project-Based Learning?

Ms. Magby's enthusiasm for PBL inspired several other teachers to implement this approach to instruction in their own classrooms. For example, down the hall in Mr. Vernon's third grade classroom, students are asked to grow and sell plants at an upcoming community event to raise money for a field trip. Students are charged with surveying their parents and relatives on what kinds of plants they would be more likely to buy and researching how to grow and care for those plants from seedlings. They are also responsible for creating marketing materials to help promote their products before and during the community event and developing a report to summarize the success of the plant sale.

The project above has several components and integrates content from all subject areas; this can appear overwhelming at first. To begin implementing PBL, teachers use content standards to develop project criteria that are driven by a real-world problem.

Figure 1. Components of Project-Based Learning

Component	The Project Must:
1. Problem	- Be problem or question driven - Be based on a real-world situation - Be developmentally appropriate - Be open-ended - Be able to be solved in a variety of ways
2. Curriculum	- Be central to the curriculum - Be content focused - Target the use of specific skills (i.e. critical thinking; collaboration)
3. Product	- Require transformation of prior knowledge - Require research and field work - Be created for an authentic audience
4. Collaboration	- Be student driven - Provide opportunity to incorporate student talent - Provide opportunity for student voice to be heard
5. Assessment	- Be complex and multifaceted - Provide a rubric to guide students - Make use of formative assessments throughout
6. Reflection	- Include self-reflection that occurs throughout - Include peer evaluation - Incorporate peer feedback

Through this, the teacher identifies a problem that the children will work to solve. The teacher devises a question that will drive the project and will allow students to develop solutions to the problem.

Mr. Vernon posed an authentic problem of raising money for the field trip. This project was designed to develop student's fluency in addition and subtraction, as well as provide a real world context for multiplication to determine the volume of plants to be produced. Students also learned about economics and generated writing and art projects for an authentic audience, while learning about how plants survive in their environments--all of which are skills required in the third grade standards. This model of integrating content areas to PBL gives students a real reason to develop academic skills while maintaining a high level of rigor.

Ms. Magby also posed a real-world problem regarding fixing a hole in a child's heart as a way to teach students about grade level science standards focused on the circulatory system. She was able to integrate English Language Arts standards such as comprehension by having students read articles about this topic, writing by asking students to turn in a reflection at the end of the project, and speaking and listening by encouraging students to provide feedback to peers.

When trying to develop an assessment to measure understanding through PBL, it is important to remember that the main goal is for students to deepen their understanding of a variety of concepts (Wray, 1999; Frey et al., 2012). Gaining factual knowledge is only a small piece of engaging in PBL (Wray, 1999; Frey et al., 2012). Figure 1 provides an overview of six key components to consider when developing a successful learning project (Wray, 1999).

Teachers can create a checklist for students to follow to help them stay on track throughout the project. The checklist should include: various steps in the planning process, formative assessments, peer assessments, teacher feedback, student research, various revisions, presenting the project, and student reflections (Newell, 2003). It is important to note that requiring students to present their projects to an audience provides opportunities for students to showcase their work and review their peers' presentations. It also allows teachers to assess students' knowledge and true comprehension of the material. Presentations truly reveal how much students mastered the content and learned through the project process. To help teachers begin thinking about ways to implement PBL in their own classrooms, a sample list of topics appropriate for PBL has been provided in Figure 2.

Figure 2:

Teacher Action	Description
Examination	- Examine throughout - Final product
Observation	- While students work - Use checklist or rubric
Question	- Ask students what they are doing - Reflection questions - Prediction questions

Figure 3. Primary Ways to Assess PBL (Wray, 1999)

Grade Level	Topic	Content Area	Project Summary
K	Weather	Science	Students will observe and investigate different types of weather. They will use weather instruments to measure and record data. In their classrooms they will create a station where students can view daily weather and weather trends.
1	Habitats	Science	Students will design and test habitats for different types of insects and animals. Groups will decide which habitat may work best for which animal and why. The animals can include, but not be limited to: darkling beetles, rabbits, frogs, goldfish, and baby chicks.
2	Fables & Folktales	English Language Arts	Students will conduct their own author study focused on fables and folktales. They will work to create newspaper-style reviews for each book they read by a self-selected author in the given genre. Students will then share their reviews with another class aiming to teach their peers about the characteristics of fables and folktales.
3	Persuasive Writing	English Language Arts and Social Studies	Students will research and read about girls' education rights around the world. They will work in groups to decide on ways to raise money for girls' education efforts. Some ideas for fundraisers include organizing a 5Kwalk with care.org, raising money through trick or treat for UNICEF, or planning a fundraiser through the Malala fund at malala.org. They will then engage in a writer's workshop in which they use what they learn about the persuasive genre to convince the school community to participate in a fundraiser. Groups will be assigned another class in the school to present their persuasive writing to and host a school wide vote on which fundraiser to do. Students will then work to organize the fundraiser.
4	Informational Writing	English Language Arts	Students will work together in small groups to create and produce a monthly newspaper for the school. They will conduct interviews with faculty, staff, students, and parents to write articles that address issues the school faces. The students will incorporate traditional elements of a newspaper including: editorials, news articles, opinion pieces, entertainment, and sports sections. Students will apply and interview with peers for classroom based jobs related to the newspaper such as section editor, copy editor, reporter, photographer, graphics, etc.
5	US History	English Language Arts and Social Studies	Students will conduct research about child labor during the Industrial Revolution. They will research child labor that continues throughout the world today and come up with ways they can help bring awareness to this issue. They will work in groups to write their own one act plays to send to SCREAM, an organization that works to end modern day child labor.
6-8	Conservation	Science and Social Studies	Students will be challenged to improve the quality of water in their communities while also working to raise awareness about water conservation. They will conduct research about water quality, specifically learning about the water crisis in Flint, MI. Groups will then collect data regarding the quality of water in their school and homes. They will work to come up with solutions to the water quality issues faced in their own communities and plan ways to educate community members about water quality and consumption.

How Can Educators Assess Projects?

According to Wray (1999), there are three primary ways to assess project work, all of which should be incorporated into the overall assessment of the success of the project. Figure 3 provides a description of how teachers might approach assessment of project-based learning products. Ms. Magby incorporated each of these methods into her PBL lessons to create a safe learning environment for her students. As students are constantly receiving feedback from the teacher, they are able to shape their project to fit the rubric, reducing failure and increasing engagement for the duration of the project. Additionally, teachers can track student progress throughout the project to see how their students' understanding of the content evolves and deepens over time.

In the following sections we will further discuss project-based learning as a form of assessment. Specifically we will share ideas for developing a rubric, pre-assessment, formative assessment, and post-assessment. Ms. Magby worked to incorporate each of these into her project-based learning lessons.

Developing a Rubric

As with any performance task, PBL requires a standards-based rubric that students can refer to, use

Figure 4: Sample Rubric

Skill	1 point	2 points	3 points	4 Points	Total
Data Analysis	Did not collect data, AND did not make decisions based on data.	Data is unorganized OR doesn't make accurate decisions based on data.	Data is somewhat organized OR decisions are not accurately based on research.	Data is well organized and decisions are based on the data collected from research.	4 points possible
Research	Research is poorly organized AND does not use reliable sources.	Research is poorly organized OR does not use reliable sources.	Research is somewhat organized. Uses some research to create a care plan.	Research is organized. Uses research to create logical steps to care for the plant.	4 points possible
Botany	Does not care for plant.	Some effort into plant care and does not make a plan or plan is not documented.	Cares for plant but does not document plan OR plan is not based on research.	Uses research to accurately care for plant and documents the care plan.	4 points possible
Marketing	Materials are plain AND unorganized AND have more than 15 errors.	Materials are plain OR unorganized OR has more than 10 errors.	Materials have some creativity OR there are several errors.	Materials are presented creatively and with minimal errors in final product.	4 points possible
Cost Analysis Report - Final	Report is missing many key parts, is not based on reflections, student does not describe what worked/ did not work in their project, AND has more than 20 errors.	Report is missing several key parts, is not based on reflections, OR student does not describe what worked/ did not work in their project; OR more than 10 errors.	Report has all parts and somewhat based on reflections. Student inaccurately describes or does not describe what worked/did not, fewer than 10 errors.	Report is thorough and clearly based on reflections throughout the project. Student accurately describes what worked/did not, minimal errors.	4 points possible

for self-assessment, and receive feedback on through the project. When used appropriately, rubrics "divide an assignment into its component parts and provide a detailed description of what constitutes acceptable or unacceptable levels of performance" (Stevens & Levi, 2005, p. 3). Additionally, components of the rubric must be aligned with the content standards the project addresses. Rubrics can be used as either formative or post assessments. Using the project rubric as a formative assessment allows teachers and students to gain insight into how the project is developing against the content standard; thus providing a clear picture of how well the student is mastering the skills and knowledge embedded within the project (see Figure 4).

The sample rubric in Figure 4 was developed for Mr. Vernon's plant sale project. The rubric was given to students in advance so they would know what was expected of them during the project. Additionally, Mr. Vernon continuously checked in with his students to monitor their progress on the rubric so he could provide immediate and descriptive feedback along the way.

The PBL rubric should be specific, but still to allow for multiple interpretations of the project. The rubric should include skills, concepts, and the final product presentation. Teachers can even involve students in the rubric development process. This approach creates an even stronger partnership and collaboration between the teacher and learner (Stevens & Levi, 2005).

Effective rubrics evaluate student thinking and their presentation of material. Rubrics should help teachers determine if students comprehend the material used for the project, and their ability to synthesize the material into a cohesive project that addresses the problem at hand. When working with older students, teachers may also want to use a rubric to assess student effort, work ethic, and time management throughout the project. It is essential that the rubric is used to provide descriptive feedback throughout the project. Also, students should be given the opportunity to assess peer projects using the rubric (Newell, 2003).

Pre-Assessment

A pre-assessment should be administered at beginning the project since it allows teachers to determine the varying stages of knowledge and development their students have before starting the project (Wray, 1999). Pre-assessments should align with the content covered throughout the project. It can be as simple as a short essay, such as: Explain how the circulatory system supplies blood throughout the body. The pre-assessment can also be a standard multiple choice test about the topic. Whatever pre-assessment model is used, it should also align with the standards and skills addressed in the rubric. Teachers can use the pre-assessment data to determine cooperative groups and guide students toward the development of their project.

Formative Assessment

As mentioned earlier, it is imperative to build formative assessments into the entire project. This provides students with an opportunity to reflect on and assess their progress, as well as provide feedback to their peers. Students can help develop the formative assessments in their cooperative groups and track their progress. Keeping accurate records and notes throughout the formative assessments is crucial. Anecdotal notes can be used for descriptive feedback on the rubric, either at a checkpoint or at the end of the project, and provide important insight to the teacher, student, and parents about student progress.

Because PBL is student driven, the students and teachers are both accountable for the process and product of the project. Having students reflect on their process, evaluate their work, and hold themselves accountable for its quality is essential to success. In teaching students to evaluate their own work, it is important to have them refer to a rubric so that they have a reference point to judge the quality of their efforts. Additionally, having students assess their progress using the rubric allows for teacher-guided improvements and revisions to draft products (e.g.

Figure 5: Sample Formative Assessments

Project/Grade Level	Assessment Question	Explanation of Assessment
Plant Project by Mr. Vernon's 3rd Grade Class	Describe how you are using the data from the parent survey to decide which plants we should sell in our plant sale. Cite specific examples from your group's data.	This assesses the student's ability to analyze their data and describe their decision making process.
Circulatory System Project by Ms. Magby's 5th Grade Class	Which part of your model seems to be getting the least blood supply? What will you do to fix it? How do you know your solution will work?	This assesses students' ability to recognize faults in their designs and think more deeply about their project.

reports, posters) before submitting the final product (Katz & Chard, 2000). Formative assessments relieve the pressure of final presentations because students know where they stand throughout the process. Figure 4 provides examples of the formative assessments used by Mr. Vernon and Ms. Magby (see Figure 5).

Post-Assessment

Because PBL uses ongoing formative assessments, post-assessment often includes a student presentation or performance and requires student reflection of the entire process. According to Newell (2003), PBL requires a foundational shift in the traditional teacher input/student output education routine. Ms. Magby's class, for example, Collin was able to find a voice in his project, which not only made him excited about the material, it gave him a new level of understanding enabling him to apply the content. In PBL, students are no longer required to memorize isolated facts, but instead are required to problem solve and understand content areas within the broader context of real world problems. This long-term approach to teaching and learning requires a more holistic examination of how students master content.

The culmination of the final production should assess student understanding of the subject and their process for developing the project. When Collin and his group shared their models with their parents in a showcase, Collin talked extensively about how his grandfather's surgery influenced his project. In turn, Ms. Magby was able to analyze the depth to which Collin tackled the subject of their project and his ability to integrate multiple skills and levels of understanding (Newell, 2003). For the culminating project, students are provided with a rubric with detailed feedback that encourages students to continue working on the project; these details help students understand that projects are never perfect and can always be improved and explored in greater depth. Collin showed social and academic growth, earning full credit on the post assessment rubric for collaboration, content knowledge, and application of content.

Conclusion

PBL is not just a snapshot of student achievement; it is a holistic approach to teaching and assessment. Students take ownership of their learning and play an active role in assessment by reflecting on their work and providing feedback to peers. Teachers, like Ms. Magby and Mr. Vernon, who use PBL develop a cohesive, supportive, and engaged classroom community, where students think critically and apply content.

Using PBL as an assessment tool allows teachers to gain insight into student understanding and reasoning about multiple subjects at once. Taking detailed notes about student progress and using detailed rubrics throughout the process allows teachers and students alike to track progress. As students receive feedback from their peers and teacher, their projects will evolve. A project is never fully "complete," it merely becomes ready to share with an audience.

When students are given a sense of agency in their learning, they not only master the content, they apply important twenty-first century skills. This paradigm shift in instructional design transforms students' educational experiences by encouraging them to tackle real problems in their world. Teachers that use PBL have clearer insight into student understanding. PBL can lead to highly engaged students that develop into lifelong learners.

We have all likely been students in classrooms like Ms. Terrle's. We may even have been versions of Ms. Terrle in our own classroom, relying on teaching through textbooks, worksheets, and memorization of facts. However, taking steps toward implementing instruction more like that in Ms. Magby's class is not out of reach. Appendix A offers a list of additional print and online resources to help begin this process. We hope the resources provided here will be a roadmap for educators to implement PBL in their classrooms.

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