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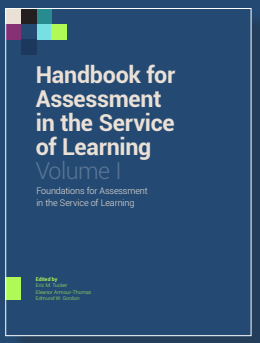

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Eleanor Armour-Thomas, Jacqueline Darvin, and Gerunda B. Hughes

Abstract

Assessment serves as a fundamental pillar of pedagogy, functioning in synchrony with curriculum and instruction to support student learning at the classroom level. This perspective aligns with Armour-Thomas and Gordon's (2013) concept of Dynamic Pedagogy, where these three pedagogical components are interdependent and reciprocally related with support for learning as its collective purpose.

Examples from AP Research and Mathematics Education courses illustrate how assessment is inseparable from curriculum and instruction, highlighting key takeaways: ascertaining where learners are in their current learning in relation to where they need to be in terms of learning goals, appraising their progress toward the learning goals, and figuring out next steps in their learning toward mastery of the learning goals. When these pillars interact effectively, learning becomes visible through students' demonstration of knowledge and skills in varied ways. Additionally, teachers and students can use the results of analysis of assessment data as actionable feedback that inform next steps in the interdependent pedagogical processes of instruction, curriculum, assessment with learning and its improvement as its focus.

This chapter references the Handbook principles of assessment in the service of learning such as transparency, assessment design, and feedback. Moving forward, empirical research is needed to explore assessment's role as a pillar of pedagogy and its enablement of learning and its improvement.

Changing conceptions of how students learn, along with educational standards that call for all students to develop deeper learning 21st-century competencies, have heightened interest in assessments that are responsive to these changes. Over the years, policy makers, educators and researchers have given much attention to the power of classroom assessments and their relationship to student learning. Black and Wiliam (1998) provided compelling results in their review of empirical studies about the positive relationship between classroom formative assessment and student learning. Other research studies have reported similar findings about the positive relationship between classroom assessment and student learning (Stiggins & Chappuis (2012); Kingston and Nash, 2011; Hughes, 2010; Furtak et al., (2016); Popham, (2008); Shepard, (2021); Johnson et al., (2019).

We use the metaphor of a "pillar" to emphasize the significance of classroom assessment in supporting learning in the same way that a pillar supports a building. We also make the claim that what gives it its foundational support for learning is its interdependence with two components of teaching–curriculum and instruction. This claim is not new since others have recognized the interdependence of the different components of the teaching, learning and assessment processes (Armour-Thomas & Gordon, 2013; Black, 2018; Farenga, Joyce, & Ness, 2002; Gordon, 2020; Chatterji, 2012; Heritage, 2007; Wiliam & Thompson, 2007; Tomlinson & Moon, 2013; Tyler, 1949).

The next section of this chapter elaborates on the conception of assessment as a pillar of pedagogy followed by two examples from courses in AP Research and Mathematics Education that demonstrate how assessment as a pillar of pedagogy supports teaching and learning in the classroom. Also, both examples refer to the *Principles of Assessment in the Service of Learning.*

Assessment as a Pillar of Pedagogy

The conception of assessment as a pillar of pedagogy at the classroom level functions as a data-gathering procedure that is designed and used to generate evidence of its interdependent relationships and functions with two other pedagogical processes, curriculum and instruction, with supporting learning as their primary purpose and focus.

Firstly, the interdependence between assessment and curriculum and its relationship to learning is an example of assessment as a pillar of pedagogy to support learning. Before a lesson or curricular unit begins, the teacher uses a variety of diagnostic tools to ascertain students' readiness for the expected outcomes of the lesson or curricular unit. Interviews or questionnaires may be used by the teacher to gather information about students' preferred ways of demonstrating what they have learned that would be relevant for the expected mastery of the goals and objectives of the lesson or curricular unit. Their cultural, social ways of knowing, their perceptions and dispositions about learning, and the environments most conducive to them learning well are some of the information generated from curriculum-embedded assessment tools that can be useful for teachers prior to the start of the lesson or curricular unit.

Another example of assessment as a pillar of pedagogy is its interdependence with instruction and curriculum that occurs during instruction. Instruction-embedded assessment can be used to appraise how well students are learning with an understanding of what is being taught, and to what extent students are making progress toward mastery of the goals and objectives of the lesson or curricular unit. Such questions include oral and written questions, classroom and homework assignments and quizzes. Interpretation of results from these appraisal assessments during this phase of the teaching-learning process can yield feedback for both the teacher and the learner. For the teacher, feedback can be used to adjust curriculum and/or instruction in subsequent instruction. For learners, feedback can be used to inform them of the next steps. Such actions can include seeking specific help from resources, peers, and/or the teacher to address problematic aspects of their recent performance that would result in improvement in their performance. If no improvement is needed, learners can use feedback to strength their learning in readiness for moving toward meeting the goals and objectives of the lesson or curriculum unit.

A third example of assessment as a pillar of pedagogy is its interdependence with curriculum at the end of the lesson or curricular unit. Here, curriculum-embedded and instruction-embedded assessment tools are evaluative of mastery of the goals and objectives of the lesson or curricular unit. Think-Pair Share, exit tickets, quick writes, and reflections are examples of these end-of-lesson assessments and demonstrations or presentations, projects or essays, and unit tests are examples of end-of-unit assessments.

This conception of assessment as a pillar of pedagogy bears some similarity to Armour-Thomas and Gordon's notion of *Dynamic Pedagogy* (Armour-Thomas & Gordon, 2013) in which assessment, curriculum and instruction are reciprocally related with learning as its collective focus and purpose. Figure 1 illustrates the dynamic interdependence of these pedagogical processes and their alignment with learning processes.

Figure 1
Dynamic Pedagogy Model

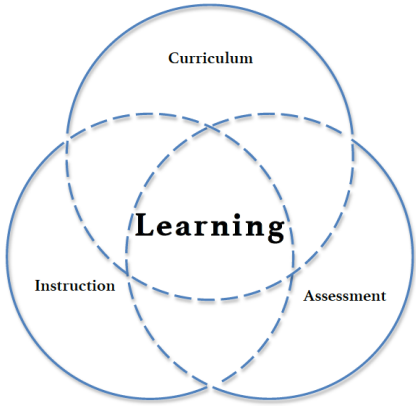

Figure 1. Interlocking circles indicate the interdependence of assessment, curriculum and instruction and the jagged lines are intended to depict the dynamic interaction among these three areas with learning as the focus (reproduced from a paper written for the Gordon Commission on the Future of Assessment in Education: Armour-Thomas & Gordon, 2013 Assessment as a dynamic component of Pedagogy).

What follows next are examples of assessment as a pillar of pedagogy in support of learning in AP Research and Mathematics Education courses.

Example One: AP Research Scaffolded Activities

Assessment as a pillar of pedagogy supports teaching and learning in the classroom and joins with the two other pillars of pedagogy, curriculum and instruction. When teachers reimagine and design assessments and learning tasks leading up to assessments that adhere to the *Principles for Assessment in the Service of Learning,* they make their feedback to learners, teachers, administrators, and parents more transparent, timely, and actionable. This can be accomplished by employing ongoing classroom formative assessments that are exploratory and reflective in nature and include a series of scaffolded learning opportunities and performance tasks for students to engage in as part of their ongoing learning processes. One such example where assessment undoubtedly can be in the service of learning for students, teachers, families, and school administrators is the AP Research course and assessment tasks that are administered by the College Board and ETS.

According to the College Board, 2024

> *AP Research, the second course in the AP Capstone experience, allows students to deeply explore an academic topic, problem, issue, or idea of individual interest. Students design, plan, and implement a yearlong investigation to address a research question. Through this inquiry, they further the skills they acquired in the AP Seminar course by learning research methodology, employing ethical research practices, and accessing, analyzing, and synthesizing information. Students reflect on their skill development, document their processes, and curate the artifacts of their scholarly work through a process and reflection portfolio. The course culminates in an academic paper of 4,000–5,000 words (accompanied by a performance, exhibit, or product where applicable) and a presentation with an oral defense* (p. 10).

By design, AP Research is an interdisciplinary course in which students, who are mostly 11th graders, conduct year-long research studies on their chosen topics. The course culminates with an academic paper and a presentation and oral defense to a panel of teachers and educational leaders. AP Research and

other inquiry-based learning scenarios rely heavily on the peer-review process for students to give and receive actionable feedback. Students are encouraged to seek feedback from their peers and expert advisors or mentors with backgrounds in the disciplines of study.

A feedback-focused collaboration began in 2020 with two AP Research teachers from East Hampton High School in Long Island, New York, meeting with a professor from Queens College, CUNY, to discuss a challenge they were having with an upcoming AP Research lesson. The lesson instructed high school students to provide feedback on each other's AP Research paper drafts, using a highlighting activity and annotated rubric. While some students were able to provide effective peer feedback, the AP Research teacher, Michael, indicated to the professor that others had difficulty commenting on the bottom two rows of the rubric that deal specifically with the communication of the student's ideas through the organization, design elements, grammar, style, word choice, and the proper citing and attributing of sources. The professor suggested that Michael should encourage students to focus on only one rubric component at a time. Starting small, with a primary focus, is less daunting to students and fosters better peer feedback. This strategy has since been applied in the AP Research classroom, resulting in more comprehensive student-to-student peer feedback, particularly on the two rows of the rubric with which students have the most difficulty. After applying the strategy, Michael commented, "What was once an intimidating task for many students is now manageable due to the activity being broken down into digestible pieces. My students are now able to provide constructive criticism to their peers and are no longer limited due to rubric fatigue."

Other examples of scaffolded classroom assessment activities that support student learning occur when the AP Research teacher takes a creative and recursive peer feedback approach with his high school students and uses different interactions of "speed dating" peer feedback opportunities throughout the course. When students are preparing their inquiry research proposals in the fall, they create digital posters and present an "elevator pitch" to their peers for feedback and to keep up with their presentation skills throughout the year. This is repeated at distinct stages, as students add more elements to their posters, such as their Research Questions, Methodology, etc. Michael instructs the AP Research students to support their peers, as they improve their research proposals, by providing

positive feedback via pink Post-it notes to help their peers see where they are doing things right and provide constructive feedback via yellow Post-it notes to show where their peers can improve.

He gives the students explicit instruction on how to provide feedback to their peers, including: When you post, be respectful. When you receive feedback, keep an open mind. Your reviewer is not attacking you. You are both attacking your research project for improvement. Make changes when they are fresh (start addressing feedback now!!). Additionally, Michael introduces key terms for the student researchers to use with one another while providing each other with feedback, including: 1. Broad: Generic, vague, covering too many subjects or areas, 2. Clear: Easy to understand, not confusing 3. Focus on the specific concept that is being addressed, 4. Narrow Parameters: Specifically define boundaries of the research project, and 5. Narrow Parameters: Boundaries of the research project that can and have to be made more specific.

Following a "speed dating" motif, students are timed and only have two minutes to give peer feedback on an aspect of another student's research poster before the alarm sounds and they must move to the next poster. The "speed dating" lessons are conducted several times throughout the year, as students add elements of their studies to their research posters, and the process is recursive and ongoing. These assessments meet William's (2011) two requirements for being described as "formative," since they include instructional and curricular activities that result in improvement in performance, and the learner must act upon the evidence gathered to improve their learning, including seeking specific help from peers and reflecting on ways to move their learning forward.

AP Research Symposia

When discussing Michael's future AP Research lessons, he and the professor also created scaffolded learning opportunities to improve students' confidence in their ability to discuss and disseminate their research. The professor suggested an authentic performance assessment opportunity that resulted in an online Research Symposium, which first took place in April of 2021 via Zoom. The symposium was established for the high school students to practice presenting their research and receive actionable and timely feedback from graduate students, who were also practicing, certified teachers taking a graduate level course in research themselves.

The symposium was scheduled just prior to the students presenting their real Project Oral Defenses (PODs), so that they would view the symposium as an authentic dress rehearsal to practice what they would need to do for a score the following week, since the course culminates in an academic paper of 4,000–5,000 words (75%), accompanied by a performance, exhibit, or product where applicable, and a presentation with an oral defense (25%).

To avoid any potential College Board conflicts of interests, the professor did not observe the high school students or listen to the specific feedback on the papers and PODS, since she is trained as an AP Research Table Leader and Reader and sometimes participates in the AP Research Reading. Throughout the collaboration, Michael and professor carefully read all materials provided by the College Board to make sure that they were not violating any of their rules. Though the College Board prohibits adults from correcting student work, they are permitted to proofread, point out strengths, errors, and areas in need of improvement.

The research symposia have improved both the students' and teachers' confidence in presenting their scholarly work and even their overall success in the AP Research course and graduate research classes. The first virtual research symposium was so well-received by the high school students and early career teachers that they continued to hold them in November and April of 2021–2024 and are planning to continue this practice moving forward.

Reflections from the Research Symposia

When asked to reflect on the experience, one of the high school researchers who participated in April of 2024 wrote: "A lot of the feedback that I received had to do with defending the purpose of my statements. Especially when I offered quotes from websites and specific people, I was told to make sure I clarify who and what these websites and people are known for, providing credibility and preventing confusion. I plan to make sure I describe or briefly mention the purpose of me including each source. I also need to proofread my work to make sure I don't have any slip ups I might have missed." Another student posited, "I got the feedback that my presentation was overall good as I was passionate about it, however I could do a better job at defining some of the key terms used that wouldn't be general knowledge. I also was told that my slides could be more uniform in their organization (font, sizing, colors, and pictures) to make it look more professional. The last piece of feedback was to add subheadings under the pictures that I took

of Atlantic Beach, so the reader knows they were my own. I plan to first add a slide in the beginning of my presentation for definitions and key words. Then, I will go through my slides and make them uniform to give a cleaner feel to the presentation. Finally, I will go in and label all of the pictures that I took as my own and the beach that the study was based on." Every year that the symposium is held, the AP Research teacher points out that the symposium serves as a critical culminating experience for his students, whereby they get to see how ready they are for the POD, based on this authentic dress rehearsal and provides feedback to them that, when acted upon, improves their PODs.

Similarly, the Queens College teachers (graduate students) embrace the experience as assessment in the service of learning and always have positive comments about the symposium and how it supports their own learning, while concurrently doing so for the high school students. Most recently, in April 2024, a teacher commented, "One concern I had over the course of the week leading up to meeting the two students assigned to me was that I wasn't sure whether or not my commentary would be helpful or useful to them. Despite my initial insecurities about my own writing abilities, I realized that my role as a mentor was not about being a perfect writer, but about offering guidance and support. I shifted my focus to providing constructive feedback that I would appreciate receiving myself. This change in mindset gave me the confidence to meet with the two students assigned to me. Additionally, I didn't know what to expect in terms of topics, but each student's topic was different from the next, and it was honestly refreshing to see and read about. That part was exciting to me." Another wrote, "Overall, my general feedback for Amy and Violet (pseudonyms) was to reread their action research papers aloud in a mirror with a pen. In doing so, they would be able to check for grammatical errors and issues with organization in their writing. I also advised them to be specific when referring to their data and the reasoning behind the limitations within their research. With that being said, I wish more schools across New York had students engage in action research to encourage real-world problem solving and student engagement."

In addition to the creation of the bi-annual research symposia, several other new practices have been implemented, including ETS professional development opportunities for the teacher in becoming a Rater (scorer) for the AP Research Reading, the creation of an informal parental network to link novice student researchers with outside experts in the fields that they are researching (something

that is encouraged by the College Board), additional in-class activities that promote timely and actionable feedback, and additional formative assessments leading up to the culminating tasks of the POD and academic paper.

How the AP Research Course demonstrates Assessment as a Pillar of Pedagogy

The position taken in this chapter is that when assessment functions as a pillar of pedagogy both teachers and learners experience it as a seamless interaction with instruction and curriculum in ways that influence student learning positively. The AP Research course illustrates a few examples of assessment and its interdependence with curriculum and instruction and its support for student learning in the classroom as described below.

The AP Research Course and Its Success Criteria

Unlike most courses for which a standardized test of achievement is administered at the end of the teaching-learning cycle, the AP Research course is quite transparent about its criteria for success as delineated in its rubric. The use of the rubric is an illustration of assessment as a pillar of pedagogy since it informs the design and implementation of instructional and curricular activities to help students achieve the goals and objectives of the course. There is a wealth of literature on success criteria and its use in assessment and other pedagogical processes for the purpose of guiding learners in what to look for in their performance and progress toward the goals and objectives at the end of a teaching-learning cycle (e.g., Moss & Brookhart, 2012; Fisher & Frey, 2014; Tomlinson and Moon, 2013); Wiliam & Thompson (2007).

Scaffolded Activities of the AP Research Course

The scaffolded activities of the course included an annotated rubric as curricular content in which instruction among peers was intended to provide feedback in ways that made features of the rubric understandable for students who were experiencing difficulty with it. Inherent in the concept of scaffolding are characteristics of probing questions that teaching persons or capable peers use for eliciting evidence of students' understanding, the provision of feedback, and the fading of instructional support until students can demonstrate their learning without it. These characteristics of scaffolding underscore the synchronistic function of assessment, curriculum, and instruction with learning processes.

Studies of classroom teaching have reported that participation in scaffolding activities facilitate learning (Fisher & Frey, 2013; Palincsar & Herrenkohl, 2002; Wentzel & Brophy; 2014). Moreover, the quality and type of feedback, a characteristic of the scaffolding concept, has been shown to play an important role in student learning (Black and Wiliam, 1998; Hattie and Timberley, 2007; Furtak et al., (2016); & Johnson et al., (2019).

The Symposia of the AP Research Course

The AP Research Symposia used an authentic performance assessment as a culminating experience of the course so that students could practice presenting their research prior to doing so on their Project Oral Defense (POD) for grading as required by the College Board. Using performance assessment formatively is another example of assessment as a pillar of pedagogy because it provides opportunities for students to receive feedback from teachers about aspects of their work still in need of improvement. For learners, the feedback also makes visible how well they make progress toward the goals and objectives of the course and their readiness to transfer what they have learned in the course to another context- the AP Research Paper administered by the College Board and ETS. The research literature on practice is quite robust on its effectiveness in improving learning (e.g., Benassi, Overson and Hakala, 2014; Harmon& Marzano, 2015; and The National Academy of Sciences; 2018).

How the AP Research Example Connects to Handbook Principles

The preceding AP Research projects/assignments exemplify and explicitly connect to Principle 1 of the Principles for Assessment in the Service of Learning which states that "Assessment transparency assists teachers, learners, administrators, and parents." The transparency of the AP Research rubric and scaffolded AP Research activities enables the students to better understand the components of the AP Research program and assessment and what they need to do to be successful. Additionally, they enable the teacher to better understand the various components of the AP Research program and what they need to do to be successful and to help support their students' success. A less obvious yet powerful benefit is that the transparency of the scaffolded activities enables the school administration to better support the various components of the AP Research program and what their teachers and students need to do and lastly,

the transparency of scaffolded activities enables families to better support the components of the AP Research program and what their children need to do.

The preceding scaffolded activities also exemplify and explicitly connect to Principle 7 of the "Principles for Assessment in the Service of Learning" which states that, "Assessment quality and validity should be available and reflect evidence related to assessment purpose to permit appropriate inferences and findings about quality, utility, and credibility." For learners, feedback from the formative assessments embedded in the scaffolded activities provides them with decisions and next steps to improve upon their AP Research Projects and PODs before being formally graded on them. Feedback from the formative assessments also provides teachers with decisions and next steps to improve their teaching and fill in learning gaps for students as they conclude their projects/PODs. Feedback from the teachers to administration regarding the success of the scaffolded activities, formative assessments, and PD opportunities enable administration to better support the research teachers with resources, financial support, coverage to attend ETS professional development, dissemination of information in the district, etc. Finally, feedback from the formative assessments and scaffolded activities enables families to better support their students because they have a better understanding of the expectations and how they can become resources for their own children and for other students in the AP Research program (i.e., serving as community "experts" on other students' projects, etc.).

Example Two: The Use of Performance Tasks in Mathematics Education

Historically, African Americans have faced systemic barriers to educational opportunities that have resulted in representation and achievement gaps over generations. The research literature reveals that these gaps can be explained in part by sociocultural differences in educators' and students' backgrounds and perpetuated by practices that reflect a lack of caring and empathy for the underserved from those who have the power to enacted changes (Gordon & Yowell, 1994). Additionally, the overall climate of academic institutions from K–12 to graduate schools, including their levels of inclusivity and support for diversity, can significantly affect African American students' engagement, sense of self-efficacy, and persistence in educational settings (Allen, 1992; DeFreitas, & Bravo, 2012). Negative experiences with faculty or peers can lead to feelings of isolation, instead

of a sense of belonging and nurturing in the school/learning environment (Cohen, 2022; McClinton, Mitchell, Carr, Melton, & Hughes, 2018; McGee and Bentley, 2017).

Community and home environments can also play a role in the persistence and performance of African American students in STEM courses, in general, and mathematics courses, in particular. Gordon (1996) speaks generally about the importance of familial support to the overall success of the teaching, learning, and assessment processes for learners. However, Kunjufu (2002) speaks about what is often a class and cultural disconnect between the expectations of middle-class teachers for parents to be "assistant teachers" at home and the capacity of parents to meet those expectations educationally, culturally, or financially. For example, depending on the socioeconomic status of the household, parents may not have the educational backgrounds (e.g., taken courses in trigonometry), cultural knowledge (e.g., knowledge of European history), or resources (e.g., money to hire a tutor) to supplement what goes on in the classroom. Additionally, parents or caregivers may have negative attitudes about certain subjects, like mathematics, because of negative experiences they had in school. They may speak negatively about their experiences in mathematics in social conversations or in the presence of their children. Children may, in turn, adopt many of those attitudes from their parents or caregivers. Kunjufu (2002) wrote:

> *I am very concerned with the math disparity between the races. Upper-grade African American youth are doing very poorly in math. There are many factors contributing to this dilemma, but in the chapter for parents, I implore you to never tell your children you were not good in math or you did not like it. Children begin to think their failure is genetically driven and it's not relevant. Parents must encourage their children to reach their full math potential* (p. 134).

Parents, caregivers, community members as well as teachers must be keenly aware of the effects that the type and tone of their comments and feedback have on young people's sense of self-efficacy–that is, a person's belief in their ability to succeed in a particular situation or area such as mathematics. It follows that students who experience positive personal perceptions of efficacy about learning mathematics content will tend to engage in more mathematics tasks, select more effective strategies for performance, expend more effort, and persist more when faced with difficulties, as compared to those students who do not feel efficacious in this area.

Two Performance Tasks in Mathematics Education

The precalculus course containing two performance tasks were housed in an introductory level mathematics course at a Historically Black College/University (HBCU) in the mid-Atlantic region of the United States. The course was designed to introduce students to the properties of a variety of functions, including rational, exponential, logarithmic and trigonometric functions–just to name a few. The focus of this discussion is on trigonometric functions–specifically sine and cosine functions. Professors had great latitude when it came to how they designed and taught the course; however, all students enrolled in the various sections of precalculus had to take a departmental final examination developed by a committee of mathematics professors.

Two examples are presented to demonstrate how a portfolio of assessment strategies, and most notably performance tasks, were used to increase African American students' engagement, motivation, effort, sense of self-efficacy, and learning in the precalculus course. Notably, Delpit (1995) wrote about the necessity for teachers to learn from and about their students. Therefore, on the first day of class during the semester, the precalculus professor asked students to share some information about their programs of study at the university and discuss frankly and freely their previous experiences in mathematics courses. Additionally, a survey was administered to the students to obtain anonymous responses about their attitudes about mathematics. The data and information from the discussions and survey were used to guide the instructional and assessment processes for the course. Specifically, the following course goals, learning objectives, and performance tasks were included on the precalculus course syllabus:

Course Goals: (1) To improve the mathematics learning experience of African American college students—that *is, to improve their attitudes about and performance in mathematics—especially among non-STEM majors* by implementing instructional and assessment strategies that are socio-culturally and socio-cognitively responsive to students enrolled in the course (proximal); and (2) to increase the representation of African Americans in STEM fields (distal).

Lesson Learning Objectives: 1. Students will be able to use the properties (e.g., amplitude and period) of trigonometric functions (e.g., y=a sin bx) to explain and represent quantitatively real-world situations. 2. Students will be able to explain/model how sine functions with different periods (radio waves, microwaves, x-rays,

gamma rays, etc.) relate to real-world phenomena; and 3. Students will be able to graph the average number of daylight hours per month for Washington, D.C. over the course of two years, using information from a credible data source, and communicate how the information is related to a real-world situation. Objectives two and three were assessed through the use of performance tasks.

The precalculus course was part of the mathematics curriculum that could be used to satisfy a general education requirement for a degree program. Therefore, there were a diverse group of students from a variety of academic programs enrolled in the precalculus course. For students who were pursuing degrees in the arts, precalculus was most likely the last mathematics course they enrolled in during their college years (i.e., non-STEM majors); whereas, for students who were pursuing degrees in the sciences, precalculus was most likely one of the first courses in which they enrolled (i.e., STEM majors). The non-STEM majors became the focus for helping to accomplish the distal course goal of increasing the representation of African Americans in STEM fields. To assist in accomplishing the distal goal—the evidence of which would not be apparent for decades in the future–the precalculus professor focused on accomplishing the proximal goal which was to create and maintain a high level of student engagement in the course, improve students' attitudes and senses of self-efficacy about their performances in mathematics, and help them achieve the learning objectives for the course. The steps in achieving the proximal goal were operationalized by incorporating students' assets, interests, and culture into the instructional activities and the assessment strategies and performance tasks of the precalculus course.

Fine Arts and Mathematics (Performance Task One)

The early foundational and very impactful research of Hale (1986), Irvine (1990), Ladson-Billings (1995a, 1995b), and others on culturally relevant and responsive pedagogy and its effectiveness with students of color was a welcomed reminder about how to maximize learning for all students. Therefore, when two students who were enrolled in a Fine Arts degree program asked if they could demonstrate their conceptual understanding about the properties of the graph of a sine function (e.g., the amplitude and period) by situating their performance in an Afrocentric cultural setting, the precalculus professor encouraged them to do so.

The students chose to write and perform a skit based on the 1990s television sitcom, *Martin*. The skit seemed like a perfect choice for two potential future screen writers or actors. In the skit, Gina explains to Martin the properties of the waves that a microwave oven uses to cook collard greens. Even Gina's choice to cook collards greens rather than kale had cultural overtones. Gina also explains how the magnitude of the period of the waves for cooking collard greens in a microwave oven differs from that of other kinds of waves with shorter or longer periods or wavelengths (e.g., radio waves, x-rays, and gamma rays).

The sitcom Martin was an award-winning comedy show that aired for five seasons in the early to mid-1990s. Cast members described Martin as a television show which had several features that appealed to young people: (a) young Black love, (b) a snapshot of the '90s African American culture and fashion, and (c) the genius of young African American comedians, like Martin Lawrence. Consequently, the students felt a connection to the show—both culturally and generationally. The Fine Arts students thought it was an excellent way to use skills they were learning in their degree program and infuse "fun" into their learning. They also recognized the need to meet with the precalculus professor several times before the performance of the skit to get feedback about how best to explain clearly and simply how "microwaves" are used (Shepard, 2000). A decision was made to explain how the period of microwaves differs from other types of waves, such as radio waves, which are used for broadcasting or the period of waves for gamma rays, which are used for killing cancer cells. Their research took them to a picture of the Electromagnetic Spectrum similar to the one depicted below.

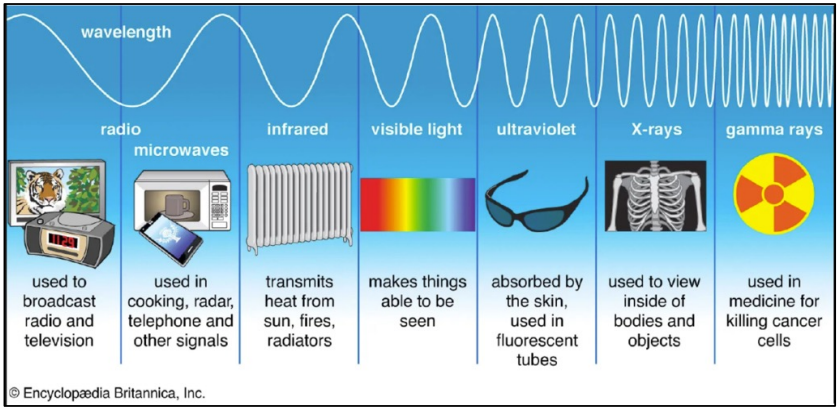

Figure 2

Collard greens are cooked in a microwave oven using waves with shorter wavelengths than radio waves which are used for broadcasting and longer wavelengths than gamma rays that are used in the medical field for killing cancer cells.

Additionally, a professor in the Mathematics Department was invited to listen and evaluate whether the students correctly explained the mathematical concepts about the period of a sine function and how it was used during their script. He gave the presentation "two thumbs up" and thanked the two students for "thinking outside the box" when it came to learning and demonstrating understanding of mathematical concepts. The mathematics professor also reminded the students that while the skit (performance task) was a creative way to demonstrate what they were learning during instruction; they would have to take a more traditional mathematics assessment–the two-hour departmental final examination–at the end of the semester. The mathematics professor encouraged the precalculus professor to prepare the students for this last assessment of the semester by administering two or three one-hour exams with items similar to the ones that appear on the departmental final examinations for precalculus.

Psychology and Mathematics (Performance Task Two)

All students enrolled in the precalculus course were assigned the following performance task: (1) consult an almanac or website for the average number of hours of sunlight for each month, January through December, of a particular year for Washington, D.C.; (2) plot the data on a graph for two consecutive years; and (3) write a few sentences about what they observed. Students discovered that their graphs of the data modeled two periods of the graph of a sine or cosine function. Some students were amazed that the average amount of sunlight per month for a particular city over the course of a year (or 2 years) can be modeled as a sine or cosine function.

There was a small group of students who were enrolled concurrently in precalculus and general psychology. The precalculus professor explained to them the relationship between the average number of sunlight hours per month over the course of the year and the psychological phenomenon known as Seasonal Affective Disorder (SAD). SAD is a mood disorder characterized by depression when there is less sunlight at certain times of the year. The students were encouraged to present their graphs from the mathematics performance task in their general psychology class so their peers could appreciate, in this example, a relationship between mathematics and psychology in a real-world context. The mathematics professor contacted the psychology professor and arranged for the students to present their graphs.

The members of the group created a PowerPoint presentation and shared the results of their performance task (mathematics) and their discussion about Seasonal Affective Disorder (psychology) with their peers and professors in their general psychology class. At the end of the presentation, the students received a round of applause from their peers and from their precalculus and psychology professors. They also received extra credit for their extra effort!

How the Precalculus Course Demonstrates Assessment as a Pillar of Pedagogy

As stated earlier in the introduction to this chapter, the concept of assessment as a pillar of pedagogy at the classroom level acts as a means for gathering information that can/should/is used to inform and document the interdependence of curriculum, instruction, and assessment in the service of and support for learning—for both students and their teachers. Thus, given that the focus in the precalculus

course was on trigonometric functions (e.g., sine and cosine functions)–it is reasonable to ask: "What assessment strategies were most effective for gathering information about students' readiness for learning the mathematics curriculum so they could successfully meet the goals and learning objectives of the precalculus course?" Similarly, it is equally important to identify and use assessment strategies that increase students' engagement, motivation, effort, attitudes, and sense of self-efficacy during instruction to facilitate learning. Finally, how does the use of these assessment strategies maximize students' abilities to demonstrate what they have learned after instruction?

The two performance tasks in the precalculus course, Fine Arts and Mathematics and Psychology and Mathematics, both demonstrate how the concept of assessment as a pillar of pedagogy was used in the service of learning in three ways: (1) knowing about learners and the curriculum through assessment prior to instruction; (2) allowing learners' choice in assessment during instruction; and (3) preparing learners for choice in assessment after instruction. A discussion of each illustration of the pillar concept in the mathematics performance tasks follows.

Knowing about Learners and the Curriculum through Assessment Prior to Instruction

Before the unit on trigonometric functions began, the instructor had in-class discussions with students about their backgrounds, interests, and motivations. Students talked about their major fields of study at the university, where they were from, and the reasons why they were enrolled in the Precalculus course. These discussions provided opportunities for the professor to learn about the students and for the students to get to know about each other. The professor also administered a survey to obtain students' responses about their attitudes about mathematics and previous experiences in mathematics courses.

Using assessment tools to generate information about learners' prior experiences in the content area in which they would be expected to demonstrate new learning, is a necessary first step of assessment as a pillar of pedagogy. The information obtained from these formal and informal assessments was used by the professor to design and organize subsequent teaching-learning experiences that were likely to elicit and sustain high engagement from the students in ways that would enable them to meet the goals and objectives of the precalculus course. A well-documented finding in the research literature on how learners learn is the relevance

of learners' prior knowledge in the construction of new learning (Bailey & Pransky, 2014; Schmidt & Marzano, 2015). Also well documented in the literature of formative assessment is the importance of using assessments to gather information of where learners are in a curriculum area of interest prior to instruction (Brookhart & McTighe, 2017; Hattie & Timperley, 2007; Wiliam, 2011).

Learners' Choice in Curriculum and Assessment During the Implementation Phase of the Lesson

During the implementation phase of a lesson, all the pillars of pedagogy (assessment, curriculum, and instruction) are in dynamic interactions with each other in support of student learning. For example, learners are expected to participate in curricular tasks and respond to instructional strategies that are used to help them learn. Assessments are also used to appraise how well they are doing and whether they are making progress toward the goals and objectives of the lesson. Of course, how well they are doing depends, in part, on whether students are motivated to engage in these pedagogical activities and remain engaged until task completion. In both performance tasks, Fine Arts and Mathematics and Psychology and Mathematics, the students were highly engaged in the curriculum and instructional activities. They were also receptive to the feedback given to them from results of informal assessments of those activities.

Task One: Fine Arts and Mathematics

The students' choice of the sitcom Martin as a setting for demonstrating their understanding of the mathematical concepts of the period and amplitude of sine and cosine functions was a way of letting their voices be heard. The Fine Arts students were familiar with putting on artistic performances thus, the use of authentic performance tasks was well-suited for them to demonstrate their learning in the mathematics classroom. The fact that they were allowed to use an authentic, socio-cultural, nontraditional way to demonstrate what they were learning is worth noting. It demonstrated that the instructor valued their preferred ways of knowing even if it was not traditional. One of the key outcomes for the course was to improve students' attitudes about mathematics and mathematics learning. The Martin skit by the Fine Arts students engaged the other students in the class and sent a message that they, too, could find common ground among their assets, interests, and mathematics.

Task Two: Psychology and Mathematics: The group of students who were enrolled in precalculus and general psychology also had a choice. They could choose to simply graph the average number of sunlight hours per month over the course of two years for Washington, D.C. and produce a sine or cosine function for the precalculus performance task or they could extend that mathematics performance task into an interdisciplinary project in which they had to apply and explain the real-world phenomenon of Seasonal Affective Disorder to a group of peers. The students chose the latter option and were rewarded with extra credit for their extra effort in their general psychology course. Furthermore, their choice helped them to appreciate the application of mathematics in real world situations.

While the three pillars of pedagogy (curriculum, instruction, and assessment) were in play in the two examples, what mattered most was the nature and quality of the responsiveness of students to these interdependent pedagogical processes during the implementation phase of the lesson. The high level of engagement, due to the professor's allowance of choice to students in curriculum tasks and choice in assessment to show what they know and can do, may have been the critical factors responsible for the learning that occurred during the implementation phase of the lesson. There is some support in the literature that giving students opportunities for active engagement in activities of a lesson facilitates their learning (Borich, 2014; Dean et al., 2012; Fisher, Frey & Lapp, 2011; & Peters & Kitsantas, 2009). Also, researchers in mathematics education have long recognized the importance of engaging students with the content and with each other about mathematics concepts to maximize mathematics learning during instruction (e.g., Mercer et. al., 2019; Resnick et al., 2010, Webb et. al., 2023). It is our contention that learning occurs when students focus their mental effort on learning activities involving the synchronistic and dynamic interactions of assessment, curriculum and instruction.

Preparing Learners for Limited Choices in Assessment after Instruction

At the end of the semester, after instruction, all students were required to take a two-hour final examination developed by a committee of mathematics professors. The departmental final examination was an assessment of students' learning. Furthermore, departmental final examinations tend to be more traditional, more standardized. The students do not have a choice.

To prepare students for the departmental final examination, it was important to familiarize them with the format and types of items that were likely to appear on the test. For example, some features of the format of the test were as follows: (1) it was a timed test; (2) it was administered on an individual basis–no collaboration with other students was allowed; and (3) some of the test items required students to show their work in order to receive partial credit. To facilitate and monitor students' familiarity with the format of the departmental final examination, the instructor administered two one-hour tests during the semester with content, item types, and formats similar to those that would likely appear on the departmental final examination. One purpose of the one-hour tests was to minimize levels of test anxiety among students so that they could maximize their performance. Assessment as a pillar of pedagogy works differently here when the attributes of the assessment become the focus of instruction. The professor conducted a test analysis on the results of each one-hour test to determine if there were any common areas of concern among the students' responses with respect to the content, item types, or formats. The results of each test analysis were used to provide corrective feedback to students–individually and collectively–where necessary. Empirical studies have underscored the effectiveness of the quality and type of feedback from assessment given to students to improve their learning (Hattie and Timberley (2007; Furtak et al., (2016) & Johnson et al., (2019). It is worth emphasizing, though, that students must act on the feedback in meaningful ways if it is to have an impact on their learning.

Application of the Principles for Assessment in the Service of Learning

Principle 1: *Assessment **transparency** provides clear information about assessment content and use to assist learners, teachers, administrators, and parents.*

Students are better equipped to achieve course goals or learning objectives if they understand what the goals and objectives are, assume ownership of them, and can self-assess progress toward them (Nicol & MacFarlene-Dick, 2006). Understanding the goals and objectives means that there is significant agreement between teachers' expectations and students' conceptions of what is expected of them. One way to clarify expectations is to provide students with written statements of intended outcomes. Students enrolled in precalculus were given a course syllabus that outlined the use of authentic and culturally relevant and responsive performance tasks during instruction as well as a traditional departmental final examination which would be developed by a committee of mathematics professors at the end of the semester.

Principle 3: *Assessment design supports learners' **processes**, such as motivation, attention, engagement, effort, and metacognition.*

Culturally relevant and responsive pedagogy (Ladson-Billings, 1995a, 1995b) connects mathematics content to students' lived experiences and facilitates their engagement, motivation, attention, and effort in and understanding of the content. The performance of the skit, based on the sitcom Martin served as a means for teaching students about the mathematical concept of the period of a sine/cosine function as well as an end for assessing students' knowledge and understanding of the concept. The skit was an "instructment"–the combination of **instruction** and **assessment**. An "instructment" is more than a class activity. It also provides valuable feedback to students and teachers about how well students are learning the goals and objectives of the intended curriculum. The notion of an "instructment" builds on the work in the area of formative assessment (Black & Wiliam, 1998; Johnson, 1995).

Principle 5: ***Feedback**, adaptation, and other relevant instruction should be linked to assessment experiences.*

High quality feedback helps students improve their learning and performance. The quality of the feedback is, in part, a function of its relevance, target, timeliness, and tone. Hattie and Timperley (2007) note that feedback should be relevant to the task and address the needs of the student(s). Task-related feedback contains information about how well the goal of the task is understood, how well the task is being accomplished, and whether engagement and involvement in the task led to the attainment of the intended learning outcome(s). Feedback about performance on a task can be targeted at the individual or group level. While individual feedback to each student is ideal, teachers sometimes give feedback to a group of students about group performance. In this latter case, the usefulness of the feedback about the performance may be confounded by the perception that the feedback pertains to other members of the group and not to oneself. Students in the precalculus course received individual and group feedback before and after their performances. Finally, teachers should be aware of and sensitive to the tone–praise and criticism–when giving feedback. Practice the principle "Do no harm!"

Takeaways for Teachers

In this chapter, we make the claim that assessment as a pedagogical process of teaching is inseparable from other pedagogical processes of teaching (curriculum and instruction) when understanding and the improvement of learning are its primary focus. There are several takeaways from the preceding AP Research and Pre-Calculus examples that can serve as guidance for teachers who wish to use the metaphor of *Assessment as a Pillar of Pedagogy in the Service of Learning* in their classroom.

1. Knowing where students are in relation to new learning, where they need to be when a learning cycle ends, and what progress they are making toward where they need to be when a learning cycle ends all involve the interdependent relationships and functions of assessment, curriculum, and instruction.
2. Feedback from results of assessment about student learning is meaningful when it is used to fill learning gaps by teachers in the adaptations they make in curricular and instructional tasks for learning.
3. Students' mastery of learning goals and objectives depends, in part, on opportunities they are afforded for engaging in learning activities where assessments are linked to curricular and instructional tasks.
4. Assessments that offer students choice in modalities of representation of what they know and can do must be complemented by teachers' choice in modalities of representation of curricular and instructional tasks for learning.
5. Culturally relevant assessments for learning must be compatible with culturally relevant curricular and instructional tasks for learning.
6. A learner's engagement in assessment tasks is likely to be sustained when its results are used to design curricular and instructional tasks of interest to them and address their needs.
7. Assessments with embedded scaffolded instructional and curricular features are likely to influence student learning positively.
8. Features of assessment when used in instructional and curricular tasks are likely to influence students' learning positively.
9. Peer and teacher feedback from assessments influence students' subsequent engagement in instructional and curricular tasks.
10. Learning is facilitated when the interdependent relationships of assessment, curriculum and instruction are in alignment with learning goals and objectives.

Conclusion

When evidence is generated from assessments that students are learning and making progress in their learning, we can argue that assessment is in the service of learning. But a closer look at this claim reveals that for assessment to function in this way, it must be integrated with other pedagogical processes that share a similar purpose of assessment to inform and improve learning. As students engage in activities when these interdependent pillars of pedagogy are in operation, the evidence of learning and its improvement become visible when they demonstrate what they know and can do in a variety of ways (e.g., their verbal exchanges with peers and or the teaching person and digital, figural, graphical representations of their work). Analyses and interpretations of the evidence of the processes for learning can be used by the students and their teachers to inform changes in one or more pillars of pedagogy and learning processes that drive subsequent learning and teaching. In this chapter, examples from two disciplinary domains of AP Research and Mathematics Education were used to demonstrate assessment and its inseparability from other pillars of pedagogy that have learning as its central focus. Research support for the notion of the interdependence of assessment, curriculum and instruction and its relationship to learning is referenced, as are principles of transparency, assessment design and feedback, selected from the *Principles of Assessment in the Service of Learning.* Moving forward, the issues discussed in this chapter offer some guidance for a research and development initiative to generate empirical evidence of assessment as a pillar of pedagogy in the service of learning.

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