2021

# Middle School Teacher Perceptions of Digital Tool Integration for Formative Assessment and Feedback

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This is to certify that the doctoral study by

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has been found to be complete and satisfactory in all respects,
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Abstract

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Project Study Submitted in Partial Fulfillment

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Abstract

District leaders in a suburban New England middle school expect that teachers will use technology to administer formative assessments and use the resulting feedback to plan subsequent instruction, but it is often unclear how or if feedback is being used to do so. Anytown Middle School (a pseudonym) teachers inconsistently use digital tools for formative assessment and feedback. The purpose of this qualitative case study was to explore how teachers perceive the use of digital tools to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. Guided by the technological pedagogical content knowledge (TPACK) conceptual framework, the research questions focused on understanding how teachers integrate digital tools to facilitate formative assessment and use feedback. Eight classroom teachers, who indicated in a prestudy survey that they used technology for formative assessment and feedback, were purposefully selected to provide study data via interviews and lesson plans. The study results indicated inconsistent demonstration of technological content knowledge (TCK) and TPACK by teachers when integrating digital tools to facilitate formative assessment and an inability to articulate how digital feedback informs subsequent instruction. A 3-day professional development opportunity was crafted to assist district leaders in addressing the inconsistent teaching practices illuminated by the study. The project and study findings may contribute to positive social change by providing teachers with specific strategies to improve TCK, TPACK, and planning practices, leading to effective digital formative assessment and feedback, which has been shown to have a positive influence on student achievement and in preparing students for 21st and 22nd century learning as well as a rapidly evolving global society.

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# Dedication

First and foremost, I dedicate this project study to my spouse, Itzá, whose enduring love, patience, and unending and unconditional support made the completion of this possible. Throughout this process, and indeed since the beginning of our time together, you have been the air that I breathe and the gravity that tethers me. Like every other task in our lives, I simply could not have done it without you. I am eternally humbled and grateful every second of every day that we have chosen to ride this rock around the sun together. Yo te amo.

Also, I dedicate this work to my parents, Jimmie and Joan, both of whom passed from this earth during the completion of the project. Throughout my life, my mom praised me for my "sticktuitiveness," which was clearly a trait that was inherited from both her and my dad. Beginning when I was a toddler, my dad worked a full-time job and attended night school part-time for nine years to become the first person in our extended family to earn a college degree. In word and in deed, he and my mom continually modeled a tremendous work ethic and upheld the values of finishing what you start and earning what you get. I thank them for this commitment and for passing these values on to me. I only wish they were here to enjoy this achievement with me.

I would also like to dedicate this project to my mother-in-law, Elena Campos. Over the last twenty-plus years, she has become a second mother to me and has graciously welcomed me into her family, loved me, fed me delicious food, and treated me as one of her own. Thank you, Elenita.

Finally, this project is dedicated to all of those who have ever called themselves "teacher." You live and breathe every student's joys and triumphs. You teach, you push, you pull, you threaten, you high-five, you bang on the desk, you question, you answer, and hopefully you laugh - a lot. Then at the end of the school year, your students simply walk out of your room and they are gone. When August rolls around, you lace up your teacher sneakers and do it again. Teachers are the real MVPs.

## Acknowledgments

Many thanks and much gratitude to my Walden University Committee members: Dr. Heather Pederson, Dr. Karen Hunt, and Dr. Kay Abernathy. Your thoughtful feedback and astute guidance charted the path toward completion. I am eternally grateful for your efforts and commitment to help me reach the finish line.

To Dr. Dorothy Mohr, who first planted the seed and encouraged me to begin this doctoral journey. Throughout my time working for her, she was my professional North Star, helping me to orient my teaching and academic pursuits toward advancing the needs of our most precious resources - students and staff. Thank you, Boss.

To Dr. Linda Fox and Dr. Janet Holden, whose guidance, encouragement, and reassurance that I could actually finish this ensured that I would and could push through. Your wisdom, commitment to lifelong learning, and unending dedication to practice have served as models for me throughout our time as colleagues. It has been a professional honor to work alongside both of you. It has been a personal honor to call you both my friends.

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# Section 1: The Problem

The problem under study was situated in a suburban middle school in the northeastern United States, which I refer to in this study as Anytown Middle School (a pseudonym). Specifically, the problem addressed in this qualitative case study was the inconsistent digital tool integration by Anytown Middle School teachers to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. Formative assessments can be particularly stimulative to student learning when resulting evidence is interpreted and used by classroom teachers to affect subsequent instructional decisions; this effect is particularly powerful when formative assessment is coupled with timely feedback to students (Black & Wiliam, 1998a, 2009; Clark, 2012; Hattie & Clarke, 2019). As technological options to facilitate formative assessments in the classroom environment have been introduced, researchers have begun to recognize the potential for digital tools to facilitate timely teacher response and foster adjustment to student needs throughout the learning process (Faber et al., 2017; Lee et al., 2015; McMillan et al., 2013; Shirley & Irving, 2015). Teachers, however, are not utilizing digital tools to their full potential as a means of formative assessment delivery or for gathering resulting data to provide feedback to students (Hooley & Thorpe, 2017; Luckin et al., 2017; Spector et al., 2016; Sweeney et al., 2017).

Technological advancements have been made to support formative assessment in instructional settings across the educational discipline; yet, these improvements have failed to yield large-scale implementation (Bhagat & Spector, 2017; Luckin et al., 2017). Alenezi (2017) contended that access to educational technology does not lead to a level of implementation commensurate to the saturation of technology in the educational setting. Spector et al. (2016) stated that despite the ready availability of advanced technologies in schools, there has been insufficient adoption of these tools to support formative assessment. Researchers have found a prevalence of inconsistent digital tool integration to facilitate formative assessment and use the resulting feedback to inform subsequent instruction (Abrams et al., 2016; Hooley & Thorpe, 2017; Luckin et al., 2017; Zhan & So, 2017).

## The Local Problem

The research problem under study has been demonstrated at a suburban middle school in the northeastern United States. The Anytown Middle School operates in a 1:1 Chromebook environment, where every student in Grades 6–8 is issued a district-owned Chromebook for educational use during the school year. Despite such ubiquitous technology access, there is evidence that teachers are using the tools inconsistently to facilitate formative assessment and feedback. The Anytown Middle School technology integrator reported that teachers rarely consider using digital tools to conduct formative assessments in their classrooms. These observations are supported by data obtained via GoGuardian, the Anytown School District's Chromebook management software. GoGuardian provides a school-wide measurement of the amount of time spent by Chromebook users on each website, application, and extension. Between May 5, 2018 and June 4, 2018, of the top 25 sites accessed by Anytown Middle School students via Chromebooks, only two were digital formative assessment tools. The existence of the research problem in the local setting was further bolstered by results derived from a 2018 district-wide survey conducted using BrightBytes (Version 3.0) software. Anytown Middle School teachers were asked to respond to the statement, “Teachers administer digital or online assessments to a majority of their students.” With 34 of 35 teachers responding to the survey, 78% indicated that digital or online assessments were administered to their students either monthly or less frequently. These data suggest that Anytown Middle School teachers are inconsistently integrating digital tools to facilitate formative assessment and using feedback from such assessment to inform subsequent instruction.

## Rationale

The Anytown School District uses the 2007 Danielson Framework for Teaching to administer formal evaluations of teachers. In completing these evaluations, district administrators have noted inconsistent digital tool integration in formative assessment and feedback. Component 1f, Designing Student Assessments provides administrators with guidelines to evaluate how teachers approach the design of formative assessments as well as how teachers use the assessment results in subsequent instruction (Danielson, 2007). Component 1d, Demonstrating Knowledge of Resources provides criteria for evaluating what a teacher knows about and how a teacher avails themself of resources that will extend content knowledge and pedagogy (Danielson, 2007). Despite teachers and students having ready access to digital formative assessment tools, these tools are not being used consistently for such tasks. A district principal reported that during evaluative classroom observations, teachers often employ paper and pencil-based formative assessments rather than using district-provided digital tools. According to the principal, this strategy negates the Danielson model's criteria for designing formative assessments to derive diagnostic information. A district assistant principal echoed this contention. In referencing the Danielson Framework and the criteria surrounding the importance of using student assessments for planning, the district assistant principal noted the absence of teacher follow up even when digital formative assessments were used. The district assistant principal stated that although the administrative expectation is that teachers will use the digital feedback from formative assessments to plan subsequent instruction, it is often unclear how or if feedback is being used to do so.

Data acquired from school district stakeholders supported the deficiencies noted by administrators. As a Future Ready school district, the Anytown School District uses the Future Ready Schools Framework to provide guidelines and recommendations specific to stimulating digital learning and fostering instructional best practices. These guidelines and recommendations are then used to develop the Anytown School District Future Ready Technology Plan. This document specifies district-wide goals and action plans including those specific to curriculum, instruction, and assessment. Developed from survey data collected from administration, teachers, parents, and students, the Future Ready organization compiled a Digital Learning Readiness Report for the Anytown School District. In this report, digital learning is, in part, defined as encompassing a myriad of tools and practices that function to emphasize high-quality instruction while ensuring that feedback is provided through formative assessment.

The Digital Learning Readiness Report identified district-wide digital readiness gaps related to inconsistent digital tool integration to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. Part of Gap 4.1 stated that there is little evidence of coordination to create a digital environment where technology and formative assessment are aligned to stimulate the learning process. In parallel, Gap 5.2 noted the absence of established protocols for district teachers to follow for using digital tools to synthesize and analyze diagnostic formative data for teaching and learning. Gap 5.1 of the readiness report cited minimum data culture when underscoring that teachers in the district are not using data to inform their teaching. These gaps provide demonstrative evidence that there is inconsistent digital tool integration by Anytown Middle School teachers to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. Understanding how Anytown Middle School teachers perceive the use of digital tools to facilitate formative assessment and use the resulting feedback to inform subsequent instruction may help district staff to build or improve upon effective teaching practice within the Danielson Framework.

## Definition of Terms

The following terms and their respective definitions were used in this project study:

*Connected classroom technology (CCT)*: Technology that connects a teacher's device to student handheld technology to enable teacher-student communication and engagement with course content (Irving et al., 2016).

*Digital tool*: Software programs or other technologies that collect student responses for analysis (Bugaj & Poss, 2016).

*Feedback*: Any message communicated to a student with the intention of helping the student improve (a) by providing direction for "where to next" or how to make improvements to the work, (b) in a time frame that allows for student revision or application of the feedback, and (c) in a manner that is accessible to the student (Hattie & Clarke, 2019). Black and Wiliam (1998a) referred to feedback as "any information that is provided to the performer of any action about that performance" (p. 53).

*Formative assessment*: Teacher and student activities that provide information to be used subsequently as feedback. The feedback will inform, then modify, teaching and learning practices. Formative assessment requires that teachers, students, or both use the feedback information to guide the teaching and learning process (Black & Wiliam, 1998a).

*Formative assessment probes*: A questioning technique aimed at finding out prior knowledge of students to determine subsequent instruction without scoring the responses (Bulunuz et al., 2016).

*Information and communication technology (ICT)*: Technology encompassing the infrastructure used to facilitate instruction using computational devices (Genlott & Grönlund, 2016).

*Student response systems (SRSs)*: Also called clicker systems; wireless, remote control digital tools that allow for anonymous responses to multiple-choice questions from large groups of students (Egelandsdal & Krumsvik, 2017).

*Summative assessments*: Activities that are implemented at the end of an instructional sequence to provide data that measures student learning (Spector et al., 2016).

*Technology-enhanced assessments (TEAs)*: Assessments that use technology to enhance the educational value of the assessment process and the feedback loop (Sweeney et al., 2017).

## Significance of the Study

There is evidence that teachers are not using digital tools consistently to facilitate formative assessment and use the resulting feedback to inform instruction on a global level (Lin & Lai, 2013; Maier et al., 2016; Reid, 2015) or at the local level. This study could be significant because it may provide Anytown School District leaders with a clearer understanding of how teachers perceive digital tool integration to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. This may allow district leaders to make informed decisions regarding professional development (PD) to bolster teacher performance regarding evaluative components in the Danielson Framework. Such PD could foster positive social change by benefitting student learning and assisting other school districts whose teachers exhibit similar inconsistencies in digital tool integration to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. I conducted a qualitative case study to address the research questions and guide the development of subsequent supports.

## Research Questions

RQ1: How do Anytown Middle School teachers integrate digital tools to facilitate formative assessment?

RQ2: How do Anytown Middle School teachers integrate digital tools to use feedback resulting from formative assessment to inform subsequent instruction?

## Review of the Literature

This literature review contains topics including definitions of formative assessment and feedback as well as their benefits to teaching practice. Discussion of inconsistent application of formative assessment and feedback along with technological, pedagogical, and content knowledge (TPACK) related challenges to their implementation follows. I also present research centered on technology integration, focusing on inconsistent digital tool integration for formative assessment and feedback. The benefits of digital tool integration for formative assessment and feedback are provided, as are TPACK-related challenges to their implementation.

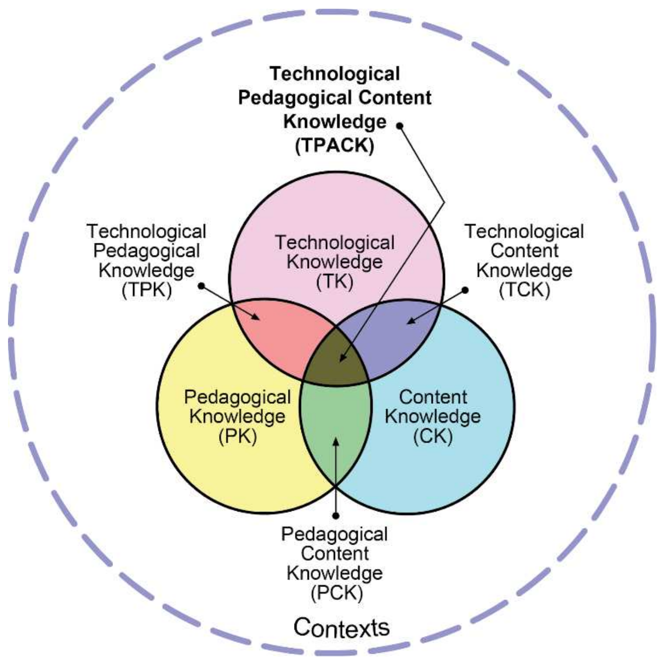
I located research articles and publications that guided the literature review using a comprehensive search of the resources available in the Walden University Library. Narrowing my searches to peer-reviewed and full-text articles that were published in the last 3 years (2016–2019), I used the following databases: ProQuest Central, EBSCO, ERIC, Education Source, SAGE Journals, ScienceDirect, and Thoreau Multi-Database Search. Older literature, however, was cited to provide foundational research related to formative assessments and the TPACK framework. I conducted database searches using the following keywords and phrases: *formative assessment, feedback, formative assessment and feedback, technology, ICT, student response systems, classroom response systems, digital, digital tools, TPACK, and formative assessment and TPACK*. When relevant articles were procured, I often used the reference lists of these articles to find other applicable research. Due to the qualitative nature of this study, qualitative literature in which TPACK was employed as the conceptual framework was referenced to assist in project development.

**Conceptual Framework**

The conceptual framework that grounded this study was Mishra and Koehler's (2006) TPACK framework (see Figure 1). This framework underscores the interconnectedness of its integrated knowledge components: technological knowledge (TK), pedagogical knowledge (PK), content knowledge (CK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge.

**Figure 1**

*TPACK Framework*




*Note*. From "Technological Pedagogical Content Knowledge (TPACK) Framework," by M. Koehler and P. Mishra, 2012. Copyright 2012 by http://www.tpack.org. Reproduced by permission of the copyright holder.

Mishra and Koehler (2006) stressed that successful technology integration in the classroom is reliant upon the teacher's ability to navigate the complexities of all TPACK knowledge components, both independently and simultaneously. By extension, the successful implementation of digital tools to facilitate formative assessment and use the resulting feedback to inform subsequent instruction can be clarified by examining the connections outlined by the TPACK framework (Sweeney et al., 2017). By exploring how teachers employ the TPACK knowledge components through the digital formative assessment process, it was possible to develop an understanding of how Anytown Middle School teachers perceive the use of digital tools to facilitate formative assessment and use the resulting feedback to inform instruction. District leaders can use this understanding to make informed decisions regarding PD or other instructional supports to bolster teacher performance regarding evaluative components in the Danielson Framework.

***History of Conceptual Framework***

The TPACK framework was built upon the foundation first established by Shulman's PCK (Mishra & Koehler, 2006). Shulman (1986) argued that focusing on teacher PK or CK as independent constructs was an insufficient strategy for understanding teacher knowledge. Focusing instead on the intersection of PK and CK provides a more complete characterization of the complexities of teaching. In this way, Shulman's PCK attempted to frame teacher knowledge by inextricably linking the core components of teaching and learning: PK and CK. The embodiment of the interplay between PCK provides teachers with the knowledge for successful practice (Shulman, 1986).

Just as Shulman rejected the notion that PK and CK were constructs to be applied independently, Mishra and Koehler (2006) noted that in the field of education, technology integration is generally erroneously considered as independent from the teaching and learning process. Extending the work of Shulman, Mishra and Koehler recognized the necessity to assess the teacher knowledge that is required to integrate technology into teaching while situating this knowledge among the PCK components of teaching and learning. Consequently, the TPACK framework for educational technology was derived by Mishra and Koehler to "capture some of the essential qualities of teacher knowledge required for technology integration in teaching, while addressing the complex, multifaceted, and situated nature of this knowledge" (p. 1017). In creating a perspective of TPACK that can help to account for what teachers know and can do, the TPACK framework can help to inform how Anytown Middle School teachers integrate digital tools to facilitate formative assessments. The TPACK framework can also help to inform how Anytown Middle School teachers integrate digital tools to use feedback resulting from formative assessment to inform subsequent instruction.

***Constructs of Conceptual Framework***

According to Koehler and Mishra (2009), TK will always be in a state of flux, requiring teachers to continually adapt to the possibilities of best applying a tool to achieve instructional goals. Espoused by Koehler and Mishra as the basis for effective teaching with technology, the TPACK framework on a holistic level requires that teachers develop

> an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones. (p. 66)

While this holistic definition encompasses the interplay of all individual TPACK knowledge components, Mishra and Koehler's (2006) TPACK framework followed the work of Shulman (1986) in considering pairs and triads of knowledge constructs integral to effective teaching with technology integration. These knowledge constructs were PCK as laid out by Shulman (1986), along with TCK, TPK, and the aforementioned TPACK. TCK contains teacher understanding of technologies that are suited for facilitating subject matter learning in their content areas, with a focus on how the subject matter can be represented and/or how the content can be used to alter the technology (Koehler & Mishra, 2009). TPK is knowledge of how to use technology in developmentally appropriate ways as a means of maximizing affordances and minimizing the constraints of available tools (Koehler & Mishra, 2009). In creating the PCK framework, Shulman argued that effective teaching practice required transformative teaching that combines CK and PK. The TPACK framework takes this one step further by outlining the knowledge components that are essential for effectively integrating technology in teaching.

Mishra and Koehler (2006) intended for the TPACK framework to foster more effective technology integration and to allow for the development of "scholarship and research into the nature and development of teacher knowledge" (p. 1044). The TPACK framework was designed to help educators gain a better understanding of effective technology integration in the classroom and to allow researchers to "make predictions and inferences about contexts under which good teaching will occur" (Mishra & Koehler, 2006, p. 1044). In this project study, I addressed inconsistent digital tool integration by teachers to facilitate formative assessment and use the resulting feedback to inform subsequent instruction on both a global and local level by operationalizing the TPACK knowledge components. Mapping teacher knowledge of the TPACK components and their knowledge of the interplay between the components can assist teachers in instructional planning that reflects best practices for effective technology integration (Harris et al., 2009; Mishra & Koehler, 2006).

### *Rationale for Conceptual Framework*

My choice of the TPACK framework as the conceptual framework for this study was supported by the qualitative nature of the study. I developed the research questions from the stated problem and the accompanying research that supported a gap in practice at both the global and local levels (see Ravitch & Carl, 2016). Qualitative research fosters inquiry that recognizes the complexity and subjectivity of the participants and their attempts to make meaning of their lived experiences (Ravitch & Carl, 2016). Using the TPACK framework to guide the inquiry, I attempted to better understand the gap in practice. This recursive process, building on all the TPACK components, mirrors the complexity of integrating the TPACK knowledge components for effective educational technology use. I operationalized the TPACK knowledge components to explore how Anytown Middle School teachers integrate digital tools to facilitate formative assessments and use feedback resulting from formative assessment to inform subsequent instruction. Given these parameters, a qualitative study approach was an appropriate choice.

In this project study, I relied on interviews with Anytown Middle School teachers and lesson plans from the study participants to gather data for analysis and to ultimately answer the research questions. To make sense of teachers' understanding of TPACK knowledge components, it was necessary to interpret the meanings that individual study participants bring to them (see Denzin & Lincoln, 2013). Ravitch and Carl (2016) stressed that "there are multiple, situated truths and perspectives" (p. 5). Similarly, in the TPACK framework, it is noted that effective technology integration requires interdependent yet differentiated knowledge components depending upon the content, activity, and instructional task (Harris & Hofer, 2011). I used interviews to derive meaning from Anytown Middle School teachers' understanding of these knowledge components as they integrate digital tools to facilitate formative assessments. Interviews were also used to derive Anytown Middle School teachers' understanding of knowledge components as they integrate digital tools to use feedback resulting from formative assessment to inform subsequent instruction. I performed document analysis of lesson plans to support and develop themes in tandem with the data acquired during the interview process. Analysis of lesson plans was germane to understanding how Anytown Middle School teachers integrate digital tools to use feedback resulting from formative assessment to inform subsequent instruction.

**Review of the Broader Problem**

The formative assessment theory developed by Black and Wiliam (1998a) provided the foundation for defining both formative assessment and feedback for this project study. The researchers declared that formative assessment encompasses any activity performed by a teacher or student that informs feedback to alter subsequent teaching and learning. Other researchers, however, noted some general distinctions in their definitions of formative assessments. Irving (2015) and Elmahdi et al. (2018) defined formative assessment as a planned process designed to elicit evidence of students' learning status to guide subsequent instruction by teachers or to guide learning strategies by students. Not identifying formative assessment as a planned process, Bhagat and Spector (2017) limited formative assessment to any feedback that the teacher provides to the learning during instruction that serves to foster learner success. While there are minor distinctions in how researchers have defined formative assessment, a critical point of agreement is that formative assessment functions to inform subsequent instruction.

Feedback is viewed as the vehicle to inform subsequent instruction. Formative feedback is any information communicated to the learner about an ongoing performance intended to bridge the level of learning required by the task (Black & Wiliam, 1998a, 1998b, 2009; Shute, 2008). In a seminal work on feedback, Sadler (1989) stated that feedback is the bridge between where a student is in their learning and where they need to be. Sadler warned, however, that if students are unable to take appropriate action from feedback to close the learning gap, the formative feedback loop to facilitate learning will not be closed. Because formative assessment and the subsequent feedback are designed to inform adjustments to teaching and learning, the concepts of formative assessment and feedback are inextricably linked. Without feedback, there is no formative assessment (Black & Wiliam, 1998a).

***Benefits of Formative Assessment and Feedback: Conceptual Understanding***

The use of formative assessment and feedback in teaching practice could be recommended to be an effective instructional strategy to bolster conceptual understanding. In a review of literature, Black and Wiliam (1998a) found that teacher use of formative assessments increased the conceptual understanding and motivation of students. The researchers also stressed that given the expansive contexts and range of conditions under which significant gains have been demonstrated, such improvements are achievable by many. Subsequent research studies substantiated this argument, demonstrating that learning activities completed using formative assessment increase both cognition and motivation (Kopittke et al., 2012; Torrance & Pryor, 2001; Trauth-Nare & Buck, 2011). The wide range of student groups, content areas, and formative assessment strategies that were used in hundreds of independently conducted studies indicated that there was tremendous potential to incur benefits in conceptual understanding across the educational spectrum. Bulunuz et al. (2016) likewise suggested that student gains in conceptual understanding can be realized from teacher use of formative assessment methods. The researchers found that formative assessments continually presented opportunities for students to develop their interpretation and reasoning skills while simultaneously providing data to guide teacher planning for subsequent instruction. Concluding their study, Bulunuz et al. noted that students ultimately scored higher on the standardized science test than on preceding formative assessment probes, which indicated an advantage to promoting conceptual understanding through formative assessment methods.

### *Benefits of Formative Assessment and Feedback: Student Achievement Gains*

In addition to the findings from Bulunuz et al. (2016), definitive student achievement gains have been documented following the integration of formative assessment. A Black and Wiliam (1998b) research review surveyed more than 20 studies whose focus was innovations that intended to strengthen formative assessment processes. These studies included participants whose students ranged from 5 years of age to university undergraduates and were conducted across a multitude of school subjects in several different countries. In their analysis of study results, Black and Wiliam reported quantitative proof of learning gains on test scores as compared to typical student scores on the same tests. Wiliam et al. (2004) also reported a similar increase in standardized test scores following a collaborative study aimed at helping teachers to develop formative assessment strategies. Using a total of 24 teachers in six secondary schools (two math and two science teachers per school), researchers found that by focusing on improving formative assessment practice, benefits to mandated standardized assessments resulted.

In a similar study, efforts were made to improve standardized assessment scores of a mid-sized suburban school district in the Midwest by focusing on supporting teachers in their formative assessment practices. This study was conducted in a public school district with 529 teachers and 10,000 students and reported a statistically significant increase in state reading test scores between Grades 3 and 4 (Curry et al., 2016). Ali and Iqbal (2013) saw similar results in a study comprising participants from four eighth-grade science classes. Analysis of posttest achievement scores showed that the experimental group, regardless of gender, scored significantly higher than the control group (Ali & Iqbal, 2013). Across the decades and in consideration of hundreds of research undertakings, the beneficial nature of formative assessment to student learning and achievement is a recurring finding.

### *Inconsistent Use of Formative Assessment and Feedback*

Despite the significant volume of research that speaks to the benefits of formative assessment and feedback, there is also evidence of inconsistent integration of formative assessment and feedback instructional strategies by teachers. There was a myriad of challenges to teachers to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. Several general concerns highlight these challenges. Black and Wiliam (1998a) suggested that formative assessments were not well understood by teachers and are resultantly weak in practice. The researchers noted that formative assessment implementation necessitates a change in teacher perception of their role in classroom practice. Black (2015) reiterated the same concerns, stressing a need for continued attention in support of developing the formative assessment practices implemented by practitioners and examined by researchers. A systemic emphasis on summative assessments rather than formative assessments has hindered the evolution of formative assessment practice (Chanpet et al., 2018; Spector et al., 2016; Sweeney et al., 2017). Hooley and Thorpe (2017) noted that teachers primarily use summative assessments to track student reading comprehension rather than use formative assessment strategies to scaffold instruction. A general emphasis on high-stakes testing and accountability also minimizes the priority given to formative assessment as an instructional strategy (Chanpet et al., 2018; Curry et al., 2016; Shirley & Irving, 2015). A shift in mindset and priorities, from classroom teachers and the educational community at large, will be necessary to help educators reexamine their roles in the teaching and learning process.

***PK Component Challenges***

Some challenges experienced by teachers to facilitate formative assessment and use the resulting feedback to inform subsequent instruction are pedagogical in nature. Such PK component deficiencies contribute to formative assessment and feedback as being a weak area of teacher practice (Fuller & Dawson, 2017; Irving, 2015; Shirley & Irving, 2015). Chanpet et al. (2018) suggested that there are characteristics inherent in traditional face-to-face classrooms that contribute to problematic pedagogy. Teachers can participate in only one interaction at a time, thereby limiting the teacher or student feedback. This feedback also cannot be reviewed later by either teacher or student for subsequent action (Chanpet et al., 2018). Face-to-face classrooms are also ripe with inefficiencies given the need to communicate similar messages in different contexts with multiple combinations of individuals and groups of students. Teacher lecture is a common strategy meant to create efficiency by maximizing content coverage; however, this strategy provides minimal opportunity for teachers to formatively assess student thinking or for students to formatively adapt their understanding and learning behaviors (Alt, 2018; Irving, 2015). This same strategy, however, creates a logistical challenge to collecting, aggregating, and analyzing data during real-time instruction. Performing data analysis while instruction is ongoing and providing subsequent feedback is both challenging and demanding to classroom teachers (Abrams et al., 2016; Irving, 2015; Yilmaz, 2017). The complexity of facilitating formative assessment and using the resulting feedback requires a repertoire of instructional tools and strategies to meet the learning needs of students.

### *CK Component Challenges*

Challenges to facilitate formative assessment and use the resulting feedback to inform subsequent instruction can be specific to the content in which the activity is being applied. Much of the difficulty of planning such activities lies in the difficulty of aligning assessment tasks to the curriculum (Zhan & So, 2017). Learning tasks are designed and implemented differently given classroom context and disciplinary area. Learning activities such as science laboratory experiments or sentence structure analysis are specific to the content area (Harris & Hofer, 2011). Abrams et al. (2016) reported teacher inadequacy of locally developed formative assessments. Teachers developed formative assessments that yielded student learning data insufficient to determine subsequent instructional strategies and to address common learning misconceptions (Abrams et al., 2016). Teachers mentioned other difficulties specific to aligning formative assessment to curriculum, namely the expansion of content in state curriculum requiring a higher level of student cognitive demand, coupled with an inadequate local infrastructure to support the synthesis of formative assessment data (Abrams et al., 2016).

The complexity of the subject matter also presents a unique challenge to teachers. Subject matter that includes complex problem solving or project-based learning may present limitations by how students are relegated to communicate. Mathematical explanations, articulation of laboratory reports, or learning gleaned from projects or other large-scale activities require students to articulate their thoughts or actions in nontraditional ways (Soto & Ambrose, 2016). Relying on the written work of students to communicate the intricacies of their learning in these types of formative assessments can lead to inaccurate judgments from teachers as to the level of student understanding.

***PCK Component Challenges***

Facilitating formative assessment and using the resulting feedback to inform subsequent instruction is a complex process. Focusing on either teacher PK or CK components independently is insufficient to understand teacher knowledge (Shulman, 1986). Focusing on the overlap of PCK allows for a more complete characterization of the complexities of teaching in general and in facilitating formative assessment and feedback specifically (Koehler & Mishra, 2009). In this overlap, teachers are continually challenged to interpret their subject matter and find a multitude of manners in which the content can be represented and made accessible to all learners (Mishra & Koehler, 2006). While Spector et al. (2016) reported concerns regarding “potentials, concerns and issues with regard to the role of technology” in formative assessment, these same concerns are widely applicable to the overlap of pedagogical and content challenges inherent in formative assessment and feedback (p. 58). The authors lamented the challenges of classes with high numbers of students, multi-grade classrooms, and a combination of these environments across the educational landscape. Spector et al. argued that additional challenges exist in the form of developing complex formative assessment tasks, filtering and synthesizing the voluminous resources and data that result, providing relevant and timely feedback to learners that is individualized and conducive to learning, and emphasizing formative assessments rather than overemphasizing summative assessments. These challenges are clear barriers to the ability of teachers to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. Only by tackling these challenges can educators master the inextricable combination of PK and CK that are the basis for successful teaching practice (Shulman, 1986).

**Technology Integration**

The benefits of facilitating formative assessment and using the resulting feedback to inform subsequent instruction are resounding but the complexity of the PK and CK teacher knowledge components to effectively execute these tasks in the classroom inhibit the process. The broader problem of this project study adds the TK component for consideration. Like the applications of Shulman's (1986) PCK framework, Mishra and Koehler (2006) contended that successful technology integration in the classroom is reliant upon the teacher's ability to navigate the complexities of TPACK components. By extension, the successful implementation of digital tools to facilitate formative assessment and use the resulting feedback to inform subsequent instruction can be clarified by examining the connections outlined by the TPACK framework (Sweeney et al., 2017). Despite technological advancements, researchers have consistently found a prevalence of inconsistent digital tool integration to facilitate formative assessment and use the resulting feedback to inform subsequent instruction.

In recent years, educational institutions have committed tremendous financial resources to technology integration (Bhagat & Spector, 2017; De Witte et al., 2015; Spector et al., 2016). De Witte et al. (2015) noted a considerable improvement of infrastructure dedicated to ICT in secondary schools while Sweeney et al. (2017) and Romero-Martín et al. (2017) noted the push toward digital technologies in higher education. High-stakes testing measures and educational reform movements coupled with more available technology have shifted the focus of many school administrators to a greater emphasis on data-driven instruction (Curry et al., 2016; Hooley & Thorpe, 2017). School administrators expect that teachers will use the digital tools available to derive data to guide student learning. Teachers, however, find the integration of technology into everyday classroom activities to be challenging (Liu et al., 2017; Sweeney et al., 2017). As a result, technology integration in the classroom tends to be infrequent, sporadic, and particularly limited due to curricular constraints (Liu et al., 2017). Despite the ever-increasing access to technology in the classroom and the increasing expectations for teachers to use technology to derive data to drive instruction, technology integration has yet to occur on a level commensurate with recent investments (Alenezi, 2017; Bhagat & Spector, 2017; Spector et al., 2016). Researchers have found a prevalence of inconsistent digital tool integration by teachers in the field of education (Alenezi, 2017; Bhagat & Spector, 2017; De Witte et al., 2015; Liu et al., 2017; Spector et al., 2016).

**Inconsistent Digital Tool Integration for Formative Assessment and Feedback**

While teacher integration of technology in education has proven to be an inconsistent endeavor for teachers, researchers have also found this inconsistency in digital tool integration to facilitate formative assessment and use the resulting feedback to inform subsequent instruction (Bhagat & Spector, 2017; Mohamadi, 2018; Spector et al., 2016; Zhan & So, 2017). This is a gap that exists both in research and in practice. As to the gap in research, Zhan and So (2017) testified that little is known of how teachers view and experience digital formative assessment in the classroom. The sparsity of research that does exist rarely targeted how technology was used by teachers to support their facilitation of formative assessment and feedback (Zhan & So, 2017). Mohamadi (2018) concurred by observing a lack of research that outlines how ICT has been integrated into the classroom to advance assessment. In a review of earlier research, Bhagat and Spector (2017) found that the recent explosion of digital tools in the educational arena had not translated into any large-scale implementation of digital tool integration to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. On the contrary, much of the technology integration was used by students to simply access learning resources (Bhagat & Spector, 2017). Bhagat and Spector testified that formative assessment has been largely neglected and despite the potential power of using digital tools to facilitate formative assessment, little evidence exists to support the occurrence. Also lacking in the body of research were explorations of strategies used by teachers to provide instructional feedback because of digital formative assessments (Spector et al., 2016).

Although referring specifically to higher education, Sweeney et al. (2017) pointed to the existing gap in teacher practice. Despite the ready availability of technology-enhanced assessments in higher education settings, the shift to digital formative assessment and feedback methods has been slow to evolve (Sweeney et al., 2017). The findings of Faber et al. (2017) aligned with Sweeney et al. despite being conducted in a grade three classroom. Faber et al. testified that teachers do not primarily use digital tools to improve their instructional activities, thereby limiting the knowledge of the contributions possible from formative assessment activities conducted by digital means.

Maier et al. (2016) found that inconsistent digital tool integration is also prevalent in secondary classrooms, where commonly applicable technology is available but not widely applied. A study conducted by Hooley and Thorpe (2017) in a high school government class found that activities used to formatively assess reading comprehension progress are largely conducted using analog strategies. Bugaj and Poss (2016) also noted the same reliance on analog strategies when teachers and specialists work with students with disabilities. The potential capacity of digital tools to operationalize student learning data to enhance student learning remains elusive (Luckin et al., 2017). Consequently, a problem of inconsistent digital tool integration by teachers to facilitate formative assessment and use the resulting feedback to inform subsequent instruction has been identified.

Despite teachers in the Anytown School District having ready access to digital formative assessment tools, these tools are not being used consistently to facilitate formative assessment and use the resulting feedback to inform instruction (BrightBytes, 2018). District administrators have noted this inconsistency in practice during the process of completing evaluative observations of teachers. In applying the Danielson Framework for Teaching evaluation rubric, district administrators lamented the inconsistent application of Component 1d, Demonstrating Knowledge of Resources. Component 1d outlines the criteria by which teachers evaluated relative to what a teacher knows about and how a teacher avails herself of resources that will extend content knowledge and pedagogy (Danielson, 2007). Understanding how Anytown Middle School teachers perceive the use of digital tools to facilitate formative assessment and use the resulting feedback to inform subsequent instruction has the potential to help district staff build or improve effective teaching practice within the Danielson Framework.

**Benefits of Using Digital Tools for Formative Assessment and Feedback**

There is significant research that supports that formative assessment and feedback can be beneficial when applied in the classroom. These benefits have been demonstrated both in terms of conceptual understanding as well as in established learning gains demonstrated through student achievement measures. Digitizing the formative assessment and feedback loop amplifies the possibilities for beneficial application in classroom settings by increasing the timeliness in which these processes can occur and the real-time data that can be procured. In a synthesis of digital formative assessment literature, Spector et al. (2016) emphasized that the influx of technology in the field of education has placed an even greater emphasis on formative assessments. The researchers noted that as reliance on technology has increased, so has the need for timely feedback. The need for meaningful and timely feedback that is necessary for effective formative assessments is not conceivable without using technology (Spector et al., 2016). Spector et al. specifically identified the tremendous benefit that can result from the data that is collected and aggregated by digital formative assessment tools. Conducting formative assessments using technology allows teachers to facilitate numerous and ongoing data collection aimed at understanding how student learning is progressing. The data generated can subsequently be used to make adjustments tailored to differentiated student needs (Spector et al., 2016).

Barana and Marchisio (2016) echoed the overarching benefits of digital formative assessments found by Spector et al. (2016). In developing an educational model for automating formative assessment, the researchers stressed the advantage of meaningful and timely feedback. Barana and Marchisio also emphasized that the immediate availability of data when automating formative assessments fosters immediate feedback and adaptivity to inform future improvements for both teachers and students. In promoting the use of technology for administering formative assessments, Bhagat and Spector (2017) also recognized the potential advantages of increasing the use of technology to conduct digital formative assessments. Like Barana and Marchisio, Bhagat and Spector noted the potential time savings in automating formative assessment processes rather than performing manual corrections. Additionally, Bhagat and Spector viewed digital formative assessments to aid complex problem-solving tasks, providing a more complete record of the learner processes.

### ***CCT***

Several studies relating to using digital tools to facilitate formative assessment and use the resulting feedback to inform subsequent instruction focused on specific digital tools and their implementation. While touting technological advancements as supportive to formative assessment practices, Irving et al. (2016) emphasized potential benefits in using CCT. Irving et al. saw CCTs as critical to the formative assessment process, specifically in terms of the assistance these technologies can provide to the feedback process. Likewise, Varier et al. (2017) echoed the benefits of CCT in their qualitative research that examined the integration of one-to-one technological devices in a large mid-Atlantic school district. In this study, teachers and students in elementary, middle, and high school attributed increased opportunities to give and receive feedback to the presence of the technological device (Varier et al., 2017). Such modern technologies supported immediate electronic response capabilities, providing teachers with increased and enhanced opportunities to provide feedback throughout the learning process (Varier et al., 2017) and allowing for teachers and students to make classroom decisions based on timely feedback (Irving et al., 2016). Based on the results of their longitudinal study in a national trial of Algebra 1 students and teachers, Irving et al. posited that classrooms facilitated with CCT and the immediate feedback loop made possible in this technological environment fostered positive effects on student achievement. Similarly, Shirley and Irving (2015) explored the experiences of four middle and high school science teachers, focusing on their integration of CCT as a strategy to facilitate effective formative assessments. The researchers found that CCT facilitated instructional tasks helped both teachers and students better understand the extent to which learning was occurring and subsequently influenced ongoing instructional decision-making (Shirley & Irving, 2015). The use of connected classroom technology provided teachers with timely and accurate learning data. Basing subsequent instructional decisions on timely and accurate data improved the formative feedback loop (Varier et al., 2017) and benefited the teaching and learning process (Irving et al., 2016; Shirley & Irving, 2015).

### ***SRSs***

SRSs or clicker systems are also becoming more prevalent in classroom settings thanks to advances in technology. Fuller and Dawson (2017) examined how an integration specialist helped district middle school teachers combine literature-based strategies and SRS technology to perform digital formative assessments, then adjust subsequent instruction. Through this examination, the researchers found benefits for both teachers and students (Fuller & Dawson, 2017). Using the SRS technology, teachers were able to collect data, monitor student progress, and make adjustments during the learning process, while students were reflective and exhibited engaged behavior (Fuller & Dawson, 2017).

Research conducted using SRSs as a means of facilitating formative assessment during classroom lectures has also shown to be beneficial for both teachers and students. During instructional delivery in a one-to-one Chromebook environment, teachers reported that the availability of a technological device increased and enhanced opportunities for feedback (Varier et al., 2017). Teachers also testified that the immediacy of feedback enabled by the presence of technology allowed for mitigation of misconceptions or other student errors earlier in the learning process (Varier et al., 2017). By shortening the feedback loop, instructional adjustments were possible throughout the learning process rather than waiting for the summative exam. Students reported benefits inherent in clicker-based student response systems during classroom lectures. Egelandsdal and Krumsvik (2017) found that students perceived an increased ability to self-monitor their learning. Students also expressed that they were more aware of their level of understanding and on what they should focus on to further their learning (Egelandsdal & Krumsvik, 2017). Likewise, Yilmaz (2017) found that the use of a clicker system was effective in supporting immediate feedback to students while assisting them in ongoing self-assessment and self-regulation. Students testified that the immediate feedback helped them to see their level of accuracy and to compare it to others in the course (Yilmaz, 2017). Additionally, students reported higher levels of engagement and the ability to identify misconceptions more clearly they had relating to the course material (Yilmaz, 2017). Dobbins and Denton (2017) echoed the use of mobile technology in lectures to facilitate engagement. Students found the student response system Textwall enabled them to become more involved in-class lectures and encouraged a level of comfort to communicate not present absent the technology (Dobbins & Denton, 2017). Student response systems provided significant benefits to both teachers and students in facilitating formative assessment and using the resulting feedback to inform subsequent instruction.

***Link to Danielson Component 1f***

Existing literature supported the contention that it may be beneficial to use digital tools to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. Component 1f, Designing Student Assessments is used in the Anytown School District as part of the Danielson Teaching Framework to evaluate how a teacher approaches the design of formative assessments as well as how teachers use the assessment results in subsequent instruction. A district principal reported that during evaluative classroom observations, teachers often employed paper and pencil-based formative assessments rather than using district-provided digital tools. A district assistant principal echoed this contention, noting the absence of teacher follow-up even when digital formative assessments were used. Despite research espousing the benefits of using digital tools for formative assessment and feedback and an evaluation model that measures such performance, there was evidence of inconsistent use of digital tools to facilitate formative assessment and use the resulting feedback to inform instruction.

**Challenges to Using Digital Tools for Formative Assessment and Feedback**

Teachers face significant challenges to integrate digital tools to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. Black and Wiliam (1998a) argued that formative assessments were not well understood by teachers, resulting in weak practice. Black (2015) stressed a need for the continued support of teachers from both practitioners and researchers to assist in developing formative assessment practices. More current research indicated that a lack of basic understanding, as well as a need for continued supports, existed relative to digital formative assessments and feedback.

Teacher understanding of the myriad of ways that digitals tools can be used to collect and analyze data has failed to evolve as quickly as technology has (Bugaj & Poss, 2016; De Witte et al., 2015). Sweeney et al. (2017) found that teachers simply did not understand the nuances of technology and how the tools could be applied to positively affect teaching and learning. Lost in the nuance were the benefits and the full potential possible when using technology to facilitate formative assessments and use the resulting feedback to inform subsequent instruction (Sweeney et al., 2017). Even as technology quickly moved into the educational arena, researchers found that teachers continued to be resistant to integrating technology (Barana & Marchisio, 2016; Elmahdi et al., 2018). Reasons for this reluctance included perceived limitations in the ability to use the technology, skepticism as to the efficacy of the technology, and inadequate PD (Soto & Ambrose, 2016).

As technologies to facilitate formative assessment continued to emerge and become more powerful, the need for adapting PD for educators to accommodate the changes may be necessary (Spector et al., 2016). Barana and Marchisio (2016) noted that most teachers were the recipients of “traditional” education and therefore lacked not only the confidence but the suitable training to integrate technology effectively. Shifting the paradigm from analog to digital formative assessments may require practice and training in the form of PD (Bugaj & Poss, 2016; Zhan & So, 2017). Romero-Martín et al. (2017) reflected that this change in teaching and learning, like other changes before it, required a significant commitment to “proper training and professional development” (p. 65). The researchers echoed Spector et al. in calling for ongoing PD opportunities to operationalize these emerging technologies to “scale up and achieve sustained success” (Romero-Martín et al., 2017, p. 65). PD was identified as a research recommended strategy to help overcome the challenges faced by teachers to use digital tools to facilitate formative assessment and use the resulting feedback to inform instruction.

Successful integration of technology in practice required teachers to understand the complexities of technology, content, and pedagogy, both in isolation and in relationship to one another (Mishra & Koehler, 2006). This TPACK knowledge results from “teachers’ concurrent and interdependent understanding of content, general pedagogy, technology, and learning contexts” (Harris & Hofer, 2011, p. 212) and was informed by the intersections of four knowledge types: PCK, TCK, TPK, and TPACK.

There were challenges to integrating technology that related to each of the four knowledge types.

### *TCK*

Teachers were challenged by developing knowledge of content and by selecting digital tools that best supported the conveyance of that subject matter (Harris & Hofer, 2011; Mishra & Koehler, 2006). Instructional applications of technologies into content-based teaching were found to lack successful integration into teaching and learning (Harris et al., 2009). Despite the increasing availability of classroom technologies, teachers continued to use familiar analog materials and strategies to convey content (Blau et al., 2016; Pape & Prosser, 2018). Harris and Hofer (2011) noted that many teachers were unaware of the wide range of curriculum-based activity approaches and strategies that could be operationalized when assisted by digital tools.

### *TPK*

Teachers were challenged to know how to use particular digital tools in teaching. TPK required that teachers understood how the application of different technologies could change teaching and learning (Harris & Hofer, 2011; Koehler & Mishra, 2009). This knowledge component required that teachers build a more complete understanding of both the pedagogical and technological constraints and affordances of their discipline (Koehler & Mishra, 2009). Studies of K-12 teachers' application of digital tools in practice demonstrated a lack of pedagogical sophistication (Harris et al., 2009). Teachers typically relied on lecturing and class discussion to stimulate learning as well as to formatively assess and provide feedback rather than use digital tools to facilitate such interactions (Egelandsdal & Krumsvik, 2017; Elmahdi et al., 2018; Romero-Martín et al., 2017).

### *TPACK*

Teachers were challenged to teach content using digital tools that best supported their content and simultaneously addressed the needs and preferences of students (Harris & Hofer, 2011). Shirley and Irving (2015) argued that

> Teachers need to be equipped with the necessary skills to implement the technology on a routine basis and train students in how to use it for learning. Similarly, teachers need support in developing the pedagogical skills to know when and how to implement technology to promote student learning as well as in making appropriate subsequent instructional decisions. (p. 65)

TPACK knowledge components were not well understood by teachers. The requirements for teachers to develop the multifaceted and nuanced knowledge components to integrate technology successfully continued to be a challenge. The challenges that have been outlined contributed to inconsistent technology integration (Harris & Hofer, 2011; Harris et al., 2009), and by extension to inconsistent digital tool integration to facilitate formative assessment and use the resulting feedback to inform subsequent instruction.

## Implications

The results of this project study were intended to provide Anytown School District leaders with a clearer understanding of how teachers perceive digital tool integration to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. Based on findings from this project study, a 3-day PD workshop was developed to address the study problem. These workshop opportunities were designed to provide immediately applicable supports to Anytown School District teachers. As research has shown that digital formative assessments can be beneficial to teaching and learning, this study illuminated teacher deficiencies in the TPACK knowledge components which district leaders can use to develop ongoing supports. In attempting to understand how teachers use digital tools for formative assessment and feedback, the TPACK framework can be used to assist in informing district leaders as to what teachers know, what they need to know, and how they might develop what they need to know (Mishra & Koehler, 2006). As a result, district leaders can make informed decisions regarding future PD to bolster teacher performance relative to the evaluative components in the Danielson Framework. The PD opportunity created as the deliverable for this study may also foster positive social change by benefitting student learning and assisting other school districts whose teachers exhibit similar inconsistencies in digital tool integration to facilitate formative assessment and use the resulting feedback to inform subsequent instruction.

Quality technology integration in practice requires that teachers have knowledge of the "complex relationships between technology, content, and pedagogy, and using this understanding" (Mishra & Koehler, 2006, p. 1029). The inconsistent use of digital tools to facilitate formative assessment and use the resulting feedback to inform subsequent instruction, both at the local level and in general practice, indicates that TPACK knowledge components are not well understood by teachers. Because the TPACK framework offers constructs for each combination of knowledge components, teachers may increase their propensity to integrate technology for teaching and learning by developing skills within these constructs. Teachers, however, need assistance in developing skills to effectively integrate technology for student learning and in making appropriate adjustments to instruction (Shirley & Irving, 2015). Researchers have contended that using TPACK as the basis for PD may increase teacher knowledge and thereby positively affect technology integration (Blau et al., 2016; Koh et al., 2017; Matherson et al., 2014). The gap of inconsistent digital tool integration to facilitate formative assessment and use the resulting feedback to inform subsequent instruction is a daunting one. Ongoing PD, including a commitment to coaching and administrative support to improve teacher knowledge of TPACK components, may resultantly prove beneficial to teaching and learning (Blau et al., 2016).

## Summary

There is evidence that digital tools are being used inconsistently to facilitate formative assessment and to use the resulting feedback to inform instruction on a global level and at the local level. The literature examined in Section 1 provided an overarching definition of formative assessment and feedback by which the study can be framed. There is substantial evidence that formative assessment and feedback is beneficial to teaching and learning (Ali & Iqbal, 2013; Black & Wiliam, 1998a, 1998b; Bulunuz et al., 2016; Curry et al., 2016; Kopittke et al., 2012; Torrance & Pryor, 2001; Trauth-Nare & Buck, 2011; Wiliam et al., 2004). Research conducted relative to formative assessment and feedback, however, has found that the integration of formative assessments and feedback are a weak part of teacher practice that is inconsistently implemented (Bhagat & Spector, 2017; Mohamadi, 2018; Spector et al., 2016; Zhan & So, 2017). This weakness of practice and inconsistent integration has also been found when technology is added to the expectations placed upon teachers, despite significant evidence as to the benefits that can be gained from digital formative assessment and feedback (Barana & Marchisio, 2016; Bhagat & Spector, 2017; Spector et al., 2016).

Section 2 will justify the qualitative tradition as the appropriate methodology chosen for this case study. The subsequent section will also outline the methodology used to conduct the research for the project study at the selected site, an outline of procedures for the selection of participants, data collection procedures and their justification, and protocols for how data analysis occurred.

# Section 2: The Methodology

In Section 1, I established that digital tools are being used inconsistently to facilitate formative assessment and use the resulting feedback to inform instruction, despite a substantial body of literature that supports the beneficial nature of digital formative assessment and feedback to teaching and learning. The purpose of this qualitative case study was to explore how Anytown Middle School teachers perceive the use of digital tools to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. In Section 2, I outline the qualitative research design and approach for this study, including a discussion of the criteria for selecting study participants; description of and justification for data collection instruments and procedures; and an overview of the data analysis process, complete with a summary of the data analysis results.

## Qualitative Research Design and Approach

Ravitch and Carl (2016) identified the qualitative case study as a methodology to provide an in-depth perspective of one issue bound by both time and place. In this study, I examined an existing gap in practice involving a single case at Anytown Middle School. The problem addressed in this qualitative case study was inconsistent digital tool integration by Anytown Middle School teachers to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. Applying a qualitative case study approach facilitated the process of answering the research questions driving this study. The research questions were:

RQ1: How do Anytown Middle School teachers integrate digital tools to facilitate formative assessment?

RQ2: How do Anytown Middle School teachers integrate digital tools to use feedback resulting from formative assessment to inform subsequent instruction?

Research conducted using a qualitative tradition encourages the exploration of individual experiences and how the participants make sense of them (Ravitch & Carl, 2016). The purpose of this study was to explore how Anytown Middle School teachers perceive the use of digital tools to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. Qualitative research allowed me to address this singular problem at the Anytown Middle School with focus and precision.

The interview process and the examination of lesson plans made it possible to assess participants in their natural settings from an inquiry perspective so that meaning could be derived from lived experiences (see Denzin & Lincoln, 2013; Ravitch & Carl, 2016). Participant interviews and lesson plan examinations allow for the researcher to view the lived experience through the eyes of the participant (Denzin & Lincoln, 2013). The use of a case study methodology positioned me to operationalize interview and lesson plan data to provide insight into typical experiences and look for patterns and emergent themes among these individual perspectives. Such data collection methods also allowed for the analysis of how Anytown Middle School teachers integrated digital tools to facilitate formative assessment in the context of the Danielson framework and use feedback resulting from formative assessment to inform subsequent instruction.

I considered several other qualitative research designs for the study but found them to be unsuitable. Yin (2016) identified ethnography, narrative analysis, grounded theory, and phenomenology as alternatives to qualitative case study research design. Ethnography includes the immersion of the researcher in the world of the participant as a means of deriving cultural meaning and understanding interactions between individuals (Merriam & Tisdell, 2016; Ravitch & Carl, 2016). While this study required that I derive meaning from participant experiences, there was not a necessity to perform repeated data collection or conduct extensive observations over an extended amount of time as is required in an ethnographic study.

A narrative analysis would also have been an inappropriate design. Narrative analysis requires the gathering of participant stories as a means of constructing reality during the process of data collection (Merriam & Tisdell, 2016). While narratives may be gathered during the interview process, these stories alone would not have provided the depth of knowledge necessary to fulfill the purpose of this study. I did not gather stories; instead, I sought responses to specific questions as well as data documenting digital formative assessment and feedback use from lesson plans.

Grounded theory and phenomenology were also rejected as potential qualitative research design methods. Grounded theory involves the development of theoretical ideas from data formed by determining relationships that appear plausible among various concepts (Ravitch & Carl, 2016). The findings from this study did not include volumes of data across time that would be required to propose an independent theoretical idea. Instead, in this project study, I used data to produce a rich and descriptive understanding of how Anytown Middle School teachers perceive the use of digital tools for the purpose of facilitating formative assessment and using the resulting feedback to inform subsequent instruction. Phenomenological studies focus on commonalities among experiences and constructed realities of a small group of participants (Merriam & Tisdell, 2016). Phenomenological studies differ from qualitative case studies, however, in that they are not bound by space or time. This qualitative case study addressed one problem as identified in one middle school during the study's limited time frame; therefore, I did not engage in the site for a prolonged period with repeated data collection.

## Participants

The study took place at a middle school in the northeastern United States and included eight purposefully sampled teachers as participants. Anytown Middle School employs approximately 35 classroom teachers. In consideration of this, I selected a small sample size. Qualitative studies have no requirements stipulating a minimum number of participants (Merriam & Tisdell, 2016; Patton, 2015). Instead, the focus was to gain the maximum amount of information relevant to the project study.

### Criteria for Selecting Participants

I used purposeful sampling to support an in-depth focus on the study phenomenon and facilitate the selection of participants who could illuminate issues of central importance to the purpose of the study (see Burkholder et al., 2016; Patton, 2002). To facilitate purposeful sampling, study participants shared some similar experiences. All participants were classroom teachers at the Anytown Middle School where all students and teachers have access to a Chromebook or laptop for their educational experiences.

Potential participants had equal access to and training regarding a plethora of digital formative assessment tools. This common knowledge ensured that a degree of participant homogeneity existed. Guest et al. (2006) contended that participants with similarities of experiences assist the researcher in achieving thematic exhaustion.

I also chose participants based on their unique experiences that could directly assist in answering the study research questions. Ravitch and Carl (2016) posited that intensity samples include "information-rich cases that manifest the phenomenon intensely but not extremely" (p. 130). Intensity sampling was used in this case study, and I sought a minimum of eight participants who purposefully chose to use digital tools to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. Patton (2002) recommended exploratory work be done to identify intense samples that contain a depth of information and knowledge about the area of interest. A prestudy survey (see Appendix B) was constructed to facilitate this sampling. Survey Questions 4 and 5 asked teachers about their current use of digital tools for formative assessment and feedback. To gather an information-rich sample, I prioritized selecting participants who, in their classroom teacher role with students, answered that they often use digital tools for formative assessment and feedback, followed by those who answered that they sometimes use the tools for these purposes. Guest et al. (2006) suggested that the sampling process can minimize the number of participants by extracting the maximum amount of information. By selecting participants who integrate digital tools to facilitate formative assessment and use the feedback resulting from formative assessment to inform instruction, the expectation was that the sampling process would minimize the number of participants necessary to extract the maximum amount of information relevant to the project study.

**Gaining Access to Participants**

As suggested by Yin (2014), a critical first step in gaining access to study participants is to seek approval from the university review board. Accordingly, I sought approval from Walden University's Institutional Review Board (IRB). Similar approval was procured from the school district where I intended to conduct the study. Current policies in the school district indicated that approval to conduct a doctoral study in the district must be granted by the superintendent. The principal of Anytown Middle School had previously expressed support for the project study to be conducted at the site. Using the district email system, I sent the Anytown School District superintendent and Anytown Middle School principal documentation regarding the study procedures, potential risks and benefits, and an outline of efforts to establish protection from harm and ensure confidentiality for all parties via email attachment. The Walden University sample consent form was used. Participants were provided with the same documentation via email attachment, along with a notification stating that they could opt out of the study at any point without repercussions. This procedure is recommended by Yin who espoused the imperative nature of notifying all persons "to the nature of your case study and formally soliciting their volunteerism in participating in the study" (p. 78). Using this process of notification and gaining consent protects participants from harm and deception (Yin, 2014). As an additional layer of protection, I did not disclose participant names and assigned pseudonyms to all participants and locations.

I solicited participants from the Anytown Middle School teaching staff. To gauge interest in serving as a study participant, I secured potential participants' email addresses from the district website and emailed all Anytown Middle School teachers information containing study specifics. For interested teachers, a prestudy survey was administered to ascertain classroom teaching role and perceived use of digital tools to facilitate formative assessment and use the resulting feedback to inform subsequent instruction.

### Researcher-Participant Working Relationship

The researcher-participant working relationship should centralize respect as well as address participant concerns and needs (Ravitch & Carl, 2016). Establishing rapport and trust prove invaluable to engaging participants and encouraging their contributions to the study (Laureate Education, 2016). To this end, it was imperative for me to be honest and forthcoming with participants throughout every aspect of the study. Transparency with regards to participant expectations and confidentiality was paramount. Yin (2016) suggested answering such questions as they arise throughout the study in a conversational manner rather than with a formal or legalistic connotation. Setting forth clear expectations and information regarding the interview process and the document analysis process was also necessary to ensure participants were comfortable with the process (see Laureate Education, 2016).

## Data Collection

Successful technology integration in the classroom is reliant on a teacher's ability to navigate the complexities of the TPACK knowledge components. By extension, it was necessary to analyze teachers' application of the TPACK knowledge components in everyday practice when integrating digital tools to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. In this study, I used data from interviews and lesson plans as data collection instruments to answer the research questions.

The data collection instruments selected for this study were true to the qualitative tradition and allowed for the answering of the research questions. Because the study purpose was to explore how Anytown Middle School teachers perceive the use of digital tools when facilitating formative assessment and using the resulting feedback to inform subsequent instruction, I constructed data points to make meaning from participant experiences. Qualitative methodology positioned me as a researcher such that I could begin to understand how the participants "see, view, approach, and experience the world and make meaning of their experiences as well as specific phenomena within it" (Ravitch & Carl, 2016, p. 7). By operationalizing TPACK components, the qualitative data resulting from interviews and lesson plans produced emerging themes that amplified the voices of participants, focusing on the human interactions and answering the research questions (see Ravitch & Carl, 2016).

**Interviews**

Semistructured interviews were the primary data collection procedures in this project study. I conducted virtual meetings via Zoom conferencing to perform the interviews, record the meeting audio, and generate the resulting transcripts because schools were meeting remotely at the time of the study due to the COVID-19 pandemic. I developed the interview protocols for this study and have included them in Appendix C.

Interviews were conducted to gather rich individualized and contextualized data as well as to understand how study participants construct their reality with respect to the research topic (see Ravitch & Carl, 2016). Merriam and Tisdell (2016) stressed that semistructured interview questions should be prepared in advance to derive the necessary data from participants. Following the qualitative methodology, the interview questions were open ended, thereby allowing participants to communicate their perceptions and experiences (see Patton, 2015). Unstructured follow-up questions were prepared to allow for flexibility (see Merriam & Tisdell, 2016). Through a series of planned questions and follow-up probes that I developed, a customized conversation was sought in order to make sense of the participants' individual experiences and understand the variation of perceptions within the context of the participant group (see Ravitch & Carl, 2016). Semistructured interviews allowed for gathering the rich data necessary to answer how the participants integrate digital tools to facilitate formative assessment and use feedback resulting from formative assessment to inform subsequent instructions. I then coded the interview data to derive emergent themes from participants' application of TPACK knowledge components relative to the study problem. These data provided evidence that answered how Anytown Middle School teachers integrate digital tools to facilitate formative assessment and use feedback resulting from formative assessment to inform subsequent instruction.

**Lesson Plans**

Lesson plans were used as a secondary data point for triangulation in the project study. On the day of the participant interview, participants were asked to submit digital copies of two lesson plans from lessons conducted in the traditional classroom setting prior to the transition to remote learning necessitated by the COVID-19 pandemic. Teachers were asked to choose plans from lessons that include the use of digital tools to facilitate formative assessment and feedback. I wrote a brief protocol for the submission of lesson plans by participants and have attached it in Appendix D. The addition of supporting documentation helped to clarify participant behaviors regarding digital formative assessment and feedback while adding an extra layer of trustworthiness to the study (see Shenton, 2004). Document data such as lesson plans can be used to provide verification of interview data and allow for additional connections and insight about the study topic (Yin, 2014). In this case, lesson plans confirmed and clarified how Anytown Middle School teachers integrate digital tools to facilitate formative assessment. As a means of examining consistency of practice, study participants were asked to provide two lesson plans from lessons conducted in the traditional classroom setting prior to the transition to remote learning necessitated by the COVID-19 pandemic. Teachers were asked to choose plans from lessons that include the use of digital tools to facilitate formative assessment and feedback. This documentation provided additional evidence that was analyzed to determine how teachers integrate digital tools to use feedback resulting from formative assessment to inform subsequent instruction. The use of study documents to corroborate and augment other source evidence is critical to case study research (Yin, 2014). Teacher lesson plans served as substantiation of evidence gleaned from the interview process and fit directly within the TPACK conceptual framework. To account for the potential disconnect between stated teacher pedagogical beliefs and actual instructional practice, artifacts such as lesson plans can be used to triangulate testimony from teacher interviews (Harris et al., 2010). This triangulation helped me to understand the nature of teacher TPACK inference (see Harris et al.).

Like the interview data, lesson plans were coded to derive emergent themes from participant application of TPACK knowledge components. A general outline of the coding procedures for interview data, lesson plan documentation, as well as my reflective notes is provided in Appendix E. Using thematic coding, a priori codes reflecting TPACK knowledge components were used to analyze interview data, reflective notes, and lesson plan documentation. The documentation was then subjected to open coding as a means of seeking commonalities and differences from the data. Finally, data were reassembled via axial coding to determine overarching themes and their related subcategories (see Saldaña, 2016). Lesson plan documentation as supporting data provided an opportunity to gain a deeper insight into participant behavior as well as an additional verification of determinations from the interview process (see Shenton, 2004). The resulting data supplied evidence to answer how Anytown Middle School teachers integrate digital tools to facilitate formative assessment and how they integrate digital tools to use feedback resulting from formative assessment to inform subsequent instruction.

**Procedures for Data Collection**

Facilitated by the partner agreement, permission to conduct the study was sought from the site superintendent and the site principal. I asked permission to email all Anytown Middle School teachers and to virtually meet with those who agreed to move forward and possibly participate in the study. The email to Anytown Middle School teachers contained the informed consent form, which includes an overview of the project study, the evidence collection process, participant requirements, expectations of confidentiality, and plans for results sharing. I offered to virtually meet with those teachers who agreed to participate to explain the study, answer questions, and ask that they review the study requirements. These teachers were asked to complete the prestudy survey as a means of ensuring that potential participants either often or sometimes use digital tools to facilitate formative assessment and use feedback resulting from formative assessment to inform instruction. Based on the prestudy survey results, study participants were selected and were asked to email me their consent to participate. Interviews were then scheduled with consenting participants.

Interviews were scheduled with participants via email. One interview per participant was conducted. Interviews lasted an average of 49 minutes, the longest of which was 65 minutes and the shortest 40 minutes. Upon agreement of an agreeable date and time for the interview, participants were emailed a hyperlink to access the virtual meeting location. Interviews were conducted and recorded using Zoom conferencing with my password-protected Zoom account. This application allowed for live conferencing, audio recording, secure cloud storage, and the generation of an interview transcript that was used during the coding process (see Zoom Video Communications, 2020). Each participant was encouraged to be open with their responses and was reminded that all their responses would be confidential. As the TPACK framework served as the conceptual framework of the study as well as the foundation for data analysis, interview questions were designed to reflect the thematic coding that would be necessary to complete the data analysis. Table 1 shows the interview questions used during data collection, as well as the research questions and TPACK knowledge component each question was developed to correspond with to glean relevant study data.

**Table 1**

*Interview Questions Aligned to Research Questions and Conceptual Framework*

| Interview Questions | Research Questions | TPACK Knowledge Component |
|---|---|---|
| 1: Talk about your knowledge of digital formative assessment tools. How do you develop the technological knowledge necessary to use digital tools to facilitate formative assessment? | RQ1, RQ2 | TK |
| 1a: What supports help in this process? | RQ1, RQ2 | TK |
| 1b: What barriers exist in this process? | RQ1, RQ2 | TK |
| 2: Talk about your formative assessment planning process. In designing and planning for formative assessments, how do you determine whether to implement technology? | RQ1, RQ2 | TPK |
| 2a: In designing and planning for formative assessments, how do you determine which, if any, digital tools to use? | RQ1, RQ2 | TPK |
| 3: In your classroom teaching, how are digital tools used during formative assessment to help students understand concepts specific to your content area? | RQ1 | TCK |
| 3a: When formative assessment is administered and feedback is collected, how are the digital tool(s) then used to inform subsequent instruction? | RQ2 | TCK |
| 4: Talk about some classroom experiences with digital formative assessments when the learning process has been most positively affected. In your discussion, include how you knew the learning process was positively affected. | RQ1, RQ2 | TPACK |
| 4a: How do you think lesson design helped to facilitate the results? | RQ1, RQ2 | TPACK |
| 4b: What specific resources helped to facilitate the results? | RQ1, RQ2 | TPACK |
| 4c: How did the resource(s) help to facilitate the results? | RQ1, RQ2 | TPACK |
| 4d: What supports helped to make this possible? | RQ1, RQ2 | TPACK |
| 4e: What barriers impeded the experience? | RQ1, RQ2 | TPACK |

On the day of the participant interview, participants were asked to submit digital copies of two lesson plans from lessons conducted in the traditional classroom setting prior to the transition to remote learning necessitated by the COVID-19 pandemic. Teachers were asked to choose plans from lessons that include the use of digital tools to facilitate formative assessment and feedback. The lesson plans were submitted via email to my personal, password-protected email account. Lesson plans were subsequently transferred to my personal Google Drive. Like the interview data, participants were assured that all documentation will remain confidential. To bolster credibility and reduce potential bias, participants were invited to perform member checks (see Ravitch & Carl, 2016). After data analysis, participants were emailed a copy of draft findings to check their own data. Participants were asked specifically to check for the accuracy of my interpretations of that data and the viability of the findings in the setting. Each participant was provided an opportunity to discuss the findings with me upon request. None of the participants noted discrepancies between my findings and their intended messages, so no changes resulted from the member checking process.

During the interview process, I took field notes, paying special attention to both responses and nonverbal feedback (see Patton, 2015). Following each interview, I made notes on my impressions in a reflective journal regarding emerging ideas and connections (see Yin, 2016). As recommended by Ravitch and Carl (2016), I also exercised reflexivity in using reflective journaling to rigorously examine any potential bias that I might have given my background in technology integration.

Participant identity was protected by using pseudonym references such as Participant 1 and Participant 2. Data were and continues to be secured according to Walden University IRB procedures. All reflective journals remain in a locked cabinet in my home office. A list of participant identities and their corresponding pseudonyms have been placed on a blank flash drive and are stored in the locked cabinet in my home office. Google Drive was used to house all other data collected and is accessible via a password known only to me. All materials will be stored until 5 years after the completion of my study. At that time, all study data will be destroyed by permanently deleting emails relative to the study and the Google Drive folder housing study electronic files. Hard copies of study materials, including my reflective journals, will be shredded.

## Role of the Researcher

I currently serve in the role of instructional coach at the high school in the Anytown School District, a role I have held for nearly 3 years. Before this role, I served as a technology integrator for 3 years and a business education teacher for 9 years in the same school. As an instructional coach, I perform periodic technology training that is available to all district staff, including teachers at the Anytown Middle School. This training has included at least one district-wide workshop per year during the school year and one summer technology camp, all of which are optional for staff to attend. Attendees have no responsibility to me for the implementation of any of these training components in their classrooms. As a result of these training sessions, I have become professionally acquainted with less than 10 Anytown Middle School staff. These relationships did not expand outside of the training sessions. Additionally, none of my roles in the district have been or currently are, supervisory. My current professional position as an instructional coach is generally one that is well respected and looked upon positively. With respect to Anytown Middle School, I am an unbiased external support professional.

As a former technology integrator and one who has a personal and professional investment in the integration of technology in education, there is an inherent risk of bias in the study. Reflecting upon this, I embraced an acute realization of the criticality that my study was prepared with the utmost care to alleviate any unintended bias. Through reflective journaling, I reflected upon my ideas, feelings, and practices in real-time as a means of formulating good research habits and documenting the evolution of my thought processes (see Ravitch & Carl, 2016).

## Data Analysis

An inductive process was used to analyze the data collected through participant interviews, lesson plan documentation, and notes from my reflective journaling. As espoused by McMillan and Schumacher (1997), this process was cyclical and occurred continuously throughout the data collection process. Data from participant interviews and participant lesson plans were recursively analyzed to reach conclusions germane to the study. This qualitative approach was intended to produce both the rich, thick descriptions and the detail-oriented data needed to contextualize the study setting and sample such that study design and findings were transferable (see Ravitch & Carl, 2016; Yin, 2016).

Using the TPACK framework as a foundation for the data analysis, coding procedures for both interview and lesson plan analysis were conducted after data collection and began with thematic coding. Saldaña (2016) suggested that the researcher make a provisional list of codes to align with the conceptual framework as a means of facilitating an analysis that will answer the research questions and study objectives. To that end, a priori codes reflecting the TPACK conceptual framework were utilized. The a priori codes chosen for thematic coding were TK, TPK, TCK, and TPACK. As Mishra and Koehler (2009) intended for the TPACK framework to assist the researcher in examining the nature and development of teacher knowledge when technology is integrated into the educational process, the TPACK knowledge components were used to provide the basis for the thematic coding process.

Open coding followed the thematic coding process. During open coding, I broke the data into discrete parts to examine them for similarities and differences (see Saldaña, 2016). The act of open coding was completed so that emergent codes could be identified. The second cycle process was executed via a priori coding, operationalizing TPACK knowledge components. The codes TK, TPK, TCK, and TPACK were used to categorize dominant data from interview transcripts, lesson plan documentation, and reflective notes. Subsequently, the axial coding process allowed me to link categories with applicable subcategories and to assess relationships among them. Regrouping and reducing the volume of initial codes during axial coding allowed me to finalize conceptual categories that were used to guide subsequent PD (see Saldaña, 2016).

**Evidence of Quality and Procedures**

In this study, triangulation, member checks, and peer review were integrated into the data analysis process to ensure the accuracy and credibility of the study findings. Multiple data points in the forms of participant interviews and document analysis of lesson plans were used to triangulate data to ascertain emergent patterns and to strengthen my findings (see Merriam & Tisdell, 2016). Member checks were performed to bolster the study's credibility. As recommended by Shenton (2004), a member check was offered following the data analysis process to verify the inferences made from the analysis process and to ensure that the participants' articulations were accurately captured. One participant discussed the findings with me but did not indicate that changes to their articulations were necessary. Participants were given the opportunity to review a draft of the data findings for accuracy and to discuss my interpretations of their feedback upon request. One of my professional colleagues assisted me by serving as a peer reviewer. My colleague, an educator for more than 25 years, teaches at the high school where I work and previously earned an Ed.D. degree. After signing a confidentiality agreement, my colleague reviewed all the unidentified data for the logical development of codes, themes, and subsequent findings. Once the peer reviewer had examined the study data, we met to discuss my coding strategies and my subsequent interpretation of the study data. As suggested by Yin (2016), feedback from the peer debriefings was used to make revisions and improvements meant to strengthen the data collected. The peer reviewer concurred that the codes, themes, and ultimate findings as determined through the data analysis process were appropriate and accurately reflected the data collected.

**Discrepant Cases**

To ensure the accuracy and credibility of study results, I made every effort to identify and address discrepant cases. The datum that was perceived to be an outlier or that was contradictory to other themes that emerged from the study were recorded and analyzed as a means of furthering study credibility. Ravitch and Carl (2016) testified that such outliers provide valuable checks on the research process by forcing the researcher to evaluate evidence that may provide insights that challenge our findings. To this end, discrepant data were scrutinized in a manner to seek explanations for such incidents, to amend emergent patterns as necessary, and to explore possibilities for future study (see McMillan & Schumacher, 1997). After a careful and thorough examination of all study data, no discrepant cases were identified.

## Data Analysis Results

The study was conducted at a middle school in the northeastern United States, using purposeful sampling that included eight teacher participants. Anytown Middle School employs 36 classroom teachers. In consideration of this, a small sample size of eight participants was selected. Qualitative studies have no requirements stipulating a minimum number of participants (Merriam & Tisdell, 2016; Patton, 2015). Instead, the focus was to gain the maximum amount of information relevant to the project study. In this case study, I selected a small number of participants who choose to employ digital tools to facilitate formative assessment and feedback in their classroom teaching role with students.

### Process to Gather and Record Data

As suggested by Yin (2014), a critical first step in gaining access to study participants was to seek approval from the university review board. Walden University's IRB approved my study (Approval #06-08-20-0359401). Similar approval was sought from the school district in which I conducted the study. Policy in the school district indicated that approval to conduct a doctoral study in the district must be granted by the superintendent. The superintendent also required that I attain permission from the building principal of Anytown Middle School to conduct the study.

Using the school district email system, the Anytown School District superintendent and Anytown Middle School principal were provided with documentation regarding the study procedures, potential risks and benefits, and an outline of efforts to establish protection from harm and ensure confidentiality for all parties. This documentation was sent via an email attachment. The Walden University sample consent form was used. Due to the COVID-19 pandemic, schools were meeting remotely during the time that I was preparing to collect study data. Given these constraints, I met with both the superintendent and the principal of Anytown Middle School via Google Meet to answer questions and to gain approval to move forward with the study at the site. Facilitated by the partner agreement, permission to conduct the study was sought from the site superintendent and the site principal. During the Google Meet, I asked for permission to email all Anytown Middle School teachers, to distribute a prestudy survey to those who consent, and to virtually meet with those selected participants who agree to move forward and continue to participate in the study. After securing permission to proceed from the district superintendent and the site principal, the district superintendent provided a letter of cooperation to Walden University IRB. Walden University IRB subsequently approved the study.

Participants were solicited from among the Anytown Middle School teaching staff. I secured potential participants' email addresses from the district website and emailed all Anytown Middle School teachers information containing study specifics. The email to Anytown Middle School teachers contained the informed consent form, which included an overview of the project study, the evidence collection process, participant requirements, expectations of confidentiality, and plans for results sharing. The informed consent form directed teachers who wished to consent to participate to respond with the words "I consent" to the accompanying email. Twelve teachers responded to this email. Two teachers expressed interest in participating but communicated that they did not often use digital tools for formative assessment and feedback. Of the remaining 10 teachers, nine consented to participate in the study by emailing me a confirmation of consent. These nine teachers were sent the prestudy survey. Shortly after taking the prestudy survey, one teacher opted not to continue in the study. The other eight teachers were selected to participate in the study based on their answers to the prestudy survey. These eight teachers completed the data collection process. Each participant who inquired or was selected to participate in the study was sent an email of gratitude and thanks for their interest. As the time commitment to participate in the study were multiple hours across multiple days, each participant was also mailed a thank you card and a gift card valued at $20 via the United States Postal Service as a thank you for volunteering time and energy to contribute to the study.

In this study, it was imperative to select participants who could speak to issues that are germane to the purpose of the study (Burkholder et al., 2016; Patton, 2002). The prestudy survey was used as a means of ensuring that potential participants either often or sometimes use digital tools to facilitate formative assessment and use feedback resulting from formative assessment to inform instruction. I prioritized selecting participants who, in their classroom teacher role with students, answered that they often use digital tools for formative assessment and feedback, followed by those who answered that they sometimes use the tools for these purposes. Participants were asked, “In your current teaching, do you integrate digital tools to facilitate formative assessment?” Six participants indicated that in their current teaching they often integrate digital tools to facilitate formative assessment and two participants indicated that they sometimes integrate digital tools to facilitate formative assessment. Participants were also asked, “In your current teaching, do you integrate digital tools to use feedback resulting from formative assessment to inform subsequent instruction?” Four participants answered that they often integrate digital tools to use feedback resulting from formative assessment to inform subsequent instruction. Four participants answered that they sometimes integrate digital tools to use feedback resulting from formative assessment to inform subsequent instruction. Given these responses, the eight remaining participants were asked to participate in an interview and to submit lesson plan documentation.

Interviews were subsequently scheduled with participants via email. One interview per participant was conducted. Each interview lasted between 40 and 65 minutes while the average interview length was 49 minutes. Participants chose the date and time for the interview. The data collection occurred during the last week of the school year and the first 2 weeks of school vacation. Per the partner agreement with the school district, interviews took place outside of contract time while school was in session. Upon agreement of a date and time for the interview, participants were emailed a hyperlink to access the virtual meeting location. Interviews were conducted using Zoom conferencing. Using my password-protected Zoom account, the Zoom application was used to facilitate live conferencing, to provide an audio recording of the interview, and to generate a transcript of the proceedings that could be used during the coding process (see Zoom Video Communications, 2020). Each participant was given the opportunity to ask clarifying questions both before and after the interview. Participants were also encouraged to be open with their responses and were ensured that all their responses were confidential.

During the interview process, I took field notes paying special attention to both responses and nonverbal feedback (see Patton, 2015). Following each interview, I took notes on my impressions in a reflective journal regarding any emerging ideas and connections (see Yin, 2016). As recommended by Ravitch and Carl (2016), I attempted to exercise reflexivity in using reflective journaling to rigorously examine any potential bias that I might have given my background in technology integration.

In the informed consent form, participants were also asked to submit digital copies of two lesson plans from lessons conducted in the traditional classroom setting prior to the transition to remote learning necessitated by the COVID-19 pandemic prior to the commencement of the interview. Teachers were asked to choose plans from lessons that included the use of digital tools to facilitate formative assessment and feedback. The lesson plans were submitted via email to my personal, password-protected Gmail account. Like the interview data, participants were assured that all documentation will remain confidential. To bolster credibility and reduce potential bias, participants were invited to perform member checks (see Ravitch & Carl, 2016). After data analysis, participants were emailed a copy of draft findings and were informed of their participant designation, e.g. Participant 1, so that they could check their own data. Participants were asked specifically to check for accuracy of my interpretations of that data and viability of the findings in the setting. Each participant was provided an opportunity to discuss the findings with me upon request.

Participant confidentiality was guarded throughout the data collection process and will continue to be guarded and respected until which time I am required to destroy all study data. Data were secured according to and approved by Walden University IRB procedures. All email correspondence with participants that used the school district email domain was copied to my personal password-protected Gmail account, then deleted from my district mailbox and emptied from the digital trash. The same personal Gmail account and the corresponding Google Drive were used to house all digital data collected and is accessible via a password known only to me. Zoom interview audio recordings and transcripts were downloaded to my personal password-protected Google Drive. Upon this transfer of Zoom materials, study materials were deleted from my Zoom account and my Zoom account was canceled. Participants were asked to email their lesson plan documentation to my personal password-protected Gmail account. Lesson plan documentation was then transferred to my personal password-protected Google Drive. The identity of all participants was protected by using pseudonym references such as

Participant 1 and Participant 2. A list of participant identities and their corresponding pseudonyms is kept on a blank flash drive and is stored in a locked cabinet in my home office. All reflective journals remain on my person or in a locked cabinet in my home office. All study materials will be stored until 5 years after the completion of my study. At that time, all study data will be destroyed by permanently deleting emails relative to the study and the Google Drive folder housing study electronic files. Hard copies of study materials, including my reflective journals, will be shredded.

**Process to Generate Data**

Through the data analysis process, I derived to understand Anytown Middle School teacher practice with respect to digital tool integration to facilitate formative assessment and feedback. I sought to enable an analysis that would directly answer my research questions. I began the process to generate data with a provisional start list of codes emanating from the conceptual framework. A priori codes can be used to harmonize with the conceptual framework to assist in answering the study's research questions (Saldaña, 2016). Therefore, establishing TK, TPK, TCK, and TPACK as a priori codes helped me to pinpoint the data necessary to understand how teachers integrate digital tools to facilitate formative assessment and how teachers integrate digital tools to use feedback from formative assessment to inform subsequent instruction.

Saldaña (2016) contended that the a priori process requires reading the data and looking for data specific to the code. Consequently, the a priori coding process involved reading the interview transcript data and the lesson plan data in search of teacher knowledge specific to the TPACK knowledge component. A priori coding was completed in the 6 weeks following the completion of the interviews and the subsequent gathering of participant lesson plans. After reading each interview transcript, I listened to each audio recording while simultaneously editing the transcript for accuracy. Throughout the a priori coding process, I accessed both the transcript and the audio recording to ensure the accuracy of both audio processing and interpretation of participant meaning. Each transcript and lesson plan were read recursively to ensure appropriate and accurate application to the corresponding a priori code.

A priori coding was completed by focusing on one a priori code at a time, then through analysis of each participant's responses to one interview question at a time. By reading and evaluating each participants' answer to the same interview question, I attempted to better see their lived experiences with the goal of better deriving the similarities and differences between teacher experiences, and ultimately, to better answer the research questions. I began the a priori coding process by reading each participant's interview transcript for Interview Question #1 and generating codes from the transcript that reflected teacher TK per Mishra and Koehler (2009). Upon completing the a priori coding for each interview question, I examined each participant's lesson plans, again reading recursively to derive codes applicable to the TK component. Finally, I examined my reflective journal, seeking to derive codes applicable to the TK component.

To coordinate the coding procedures, I used a conceptual matrix in Google Docs. This table format allowed for ease of visual referencing between participants and related data. Miles and Huberman (1994) recommended the conceptual matrix as a means of helping the researcher to identify themes and draw inferences from the illustrated data.

The matrix also assisted in subsequent axial coding by providing a format from which I could identify patterns and clusters of ideas while allowing ease of comparison (Miles & Huberman, 1994).

During a priori coding, data from interviews, lesson plans, and my reflective journals were analyzed to identify data reflecting each TPACK knowledge component. Starting with the TK component, I recursively analyzed the first interview question and “pulled out” any demonstration of TK as reflected by each participant. Continuing to focus on TK, I repeated this process for Interview Questions 2, 3, and 4, participant lesson plans, and my reflective journals, each time creating a new conceptual matrix. A sample conceptual matrix is shown in Table 2. Upon completion of a TK analysis of all study data, I completed an analysis of TPK, TCK, and TPACK, following the same procedures.

**Table 2**

*A Priori Codes: TK From Interview Q1*

| Participants | TK – A Priori Codes |
|---|---|
| P1 | |
| P2 | |
| P3 | |
| P4 | |
| P5 | |
| P6 | |
| P7 | |
| P8 | |

Following a priori coding, I conducted a cycle of open coding. Saldaña (2016) suggested that open coding allows the researcher to break data down into discrete parts as a means of comparing them for both similarities and differences. Several readings of the a priori codes for each TPACK knowledge component were required to develop finalized open codes. Ravitch and Carl (2016) noted that open coding may require multiple rounds of analysis with an initial round concentrated on data that stands out and a subsequent round that focuses more specifically on answering the study's research questions. Over 3 weeks, I read and reread the a priori codes for each interview question, from lesson plan data and my reflective journal, focusing the analysis on one TPACK knowledge component at a time. By focusing on one TPACK knowledge component, I was able to better understand and identify teacher perceptions and instructional practices as they related to that corresponding knowledge component. Through this process, I was able to derive a set of codes for each interview question and for each knowledge component. This arrangement of codes ultimately assisted me in concentrating on codes that could be used to answer my research questions.

Second cycle axial coding was used to finalize the coding process. The goal of axial coding is to extend the analysis done during open coding by reassembling the data into dominant categories (Saldaña, 2016). Axial coding was used to chunk or categorize the data that was culled in open coding and to situate concepts so that I could then develop findings to answer my research questions (see Ravitch & Carl, 2016). To do so, I removed redundant codes and combined the most representative codes into representative categories within each research question and within each TPACK knowledge component. Emergent themes resulted from axial coding. The emergent themes for RQ1, delineated by TPACK component are displayed in Table 3. The emergent themes for RQ2, delineated by TPACK components are displayed in Table 4.

**Table 3**

*Themes From Axial Coding for Research Question 1*

| TPACK Knowledge Component | Emergent Themes |
|---|---|
| TK | Teachers access supports |
| | Teachers identify allowances of digital formative assessment tools |
| | Teachers identify digital tools to use for formative assessment on lesson plans |
| TPK | Teachers access supports |
| | Digital formative assessment tools are used by teachers to identify student needs |
| | Digital formative assessment tools are used by teachers to encourage student engagement |
| | Digital formative assessment tools are used by teachers to derive diagnostic information |
| | Use of digital tools for formative assessment is inconsistently noted in teacher lesson plans |
| TCK | Teachers inconsistently access supports |
| | Teachers inconsistently integrated digital formative assessment tools that focused on how the subject matter could be represented |
| | Teachers inconsistently used digital formative assessment tools that combined content resources and formative assessment capability |
| | Use of digital tools for formative assessment is inconsistently noted in teacher lesson plans |
| TPACK | Teachers inconsistently demonstrated TPACK when integrating digital tools to facilitate formative assessment |
| | Use of digital tools for formative assessment is inconsistently noted in teacher lesson plan |

**Table 4**

*Emergent Themes From Axial Coding for Research Question 2*

| TPACK Knowledge Component | Emergent Themes |
|---|---|
| TK | Feedback from digital tools is accessed by teachers and students, but how this feedback informs subsequent instruction is unclear |
| | Teacher lesson plans do not address how digital tools are integrated to use feedback from formative assessment to inform subsequent instruction |
| TPK | Digital tools are used to provide teachers with feedback to identify student learning gaps |
| | Digital tools are used to provide feedback to students |
| | Teacher lesson plans do not address how digital tools are integrated to use feedback from formative assessment to inform subsequent instruction |
| TCK | No codes were evident. |
| TPACK | No codes were evident. |

## Data Analysis

Following my proposed methods, I completed the data analysis to identify emergent themes to answer the project study research questions. Koehler and Mishra's (2009) TPACK conceptual framework supplied the guidelines for answering the study research questions. The TPACK framework for technology integration underscores the interconnectedness of integrated knowledge components to the teacher's ability to successfully integrate technology in the classroom and, by extension, to successfully implement digital tools to facilitate formative assessment and use the resulting feedback to inform subsequent instruction.

## RQ1: Emergent Themes From Interviews

In analyzing teacher TK, TPK, TCK, and TPACK, I operationalized the TPACK framework to answer Research Question #1: How do Anytown Middle School teachers integrate digital tools to facilitate formative assessments?

### *TK: Teachers Access Supports*

Interview data indicated that Anytown Middle School teachers access supports to bolster their technological knowledge as a means of integrating digital tools to facilitate formative assessment. Knowledge of technology and the associated digital tools are in a constant state of flux, requiring teachers to evolve along with technological advancements (Koehler & Mishra, 2009). This adaptation is demonstrated by Anytown Middle School teachers. Using their fellow teachers, instructional coaches, and social media, the study participants availed themselves of a variety of technological supports to facilitate their integration of digital tools to facilitate formative assessment. Participant 3 (P3) and P7 specifically noted that "word of mouth" drives the acquisition of technological knowledge. P3 stated that "I feel like a lot of teachers have awesome perspective" while P7 noted that "I get my technological knowledge first through peers" and any colleague who mentions a new digital technology is "my primary source" of developing technological knowledge. P8 echoed the value of deriving technological knowledge from talking to other teachers about using specific tools, noting interest by saying, "Oh, that sounds cool. Maybe I'll try that in my room." Sharing technological knowledge with colleagues also proved to be a beneficial collaborative experience to P5 who testified that, “you become the best that you can be, and even better when you collaborate; so, I spend a lot of time talking to other teachers.”

In relaying individual conversations and collaborative experiences, study participants spoke to the technological knowledge gleaned from interactions with instructional coaches. P2, P4, and P8 discussed interactions with an instructional coach where new tools were discussed as possibilities for implementation as vehicles for formative assessment. The instructional coach would always share something new “like Flipgrid” with P2, while P8 appreciated learning from both school and other district instructional coaches by discussing, “Hey, how’s this tool work and how can I use it?” P4 remarked upon working very closely with the instructional coach during the previous year and being introduced to “a plethora of things…like Edpuzzle, Screencastify, and Flipgrid.” P7 noted multiple collaborations with three different instructional coaches over the previous 2 school years, working with coaches to implement technologies to which the teacher had not yet been exposed:

> [Instructional coach 1] was a huge, huge resource for sharing digital knowledge with me for the last couple years. And this year, I collaborated with [instructional coach 2] several times over new technology that I hadn't implemented yet…and [instructional coach 3] as well. But that's where…I get my initial introduction really to any digital technology.

Social media, particularly Twitter, was espoused by study participants as a frequent source of support. P1 noted that it was common to “research on my own” to find new technological tools for formative assessment and feedback, with Twitter being the go-to medium for such supports. P2 agreed with this assessment, stating that "you find the best tools on Twitter. I found a lot on Twitter." P5 and P8 made use of both local and nationwide educators through social media forums. Upon reading about tools used by someone on Twitter, P8 strategized to "…go look it up and I'll decide maybe that'll work in this case in my lesson." Study participants from Anytown Middle School consistently and frequently accessed supports to find and make use of digital tools to facilitate formative assessment.

***TK: Teachers Identify Allowances of Digital Formative Assessment Tools***

To integrate digital tools to facilitate formative assessment, study participants identified a multitude of digital formative assessment tools that they used to deliver formative assessments and to take advantage of the affordances inherent in the tool. Technological knowledge requires that teachers continually adapt to the possibilities presented by applying a tool as a means of successfully fulfilling instructional goals (Koehler & Mishra, 2009). Bhagat and Spector (2017) suggested there were advantages to increasing the use of technology to conduct digital formative assessments. This time-saving technological affordance was noted by P1, P2, P4, P6, and P7. In referencing the use of Google Forms as a digital formative assessment tool, each of these participants noted that the tool allowed for "quick" check-ins to garner an assessment of student progress. In referencing how and when to implement technology in the formative assessment process, P4 stated that "…if I had my best life, I'd be able to use Google forms for all of my quizzes, because I think it's very quick.” To delineate the advantage that digital formative assessments provide, P7 summarized,

> …with it being a digital formative, I have quicker feedback which allows me to change my direction of instruction in a much more timely and efficient way versus having to grade 100 things on paper. If I have something through a Google Form, I have the results immediately…

Such immediacy of results made possible through the automation of formative assessment processes presents potential time savings when compared with performing manual corrections (Barana & Marchisio, 2016; Bhagat & Spector, 2017).

### ***TPK: Teachers Access Supports***

Anytown Middle School teachers relied on technological pedagogical supports to integrate digital tools to facilitate formative assessment. Using colleagues, including instructional coaches, and exploration of social media, study participants. The crux of TPK is for teachers to understand how digital tools can potentially impact both teaching and learning (Harris & Hofer, 2011; Koehler & Mishra, 2009). P4, P6, and P7 spoke of interactions and collaborations with both colleagues and instructional coaches that they used to adjust their digital formative assessment practices. This collaborative sharing focused on the demonstration of the tools in practice and discussions of potential uses. P4 mentioned learning about digital formative assessment tools and practices “through seeing other teachers use it” and working with the instructional coach to see “how to use them and…what they can be potentially used for.” Other participants developed TPK by exploring social media for tools and strategies. P8 expounded on the vitality of resources on social media community, referring to Twitter as the teacher's professional learning community (PLC). Both P8 and P1 spoke of reaching out to teachers on Twitter who had tweeted about tools and processes that sounded applicable to their classroom needs. P1 summarized this strategy by saying that "it's helpful to see…what works and what didn't work for them, and why."

***TPK: Digital Formative Assessment Tools are Used by Teachers to Identify Student Needs***

TPK requires that teachers understand how the integration of various digital tools can be used to affect teaching and learning (Harris & Hofer, 2011; Koehler & Mishra, 2009). Anytown Middle School teachers reflected this understanding by using a variety of digital formative assessment tools to identify student needs. In participant interviews, every participant testified as to the veracity of digital tools to allow them to identify what students know and what students do not know with relationship to the teaching objectives. P 8 reflected upon using a "variety of tools" – including Padlet, Kidblog, Google Forms as a "touchpoint" to see where students are. Vocabulary.com was used by both P1 and P2 to check in with students on their existing knowledge of a topic so that they could areas of student mastery could be identified and to pinpoint students who have gaps of knowledge that need to be addressed in subsequent instruction. Utilizing Kahoot! as a digital formative assessment, P4 used the whole class results in real-time to address concepts where it appeared many students struggled by pausing the Kahoot! exercise and addressing the knowledge gap with the class. P3 and P5 mentioned a variety of interactive websites that allow for formative assessments to quickly identify what students know and do not know. In touting the website CueThink, P3 underscored the advantage that digital feedback from formative assessment provides to teachers when breaking down student responses: “Having all of the digital feedback in one area; it’s easier and succinct and makes it a lot easier to figure out.”

In expounding upon the benefits of digital formative assessment tools to teaching and learning, Irving et al. (2016) posited that connected CCTs support immediate electronic responses and, as a result, providing teachers with real-time data reflecting student needs. As the Anytown Middle School operates in a one-to-one Chromebook environment, participants facilitated student Chromebooks as a means of soliciting digital feedback from students. Every participant mentioned their use of Google Forms to gain immediate data that is then potentially actionable to address student needs. As explained by P1, Google Forms “will show you the percentage of kids that got answers correct or incorrect. So, from that data, you can see what wasn’t clear and what I can do to help these kids understand that better.” Identification of student needs could be done with a “very quick Google Form” according to P7.

> In just five or six questions for me about what we've been talking about the last day or two, I immediately, before the kids even leave the classroom, I can pull up how they did as a class as a whole, I can look at individual questions. I can look at the graphs that they give me on the responses section, and I can look at it and go...they just don't get that concept.

Demonstration of TPK requires that teachers maximize the affordances of the technological environment (Koehler & Mishra, 2009). Anytown Middle School teachers used the one-to-one Chromebook environment to facilitate formative assessment. Middle School teachers used a variety of digital formative assessment tools to identify student needs.

***TPK: Digital Formative Assessment Tools are Used by Teachers to Encourage Student Engagement***

TPK requires that teachers exhibit an open-minded and forward-looking mindset when integrating technology in the classroom (Koehler & Mishra, 2009). Instead of using technology simply because it is available, the TPK mindset should reflect technology use for the sake of student learning (Koehler & Mishra, 2009). Anytown Middle School teachers exhibited TPK by integrating digital tools to facilitate formative assessment as a means of encouraging student engagement, seeing this as a natural steppingstone for facilitating learning. Participants noted the immediate gratification experienced by students when participating in formative assessments conducted through Kahoot! and Google Forms. According to P1, students were enthralled with Kahoot! because they immediately see "whether they are correct or not" and where they placed in their class. This student feedback was noted by P6 with respect to the use of Google Forms for formative assessment: "I think kids are immediately gratified whether they gratified in the fact that, yes, I am getting it, or no, I'm not." Student engagement was also propagated by unique features of the digital formative assessment tools. P5 used the YouTube channel Fort Bend Tutoring to solidify the use of content-specific vocabulary through student reflection. The narrator of the channel has a "very Southern accent that makes students…really, truly, pay attention to what is being said because the dialect is slightly different." In describing a formative assessment process where students interacted with drawings to facilitate their learning, P3 spoke about the engagement displayed by students who are interfacing with materials to demonstrate their thinking: "They'll draw something and say this is what I'm thinking, and suddenly that drawing and that process that they originally couldn't see…will just click for kids." P3 attributes this capability to the touchscreen Chromebooks that students have access to in the classroom since they can work "directly on something." While P3 touts how students can interact when participating in digital formative assessments, P8 expanded on the capability of digital tools to allow for more robust responses from students who might normally be reluctant to participate in class discussions. P8 noted that administering digital formative assessments can "give those people a chance who don't who might want to voice their opinion but don't feel comfortable saying out loud in the class."

Participants discussed the preference of some students to complete formative assessments using their Chromebook rather than completing a paper-based formative assessment. To that end, P1, P2, P7, and P8 testified to providing students with the option to choose their own digital tool to complete the formative assessment. P2 stated that students liked being able to choose which formative assessment tool to use and some were able to identify tools and strategies that facilitated their ability to complete the formative assessment. This was echoed by both P7 and P8. P7 noted that "some kids love the digital piece" so when administering formative assessments, digital options are provided to facilitate this student preference. P8 tried "a lot of different tools," including

Google Forms, Kidblog, Flipgrid, and Padlet, to “see what’s going to work best for kids. And they’d have an option of a digital or a hard copy.”

While these options to allow for student choice prevailed, participants clearly outlined examples of how student engagement was improved by providing digital formative assessment alternatives. Simple accessibility to course material is necessary for engagement. P3 connected the touchscreen Chromebooks to greater accessibility for autistic students and students with gross and fine motor skill issues. “It makes things a lot more accessible to them, which is imperative.” P1 chose to use Kidblog for journaling formative assessments because students “seem to like that better than writing in a [paper] journal.” Also using Kidblog as well as Padlet to formatively assess, P8 highlighted that the interactive aspect of both tools allowed students to see right away what their peers were doing, allowing them to “feed off of each other’s knowledge and information,” and option that simply would not be possible if done on paper. P7 stated that some formative assessment exercises might yield the same data for the teacher regardless of whether the assessment was done digitally or on paper. However, the increase in active engagement fostered by the digital format sometimes makes it an easy choice. They elaborated:

> Do I get the same data from students? Yes. Are the kids more actively engaged in the process with the QR code [formative assessment activity] versus just a multiple-choice piece of paper? Yes. The kids are more engaged in the activity, which also means I’m probably getting better data.

***TPK: Digital Formative Assessment Tools are Used by Teachers to Derive Diagnostic Information***

Expert teachers design formative assessments as a means of deriving diagnostic information (Danielson, 2007). "Teachers should be able to explain how they intend to use assessment of learning in their instruction" (p. 62). Through the interview process, Anytown Middle School teachers used digital formative assessment tools to derive diagnostic information from their students, first to see what students know and understand; then to modify teaching and learning practices. In this way, participants integrated digital tools to better understand the extent to which learning was occurring and to influence ongoing instructional decision-making (Shirley & Irving, 2015).

Each participant described integrating digital formative assessment tools as a means of deriving diagnostic information by finding out what students know and understand. P7 attempted to build formatives that would provide the "best opportunity to show me what [students] know. And if technology supports that, then that's the route I go." Using digital formative assessments to check for student knowledge was echoed by P1, P2, P3, P4, P5, and P8. All noted that it is critical to understand where students are on a particular topic, both at the beginning of a lesson and as the lesson progresses. P8 described using Padlet to facilitate an exercise that asks students to respond to what they know, what they want to know, and what they learned about the topic to "get some basic information about what kids know." P8 used both BrainPOP and Google Forms as a "starting point formative" to check for understanding. Kidblog was used by P1 to "see where they are on a particular topic as a quick check-in" prior to or early in the instructional process. As teaching and learning progressed, P2 underscored the need to integrate digital formative assessments to “check on their knowledge” and to “see what they’re thinking.” Participants made use of student responses from digital formative assessments to do so. According to P3, Desmos recorded student chats, allowing the teacher to quickly look at the chat logs to determine student understanding. To see how students were grasping concepts from reading assignments, P4 and P8 used the student responses generated from using Google Forms and Kidblog respectively. P5 made use of an interactive website “to see what students know and don’t know.”

After deriving diagnostic information, Anytown Middle School teachers used the diagnostic information to modify teaching and learning practices. Teachers mentioned using data resulting from digital formative assessment data to adjust instruction in the near term. P5 described using Kahoot! during a review exercise to impact instruction in real-time by pausing the game if “more than half the class went to an incorrect answer and, in that moment…explain why it’s that answer.” By immediately returning automatically scored Google Forms assessments, P6 noted the advantage of communicating immediate feedback to students: “This is what you got right. This is what you got wrong.”

Formative assessment requires that teachers, students, or both use the feedback information to guide the teaching and learning process (Black & Wiliam, 1998a). Ps 1, 2, 3, 5, 7, and 8 specifically mentioned using data derived from digital formative assessments to modify teaching and learning processes. Ps 1 and 2 used feedback from digital formative assessment tools to identify gaps in student knowledge, respectively noting that it "helps me to figure out where I need to go from there" and "if you get 60% of them checking off the wrong box…let's reevaluate that for tomorrow." This strategy was echoed by P7: "If I have something through a Google Form, I have the results immediately and I can be like, wow, 90% of my kids did not understand that concept. Let me do something about it tomorrow." Taking a more long-term approach, P8 uses Google Forms to impact future teaching. "I can then take all this information that they've sent me and said, Okay, well, this part worked well for 75% of the kids. So, I think I could do that again." Participants also mentioned using the private comment features of Google Classroom as a means of providing an immediate modification to the teaching and learning process. P2 posts private comments for students in Google Classroom, communicating that students are on the right track while P5 uses the private comment exchanges to have conversations with students to "tell their ability to be able to explain and understand what you are asking." P3 used Google Classroom private comments for specialized instructions, noting that "some kids can't work on the same materials." Data gathered from participant interviews established that Anytown Middle School teachers used digital formative assessment tools to derive diagnostic information from their students, first to see what students know and understand, then to modify teaching and learning practices. Study participants demonstrated TPK by communicating their understanding of how integrating digital tools to facilitate formative assessment can change teaching and learning.

### *TCK: Teachers Inconsistently Access Supports*

Danielson Component 1d, Demonstrating Knowledge of Resources provides criteria for evaluating what a teacher knows about and how a teacher avails herself of resources that will extend content knowledge and pedagogy (Danielson, 2007). Anytown Middle School teachers demonstrated the capacity and wherewithal to seek out resources to integrate digital tools to facilitate formative assessment by accessing a variety of supports. Throughout the interview process, teachers mentioned accessing supports including colleagues, instructional coaches, social media, various online resources found through individual Google searches and PD. Developing TCK, however, requires that teachers understand how technologies are suited for facilitating subject matter learning in content areas, with a focus on how the subject matter can be represented and/or how the content can be used to alter the technology (Koehler & Mishra, 2009). Anytown Middle School teachers inconsistently accessed supports that were TCK specific. P3, a mathematics teacher, testified to taking advantage of social media in addition to "different common websites" used by other mathematics educators. This strategy was mirrored by P5. P5 sought out feedback from teachers on social media who taught the same subject(s) and were already making use of digital formative assessment tools that they were  interested in exploring. Teachers were challenged by developing knowledge of content and by selecting digital tools that best supported the conveyance of that subject matter (Harris & Hofer, 2011; Mishra & Koehler, 2006). Harris and Hofer (2011) noted that many teachers were unaware of the wide range of curriculum-based activity approaches and strategies that could be operationalized when assisted by digital tools. As

Anytown Middle School teachers generally availed themselves of resources at their disposal, it is likely that they too are unaware of a wider range of TCK approaches and strategies that can be integrated to facilitate formative assessment.

### ***TCK: Teachers Inconsistently Integrated Digital Formative Assessment Tools That Focused on how the Subject Matter Could be Represented***

Koehler and Mishra (2009) contended that TCK contains teacher understanding of technologies that are suited for facilitating subject matter learning in their content areas, with a focus on how the subject matter can be represented and/or how the content can be used to alter the technology. One affordance of technology is that it can foster new and varied content area representations (Koehler & Mishra, 2009). When discussing how they integrate digital tools to facilitate formative assessment, Anytown Middle School teachers inconsistently relayed these types of affordances during the study interviews. Noting how the Chromebooks allow for formative assessment activities that are not possible on pieces of paper, P3 expounded upon the capability to "bring a lesson to life" by digitally illustrating and engaging students in activities involving geometry and spatial awareness concepts. Similar spatial awareness representations were utilized by Social Studies teacher, P7. They described a digital formative assessment using Google Tour Builder, where students were asked to create a cross country tour that compiled information about "things like national parks…but they also get the visual of the distance between locations."

Teachers typically relied on lecturing and class discussion to stimulate learning as well as to formatively assess and provide feedback rather than use digital tools to facilitate such interactions (Egelandsdal & Krumsvik, 2017; Elmahdi et al., 2018; Romero-Martín et al., 2017). P8, however, demonstrated TPK by maximizing the affordance of the digital formative assessment tool to represent course content. To alter how the subject matter was being represented, P8 assigned students an assignment using Kidblog, asking students to demonstrate learning derived from content readings and video instruction. During this activity, students were asked to post their blogs such that their peers could comment on the post and interact with the post's author. In this way, the teacher aimed to "give other people voice who don't necessarily have a voice if you're just having class discussions. Digital tools are one way can make it a more even playing field." In analyzing interview transcripts, however, Anytown Middle School teachers inconsistently integrated digital formative assessment tools that focused on how the subject matter could be represented.

***TCK: Teachers Inconsistently Used Digital Formative Assessment Tools That Combined Content Resources and Formative Assessment Capability***

To facilitate formative assessment, Anytown Middle School teachers inconsistently demonstrated TCK by using digital formative assessment tools that contained both embedded content materials and the capacity to conduct digital formative assessments. Koehler and Mishra (2009) argued that technologies suited for subject matter learning can provide teachers with the flexibility necessary to navigate content decisions. The use of such technologies was inconsistently reported during participant interviews. P1 and P2, both language arts teachers, used the website Vocabulary.com to integrate digital formative assessments, aiming to improve content literacy. Marketed as a game-based tool to help students expand their vocabulary, Vocabulary.com uses algorithms to personalize the student learning experience while providing a weekly summary of student performance to teachers (Vocabulary.com, n.d.). CueThink was used by P3 to break down the concepts of mathematical problem solving using a four-phase process that not only leads students through problem-solving but also integrates tools for documenting their solutions. Within this interactive site, teachers are provided with real-time analytics of student performance (CueThink, n.d.). P5, also a mathematics teacher, touted an interactive website called Math Interactives from Alberta Education (LearnAlberta.ca, n.d.). According to P5, the site is great to see what students know and do not know. Students work through problems, but if they choose an incorrect answer, they are prompted "at what step they messed up on…and a little prompt will come up and will provide helpful links and videos so that students can do them successfully." Social studies teacher, P7, described using the site iCivics.org to integrate a digital formative assessment relating to the Bill of Rights. Since the site records student scores, the teacher explained that student scores could be accessed for formative assessment purposes. P4 uses BrainPOP as a "check your understanding or do you have some fundamental understanding or baseline to this topic." A science teacher, P4 appreciated that BrainPOP provided a concise, simplified explanation of a lot of core science topics and includes related quizzes. While each of these examples garnered from participant interviews illustrates teacher TCK, across participant interviews, Anytown Middle School teachers inconsistently used digital assessment tools that combined embedded content resources and formative assessment capability.

***TPACK: Teachers Inconsistently Demonstrated TPACK When Integrating Digital Tools to Facilitate Formative Assessment***

To demonstrate TPACK when integrating technology in instruction, Koehler and Mishra (2009) contended that teachers must “flexibly navigate the spaces defined by the three elements of content, pedagogy, and technology and the complex interactions among these elements in specific context” (p. 66). Developing effective solutions in the classroom demand both fluency and flexibility in the three TPACK components as well as the capacity to combine the components within the instructional contexts (Koehler & Mishra, 2009). In integrating digital tools to facilitate formative assessment, Anytown Middle School teachers inconsistently demonstrated TPACK. During participant interviews, isolated TPACK contextualized within digital formative assessments were described by P3, P5, and P8. P3 engaged students in a digital formative assessment where students used Google Drawing to explain their mathematical thinking to other students. With a group of students collaborating on one Google Drawing, the teacher encourages live manipulation of the drawing while the student attempts to explain their solution processes. As the teacher explained, this live and interactive experience “oftentimes allows students to process concepts that they originally couldn’t see.” This integration of a digital tool to facilitate formative assessment embodies the flexibility and problem solving of TPACK by applying Google Drawing in a way that helps to meet instructional goals (TK), by eschewing functional fixedness through the application of a customized purpose for the use of the digital tool (TPK), and by illustrating an understanding of how a technological choice can be used to alter how the subject matter is represented (TCK) (Koehler & Mishra, 2009).

P5 demonstrated TPACK by integrating Google Forms to facilitate formative assessment. The teacher-built content-based questions with different paths depending on whether students answered questions correctly. If the student answered a question correctly, they progressed through the Google Form. If the students answered a question wrong, the branching Google Form created by the teacher would provide the student with instructional material to mitigate the mistake. "With that, I provided a video for them, and the video came in the form of something from YouTube or a snippet from Khan Academy or was a Screencastify of myself, and then they would answer a similar question." P5 also accessed the analytics from the completed Google Forms to inform subsequent instructional strategies. Like P3, P5 demonstrated TPACK by flexibly applying Google Forms in a way that helped to meet instructional goals (TK), rejected functional fixedness by customizing the functionality of Google Forms (TPK), and illustrated an understanding of how the technological choice could be used for subject matter teaching and learning (TCK).

P8 demonstrated TPACK by using the digital tool Kidblog to facilitate formative assessment. Using Kidblog to foster class discussion, students created blogs to demonstrate their understanding of readings and other related course content in one unit. Blogs were then shared with other students such that their peers could comment on the post and leave a comment with the post's author. P8 moderated the comments to ensure applicability and appropriateness. Touting the interactivity that this format propagated, P8 stated that the interactivity of the digital exercise "took it to the next level of sharing; what you think about it… and then maybe seeing what other people think about it and potentially affecting the way you think about it." Additionally, P8 noted that

> The blogs, I think, even though it wasn't anonymous, it gives people a voice who don't want to do that kind of talking out in front of the class. So that's the other time I really like to use digital tools is to give those people a chance who might want to voice their opinion but don't feel comfortable saying out loud in the class.

Like P3 and P5, P8 demonstrated TPACK by operationalizing Kidblog in a way to meet instructional goals (TK), maximized the affordance of the tool to allow for robust class discussion (TPK), and focused on how the subject matter could be represented for teaching and learning (TCK).

P3, P5, and P8 communicated their capacity for developing solutions to flexibly navigate each TPACK component, both independently and in combination. These anecdotes, however, were isolated incidents related during participant interviews. Anytown Middle School teachers inconsistently demonstrated TPACK when integrating digital tools to facilitate formative assessment.

**RQ1: Emergent Themes From Lesson Plans**

In coordination with the data acquired through participant interviews, the analysis of participant lesson plans was performed to support and develop themes. Additionally, throughout my analysis, I took reflective notes on my thoughts regarding how or if the lesson plan documentation provided data germane to answering how Anytown Middle School teachers integrate digital tools to facilitate formative assessment. Participants were asked to submit digital copies of two lesson plans from lessons conducted in the traditional classroom setting prior to the transition to remote learning necessitated by the COVID-19 pandemic. Teachers were asked to choose plans from lessons that include the use of digital tools to facilitate formative assessment and feedback. I examined each plan focused on identifying individual TPACK components. The lesson plan format and instructional content varied widely among participants, revealing minimal emergent codes for each TPACK component.

***TK: Teachers Identify Digital Tools to use for Formative Assessment on Lesson Plans***

Each lesson plan submitted by each study participant included a notation of technology use. TK demands that teachers continually adapt their application of technology to best apply to instructional needs (Koehler & Mishra, 2009). Black and Wiliam (1998a) provided the foundation for defining formative assessment for this study, positing that formative assessment encompasses any activity performed by teacher or student that informs feedback to alter subsequent teaching and learning. While application of technology was noted in each lesson plan submitted for this project study, most lesson plans did not clearly articulate how or if the digital tools noted in the lesson plan would be integrated to facilitate formative assessment. This clarification is absent in P1's first lesson plan (LP1). P1 wrote that "One student for each group will use their Chromebook to record and post their Flipgrid for a formative assessment" and

> Student achievement of the lesson will be assessed by walking the room and monitoring the groups. If a student is struggling I will assist the group as a whole

> and help them work through it. Their Flipgrid will be their formative assessment that will integrate work from their stations.

P2 provided detailed unit plans, each outlining 2 weeks of lesson plans. While LP1 included the use of Flocabulary, Google Docs, and Google Classroom, there was no specific reference to their use as formative assessments. LP2 included the use of the digital resource Study Sync to administer a formative assessment, but the plan simply stated, “Quiz to check for understanding - in StudySync (Formative) students will be able to see their grade.” P4 mentioned the use of digital tools as quizzes, planning to integrate BrainPOP in LP1 and Edpuzzle in LP2. The plans, however, do not include the word “formative,” nor is there any reference to using these activities to inform feedback to alter subsequent teaching and learning. Lesson plans provided by P5 mentioned that students would be using Google Sites to develop digital portfolios, but the only mention of a formative assessment does not mention the use of any tool to administer the formative. In a section titled “Lesson Assessments,” P5 lists “Formative Assessment: Vocabulary Quiz” as one of the assessments. P7 submitted two detailed unit plans, each including a section for the teacher to list “Assessment Evidence.” Each unit plan includes the words “Formative Assessments” as “Assessment Evidence” but provided no further detail articulating how or if the digital tools noted elsewhere in the plans would be integrated to facilitate formative assessment. Lesson “task lists,” and Google Forms used to solicit feedback from students were submitted by P8, accompanied by the note: “I do not really have any formal lesson plans that specifically show that I used these digital tools for formative assessment and feedback.” All participant lesson plans included the use of digital tools in their chosen lessons or units. It is not clear, however, how or if the digital tools were integrated to facilitate formative assessment, nor was it clear if teachers demonstrated TK by applying technology to best meet instructional needs.

### *TPK: Use of Digital Tools for Formative Assessment is Inconsistently Noted in Teacher Lesson Plans*

TPK required that teachers demonstrated how the application of digital tools could change teaching and learning (Harris & Hofer, 2011; Koehler & Mishra, 2009). Demonstration of this knowledge component using digital tools for formative assessment was inconsistently noted in teacher lesson plans. Using the interactive website CueThink in L2, P3 described an activity where students use tools embedded in the site to solve problems. At the end of class students will complete a Google Form to provide "Assessment Evidence" "about what they understood, what they need help on, and how I can improve their understanding in the future." P5's plans outline several activities that integrate digital tools, although they are not specifically identified as formative assessments. In LP1, students use a Padlet to showcase knowledge, while the teacher physically circulates around the room to check off homework and "engaging students in conversations about what they know, remember, etc." PearDeck is then used as an interactive whole class experience. In the lesson plan, P5 stated:

> While the lesson is going on, constant evaluation of student progress is happening. From PearDeck, the teacher can download and get instant feedback for tomorrow's class for small groups or independent work for laws of exponents, including negative integers. Based on their answers from the PearDeck, students

> will be placed in groups to work on an interactive website. Small, directed instruction will occur during this time.

In this way, P5 planned for the application of a digital tool to facilitate formative assessment in a way that could change teaching and learning. In LP2, P5 details how students will work through a HyperDoc to learn new content and to demonstrate their level of understanding. The HyperDoc of embedded links includes hyperlinks to interactive content-specific websites that students can use to problem-solve. P5 noted in the lesson plan:

> As students are working through the HyperDoc, the teacher should be looking at daily completion as well as the answers to make groups that better address the needs of the concepts. After reviewing daily work, the teacher should start class with common misinterpretations from students on the previous day. Daily the teacher should use a google form to assess what the students know to better understand the needs of the students.

While these plans demonstrate the application of digital tools to change teaching and learning, TPK in lesson planning was only evident in these plans.

### *TCK: Use of Digital Tools for Formative Assessment is Inconsistently Noted in Teacher Lesson Plans*

To demonstrate TCK, teachers must understand technologies that are suited for facilitating subject matter learning in their content areas, with a focus on how the subject matter can be represented and/or how the content can be used to alter the technology (Koehler & Mishra, 2009). Digital tools can also allow for the "construction of newer and more varied representations" of subject matter that "provide a greater degree of flexibility in navigating across these representations" (p. 65). To analyze participant lesson plans, I examined each plan, focusing on identifying TCK when teachers integrated digital tools to facilitate formative assessment. Demonstration of this knowledge component using digital tools for formative assessment was inconsistently noted in teacher lesson plans. Only one instance of TCK was discovered during the lesson plan analysis process. In LP2, P5 used a HyperDoc to facilitate digital formative assessment. Through this lesson, students will navigate through the HyperDoc, using the embedded resources to learn about graphing and substitution to solve systems of equations. Students use the digital tool Desmos to complete practice their skills and complete tasks and perform application tasks, supplying their answers on embedded Google Docs accessible by the teacher. According to the lesson plan, "as students are working through the HyperDoc, the teacher should be looking at daily completion as well as the answers to make groups that better address the needs of the concepts." The teacher also noted that the work that students do in their daily completions is done in conjunction with small group work to "better address the [student] needs of the concepts." The teacher reviews this work daily and starts each subsequent class by addressing "common misinterpretations from students on the previous day." P5 operationalized a HyperDoc with embedded digital tools, digital resources, and formative assessment opportunities. In doing so, the teacher demonstrated flexibility in the representation of subject matter and clearly outlined a process by which digital tools are used to facilitate formative assessment. This isolated demonstration of TCK by Anytown Middle School teachers reiterated that teachers were challenged by developing knowledge of content and by selecting digital tools that best supported the conveyance of that subject matter (Harris & Hofer, 2011; Mishra & Koehler, 2006).

***TPACK: Use of Digital Tools for Formative Assessment is Inconsistently Noted in Teacher Lesson Plans***

To demonstrate TPACK, teachers must be able to construct effective teaching solutions by flexibly using each of the key knowledge components (technological knowledge, pedagogical knowledge, and content knowledge) both independently and within contextually interrelated parameters (Koehler & Mishra, 2009). Construction of effective teaching solutions that exhibited such a demonstration was isolated to LP2 submitted by P5. As previously outlined, P5 submitted a lesson plan that demonstrated TCK understanding, using a HyperDoc to facilitate a lesson on systems of equations. In this lesson plan, P5 also demonstrated fluency in each of the other key TPACK domains both individually and simultaneously. The systems of equations lesson plan demonstrated the teacher's application of digital tools to achieve instructional goals, including the integration of digital tools to facilitate formative assessment. In the lesson plan, P5 stated: "There are daily assessments that are used to gauge engagement and mastery." The plan identifies each of these assessments as being digital formative assessments. P5 demonstrated TPK through the creation of the HyperDoc as a means of facilitating an ongoing digital formative assessment medium. To exude TPK, one must reconfigure common uses for technologies and customize them to meet pedagogical purposes (Koehler & Mishra, 2009). The HyperDoc medium and the planned implementation process illustrate the forward-looking use of technology defined by Koehler and Mishra.

Previous research shows that teachers were challenged to teach content using digital tools that best supported their content and simultaneously addressed the needs and preferences of students (Harris & Hofer, 2011). These challenges have contributed to inconsistent technology integration (Harris & Hofer, 2011; Harris et al., 2009), and by extension to inconsistent digital tool integration to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. While P5's lesson plan demonstrates TPACK fluency in the context of a systems of equations lesson, the isolation of this instance indicates that the use of digital tools for formative assessment is inconsistently noted in the lesson plans of Anytown Middle School teachers.

## RQ2: Emergent Themes From Interviews

In analyzing teacher TK, TPK, TCK, and TPACK, I operationalized the TPACK framework to answer research question 2: How do Anytown Middle School teachers integrate digital tools to use feedback from formative assessment to inform subsequent instruction?

### *TK: Feedback From Digital Tools is Accessed by Teachers and Students, but how This Feedback Informs Subsequent Instruction is Unclear*

Data gathered from participant interviews indicated that feedback from digital tools was accessed by Anytown Middle School teachers and students. Most participants communicated using digital tools to simply access the feedback gathered by the digital tools when digital formative assessments were facilitated. Google Forms was mentioned by P1, P2, P4, P5, and P8 as a digital tool that was used by teachers in this manner. P1 used Forms to "know what they (students) know," while P2 similarly noted that Forms could be used to gather student reflections to see what students are thinking. Forms were used by P4 and P8 specifically to see what students learned. P4 wanted to see "whether or not a kid is grasping the reading that we're doing or the baseline content," while P8 used Forms, as well as Padlet, Google Drawing, and Google Slides to assess "their understanding of concepts." P7 used an online game called iCivics as a review activity to "see the scores." Google Classroom's private comment function was used by P5 to "tell [student] ability to be able to explain and understand" what the teacher is presenting. These interactions indicate that Anytown Middle School teachers demonstrated TK by using digital tools to access feedback from digital formative assessments. While feedback from digital tools was accessed by Anytown Middle School teachers, it is not clear how teachers integrate digital tools to use this feedback from formative assessment to inform subsequent instruction.

Two teacher participants noted that feedback from digital formative assessments was also accessed by students. P1 and P6 discussed using the quiz feature of Google Forms to provide students with the results of the quiz immediately upon submission. Noting the capacity to indicate wrong answers and to simultaneously provide the correct answers, P6 touted the use of Google Forms because the tool "allows students to get that immediate feedback." P1 echoed this functionality stating that "I do show them which answers they got wrong right away." P1 used Kahoot! in much the same manner. Kahoot!, a gamified digital tool that teachers played with the entire class simultaneously, shows all student participants the correct and incorrect answers immediately following each question. P1 discussed taking advantage of this immediate feedback, focusing students on their incorrect answers: “They know which ones they got wrong right away…so they can make a mental note of that.” The immediacy by which digital formative assessment tools can provide feedback to students was also expounded upon by P6. Speaking about BrainPOP, Newsela, and Google Forms, P6 noted that “These tools are so instant…they all have immediate responses, so when students complete the digital assessment, they get immediate feedback as to how you did.” P6 also used Google Classroom to send immediate responses and “redirection” directly to students. Using a variety of digital tools, some Anytown Middle School teachers provided data showing that feedback from digital tools was accessed by students. However, it is unclear from the data how teachers integrated digital tools to use this feedback accessed by students to inform subsequent instruction.

***TPK: Digital Tools are Used to Provide Teachers With Feedback to Identify Student Learning Gaps***

Black and Wiliam (1998a) established that the formative assessment process occurs when a teacher or student participates in an activity that informs feedback to affect subsequent teaching and learning. Formative assessments feed forward to influence subsequent instruction, to facilitate student revisions so that their learning feeds forward, or both (Black, 2015; Black & Wiliam, 1998a, 1998b, 2009). Interview data indicated that Anytown Middle School teachers used digital tools to gather feedback from students to identify student learning gaps. However, how teachers integrate digital tools to use feedback to inform subsequent instruction is unclear.

All study participants mentioned integrating digital tools to use feedback from formative assessment to identify student learning gaps. P1 used Kidblog to “check-in,” and to see “what wasn’t clear” while P6 mentioned using Google Forms to identify questions that “are a general flag area.” P5 mentioned using digital formative assessments to “see what students know and don’t know” while P2 reflected upon assessing digital formative assessment data to find that “I really kind of need to work with them.” Listing a plethora of digital formative assessment tools, P8 testified to examining student feedback at times to find students “weren’t getting what I was teaching or what I thought this lesson would teach.” In these instances, teachers integrated digital tools to use student feedback to identify learning gaps.

P4 and P7 also used feedback from digital formative assessment tools to identify student learning gaps, but in doing so, noted the benefit of the immediacy that digital tools lend to the formative assessment process. P4 used Kahoot! as a review exercise and as a means of immediately identifying student learning gaps. This in-class Kahoot! exercise enabled the teacher to “target why answers were wrong.” The teacher stated: “If more than half the class went to an incorrect answer, in that moment, I would stop, pause the Kahoot!, and explain why it’s the answer and why those answers are incorrect.” P7 described a similar advantage to using digital tools to use feedback from formative assessment:

> With it being a digital formative, I have quicker feedback which allows me to change my direction of instruction in a much more timely and efficient way versus having to grade 100 things on paper. If I have something through a Google

> form, I have the results immediately and I can be like, wow, 90% of my kids did not understand that concept. Let me do something about it tomorrow.

P7 noted that digital tools will be used to gather feedback from formative assessment to affect subsequent instruction. However, Anytown Middle School teachers were generally unclear regarding how they would integrate digital tools to use feedback to inform subsequent instruction. The only practice that was mentioned more than once by all study participants was to use feedback from digital formative assessment to guide student grouping. P2 discussed using student products submitted through Google Classroom to “see where they were at so I could tell them the next day where they were sitting and what they were working on.” Similarly, P1, P3, and P5 noted how digital formative assessment data helped to facilitate student groupings for subsequent coursework. After assessing digital formative assessment data, P1 noted that some students struggled with comprehension and some with understanding the main idea, so station work would be created to target the deficiencies determined by assessing the digital feedback. P5 espoused the use of Google Forms and PearDeck to administer digital formative assessments “so I know how to group the students for the day's activities.” Commenting on ease of use, P3 noted that digital tools like CueThink compile student feedback “in one area where every kid answers every formative in the same way. It’s easy and succinct in OneDrive or in one Excel Sheet…so it makes it easier to group kids that need help.”

Anytown Middle School teachers integrated digital tools to use feedback from formative assessment to identify student learning gaps and to subsequently guide student grouping. Beyond the use of feedback to guide student grouping, how teachers integrate digital tools to use feedback to inform subsequent instruction is unclear. While teachers are challenged to use digital tools in teaching, TPK requires an understanding of how digital tools can be consistently applied to change teaching and learning (Harris & Hofer, 2011; Koehler & Mishra, 2009). Koehler and Mishra (2009) suggested that teachers move beyond both functional fixedness and the most common uses for digital tools.

***TPK: Digital Tools are Used to Provide Feedback to Students***

Analysis of interview data provided evidence that Anytown Middle School teachers use digital tools to provide feedback to students. In some cases, digital tools were used to conduct formative assessments so that students could simply access the feedback from formative assessments. Teachers noted the advantages of students being able to access the feedback provided by digital formative assessment tools. P1 noted that students received their results immediately when completing formative assignments using Read Works.org. “The kids will be excited because it shows their results and they like that. They can see that and…it’s nice for them to know how they did. So, that’s helpful for them and me.” Also reflecting on positive student reactions to the immediacy of feedback from digital formative assessments, P6 discussed using Google Forms frequently for this purpose.

> I tend to use those quite a bit because they give immediate feedback, this is what you got right, this is what you got wrong, this is why you got it wrong. And it’s right there, right away. I think kids are immediately gratified in the fact that, yes, I am getting it, or no, I’m not.

P6 testified to using Google Forms such that the correct answer is provided to the student and a note is integrated into the formative assessment when a wrong answer is selected. “They’re getting that immediate feedback so they can see, ‘Oh, wait, this is what I got wrong.’ And this is a reminder of why this one was the correct answer.” Using a slightly different strategy, P2 reviewed student digital formative assessments, then emailed or provided private comments on Google Classroom “saying you are on the right track, this is awesome, love this material.” P2 stressed that this feedback is a way to provide positive feedback and is particularly important given that “you may not be able to say it during class.” Anytown Middle School teachers integrated digital tools to provide feedback from formative assessment to students. Students then had opportunities to use digital tools to access the feedback. In these instances, however, it is unclear how the feedback was used by the teacher or the student to inform subsequent instruction and feed forward into learning. Formative feedback is intended to bridge the learned required by the assessment (Black & Wiliam, 1998a, 1998b, 2009; Shute, 2008). Sadler (1989) testified that if students cannot or are unable to use feedback to close the learning gap, the formative feedback loop will not be closed.

In other cases, digital tools were integrated by Anytown Middle School teachers to provide feedback to students such that they could immediately work to close the learning gap. TPK requires a creative and forward-looking approach to using technology such that the technology can be used to advance student learning and understanding (Koehler & Mishra, 2009). P3 demonstrated TPK by using Desmos to provide immediate formative feedback to students as they worked together, using the digital tool to both gather feedback from students and to help facilitate the closure of learning gaps:

> I'll have all the students join in on a Google Drawing together so that they can try to work on something together in live time and I'm usually a part of the Google Drawing, so I can see it as well live time. And oftentimes a student might try to explain something but they just can't figure out how to do it, so I'll say, 'Okay, well, let's just watch this.' And I'll turn something or they'll draw something and say 'This is what I'm thinking.' And suddenly that drawing and that process that they originally couldn't see, they can now see. To have that live feedback and that live interaction, I just think that for them it's critical.

P5 created branching Google Forms to advance student learning and understanding. Branching Google Forms are constructed such that each answer choice selected by the student will yield a different subsequent question. When students entered an incorrect answer, P5 designed the branching Google Form to provide a resource that addressed the corresponding learning gap. "I provided a video for them in the form of something from YouTube or a snippet from Khan Academy or a Screencastify of myself," designed to help students master the content and move on to the next question. P5 described how the feedback from the branching Google Forms informed subsequent instruction:

> What that allowed me to do is to be able to look at what students understood because you could see the students and if they needed to retake…a certain question and I knew I needed to focus back in on that particular content. Those branching quizzes are phenomenal. I love them in math because there's so much

> that you can do. You know, it's always just that feedback of student understanding.

Using Kahoot! as a digital formative assessment to review for a summative asssessment, P4 used the feedback from the formative assessment to immediately inform instruction by addressing learning gaps in real-time. Kahoot! allows teachers to set up the assessment to either automatically move through the questions once the correct answer is revealed or to manually move through the questions. P4 chose to use the manual mode to make use of the opportunity to provide instant feedback to the class based on the answers submitted by students.

> Let's say I had a question up there that had four answers and I see that more than half the class went to an incorrect answer. In that moment, I would stop, pause the Kahoot!, and explain why it's that answer and why those answers are incorrect. So I'd use that as a direct, like instant, "Hey, no this is not correct. This is the correct answer."

Reflecting on this experience, P4 recounted how the students used the immediate feedback to integrate clarifications and correct answers into the study guide that they had prepared immediately prior to the Kahoot! activity. "The second I'd do that [provide feedback] you'd see a bunch of kids just switching over to their study guide and editing in those study guides with what the correct answer would be." P4 testified, "I think that that was one of the most beneficial formative activities I've done."

These illustrations outlined that Anytown Middle School teachers used digital tools to provide feedback to students in ways that fed forward into subsequent instruction, specifically into immediate instruction. Barana and Marchisio (2016) and Bhagat and Spector (2017) noted the potential time savings in automating formative assessment processes. Spector et al. (2016) posited that conducting digital formative assessments allows teaches to facilitate ongoing data collection to understand the progress of student learning and can then be used to inform subsequent instructional decisions to meet student needs. To wit, by digitizing the formative assessment processes, Anytown Middle School teachers were able to create exercises where feedback could be used immediately to help students feed their learning forward.

### *TCK: No Codes are Evident*

Analysis of interview data with respect to participant TCK did not yield emergent themes to answer how Anytown Middle School teachers integrate digital tools to use feedback from formative assessment to inform subsequent instruction.

### *TPACK: No Codes are Evident*

Analysis of interview data with respect to participant TPACK did not yield emergent themes to answer how Anytown Middle School teachers integrate digital tools to use feedback from formative assessment to inform subsequent instruction.

## RQ2: Emergent Themes From Lesson Plans

In coordination with the data acquired through participant interviews, the analysis of participant lesson plans was performed to support and develop themes. Additionally, throughout my analysis, I took reflective notes on my thoughts regarding how or if the lesson plan documentation provided data germane to answering how Anytown Middle School teachers integrate digital tools to facilitate formative assessment. The lesson plan format and instructional content varied widely among participants and did not reveal emergent themes to account for how participants planned to integrate digital tools to use feedback from formative assessment to inform subsequent instruction.

***TK, TPK, and TCK: Teacher Lesson Plans do not Address how Digital Tools are Integrated to use Feedback From Formative Assessment to Inform Subsequent Instruction***

As noted previously, all teacher lesson plans submitted by study participants included a reference to technology use, though most lesson plans did not clearly articulate how or if the digital tools noted in the lesson plan would be integrated to facilitate formative assessment. Given the absence of clear processes for how digital tools were used to facilitate formative assessment, it logically followed and was supported by the data, that Anytown Middle School teacher lesson plans did not address how digital tools are integrated to use feedback from formative assessment to inform subsequent instruction. Lesson plans submitted by Anytown Middle School teachers varied in format and scope. Three participants submitted unit plans, using the Anytown School District approved Understanding by Design (UBD) planning template (McTighe & Wiggins, 2004). Examination of all lesson plan data revealed that teacher lesson plans did not address how digital tools were integrated to use feedback from formative assessment to inform subsequent instruction. The word “feedback” was rarely mentioned in teacher lesson plans and was only used once to reference the use of a digital tool being used for formative assessment to inform subsequent instruction. In an “Assessments” section of

LP1, P5 briefly described the use of PearDeck to facilitate a formative assessment and notes the plan to integrate the tool to use the feedback to inform subsequent instruction:

> While the lesson is going on, constant evaluation of student progress is happening. From PearDeck, the teacher can download and get instant feedback for tomorrow's class for small groups or independent work for laws of exponents, including negative integers. Based on their answers from the PearDeck, students will be placed in groups to work on an interactive website. Small, directed instruction will occur during this time.

P3 mentioned feedback once in both submitted lesson plans. In a "Learning Activities" section of both LP1 and LP2, P3 states that the [digital formative assessment] "games that students play involve immediate feedback from their peers" and later mentions that students will complete a Google Form "to help them inform the teacher of where they feel confident and where they need more help." Neither lesson plan, however, articulates how the teacher will integrate digital tools to use the feedback to inform the subsequent instruction. P5 mentions feedback in LP2, but only in reference to a summative exam.

***TPACK: Teacher Lesson Plans do not Address how Digital Tools are Integrated to use Feedback From Formative Assessment to Inform Subsequent Instruction***

In the participant lesson plans, feedback is not mentioned in reference to either digital tools or formative assessments. P6 included a reference to feedback in planning to meet International Society for Technology in Education (ISTE) Standard 1c, "Students use technology to seek feedback that informs and improves their practice and to demonstrate their learning in a variety of ways." The plan, however, does not outline how the teacher will integrate digital tools to use feedback from the formative assessment to inform subsequent instruction. In their lesson plans, Anytown Middle School teachers did not address how digital tools are integrated to use feedback from formative assessment to inform subsequent instruction.

**Evidence of Quality**

Several procedures were implemented to ensure evidence of quality for this project study. During participant interviews, audio from the Zoom conferences was recorded on the cloud. I also recorded the audio on my smartphone. After the Zoom transcription was provided, each interview transcription was manually edited to corroborate the quality and accuracy of the digitally generating transcript. The audio recordings were recursively revisited as a means of clarifying and deriving meaning from participant data. My reflective journals were revisited to support the analysis.

At the conclusion of the data analysis, I recruited a colleague to serve as my peer reviewer. My colleague has earned an Ed.D. and has taught in the high school classroom for more than 25 years. As recommended by Yin (2016), the peer reviewer’s feedback was used to evaluate and strengthen the data collection process. Upon completion of the data analysis, a member check was also offered. Shenton (2004) suggested that member checks assist in certifying that participants’ communications are captured accurately and appropriately. Participants were provided with an opportunity to review a final draft of the data analysis findings.

**Outcomes**

The data collected were used to answer two research questions. The emergent themes for Research Question #1, delineated by each TPACK component, are displayed in Table 5. The emergent themes for Research Question #2, delineated by each TPACK component, are displayed in Table 6.

**Table 5**

*Emergent Themes Aligned to RQ1, Delineated by TPACK Component*

| RQ1: How do Anytown Middle School teachers integrate digital tools to facilitate formative assessment? | |
|---|---|
| TK | Teachers access supports |
| | Teachers identify allowances of digital formative assessment tool |
| | Teachers identify digital tools to use for formative assessment on lesson plans |
| TPK | Teachers access supports |
| | Digital formative assessment tools are used by teachers to identify student needs |
| | Digital formative assessment tools are used by teachers to encourage student engagement |
| | Digital formative assessment tools are used by teachers to derive diagnostic information |
| | Use of digital tools for formative assessment is inconsistently noted in teacher lesson plans |
| TCK | Teachers inconsistently access supports |
| | Teachers inconsistently integrated digital formative assessment tools that focused on how the subject matter could be represented |
| | Teachers inconsistently used digital formative assessment tools that combined content resources and formative assessment capability |
| | Use of digital tools for formative assessment is inconsistently noted in teacher lesson plans |
| TPACK | Teachers inconsistently demonstrated TPACK when integrating digital tools to facilitate formative assessment |
| | Use of digital tools for formative assessment is inconsistently noted in teacher lesson plan |

**Table 6**

*Emergent Themes Aligned to RQ2, Delineated by TPACK Component*

| RQ2: How do Anytown Middle School teachers integrate digital tools to use feedback resulting from formative assessment to inform subsequent instruction? | |
|---|---|
| TK | Feedback from digital tools is accessed by teachers and students, but how this feedback informs subsequent instruction is unclear<br><br>Teacher lesson plans do not address how digital tools are integrated to use feedback from formative assessment to inform subsequent instruction |
| TPK | Digital tools are used to provide teachers with feedback to identify student learning gaps<br><br>Digital tools are used to provide feedback to students<br><br>Teacher lesson plans do not address how digital tools are integrated to use feedback from formative assessment to inform subsequent instruction |
| TCK | No codes are evident. |
| TPACK | No codes are evident. |

Key findings related to RQ1 were that Anytown Middle School teachers demonstrated relative strength in the areas of TK and TPK yet articulated inconsistent knowledge and demonstration of both TCK and TPACK. Anytown Middle School teachers demonstrated Danielson’s Component 1d, Demonstrating Knowledge of Resources, by availing themselves of all available supports when integrating digital tools to facilitate formative assessment. From seeking out colleagues and instructional coaches, engaging on social media platforms, performing Google searches, and attending PD, the study participants sought out and demonstrated knowledge of resources that would extend their teaching practice, particularly in applying technology and pedagogy, and inconsistently with respect to content knowledge (Danielson, 2007).

The purposefully selected participants, who in prestudy surveys answered that they either often or sometimes used digital tools for formative assessment and feedback, consistently exhibited TK by articulating their capacity to identify allowances of digital tools for facilitating formative assessments. Participants also articulated that they integrated digital tools to facilitate formative assessment for several purposes: to identify student needs, encourage engagement from students, and derive diagnostic information regarding gaps in student knowledge. By operationalizing digital tools not just for the sake of using technology, but specifically to advance student understanding, participants consistently demonstrated TPK. While some study participants did communicate both TCK and TPACK components, analysis of the data indicated that these two knowledge components were inconsistently demonstrated when Anytown Middle School teachers integrated digital tools to facilitate formative assessment. TCK requires that teachers understand how, and which technologies are best suited to content-specific learning (Koehler & Mishra, 2009). Anytown Middle School teachers inconsistently integrated digital formative assessment tools that could alter how subject matter could be represented. There was also evidence of inconsistent use of digital formative assessment tools that combined content resources and formative assessment capability. Given that TPACK requires teachers to flexibly navigate each TPACK component both individually and in concert, a deficiency in one knowledge component leads to a deficiency in TPACK. To wit, Anytown Middle School teachers inconsistently demonstrated TPACK when integrating digital tools to facilitate formative assessment.

Danielson's (2007) Component 1f, Designing Student Assessments, provides evaluation criteria relative to teachers' approach to designing formative assessments, including how teachers use the results of those formative assessments to guide subsequent instruction. Key findings related to RQ2 also included relative strengths regarding TK and TPK. Anytown Middle School teachers consistently articulated the use of digital tools for formative assessment and demonstrated an intent to access the feedback that resulted from those formative assessments. This feedback was sometimes accessed by teachers and sometimes accessed by students. Teachers testified to using feedback from digital formative assessments to identify learning gaps and to making use of the digital tools to provide feedback to students. The study participants also integrated digital tools such that students would be privy to the feedback that the digital formative assessment tool could provide. What remains unclear is how any of the feedback ultimately informs subsequent instruction.

Analysis of both TCK and TPACK relative to RQ2 yielded no emergent themes. Both TCK and TPACK were relative weaknesses demonstrated by Anytown Middle School teachers when integrating digital tools to facilitate formative assessment. Additionally, Anytown Middle School teachers were not able to clearly articulate or demonstrate how they integrated digital tools to use feedback from formative assessment to inform subsequent instruction, regardless of the TPACK component. The combination of the weakness in TCK and TPACK and an inability to clearly articulate how digital feedback informs subsequent instruction led to a lack of evidence regarding Anytown

Middle School teacher TCK and TPACK.

The results of the data analysis for both research questions indicated that lesson planning that articulates the integration of digital tools to facilitate formative assessment was inconsistently executed, as was lesson planning to integrate digital tools to use feedback from formative assessment to inform subsequent feedback. Lesson plans only inconsistently reflected that teachers integrated digital tools to facilitate formative assessment. There was only one notation of an Anytown Middle School teacher planning to integrate digital tools to use feedback from formative assessment to inform subsequent instruction. Three participants submitted lesson plans using the Anytown School District unit plan template. The district employs the McTighe and Wiggins (2004) UBD template. This template includes a section for teachers to list their formative assessments, however, the template does not account for how digital tools will be used to facilitate the formative assessment. The template also does not account for how teachers will integrate digital tools to use feedback from formative assessment to inform subsequent instruction. According to Danielson (2007),

> Teachers demonstrate their skill in designing student assessment through the plans they create. With respect to assessment of learning, a unit plan should include the method to be used to assess student understanding, including, if appropriate, a scoring guide or rubric for evaluating student responses. When teachers also include assessment for learning in the plan, then the details of such assessments should be part of the plan. In addition, teachers should be able to explain how

> they intend to use assessment of learning in their instruction, and how they plan to include students in assessment activities. (p. 62)

Regardless of the format used for lesson planning, study participants did not consistently plan to integrate digital tools to facilitate formative assessment. Participants also did not plan to integrate digital tools to use feedback from formative assessment to inform subsequent instruction.

The TPACK conceptual framework that grounds this study was built upon the PCK foundation first established by Shulman's PCK (Mishra & Koehler, 2006). Shulman (1986) argued that focusing on teacher pedagogy or content knowledge as independent constructs was an insufficient strategy for understanding teacher knowledge. Expanding upon this construct, Mishra and Koehler (2006) similarly noted that in the field of education, technology integration is generally erroneously considered as independent from the teaching and learning process. Just as there was a necessity to integrate technology into teacher knowledge components from Shulman's PCK foundation to Mishra and Koehler's TPACK, there's also a necessity to expand the way teachers integrate and contextualize TPACK into lesson planning. This expansion includes planning processes that account for how teachers plan to integrate digital tools to facilitate formative assessment and how teachers integrate digital tools to use feedback from formative assessment to inform subsequent instruction.

**Project**

The findings from this project study suggested inconsistencies in the following areas: in teacher demonstration of TCK and TPACK when integrating digital tools to facilitate formative assessment and feedback; with regard to demonstration of Danielson’s Component 1f, specifically how teachers integrate digital tools to use feedback from formative assessment to inform subsequent instruction; and in lesson planning to use digital tools to facilitate formative assessment and to use feedback from formative assessment to inform subsequent instruction. A 3-day PD was created to help bridge these inconsistencies.

## Conclusion

This qualitative case study was conducted to explore inconsistent digital tool integration by Anytown Middle School teachers to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. The sample for the study was eight purposefully selected classroom teachers who testified to either often or sometimes using digital tools for formative assessment and feedback. Qualitative interviews and teacher lesson plans were the data instruments used to gather study data. Data credibility was ensured by engaging in reflective journaling, by employing a peer reviewer to assess the data collected to ensure applicability of the emergent themes developed from the data analysis process, and by soliciting participant member checks.

Research findings indicated needs for PD in the areas of TCK and TPACK when integrating digital tools to facilitate formative assessment and feedback, integration of digital tools to use feedback from formative assessment to inform subsequent instruction, and in planning strategies that provide for integration and contextualization of TPACK components, specifically when planning for the facilitation of digital formative assessment and feedback. In Section 3, I will outline a PD implementation and evaluation plan to provide support for Anytown Middle School teachers in these areas.

# Section 3: The Project

The purpose of this case study was to explore how teachers perceive the use of digital tools to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. Based on the study findings, I developed a 3-day synchronous PD seminar with an accompanying unit planning template. Through these PD seminars, teachers will use the unit planning template as a guide to build both TCK and TPACK knowledge. Participants will also use the unit planning template to engage in the assessment and development of activities to integrate digital tools for both formative assessment and the resulting feedback. Throughout the course of the 3-day PD, teachers will have the opportunity to apply concepts learned to their existing practice through the evaluation and alteration of existing content units. Such PD could foster positive social change by benefitting student learning and assisting other school districts whose teachers exhibit similar inconsistencies in digital tool integration to facilitate formative assessment and use the resulting feedback to inform subsequent instruction.

## Rationale

During this study, I examined how teachers integrate digital tools to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. In the interviews, teachers were unable to consistently articulate a demonstration of TCK or TPACK when integrating digital tools to facilitate formative assessment and feedback. Additionally, teachers did not consistently demonstrate how digital tools were integrated to use the feedback from formative assessment to inform subsequent instruction. A lesson plan analysis revealed that study participants inconsistently planned to use digital tools to facilitate formative assessment and did not plan to use feedback from formative assessment to inform subsequent instruction. These teachers, however, did make use of a variety of supports to improve their teaching practice, in both individual and collaborative settings. Teachers reported making use of PDs, individual research on their own, and collaborative ventures with other educators. The PD opportunities presented here are designed to help these teachers to bridge the knowledge and strategy gaps that became evident through the data analysis.

The problem identified in this project study was inconsistent digital tool integration by Anytown Middle School teachers to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. To address this inconsistency in practice, I created the content of the deliverable to allow teachers to practice planning the construction of digital formative assessments using a model that facilitates teacher TCK and TPACK. Teachers are asked to focus on the evaluation and development of digital formative assessment activities in one unit while using a unit planning template that encourages the use of all TPACK knowledge components, both independently and simultaneously. The sessions are organized so that teachers work actively and collaboratively within content teaching groups, mirroring best PD practices and accounting for the contextual nature and expertise required of TCK and TPACK development. By instituting action planning using the unit plan template that I constructed, teachers will leave the PD with two unit exemplars for later use (see Wylie & Lyon, 2020). To provide ongoing support to teachers and content groups who wish to continue these practices, training sessions have been chunked into short 30–90-minute sections, allowing for content groups and individuals who wish to transfer the knowledge and strategies presented to future work in PLCs. Anytown Middle School provides dedicated, though limited, PLC time each week. This mechanism of providing a means for ongoing support through PLCS fits both with the Anytown Middle School schedule and with literature-supported best practices (see Cisterna et al., 2016; Darling-Hammond et al., 2017).

## Review of the Literature

For the literature review, I procured peer-reviewed journal articles, publications, and books from the following databases: ProQuest Central, Sage Journals, Education Source, and Taylor and Francis Online. I also used the Google Scholar search engine. The search terms used were *professional development, TPACK professional development, professional development and technology integration, lesson planning, lesson planning and professional development, formative assessment professional development, feedback and professional development, best practices in professional development, professional learning communities,* and *PLC best practices*. I filtered my searches to primarily include only resources that were published in the 5 years prior to the project's development.

### Effective PD

Effective PD was defined by Darling-Hammond et al. (2017) as "structured professional learning that results in changes to teacher knowledge and practices, and improvements in student learning outcomes" (p. 2). These learning opportunities are provided both within the teacher's job context and from outside sources as a means of broadening teacher knowledge and of facilitating changes in practice (Darling-Hammond et al., 2017). All PD opportunities do not fit this mold. PD is commonly constructed as a 1-day, “shotgun” session (Brown & Militello, 2016). These sessions are not followed up with subsequent training to reinforce learning, allow for practice to integrate into the classroom setting, or provide feedback regarding the implementation of strategies gleaned from the PD. PD offerings are commonly conducted in a passive, “sit and get” format, negating the benefits that can be gained from actively designing, practicing, employing, and reflecting upon the intended learning opportunities (Brown & Militello, 2016; Matherson & Windle, 2017). Typical PD formats also eschew the benefits of social and collaborative learning opportunities and instead encourage teachers to rely on their own knowledge and expertise rather than take advantage of the benefits of working collaboratively (McKenney et al., 2016). While these strategies are widespread among teacher PD workshops and training sessions, extensive research is available that provides a blueprint for more effective PD.

Darling-Hammond et al. (2017) outlined the following seven characteristics of effective PD that served as the baseline for my project:

- Is content focused
- Incorporates active learning utilizing adult learning theory
- Supports collaboration, typically in job-embedded contexts
- Uses models and modeling of effective practice
- Provides coaching and expert support
- Offers opportunities for feedback and reflection
- Is of sustained duration (p. 4)

### *Content Focused*

Effective PD is content-focused while linking to supporting pedagogy (Darling-Hammond et al., 2017). Darling-Hammond et al. (2017) and Kleickmann et al. (2016) suggested that when PD is focused on content with attention to context-specific pedagogies and considerations, teacher practice is supported, stimulating an environment where the training can be used to meet the variety of educator needs across a diversity of settings. Including a focus on content as a core feature of PD should relate to the content being taught in the school setting, the respective instructional strategies, and the student population served by the educator (Kleickmann et al., 2016).

### *Learning is Active*

Rather than facilitate PD opportunities led by a "sage on the stage," effective PD is designed to engage teachers in activities that allow for active learning opportunities including "collaboration, coaching, feedback, and reflection and the use of models and modeling" (Darling-Hammond et al., 2017, p. 7). Active learning opportunities allow teachers the opportunity to use their PD to participate in engaging activities to analyze processes of teaching and learning (Kleickmann et al., 2016). Matherson and Windle (2017) stated that teachers prefer PD that includes facets of engagement and interactivity, specifically wishing to be presented with opportunities for hands-on application of modeled skills and strategies before implementing these new skills and strategies with students in the classroom. In this way, teachers can actively apply aspects of PD to analyze the applicability to their individual classroom contexts. Reflection throughout the PD is a key component of active learning, allowing teachers to engage in the inquiry and cognitive processing to learn from the training and to develop their own applicable understanding (Darling-Hammond et al., 2017). Smith et al. (2020) echoed the value of making time for reflection, suggesting that learning by working in teams provides PD participants with more time to engage in reflective processes.

### *Collaborative and Job-Embedded*

As a result of their study to understand perceptions of principals regarding the role that PD plays in growing teaching practice, Brown and Militello (2016) suggested that ongoing opportunities for teachers to collaborate were necessary components of effective PD. Darling-Hammond et al. (2017) concurred, broadly defining collaborative configurations to include one-on-one, small group, school-wide, or outside-school interactions to improve practice. PDs that employ collaborative models can provide a trusting and supportive environment for teachers to examine, reflect upon, and adjust their practice (Darling-Hammond et al., 2017).

Brown and Militello (2016) also stressed that to be effective, PD must be embedded within authentic instructional practices. Researchers have consistently argued that PD should be coherent with teachers' current practice. Kleickmann et al. (2016) stated that PD must harmonize with conditions woven into teacher context, including the individual teacher's goals and the state standards to which they are bound to address. The need for PD to address contextual needs is rooted in practicality. Teachers yearn for their PD to be readily applicable to their everyday teaching. Echoing this fundamental premise, Matherson and Windle (2017) stated that PD is more successful when tied directly to day-to-day teaching and focused on the needs of the students.

### *Models Effective Practice*

The practicality of contextual PD also extends to teachers' desire to see relevant and effective teaching practices modeled for them during training sessions. Matherson and Windle (2017) advocated that teachers need to not only have such practices modeled for them during PD, but teachers should also have the opportunity to practice these models before implementing them with students in their classrooms. As opposed to single-day training sessions, immediate and ongoing practice of new teaching models are critical to a transfer of practice (Brown & Militello, 2016). In their research, Darling-Hammond et al. (2017) expounded on the success of an "analysis of practice" approach. Collaborative groups of teachers participated in ongoing PD by incorporating one of three models of effective practice: "student work analysis, student-teacher dialogue analysis, and teacher thinking and behaviors" (p. 11). Following and engaging with the models designed by staff developers, teachers worked collaboratively to analyze the logic behind their practice and to adapt their practice. Study findings indicated that the students of all three groups of teachers showed significantly larger learning gains on science tests compared to students of teachers not in the study and maintained the learning gains 1 year later (Darling-Hammond et al., 2017).

### *Coaching Support*

While collaborative communities have been demonstrated to be beneficial to PD (Brown & Militello, 2016; Darling-Hammond et al., 2017; McKenney et al., 2016; Smith et al., 2020), researchers have also consistently noted the benefits that can be gleaned from ongoing coaching supports (Brown & Militello, 2016; Darling-Hammond et al., 2017; Kleickmann et al., 2016; Matherson & Windle, 2017). The effectiveness of approaches like coaching and mentoring is rooted in the relationships that these approaches support (Matherson & Windle, 2017). Learning is commonly shepherded by others, and this is particularly important when new skills, strategies, and technologies are being integrated into existing practice. Knowledgeable educators, such as coaches or mentors, can provide scaffolded supports to assist teachers when integrating new learning into their existing contexts (Kleickmann et al., 2016). Immediate and ongoing support is critical when implementing new learning. Without such supports,

> educators will either abandon the newly introduced concept or attempt to implement the skill without ever knowing if they are implementing it correctly. The sense of being overwhelmed and frustrated emerges, and thus the transference of the new skill or concept is hindered. (Brown & Militello, 2016, p. 706)

Darling-Hammond et al. (2017) amplified the need for coaching supports as being an integral component of effective PD, stating that "teachers who receive coaching are more likely to enact desired teaching practices and apply them more appropriately than those receiving more traditional PD" (p. 13).

***Reflection***

Brown and Militello (2016) lamented that reflection is an often-overlooked component of effective PD; yet, it is an imperative element to examine existing practices and innovative implementations. By examining existing and innovative practices, educators can evaluate authentic components of their practice, including lesson plans and in-class teaching to assess what works, what does not work, and how adaptations can be integrated to improve. Researchers have suggested that reflective practices can be aided through collaborative processes and with coaching support (Darling-Hammond et al., 2017; Smith et al., 2020). Darling-Hammond et al. (2017) suggested that both feedback from other members of a collaborative group and reflection are two distinct tasks and that both are needed to allow teachers to envision how modeled PD might be put into practice in their specific contexts. Such PD opportunities that incorporate “built-in time for teachers to think about, receive input on, and make changes to their practice” are correlated with student learning gains (Darling-Hammond et al., 2017, p. 14).

***Sustained Duration***

Effective PD requires a commitment to a sustained duration of time (Brown & Militello, 2016; Darling-Hammond et al., 2017; Kleickmann et al., 2016; Matherson & Windle, 2017; Smith et al., 2020). There is little agreement in research that defines the most effective definition of “sustained duration” though the consensus indicated that effective PD is not possible in stand-alone PDs (Brown & Militello, 2016; Darling-Hammond et al., 2017). Teachers testified to not looking for PD that is a quick fix or is targeted to a short-term reform (Matherson & Windle, 2017). Short-term PD sessions do not afford teachers the time necessary to reflect upon the sessions, to examine how the teachings might integrate with one’s practice, or to collaborate with colleagues or coaches regarding the new learning. On the contrary, when PD occurs across time, teachers have the opportunity for continuous and cumulative learning (Kleickmann et al., 2016). Darling-Hammond et al. (2017) summarized the benefits of sustained PD:

> Professional development that is sustained, offering multiple opportunities for teachers to engage in learning around a single set of concepts or practices, has a greater chance of transforming teaching practices and student learning. One benefit of sustained PD may be the opportunity for teachers to continue their learning outside the formal meetings of the program, whether in their own classroom, in collaboration with colleagues, or by less formal means. (p. 16)

In advocating for a team teaching and learning framework Smith et al. (2020) echoed Darling-Hammond et al. (2017). The researchers described the transformation of their study participants who participated in a sustained-duration PD experience. Participants evolved from that of a "cautious bystander to confident implementer" (Smith et al., 2020, p. 86). Sustained duration PD opportunities provide the space teachers need to become confident implementers, allowing for reflection, collaboration, direct application to practice, and support from coaches.

Anytown Middle School teachers demonstrated relative strength in the areas of TK and TPK yet articulated inconsistent knowledge and demonstration of both TCK and TPACK. Consequently, the PD that was created because of the data analysis will include facets dedicated to developing TCK and TPACK. While some study participants did communicate both TCK and TPACK components, analysis of the data indicated that these two knowledge components were inconsistently demonstrated when Anytown Middle School teachers integrated digital tools to facilitate formative assessment.

## TPACK PD

Taken independently, the TPACK framework is not PD but instead can be used to frame the knowledge that educators and trainers need to know when planning PD opportunities (Harris et al., 2009). The TPACK framework does not delineate how these PDs should be administered. Harris (2016) contended that PD aimed at building teacher TPACK should be contextually customized and should largely mirror the tenets of PD in general and specifically for PD that incorporates technology integration. To integrate technology in a meaningful way, teachers need to be equipped with the knowledge and strategies to transform their technology use in ways that foster teaching beyond traditional approaches (Almerich et al., 2016; George & Sanders, 2017). To move beyond traditional uses of technology, teachers need TPACK PD that will challenge their assumptions about what meaningful technology integration entails and to provide comfort and familiarity with the TPACK framework that can help to foster such a transformation (Koh et al., 2017). Harris and Hofer (2017) described TPACK as a three-legged stool where technology, pedagogy, and content are the legs of the stool. To construct meaningful lessons when integrating technology, a teacher's teaching stool must have in place and always be mindful of all three legs of the stool. Meaningful TPACK can be achieved only when teachers synthesize technology, pedagogy, and content in such a manner that new teaching and learning practices result (Angeli et al., 2016).

### *Eschew Technocentric PD*

In eschewing the traditional models of PD for technology integration, researchers agreed that PD that aims to build teacher TPACK by employing technocentric strategies have been insufficient (Baran et al., 2016; Harris, 2016; Hofer & Harris, 2017; Shepherd et al., 2016). Teaching technology skills in isolation has proven to be insufficient to stimulate ongoing and meaningful classroom integration (Shepherd et al., 2016). In their work with elementary school math teachers, Polly and Orrill (2016) found that the cognitive challenges for teachers when focusing on the technology rather than the content was prohibitive to learning how these tools might be integrated into the classroom. Noting the highly contextualized nature of TPACK, Harris (2016) posited that the typically short duration, large group, technology-focused training be replaced by more effective means. Baran et al. agreed that technocentric TPACK PD was disconnected from practice, and instead stressed the need for ongoing and usable PD as well as for continuous support in TPACK development. In their research using the 21st Century Learning Design to leverage technology in the classroom, Hofer et al. (2016) found that exposure to TPACK over time helped teachers to develop TPACK and to reduce their reliance on direct knowledge transmission teaching. The 21st Century Learning Design, a guided inquiry approach to using 21st-century skills, encouraged teachers to use TPACK as a means of expanding their vision of how technology can be integrated to support student learning (Hofer et al., 2016). Focusing on lesson design and how technology, pedagogy, and content interacted within the lesson design, the researchers were able to guide participants through a design strategy that connected directly to professional practice, rather than focus on the functionality of a specific digital tool. Also focusing on the planning process, Hofer and Harris advocated for a lesson planning process that placed technology-related instructional decisions *after* decisions relating to content and pedagogy strategy. In their study, Hofer and Harris noted that in-service teachers found significant value in flipping the order of the planning process so that the determination of technology options is done last rather than at the beginning of the design process. Study participants testified that this design reversal would “lead to better-integrated, more student-centered and curriculum-based learning designs” (Hofer & Harris, 2017, p. 1661). Breaking with the traditional technocentric PD strategies, current research indicates that PD whose objective is to develop teacher TCK and TPACK necessitates a focus on lesson design.

***Build TPACK Through Instructional Design***

The data from this study indicated that lesson planning by Anytown Middle School teachers about integrating digital tools to facilitate formative assessment was inconsistently executed, as was lesson planning to integrate digital tools to use feedback from formative assessment to inform subsequent feedback. Teachers’ competency for designing tech-enhanced learning experiences has been found to influence whether the technology contributes to a meaningful learning experience for students (George & Sanders, 2017). Having a foundational knowledge of each of the TPACK components and how those components interact with one another is key to the development of effective technology integration. Chai et al. (2018) testified that when teachers learn by designing in authentic contexts, teacher TPACK efficacy is enhanced. Teacher TPACK ultimately emerges through the design process (Chai et al., 2018; Koh et al., 2017). Addressing TPACK at the planning level has been found to assist teachers in enhancing lessons that include technology integration. Harris and Hofer (2017) pointed to instructional planning as being a key component in structuring TPACK PD. By operationalizing TPACK in instructional planning, teachers were able to more effectively integrate technology into their classroom practices (Harris & Hofer, 2017). This efficacy of TPACK in instructional planning was echoed by Koh (2019). Koh found that the addition of design heuristics to the planning process helped teachers to better translate tech-enhanced lessons into lessons that meet learner needs. Ultimately, using technology for purposes that create educational value is reliant on how teachers choose to integrate the technology into the lesson. Helping teachers to design activities that more effectively make use of the technology to serve educational goals is imperative (George & Sanders, 2017). Consequently, it is critical that TPACK-based PD includes opportunities for teachers to design technology-enhanced lessons that transfer directly to practice (Baran et al., 2016).

Design-based TPACK PD provides teachers with the structure and the opportunity to develop their TPACK by building upon their own classroom experiences. Hofer et al. (2016) suggested that prior PD, teachers should identify an anchor exercise. This anchor exercise is an instructional challenge or opportunity that the teacher would like to address and one that can be revisited throughout the PD. In this way, teachers can continuously reflect upon the PD links to professional practice. To facilitate TPACK development in their PD, Hofer et al. made use of the TPACK game. First developed and implemented in 2007 by Mishra, Koehler, and Harris, the TPACK game requires teachers to interact with content possibilities, pedagogical possibilities, and technological options to construct pieces from each knowledge component into an educational fit (Hofer et al.,

2016) Upon constructing the symbiotic content, pedagogy, and technology, teachers design a course assignment that draws on their learning from the PD. By using this type of instructional planning method for TPACK development, teachers can immediately incorporate their learning into their day-to-day processes, rather than experiencing TPACK learning in a PD silo.

Harris and Hofer also make use of learning activity types (LATs) in PDs as a means of assisting teachers in their quest to both develop and operationalize TPACK (Harris, 2016; Hofer & Harris, 2017, 2019). LATs were created by the researchers to "directly link students' content-related learning needs with particular content-based learning activities and related educational technologies that will best support the activities' successful implementation" (Harris et al., 2010, p. 575). Categorized by content area, the collection of LATs provides activity options coordinated with suggested technologies for teachers to peruse for use. Once teachers have selected their content objectives and noted any contextual considerations, these taxonomies can be used to help teachers authentically learn to select and interweave appropriate digital tools in the instructional planning process (Harris et al., 2010). The use of LATs in instructional planning helps teachers to better articulate their technology use and as a result helps to facilitate the use of educational technologies in more meaningful ways (Harris, 2016; Hofer & Harris, 2017). Koh (2019) concurred with this assertion, advocating for the use of LATs as starting points for teachers who are working to build TPACK and to develop competency in lesson design.

### *Build TPACK Collaboratively and Continuously*

Collaborative PD opportunities have proven to be necessary components of effective PD (Brown & Militello, 2016; Darling-Hammond et al., 2017). Integrating collaborative communities of practice has also been found to enhance the effectiveness of TPACK PD. In advocating for learner-centered TPACK PD, Polly and Orrill (2016) noted that the promotion of teacher collaboration contributes to PD, resulting in broader school-wide change as opposed to only impacting individual teacher classrooms. In their work to design TPACK PD programs for science teachers, Baran et al. (2016) touted design reforms that directly affect teacher practice, specifically noting the positive impact that the collegial support of collaborative PD. Teacher participants in the study also emphasized the benefit provided by the immediate and ongoing support of their colleagues and PD trainers (Baran et al., 2016). In their work to design PD to help teachers develop more meaningful technologically-based tasks, George and Sanders (2017) also noted the necessity for a community of practice. The researchers advocated for content-based groups to focus on their specific contextual needs through task analysis (George & Sanders, 2017).

Collaborative PD is most effective when it is conducted on a continuous, ongoing basis (Brown & Militello, 2016; Darling-Hammond et al., 2017; Kleickmann et al., 2016; Matherson & Windle, 2017; Smith et al., 2020). The benefits of sustained PD are also specific to PD opportunities focused on developing teacher TPACK. Hofer and Harris (2019) stated that teacher development of TPACK is a process that is built over time. This sentiment was concurred by Polly and Orrill (2016) who advocated for the use of learner-centered PD when building teacher TPACK. The researchers noted that learner-centered PD opportunities are generally done on an ongoing basis rather than as an independent workshop. Such longer duration efforts have been demonstrated to more effectively facilitate overall change than short duration or one-off approaches (Polly & Orrill, 2016). Additionally, short-term initiatives are not sufficient to build TPACK that is authentically transferrable to the classroom. Hofer et al. (2016) noted that one limitation of their singular PD opportunity was that PD is "optimally sustained over time to significantly impact instructional practice" (p. 234). In their 8-day PD, the researchers introduced teachers to TPACK by operationalizing the TPACK game and participant collaborative groups to coach teachers to integrate TPACK into lesson design. To compensate for the short-term duration of the PD, the researchers ensured that the approaches and TPACK lesson design principles were constructed as instructional design challenges that could be continuously replicated. In using TPACK concepts for lesson design, Hofer and Harris also suggested that incorporating the use of LATs as instructional design aids enhances teacher TPACK over time. For classroom teachers, TPACK development is a continuous process that will continuously evolve. Baran et al. (2016) succinctly summarized the necessity to recognize teachers' learning continuum through a distinct TPACK PD strategy:

> Learning is enhanced through teaching practice as they try and revise ideas about technology integration. In-service TPACK based PD programs should be an integral part of a continuous and long-term curriculum implemented to promote and enhance theoretically sound teaching practices in classrooms (p. 282).

**TCK-Focused PD**

TCK encompasses how teachers understand technologies and how that they can be used to facilitate subject matter learning. Data analysis from this project study indicated that Anytown Middle School teachers inconsistently demonstrated TCK when integrating digital tools to facilitate formative assessment and feedback, both in practice and while lesson planning. Study participants inconsistently integrated digital formative assessment tools that focused on how their subject matter could be represented and inconsistently used digital formative assessment tools that combined both content resources and formative assessment capability. Use of digital tools for formative assessment was inconsistently noted in teacher lesson plans while use of digital tools for feedback to inform subsequent instruction was not observed. To demonstrate TCK, teachers must have an understanding of technologies that are suited for facilitating subject matter learning in their content areas, with a focus on how the subject matter can be represented and/or how the content can be used to alter the technology (Koehler & Mishra, 2009). George and Sanders (2017) echoed this contention, finding that teachers' knowledge about technology-related matters for teaching their subject and their competency in applying their knowledge to lesson design, positively influences whether a teacher's classroom technology use facilitates meaningful learning. Consequently, PD with a focus on content to build TCK in Anytown Middle School teachers is suggested.

***Active PD***

Darling-Hammond et al. (2017) and Kleickmann et al. (2016) advocated for a general focus on content while applying context-specific pedagogies as a means to design

PD that supports teacher practice. PD that encourages teachers to actively plan for content, then weave contextual pedagogical considerations with appropriate technology choices can assist teachers in developing both their TCK and TPACK. Such PD opportunities can be implemented to foster teacher understanding of technologies that are suited to teaching in specific content areas. Polly and Orrill (2016) argued the body of research and merits of learner-centered PD, noting that learner-centered PD is designed to help teachers develop knowledge for teaching, and thusly aligns closely with the TPACK model. The researchers stressed the need for teachers to be able to use PD to address learning activities of their choice, then move from focusing on individual knowledge components to actively working to combine their content knowledge and pedagogies into meaningful learning. Harris et al. (2010) operationalized this focus on helping teachers to facilitate meaningful learning experiences by creating a taxonomy of LATs that can be used to drive PD opportunities and can serve as guideposts for the lesson planning process. Created for use in nine different content areas, LATs are content-specific planning aids that provide potential learning activities that can be used to teach specific content, along with possible corresponding digital tools that teachers can employ for the task (Harris, 2016; Harris et al., 2010; Hofer & Harris, 2017, 2019). Harris (2016) described LATs as an "on-the-job approach to teachers TPACK development" (p. 196). Beginning with and guided by the instructional content, Hofer and Harris (2017, 2019) used LATs in their own research and PD as planning aids. These aids could help teachers to:

> select, combine, and sequence multiple learning activity types to comprise plans for lessons, learning projects, and units based upon knowledge of their students' learning needs and preferences, curriculum standards, and contextual conditions. Teachers' TPACK is built, over time, in the process of using the LAT taxonomies to plan learning experiences that incorporate educational technologies in curriculum-based and pedagogically focused ways. (p. 2445)

Using their TPACK-based course (Hofer & Harris, 2016), the researchers underscored the need to choose specific lessons and content before moving to choosing pedagogical and technological fits for the lesson (Hofer & Harris, 2017). PD that provided teachers with the training and opportunity to actively plan by learning to consciously fit together content, pedagogy, and technology helped teachers to build both their TCK and TPACK (Hofer & Harris, 2019) over time.

***Supports in Practice***

Although teachers in the Anytown Middle School testified to taking advantage of supports to assist them with integrating digital tools to facilitate formative assessment and feedback, Koh and Chai (2016) lamented the scarcity of supports for designing ICT materials. Baran et al. (2016) suggested that teacher TPACK, and thusly teacher TCK, is a continuum, rather than a static skill set. The honing of the teachers TPACK knowledge components should be addressed on a consistent and ongoing basis through PD and through practice to enhance teacher practice (Baran et al., 2016; De Freitas & Spangenberg, 2019). While the research of both Baran et al. and Polly and Orrill (2016) reflected that teachers need to use digital tools to develop TPACK, Baran et al. designed

PD that was domain-specific in an effort to focus science teachers on their content applications. A PD design that lends itself to practice can also aid teachers in continuing to apply the learned concepts in the classroom and in their learning communities:

> Tteacher educators may implement ongoing learning with activities where teachers…revise them with mentor and peer feedback after reflecting on the feasibility of their designs. These practical and authentic TPACK based PD programs may also be implemented within science teachers' own schools to strengthen the connection. Strong professional learning communities also contribute to teachers' instructional improvement. While participating in such communities when initiated and sustained through TPACK-based PDs, teachers interact, collaborate and share. (p. 281)

Noting that mathematics teachers have difficulty integrating technology into teaching and learning, De Freitas and Spangenberg (2019) aimed to identify characteristics of PD needed to improve levels of teacher TPACK. The support recommendations that resulted from their study mirrored the findings of Baran et al. Continuous PD, including allowing teachers the opportunity to apply their learning to daily practice and within an ever-strengthening PLC of peers was recommended by the researchers. Through continuous practice with ongoing support from other educators, specifically those in their PLCs, teachers can continue to build their TPACK in their instructional planning and classroom practices.

**Formative Assessment PD**

There is significant literature to indicate that teachers inconsistently integrate digital tools to facilitate formative assessment and feedback (Abrams et al., 2016; Hooley & Thorpe, 2017; Luckin et al., 2017; Zhan & So, 2017). The literature also indicates that teachers struggle, in general, when developing and implementing formative assessments (Cisterna & Gotwals, 2018; Cisterna et al., 2016; 2018; Mills & Harrison, 2020; Wylie & Lyon, 2020). Deficiencies in performing formative assessments begins in teacher preparation programs (Cisterna et al., 2016; Mills & Harrison, 2020) and extends into in-service teaching practice. Teachers begin their teaching careers unprepared to formatively assess their students and continue to find the formative assessment process to be challenging. While the formative assessment process is perceived to be a challenging one, teachers have been shown to lack expertise in formative assessment practices and struggle to elicit deep learning from their students when conducting these assessments (Mills & Harrison, 2020).

Though the research for this project study reflected teacher perceptions of digital formative assessment and feedback in the classroom prior to the COVID-19 pandemic, emerging research indicated that remote teaching and learning during the pandemic reflected similar inconsistencies to those mentioned in this study. During the pandemic, approximately 1.5 billion students were reliant on digital technologies while learning remotely (United Nations Educational, Scientific and Cultural Organization, 2020). Due to the remote teaching environment propagated by the pandemic, engagement of technology for teaching was a necessity, even for the most technologically reluctant educators. Students noted teachers' struggles in making the transition from face-to-face teaching to virtual learning. While testifying as to the efficacy of using digital tools to receive immediate feedback during remote learning, students lamented the lack of effectiveness and opportunities for the use of digital tools to engage in their remote learning experiences (Zulkifli et al., 2021). Similarly, Perifanou et al. (2021) found that during remote learning necessitated by the COVID-19 pandemic, teachers used digital tools primarily as a means of locating and evaluating potential educational resources, while rarely using them for student feedback. In an examination of teacher assessment practices and beliefs during the pandemic, Ferretti et al. (2021) discovered a range of challenges experienced by teachers that mirror challenges teachers demonstrated prior to the transition to virtual learning. Teachers were challenged to define formative assessments appropriately, using them to assess student behaviors such as punctuality and class participation rather than as a means to feeding learning forward into subsequent instruction (Ferretti et al., 2021) Teachers also relied on summative assessments to provide instructional feedback to students. These misunderstandings and misapplications of both formative and summative assessments, according to the researchers, underestimated the potential of using digital tools for any assessment, and as a result, minimized teacher effectiveness. The universal challenge presented by the integration of effective formative assessment practice into teaching, coupled with inconsistent integration of digital tools to facilitate formative assessment and feedback, necessitates PD strategies as mitigations.

Given the challenges that formative assessments present to educators, ongoing and supported professional learning opportunities are necessary to instigate shifts in teaching practice. These contentions mirror those espoused by Darling-Hammond et al. (2017). In their research illustrating the characteristics of effective PD, Darling-Hammond et al. specifically noted the beneficial role of sustained duration PD and supportive collaboration in job-embedded contexts. In research regarding the design of professional learning experiences to facilitate formative assessment capacities in in-service teachers, researchers outlined PD programs that are most effective when instituted over time (Cisterna & Gotwals, 2018; Cisterna et al., 2016; Mills & Harrison, 2020; Wylie & Lyon, 2016, 2020). For in-service teachers to transfer knowledge and capacity for formative assessment to practice, teachers must have focused time to explore and experiment with potential strategies to meet their curricular needs (Mills & Harrison, 2020). Active application of new learning strategies over time allows for teachings to connect learning to practice. A purposefully collaborative learning environment has also been shown to be beneficial to the application to practice. Cisterna et al. (2016) advocated for the use of PLCs to provide ongoing formative assessment learning opportunities. Echoing Darling-Hammond et al., Cisterna et al. stressed that such job-embedded opportunities provide teachers with a venue for ongoing support. Mills and Harrison also suggested leveraging collaborative groups of teachers for planning and reflecting upon formative assessment practices was likely to accelerate both teacher learning and application of new strategies to practice.

The complexity of learning and implementing new strategies can be prohibitive to effective PD. To combat this complexity, both Mills and Harrison (2020) and Cisterna and Gotwals (2018) employed generalized formative assessment principles in their teacher professional learning program to support teacher development. In their professional learning model to foster understanding of the formative assessment process in middle and high school Algebra 1 teachers, Mills and Harrison used three guiding questions so that these teachers could track and advance their practice. The three guiding questions for framing formative assessment were:

1. Where are we headed? In answering this question, teachers identify the learning objectives for the instructional task.
2. Where are we now? In order for teachers to help students meet the learning objectives, teachers must have a process to find out what students know and can do.
3. How to close the gap? When students have gaps in knowledge between what they currently know and can do versus the expectations defined in the learning objective, considerations for closing the gap need to be identified.

Cisterna and Gotwals used a slightly altered set of guiding questions in their examination of in-service science teacher practices. Slightly altering Question 1 to ‘Where are we going?,’ the researchers underscored the utility of using the three guiding questions to support teacher practice, noting that the questions inherently frame the formative assessment and feedback loops. Using these three questions as visible guideposts, teachers can focus on one question at a time, but can also contextualize how each question fits into the formative assessment process. In framing PD through the lens of these three guiding questions, educators can develop and evaluate their practice relative to formative assessment and feedback.

As shown in Table 7, use of the three guiding questions for framing formative assessment and feedback mirrors the UBD framework (McTighe & Wiggins, 2004) used for unit planning by the Anytown School District. Commonly referred to as “backward design,” UBD is a three-stage planning process that compels users to begin with the end in mind when crafting curriculum, instruction, and assessment (Wiggins & McTighe, 2011). The planning template used by the Anytown School District includes the three stages in the UBD planning process: Stage 1 Desired Results, Stage 2 Assessment Evidence, and Stage 3 Learning Plan. Stage1 of the UBD planning process provides the framework for identifying the student learning objectives. Stage 2 assists the teacher in considering the evidence needed to ascertain the degree to which the learning objective has been met. In Stage 3, teachers plan the learning activities most conducive to meeting the Stage 1 learning objectives (Wiggins & McTighe, 2004). While the UBD planning template does not specifically account for the integration of digital tools for formative assessment and feedback, utilization of the backwards design concept both in unit planning and in planning for formative assessment and feedback, is grounded in literature and in practice.

**Table 7**

*Formative Assessment Guiding Questions/UBD Planning Stages*

| | Formative Assessment Guiding Questions | UBD Planning Stages |
|---|---|---|
| 1 | Where are we going? | Desired results |
| 2 | Where are we now? | Assessment evidence |
| 3 | How do we get there? | Learning plan |

## Project Description

The PD plan for Anytown Middle School teachers consists of 3 full-day instructional sessions. At the conclusion of the 3 days of PD, teachers will have two unit plan exemplars to use as guides for future planning to facilitate digital formative assessments and feedback.

### Resources, Supports, Potential Barriers, and Barrier Solutions

The Anytown School District is fortunate to have resources available to allow for implementation of this project. Each teacher in the school district is issued a personal computer for their use if they are employed. For planning, exploration of tools, access to web resources, and for digital collaboration, having a personal computing device is necessary. Throughout the school district, teachers have access to a plethora of digital tools, and specifically to digital formative assessment tools. These can be shared and collaborated on using Google Workspace for Education Plus. The district is also fortunate to have physical space to accommodate building faculty in one location to allow for collaborative content groups to participate in the PD.

Each school in the district has a dedicated instructional coach who is an experienced classroom teacher and is well versed in technology integration to provide the necessary support for the project components. As was evidenced by the enthusiasm of the project study participants, the Anytown Middle School has several dedicated teachers who not only seek out PD to build their own teaching prowess, but also are eager to learn with and from one another. In implementing reformative concepts like digital formative assessment and feedback, the support of colleagues throughout the process of skill building, planning, and classroom facilitation will be well served by the collegial support present. Support for research-based initiatives was also present in conversations with district administrators through the course of this project study. The ultimate implementation of the project will rely on the support of administrators to advocate for, support, and oversee classroom integration.

As with any new initiative, there are several barriers to anticipate and attempt to mitigate. Because planning for and working toward a commitment to digital formative assessment and feedback is an initiative, an automatic barrier exists. When districts commit to an initiative, it means that room for other initiatives is reduced. The literature indicated that one barrier to understanding of formative assessments in general is the overemphasis on summative assessment (Chanpet et al., 2018; Curry et al., 2016; Shirley & Irving, 2015; Spector et al., 2016; Sweeney et al., 2017). As a concentration on summative assessment is a global focus, to shift the emphasis onto formative assessment may inherently face skepticism. Further complicating the transition to a new initiative is finding the time to do so. The PD in this project study is designed to be presented across 3 full consecutive days. Finding time to do this in an already-cramped school calendar may prove to be challenging. The PD can be chunked into smaller sections and delivered in short bursts in PLCs. This option, however, presents its own barrier as PLC time at the Anytown Middle School is often used for meetings or other activities that must be scheduled during the school day.

To garner support for worthwhile initiatives such as helping teachers to consistently integrate digital tools to facilitate formative assessment and feedback, it is critical that stakeholders are aware of the tremendous potential benefits. As a Future Ready school district, the Anytown School District has already committed, both financially and in practice, to providing learning experiences for students that are research based and cognizant of the roles that technology can play in the field of education. Communicating to district administration, teachers, and other relevant stakeholders as to the value of building consistent digital formative assessment and feedback practices, along with drawing the connection to the foundational commitment the district has made in support, may be necessary to move this initiative forward.

**Proposal for Implementation Including Timetable**

The project deliverable was designed to be presented in a linear manner across 3 consecutive days. Ideally, teachers would participate in this PD opportunity using workshop days that are scheduled in the school calendar before students report to school. This timetable would allow for teachers to begin to become acclimated with the planning procedures and the TPACK skills necessary to plan for digital formative assessment and feedback. Additionally, implementation at the beginning of the school year will provide exposure to these concepts so that the work can continue throughout the school year during PLCs.

### Roles and Responsibilities of Researcher and Others

Project implementation will require actions by the researcher, district instructional coaches, and district administrators. As the researcher, my role was to create the PD. I also have a responsibility to work with administrators to communicate my findings and adapt the PD as necessary to account for contextual nuances so that the deliverable is adaptable to the needs of the entirety of the Anytown School District. As an instructional coach, I also have a responsibility to facilitate the PD sessions, then to work with the other district instructional coaches to adapt the content of the PD to building specific needs and to help prepare them to facilitate the training sessions. As building leaders and teacher evaluators, district administrators will have roles to direct teacher participation, collaboration, reflection, and follow through of the PD concepts. Participants' role will be to actively participate, learn with an open mind, collaborate with the team in a cooperative manner and contribute to the group conversations, group learning, and ultimately, to classroom execution.

## Project Evaluation Plan

While the project deliverable was created specifically for Anytown Middle School teachers, there are other relevant stakeholders. The deliverable is adaptable to all age groups and content areas, providing a resource that can be implemented across the school district. All administrators in the Anytown School District may find aspects of the deliverable to be applicable to the teachers under their purview. The support of district and building level administrators for the presentation and implementation of the concepts presented in the study deliverable is a linchpin to the success of the implementation.

The project deliverable was created to address deficiencies identified during data analysis. Teachers inconsistently demonstrated TCK and TPACK when integrating digital tools to facilitate formative assessment and feedback. These inconsistencies were identified through both the interview process and through the analysis of teacher lesson plans. In keeping with the theme of this project study, the evaluation plan for the project deliverable will be a formative assessment to be completed at the conclusion of each day of the 3-day PD. Teachers will be asked to reflect on their perceptions of the overall PD experience, the effectiveness of the PD to improve individual teacher TPACK, the effectiveness of the PD to improve understanding of the formative assessment process, and the utility of the adapted unit planning template. Teachers will be provided the opportunity to provide both a scaled response and an open response to each evaluative survey question, allowing for nuanced, constructive feedback. At the conclusion of the first day of the PD, the presenter will review the evidence collected via the formative assessments, then plan subsequent instruction based on that feedback. At the beginning of Day 2 of the PD, the presenter will address issues determined through the evaluation of the formative assessment evidence. This process will be repeated at the conclusion of Day 2 of the PD. At the conclusion of Day 3, the presenter will again evaluate the formative assessment feedback as a means of planning for subsequent integration of the concepts into PLC groups. By formatively evaluating PD participants, the presenter will model and apply key concepts of the PD. This formative evaluation process can also be used to gauge the efficacy of the project deliverable to address the deficiencies identified during data analysis and will provide feedback from the formative assessment that will inform subsequent PD opportunities.

## Project Implications

The project deliverable will potentially have social change implications on both the global and local level. This project was developed to provide a framework for teachers to actively plan for and articulate the learning process with an emphasis on digital formative assessment and feedback. The planning template operationalizes the TPACK conceptual framework in conjunction with a UBD backwards design approach. Used in tandem, teachers of all grade levels and all content areas can focus on best tech integration practices with attention to ensuring that teachers not only plan for formative assessment, but that they also plan to use feedback from the formative assessment to inform subsequent instruction. This wide-ranging application of tools and strategies can be used to foster positive social change by benefitting student learning and assisting other school districts whose teachers exhibit similar inconsistencies in digital tool integration to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. At the local level, the project PD can be directly applied to bridge teacher inconsistencies in demonstration of TCK and TPACK, in lesson planning to ingrate digital tools for formative assessment and feedback, and in the demonstration of Danielson Framework component 1f which outlines how teachers integrate digital tools to use feedback from formative assessment to inform subsequent instruction. Bridging these inconsistencies may lead to more effectively constructed digital formative assessments and feedback and ultimately, enhanced student learning.

Local stakeholders, specifically district administration, noted that there was evidence that despite teachers and students having ready access to digital formative assessment tools, these tools are not being used consistently for such tasks. In using the Danielson Framework for Teaching (2007) to evaluate teacher proficiency, two components were at issue: (a) Component 1f, Designing Student Assessments, which provides administrators with guidelines to evaluate how teachers approach the design of formative assessments as well as how teachers use the assessment results in subsequent instruction; and (b) Component 1d, Demonstrating Knowledge of Resources, which provides criteria for evaluating what a teacher knows about and how a teacher avails herself of resources that will extend content knowledge and pedagogy (Danielson, 2007). Using the lens provided by the TPACK-inspired planning template in the project deliverable, local stakeholders can glean valuable understanding of content group and individual teacher planning processes. District leaders can see how teachers avail themselves of available technologies when planning for the facilitation of formative assessment and feedback. This knowledge may provide district leaders with insights allowing for informed decisions regarding future PD to bolster teacher performance relative to the evaluative components in the Danielson Framework.

## Conclusion

The data from this qualitative case study indicated inconsistencies in teacher demonstration of TCK and TPACK, teacher demonstration of how to integrate digital tools to use feedback from formative assessment to inform subsequent instruction, and in lesson planning to use digital tools to facilitate formative assessment and feedback. The

PD plan outlined in Section 3 was designed to provide strategies that teachers could use to mitigate these inconsistencies and ultimately to improve teacher practice.

# Section 4: Reflections and Conclusions

The problem explored in this qualitative case study was inconsistent digital tool integration by Anytown Middle School teachers to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. Guided by Mishra and Koehler's TPACK conceptual framework in developing both the research questions and the mitigation strategies, I constructed a 3-day PD as a means of addressing the study problem. In Section 4, I discuss my project reflections and conclusions, including strengths and limitations of the project study; recommendations for alternative approaches; scholarship, project development, and leadership and change; reflections on the importance of the work; and implications, applications, and directions for future research.

## Project Strengths and Limitations

This study project has several strengths. This project was aligned with the study problem, focusing on bridging the inconsistencies that Anytown Middle School teachers demonstrated when using digital tools to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. Inconsistent use of digital tools for formative assessment and feedback has also been demonstrated in the research literature (e.g., Abrams et al., 2016; Hooley & Thorpe, 2017; Luckin et al., 2017; Zhan & So, 2017), lending additional credence to the project. The project's PD plan also reflects findings from the data analysis, focusing on bridging teacher inconsistencies in TCK and TPACK demonstration, integration of digital tools to use feedback to inform subsequent instruction, and in lesson planning to use digital tools for formative assessment and feedback. To address both local and global inconsistencies, the PD is contextually adaptable and can be flexibly implemented across content areas and grade levels. The implementation of the project follows best practices as identified in the literature review. Delivered as an active learning experience, the PD sessions employ content-focused and collaborative exercises with a multitude of opportunities for feedback and reflection (see Darling-Hammond et al., 2017; Kleickmann et al., 2016; Matherson & Windle, 2017). I also designed the PD so that it can be employed in sustained duration activities, such as content-based PLCs (see Cisterna et al., 2016; Mills & Harrison, 2020).

While the inconsistencies noted in the problem statement and from the data analysis have been addressed, there are project limitations. I purposefully selected participants to reflect teachers who either often or sometimes use digital tools for formative assessment and feedback. Given this selection of participants and the resulting data analysis, the project was constructed to account for inconsistencies in practice of those who reported using digital tools. However, one global problem identified in this study was that despite technological advancements and increased access to such tools in educational environments, teachers have not integrated technology on a level commensurate with recent investments (see Alenezi, 2017; Bhagat & Spector, 2017; Spector et al., 2016). This project does not account for teachers who may fall into this category. Baran et al. (2016) espoused that technology-focused PD may be necessary for teachers who are not already savvy to technology integration in the classroom.

The timing of the completion of this project may also present a limitation. While the data collected referred to teacher practices before the COVID-19 pandemic, I completed the project construction after teachers had spent several months adapting to online teaching. The problem addressed in this project, the data analysis, and the resulting project do not account for gains in TPACK skills that may have developed out of the necessity to adapt to the changing nature of teaching during the pandemic.

## Recommendations for Alternative Approaches

To address the study problem, I chose to select participants who reported using digital tools to facilitate formative assessment and feedback. Echoing Baran et al. (2016), an alternative approach to this study may be to instead gather data from participants who admittedly do not use technology often to facilitate formative assessment and feedback. Examining the perception of teachers who have demonstrated a reluctance to integrate technology into consistent practice would provide insight into the perceptions of a distinctly different group of educators. Adjacent to this alternative, providing a technocentric PD opportunity prior to the 3-day PD offering may be beneficial to teachers who wish to experiment with content-specific technology tools. While this study's participants all reported using digital tools for formative assessment and feedback, testimony from district administrators and district data indicate that there are many staff members who require more pointed technology practice to feel comfortable enough to integrate the tools into practice.

## Scholarship, Project Development and Evaluation, and Leadership and Change

As a career educator, I have always possessed an appreciation for scholarship, relying on literature to seek best practices and to build a knowledge base that could be used to assist fellow educators. Shifting from the role of a consumer of research to that of a qualitative researcher was both humbling and exhilarating. Finding, reading, culling, and synthesizing such a wide body of research required me to develop and hone organizational skills on an elevated level. Working with the sheer volume of information was daunting. Synthesizing this literature into genres and themes while remaining cognizant of project alignment was the most cerebrally challenging academic exercise of my life. Adding to this humbling experience was the arduous task of data analysis, requiring a potentially unlimited number of iterations to ensure adequate saturation. Qualitative research must be conducted such that the research synthesis is ongoing and recursive, requiring the researcher to operate in a nonlinear manner, continually working with an eye on maintaining alignment (Ravitch & Carl,2016).

While I have always considered myself a "scholar," this process has provided a new appreciation for what it means to conduct, then apply, scholarly research. As a classroom teacher, I commonly engaged in discussions with colleagues and administrators about district PD, emerging educational trends, or a fascinating piece of literature that I had just read. Application of these concepts, however, was generally dependent upon whether the educational concept appeared to support my own anecdotal experience. This research bias is something that I have become much more attuned to, fleshing out issues by tracking the research across time and critically examining research methods. I have also found that it is prudent to sometimes admit that simply not enough is known about a topic to make a grand pronouncement about its efficacy. It is okay to say, "I just don't have enough information about that, but let's dig a little deeper."

Being open to expanding my knowledge base has bled into my work as a practitioner. Having moved into the role of an instructional coach, I am fortunate to have the opportunity to work with teachers who are building their practice. As such, it is critical to work from a place of discovery and improvement. Using the research and development skills that I have gained through this process, I can model for teachers how to synthesize research in a way that can potentially lead to practical and applicable classroom solutions. The challenging and humbling nature of completing my first qualitative research project has also made me a better listener and a better colleague. Rather than lean on my experience and education, I have learned how the highly contextual nature of the classroom teacher presents unique challenges every single day. Like the research and development process, teaching is iterative and recursive. Teachers read, explore, discuss, tinker, succeed, fail, and then try again tomorrow. Completing this project study has provided me with unending empathy for the travails of the classroom teacher.

My current role as an instructional coach requires project development albeit on an infinitesimally smaller scale than this qualitative research project. As I have moved through this process, I have relied more and more heavily on consulting and, in some cases, deep diving into the literature in preparation for the task. This has also provided me with the opportunity to engage with building and district administrators on a scholarly level, advocating for research-informed PDs and practices. The credibility that I have earned with this project has provided me with the opportunity to work with teachers to integrate research-based practices and to sometimes have a seat at the table when administrators determine directions for initiatives and policy. Being looked upon as a scholarly practitioner by other educational stakeholders has been a gratifying part of working toward completing this project.

## Reflection on Importance of the Work

School districts around the globe have heavily invested in technologies for use in the classroom. Despite this investment, and even despite a global pandemic forcing educators to use technology while teaching remotely, teachers inconsistently integrate digital tools to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. Formative assessments are not well understood by teachers (Black & Wiliam, 1998a; Black, 2015). This struggle is hindered by a focus across the educational spectrum on high-stakes testing (Chanpet et al., 2018; Curry et al., 2016; Shirley & Irving, 2015) and summative assessments (Chanpet et al., 2018; Hooley & Thorpe, 2017; Spector et al., 2016; Sweeney et al., 2017). A shift in mindset and priorities, from classroom teachers and the educational community at large, will be necessary to help educators reexamine their roles in the teaching and learning process. While the results of this study largely echoed previous findings, the PD project takes into consideration the tremendous time limitations that teachers have both in their working day and in the PD opportunities offered to them. This project provides teachers with practices that address important concepts that teachers struggle with while giving them small-sized strategies that can be implemented quickly and effectively.

## Implications, Applications, and Directions for Future Research

This project study has the potential to positively impact social change at the individual, organizational, and the society level. Through the research process, I was able to identify specific inconsistencies of teacher practice relative to digital formative assessment and feedback, then provide a 3-day PD specifically tailored to help bridge those inconsistencies. Individual teachers can use the skills gleaned from the PD to build their TCK and TPACK, while more effectively planning to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. Teachers, their students, and the organization at large stand to benefit from the improved practices that may result. The inconsistencies revealed in this project study mirror the findings of existing research, indicating that the project deliverable could be transferrable to other school districts, schools, PLCs, or individual teachers to whom the noted inconsistencies are applicable.

This study also has methodological implications. While this qualitative case study relied on interviews and lesson plans as the data collection instruments, future researchers may consider using focus groups to elicit teacher perceptions of their experiences. Anytown Middle School teachers were forthcoming during data collection interviews. The socially oriented nature of a focus group, however, may have created an environment where more spontaneous discussion could ensue, revealing additional information that could speak to the study problem of inconsistent digital tool integration to facilitate formative assessment and feedback (see Onwuegbuzie et al., 2009; Ravitch & Carl, 2016).

Another methodological implication may concern the timing of this case study. All the data collected for the study referred to teacher experiences in the traditional classroom setting prior to the transition to remote learning necessitated by the COVID-19 pandemic. Emerging research at the time of this study pointed to a continuation of the inconsistencies relative to facilitation of digital formative assessment and feedback (see Ferretti et al., 2021; Perifanou et al., 2021; Zulkifli et al., 2021). As teachers continue to be challenged to use technologies in remote teaching environments due to pandemic-related teaching conditions, the evolution of these practices may yield differing conclusions.

Future practices and research may consider the role that TK has in building TCK and TPACK in PD. I used purposeful sampling in this project study to choose participants who reported using digital tools in their classrooms to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. Data from technologically reluctant participants were not included in the study. Considerations from participants who are less eager and willing to use technology may certainly yield differing conclusions. Researchers have agreed that PD that aims to build teacher TPACK by employing technocentric strategies have been insufficient (Baran et al., 2016; Harris, 2016; Hofer & Harris, 2017; Shepherd et al., 2016). In contrast, emerging research indicated that TK positively influences TCK and, consequently, directly influences TPACK (Rolando et al., 2021). Exploration of PD opportunities that combine a technological focus within content areas to build TK as a precursor to working toward overall TPACK is worthy of future research. Focusing on those technological tools that can be used to facilitate formative assessment and feedback within the PD opportunities is recommended to continue to shift educators' current focus on summative assessments.

## Conclusion

Inconsistent digital tool integration to facilitate formative assessment and use the resulting feedback to inform subsequent instruction is evident at both the local and global level (Bhagat & Spector, 2017; Mohamadi, 2018; Spector et al., 2016; Zhan & So, 2017). In their TPACK conceptual framework, Mishra and Koehler (2006) underscored that successful classroom technology integration is reliant upon the teacher's ability to navigate all of the TPACK knowledge components, both independently and simultaneously. When applied to digital tool integration for formative assessment and feedback, this has proven to be a challenge for Anytown Middle School teachers and for the educational community at large.

There is significant research that supports that digital formative assessment and feedback can be beneficial when applied in the classroom (Barana & Marchisio, 2016; Bhagat & Spector, 2017; Dobbins & Denton, 2017; Egelandsdal & Krumsvik, 2017; Fuller & Dawson, 2017; Irving et al.,2016; Spector et al., 2016; Varier et al.,2017; Yilmaz, 2017). Aided by technology, teachers have the capability to collect data, monitor student progress, provide feedback in a timely manner, and adjust during the learning process (Barana & Marchisio, 2016; Bhagat & Spector, 2017; Faber et al., 2017; Irving et al., 2016; Spector et al., 2016; Varier et al., 2017). Access to such technologies has greatly increased in the educational landscape; yet, teachers' application of the tools has not increased commensurate with the technological saturation (Alenezi ,2017; Bhagat &

Spector, 2017; Luckin et al., 2017; Spector et al., 2016). At the Anytown Middle School, teachers did not consistently plan to integrate digital tools to facilitate formative assessment and feedback. In this project study, I present a unit planning template that can be employed by teachers to plan for digital formative assessment and feedback while simultaneously considering TPACK components necessary to effectively integrate technology and drive student learning. I designed the 3-day PD project to model a process that teachers can use to more consistently integrate digital tools to facilitate formative assessment and use the resulting feedback to inform subsequent instruction.

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Appendix A: The Project

## Professional Development: Training Curriculum and Materials

**Title:** Improving Consistency of Digital Tool Integration for Formative Assessment and Feedback

**Project Description:** The project that resulted from the study is a 3-day professional development opportunity. While designed specifically to meet the needs of the Anytown Middle School teachers, the professional development is adaptable to K-12 teachers in any content area. To mitigate each of the inconsistencies identified in the data analysis, I created a new unit planning template that serves as the foundation for all the professional development activities. Adapted from the UBD template used by the Anytown School District, the unit plan template follows the basic tenets of formative assessment while simultaneously using UBD backwards design for unit planning. By learning to operationalize the new unit planning template, teachers will explicitly consider integrated TCK and TPACK components as they plan instructional units. The unit plan template also prompts teachers to plan for how evidence gathered from digital formative assessments will be used to feed forward into subsequent instruction.

**Materials Included:** A slide show with accompanying trainer's notes, learning objectives for the 3-day professional development, daily agendas, daily evaluation forms, and an original unit planning template have been included for reference.

**Purpose:** The purpose of this 3-day professional development is to address the inconsistencies in practice as identified in the project study data analysis. Anytown Middle School teachers inconsistently used lesson planning to facilitate formative assessment and to use feedback from formative assessment to inform subsequent instruction. Study data revealed that teachers inconsistently demonstrated TCK and TPACK when integrating digital tools to facilitate formative assessment and feedback. Teachers also inconsistently integrated digital tools to use feedback from formative assessment to inform subsequent instruction.

**Participants:** While the professional development materials created were specifically designed to meet the needs of teachers at the Anytown Middle School, the content is adaptable to teachers across grade levels and content areas.

**Learning Outcomes and 3-day PD Objectives:**

1. Introduce the TPACK Framework
2. Improve teacher TCK by helping teachers construct teaching solutions that are suited to work with subject matter when conducting digital formative assessments and feedback

3. Develop teacher TPACK by helping teachers construct teaching solutions that account for technology, pedagogy, and content knowledge when conducting digital formative assessments and feedback
4. Build teachers' foundational knowledge of formative assessments, specifically the concept of using feedback from formative assessments to inform subsequent instruction
5. Introduce planning aids that can be used to facilitate TPACK development
6. Introduce planning aids that can be used to facilitate digital formative assessment and feedback to inform subsequent instruction
7. Provide opportunities for teachers to integrate and contextualize planning aids for demonstration of TPACK
8. Present opportunities for teachers to integrate and contextualize planning aids for the facilitation of digital formative assessment and feedback
9. Present opportunities for teachers to integrate and contextualize planning aids for the use of feedback from formative assessment to inform subsequent instruction.

**Day 1 Agenda:** Using the TPACK framework to Supercharge Your Formative Assessments

| | |
|---|---|
| 8:00-8:45 | Today's Objectives<br><br>Stage 1 Planning - Where are we going? |
| 8:45-9:30 | Introduction to the TPACK Framework |
| 9:30-9:45 | Break |
| 9:45-10:15 | Our TPACK Challenges |
| 10:15-11:00 | Learning Activity Types (LATs) to Mitigate Challenges |
| 11:00-11:30 | LAT Exploration |
| 11:30-12:30 | Lunch |
| 12:30-1:30 | Stage 2 Planning - Where are we now?<br>Applying LATs to Practice |
| 1:30-1:45 | Break |
| 1:45-2:45 | Stage 2 Planning - Where are we now?<br>Adding Technologies |
| 2:45-3:00 | Daily Evaluation |

## Day 1 Evaluation

# Day 1 Evaluation

1. Grade level that you teach

*Mark only one oval.*

- ( ) Elementary
- ( ) Middle
- ( ) High

2. Content that you teach (middle and high only)

*Check all that apply.*

- [ ] Math
- [ ] Science
- [ ] Social Studies
- [ ] English
- [ ] Unified Arts

Other: [ ] ______________________

3. Following today's PD, indicate your understanding of TPACK

*Mark only one oval.*

| | 0 | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|---|
| No understanding | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) | Robust understanding |

4. Biggest takeaway and/or challenge regarding TPACK

______________________

______________________

______________________

______________________

______________________

5. Following today's PD, indicate your understanding of TCK

*Mark only one oval.*

| | 0 | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|---|
| No understanding | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) | Robust understanding |

**Day 2 Agenda:** Formative Assessment and Tech: Using TPACK to Design Digital Formative Assessments

| | |
|---|---|
| 8:00-8:30 | Today's Objectives<br><br>Address Formative Feedback from Day 1 |
| 8:30-9:00 | Introduction to Formative Assessment and Feedback |
| 9:00-9:45 | Stage 2 Planning - Where are we now?<br>Are our Formatives Formative? |
| 9:45-10:00 | Break |
| 10:00-11:30 | Stage 2 Planning - Where are we now?<br>Are our Formatives Formative?<br><br>Groups Report, Evaluate Formatives |
| 11:30-12:30 | Lunch |
| 12:30-1:30 | Technology and Formative Assessments - Inconsistencies, Challenges, Benefits, Effective Strategies<br><br>Stage 3 Planning - How do we get there?<br>Analysis of Evidence From Formative Assessments |
| 1:30-1:45 | Break |
| 1:45-2:45 | Stage 3 Planning - How do we get there?<br>Planning for Subsequent Instruction |
| 2:45-3:00 | Daily Evaluation |

## Day 2 Evaluation

# Day 2 Evaluation

1. Grade level that you teach

*Mark only one oval.*

- ( ) Elementary
- ( ) Middle
- ( ) High

2. Content that you teach (middle and high only)

*Check all that apply.*

- [ ] Math
- [ ] Science
- [ ] Social Studies
- [ ] English
- [ ] Unified Arts
- Other: [ ] ____________________

3. Check all that apply. As a result of the PD, my foundational knowledge regarding formative assessment and feedback:

*Check all that apply.*

- [ ] Is unchanged
- [ ] I have built on my foundational knowledge of formative assessments
- [ ] I have a more complete understanding of the role that feedback plays in formative assessments
- [ ] I am better prepared to plan for formative assessment and feedback
- [ ] Following formative assessment, I am better prepared to plan for subsequent instruction
- Other: [ ] ____________________

4. Check all that apply. The Stage 2 template was helpful to:

*Check all that apply.*

- [ ] Use TPACK when planning formative assessments
- [ ] Build my TCK when planning formative assessments

5. The Stage 3 template was helpful to:

*Check all that apply.*

- [ ] Helped me evaluate whether my activity was formative
- [ ] Helped me to plan to provide feedback to students
- [ ] Helped me to consider subsequent instructional options
- [ ] Helped me to consider technology options to use when analyzing formative assessment evidence
- [ ] Helped me to consider technology options to use when planning for subsequent instruction
- Other: [ ] ____________________

6. I still need help with:

____________________

**Day 3 Agenda:** Integrating UBD and TPACK for More Effective Formative Assessments

| | |
|---|---|
| 8:00-8:30 | Today's Objectives<br><br>Address Formative Feedback from Day 2 |
| 8:30-9:30 | Stage 1 - Where are we going?<br>Reminders and Suggestions for Unit Planning |
| 9:30-9:45 | Break |
| 9:45-11:30 | Stage 2 - Where are we now?<br>Reminders and Suggestions for Unit Planning |
| 11:30-12:30 | Lunch |
| 12:30-1:30 | Stage 3 - How do we get there?<br>Reminders and Suggestions for Unit Planning |
| 1:30-1:45 | Break |
| 1:45-2:45 | Presentation of Unit Plans |
| 2:45-3:00 | Final evaluation |

# Day 3 Evaluation

## Day 3 Evaluation

1. Grade level that you teach

*Mark only one oval.*

- ( ) Elementary
- ( ) Middle
- ( ) High

2. Content that you teach (middle and high only)

*Check all that apply.*

- [ ] Math
- [ ] Science
- [ ] Social Studies
- [ ] English
- [ ] Unified Arts
- Other: [ ] ____________________

3. Usefulness of Stage 1 planning template


*Mark only one oval.*

| | 0 | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|---|
| Not useful at all | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) | Incredibly useful |

4. Feedback about using the Stage 1 planning template for your future planning needs

____________________

____________________

____________________

____________________

____________________

**UBD Template for Professional Development**

| Stage 1 - Where are we going? | |
|---|---|
| Unit title: | |
| Standards/Competencies | Essential Questions/Understandings |
| | |
| Common Summative Assessments<br>Name of/Link to Assessment | |
| | |

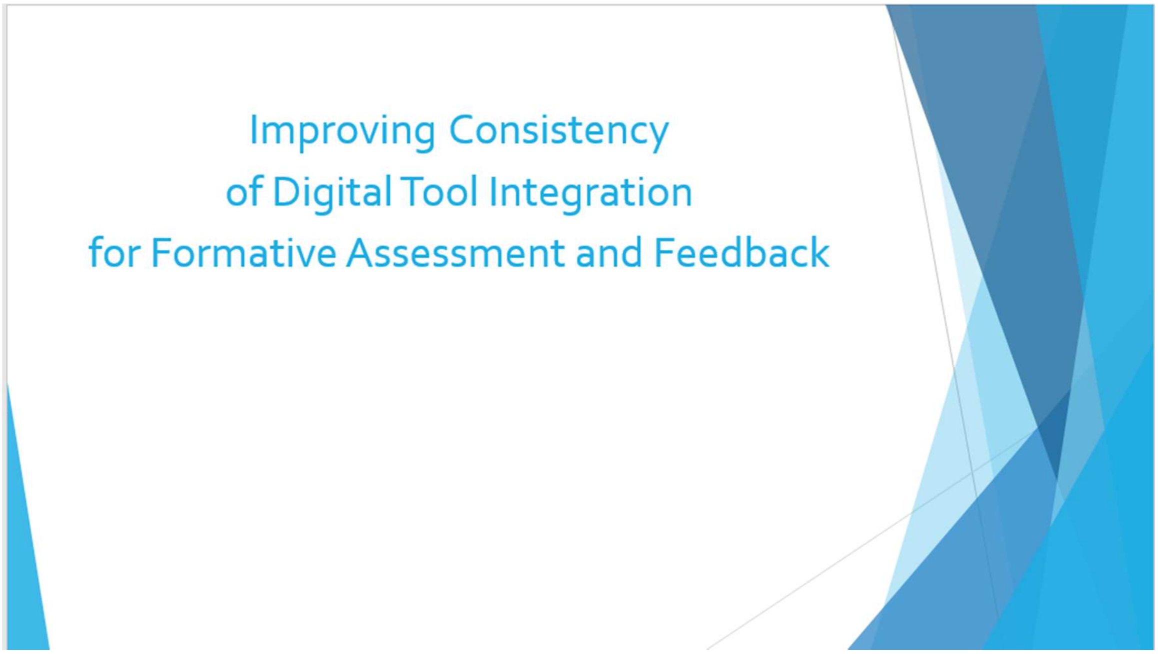
| Stage 2 - Where are we now? | | | |
|---|---|---|---|
| Formative Assessments<br>Name of/Link to activity | Description<br>Briefly describe the formative assessment | Content<br>Standard/Competency/<br>Essential Questions/Understandings | Technology Options<br>What tool(s) will be used to facilitate the formative assessment? |
| | | | |
| | | | |

| Stage 3 - How do we get there? | | | |
|---|---|---|---|
| Analysis of Evidence from Formative Assessments<br>For each formative assessment listed in Stage 2, briefly outline how you will use evidence from formative assessments to determine where students are in terms of meeting standard/competencies, understanding essential questions/understandings. | Technology to Aid Analysis of Evidence | Subsequent Instruction<br>For each respective formative assessment, identify common learning gaps and the potential instructional activities that can be used to address them. | Technology to Aid Subsequent Instruction |
| | | | |
| | | | |

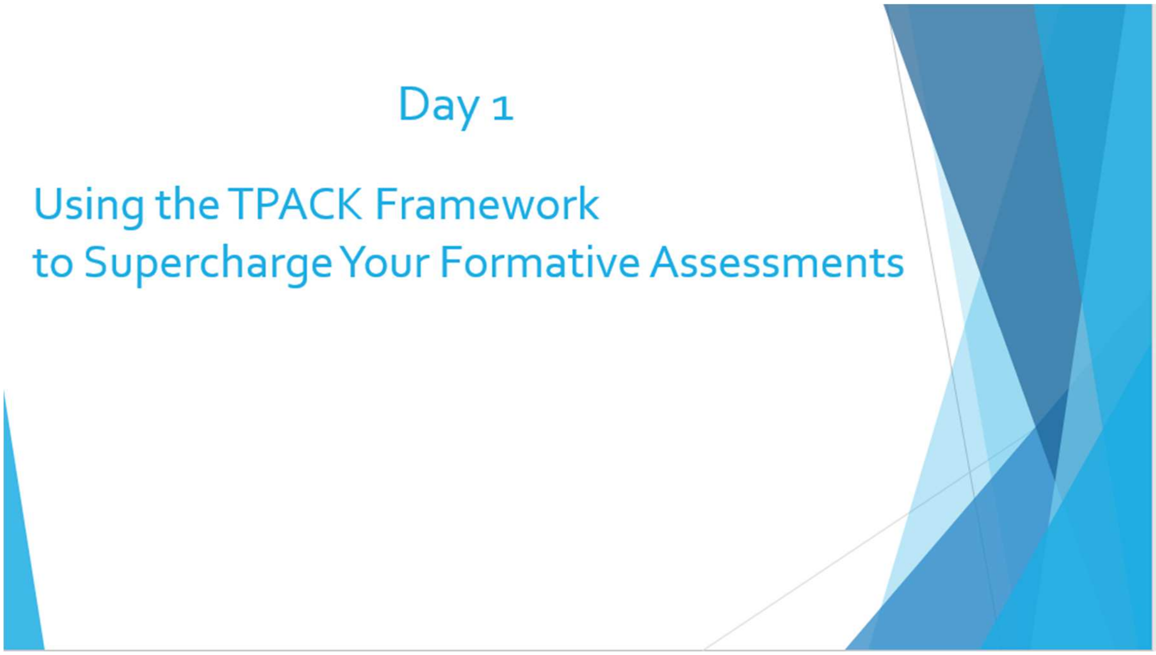
Adapted from McTighe, J., & Wiggins, G. (2004). *Understanding by design: Professional development workbook.* The Association for Supervision and Curriculum Development.

**Presentation Materials and Speaker Notes**

Slide 1



Slide 2


Day 1
Using the TPACK Framework
to Supercharge Your Formative Assessments

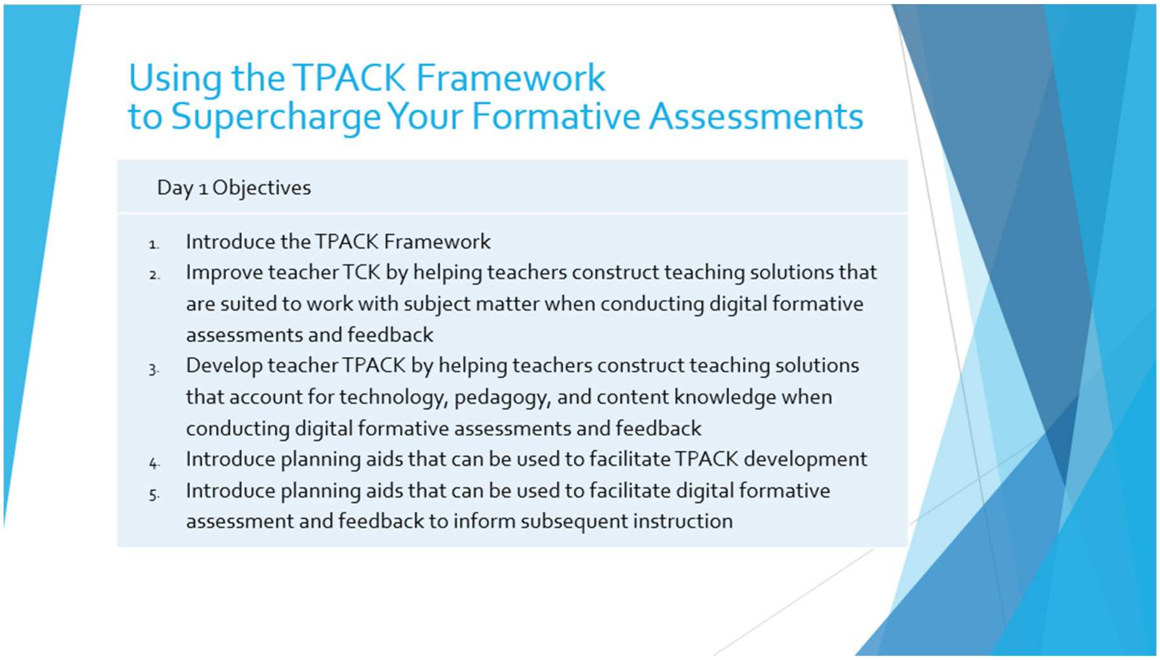
Slide 3

## Agenda

| | |
|---|---|
| 8:00-8:45 | Objectives for the day<br><br>Stage 1 Planning - Where are we going? |
| 8:45-9:30 | Introduction to the TPACK Framework |
| 9:30-9:45 | Break |
| 9:45-10:15 | Our TPACK Challenges |
| 10:15-11:00 | Learning Activity Types (LATs) to Mitigate Challenges |
| 11:00-11:30 | LAT Exploration |
| 11:30-12:30 | Lunch |
| 12:30-1:30 | Stage 2 Planning - Where are we now?<br>Applying LATs to Practice |
| 1:30-1:45 | Break |
| 1:45-2:45 | Stage 2 Planning - Where are we now?<br>Adding Technologies |
| 2:45-3:00 | Daily Evaluation |

Slide 4

Slide 5




Welcome to “Improving TPACK to Supercharge Technology Integration: A Focus on Formative Assessments. Formative assessment are a critical component of a teachers’ teaching and learning process. Technology is another imperative in today’s educational environment. During the next 3 days of professional development, we will work toward providing a process to build your knowledge base surrounding these components and will also provide you with a template to guide your planning processes.

Day 1 of this 3-day professional development will center around the TPACK conceptual framework and applying it to digital formative assessments. We are essentially mashing up these two concepts! The TPACK conceptual framework was developed by Mishra and Koehler in 2006 to serve as a framework for teacher knowledge when integrating technology. Both today, and throughout the 3-day PD, the focus will be on building your foundational knowledge of both TPACK and formative assessment, as well as to provide you with planning aids that can be used in the future by your content groups and by individual teachers. Beginning today, we will be simultaneously learning and applying our learning to our current planning processes.

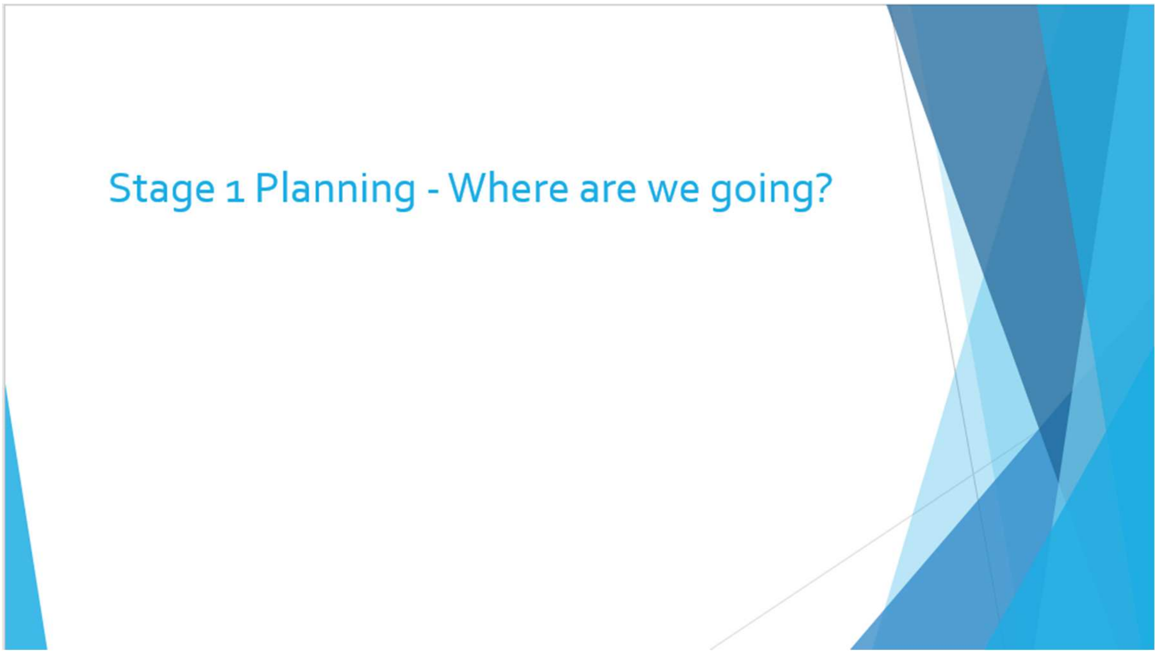
Slide 6


Teaching is highly contextualized. To that end, you will be working with your content and/or grade level teams during this 3-day professional development. As you are learning about TPACK, formative assessments, and planning to implement these concepts, it will be helpful to explore and plan with those educators whose context is like yours.

Slide 7


As we move through the PD, we will be planning instruction, and doing so in stages. Following the UBD concept of backwards design, we will begin with stage 1 to determine "Where are we going?" We are beginning with the end in mind. What are the competencies, standards, essential questions, and understandings that we want our students to learn? We must know what we want them to learn in order to plan for what's next. Stage 2 then, is answering, "Where are we now?" Once we establish the learning we are trying to accomplish, we have to formatively assess our students to see what learning that they have. And finally, our third stage is to plan for "How do we get there?" Another way to look at this is, "How do we close the learning gap?" We will plan our way through all three stages, paying attention to our content, our pedagogy, and with an eye on technologies that can be used to help us facilitate the learning. (Cisterna & Gotwals, 2018; Cisterna et al., 2016; Mills & Harrison, 2020)

Slide 8



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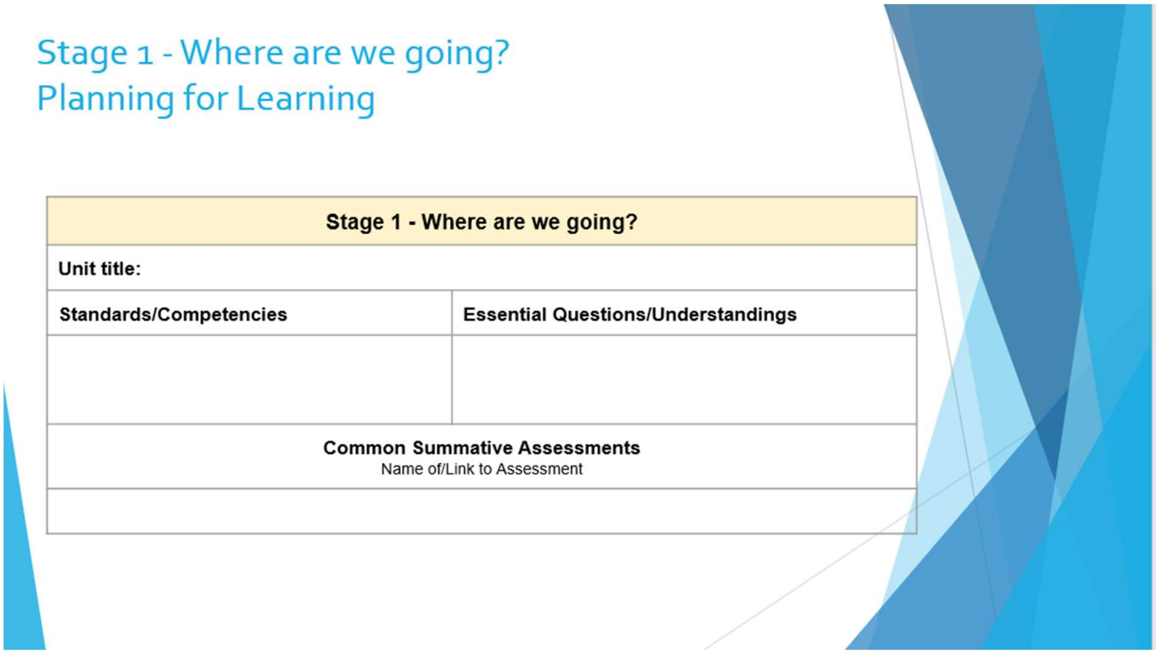


Across our 3 days, we will be planning our unit in those three stages. Here’s a peak at stage 1. Where do we begin? We begin with the end in mind. Where are we going? What learning do we want our students to glean? What standards or competencies do we wish for our students to master?

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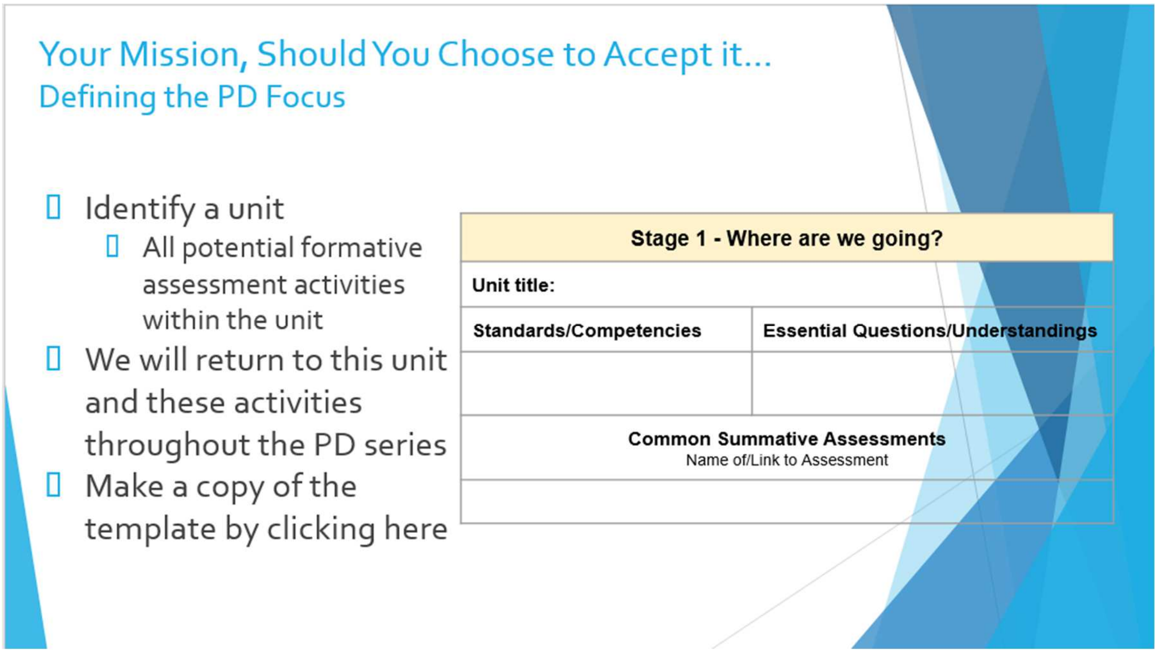


Beginning with our first umbrella, where are we going, our first “mission” will be to identify a unit to focus on for this 3-day PD. This is our Stage 1 activity. We are charting, “Where are we going?”

We want to be able to take what we’ve learned over these 3 days and immediately apply it to practice, so in your content/team groups, I’m asking you to identify one unit to center all your learning and planning around. Identify the standards/competencies/essential questions/understandings that are the learning goals for this unit. Then list the formative assessment activities that you provide for student learning of the content.

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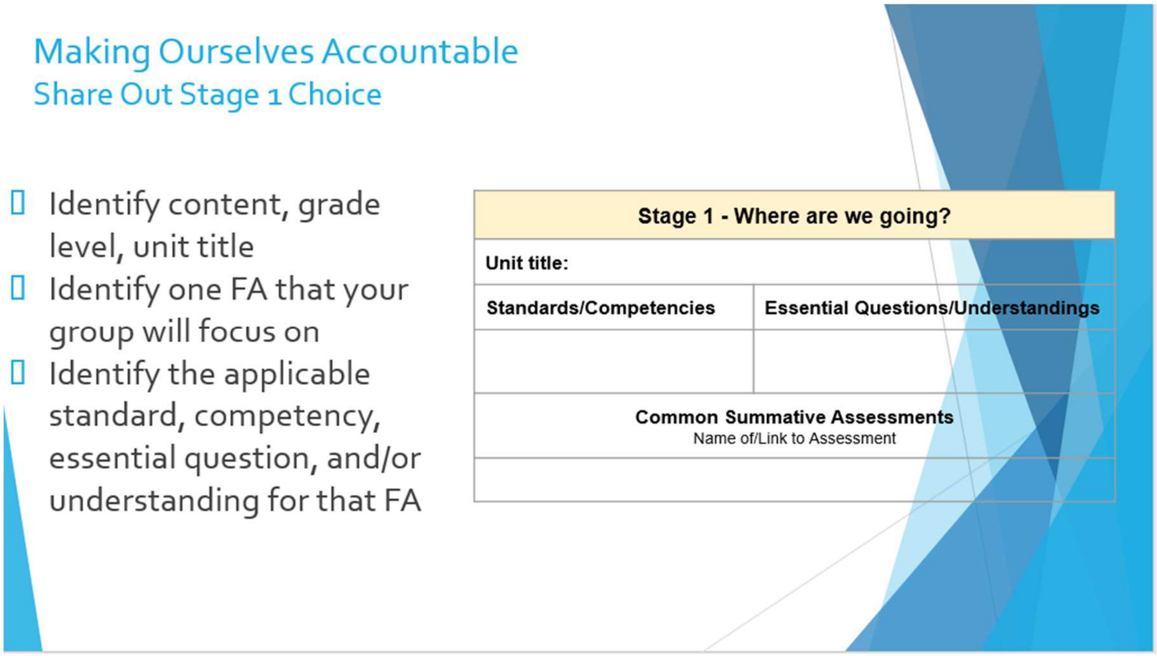


Sometimes speaking something aloud equates to speaking it into existence, so as a measure of accountability, I'm asking you to share what your content group/team has chosen to focus on for Stage 1. In this way, we are vocalizing our choice, but also providing ideas to other content groups/teams regarding topics, process, and potential cross-curricular or collaborative opportunities in the future.

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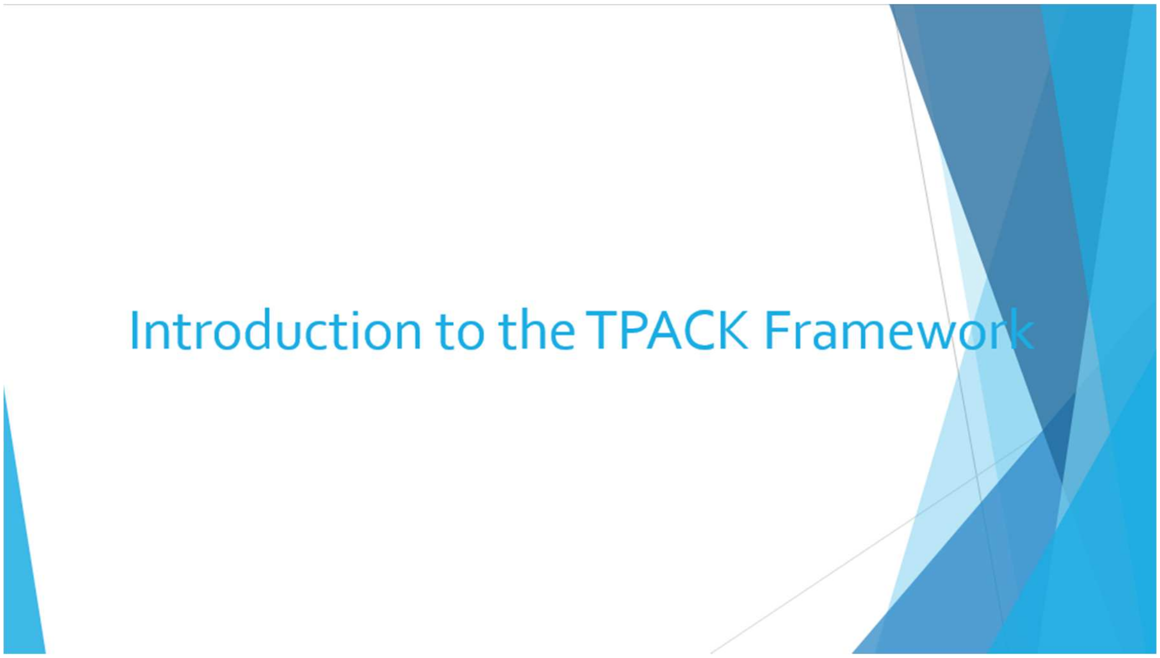

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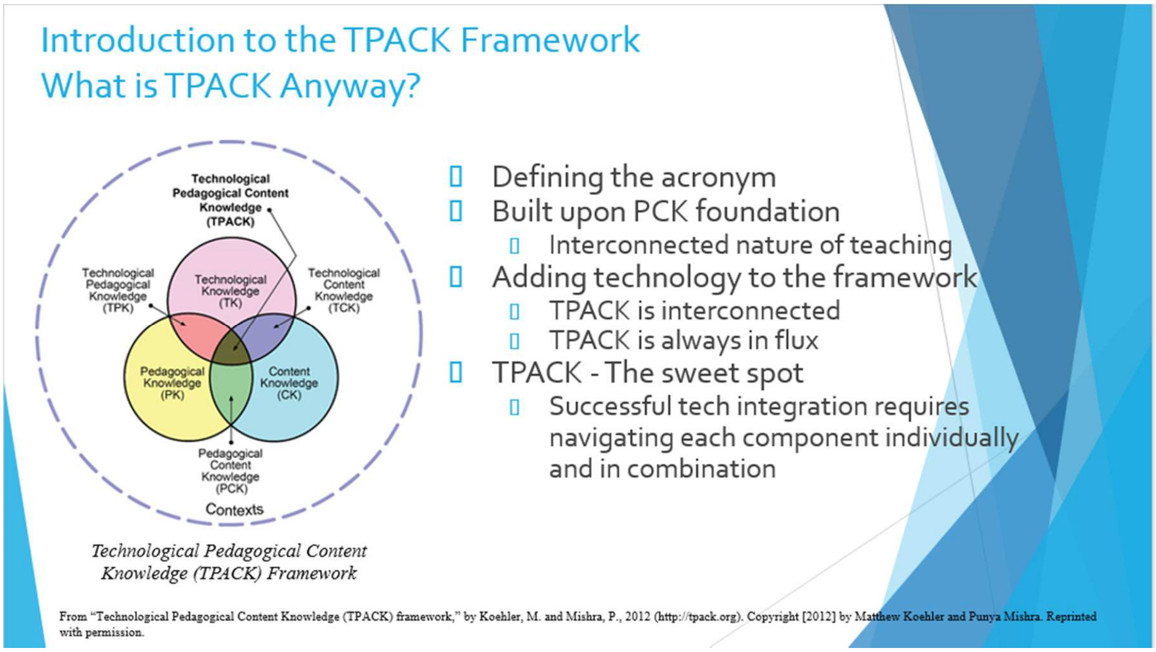


TPACK is a conceptual framework developed in 2006 by Mishra and Koehler. This framework underscores the interconnectedness of its integrated knowledge components: technological knowledge (TK), pedagogical knowledge (PK), content knowledge (CK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPCK).

Mishra and Koehler (2006) stressed that successful technology integration in the classroom is reliant upon the teacher's ability to navigate the complexities of all TPACK knowledge components, both independently and simultaneously. As we will also focus on digital formative assessments, by extension, the successful implementation of digital tools to facilitate formative assessment can be clarified by examining the connections outlined by the TPACK framework (Sweeney et al., 2017).

The TPACK framework was built upon the PCK foundation first established by Shulman's Pedagogical Content Knowledge (PCK) (Mishra & Koehler, 2006). Shulman (1986) argued that focusing on teacher pedagogy or content knowledge as independent constructs was an insufficient strategy for understanding teacher knowledge. Focusing instead on the intersection of pedagogy and content knowledge provides a more complete characterization of the complexities of teaching. In this way, Shulman's (1986) PCK attempted to frame teacher knowledge by inextricably linking the core components of teaching and learning: pedagogy and content knowledge. For effective teaching, you need to be able to weave together both pedagogy and content knowledge.

Just as Shulman rejected the notion that pedagogy and content knowledge were constructs to be applied independently, Mishra and Koehler (2006) noted that in the field of education, technology integration is generally erroneously considered as independent from the teaching and learning process. Extending the work of Shulman, Mishra and Koehler (2006) recognized the necessity to assess the teacher knowledge that is required to integrate technology into teaching while situating this knowledge among the pedagogical and content knowledge components of teaching and learning. Consequently, the Technological Pedagogical Content Knowledge (TPACK) framework for educational technology was derived by Mishra and Koehler (2006) to “capture some of the essential qualities of teacher knowledge required for technology integration in teaching, while addressing the complex, multifaceted, and situated nature of this knowledge” (p. 1017).

Note the sweet spot in the graphic: where all of the knowledge components overlap/are intertwined, illustrating that technological, pedagogical, content knowledge is that intersection of all of the knowledge components.

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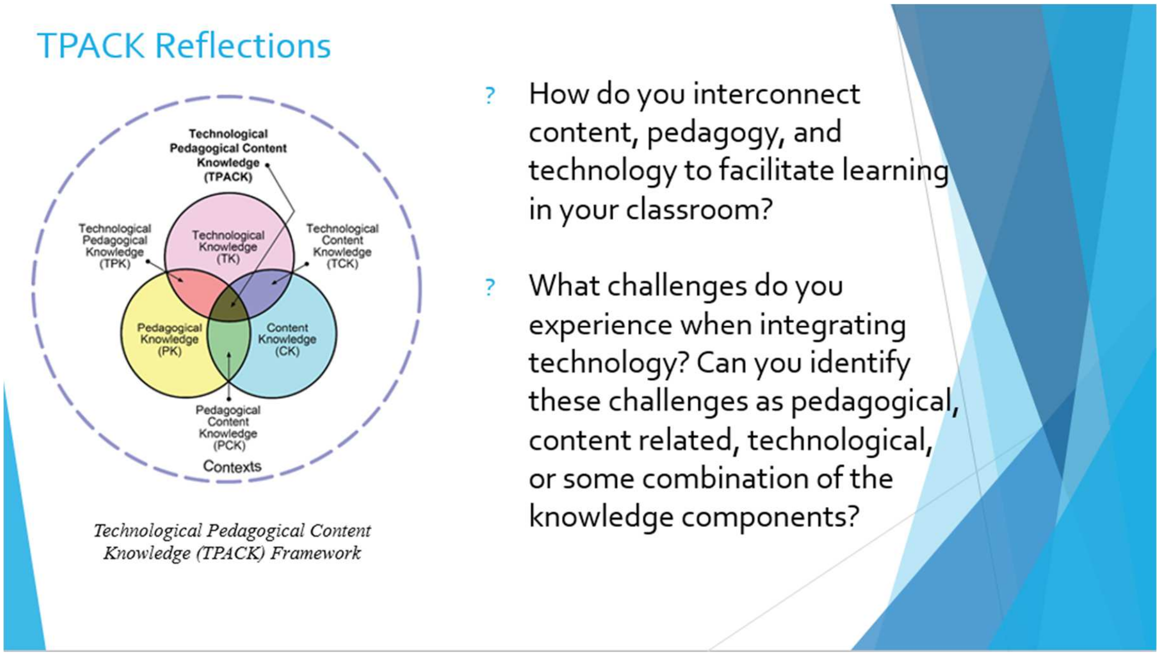


At your table: Take a look at these questions. What are your perceptions of TPACK and how you demonstrate this knowledge in the classroom? Take a few minutes at your table to reflect how or if you consciously interconnect content, pedagogy, and technology when you teach. Also, discuss your current challenges when integrating technology while teaching. What are your challenges, and can you identify one area that challenges you the most?

Group reflections: Groups report out.

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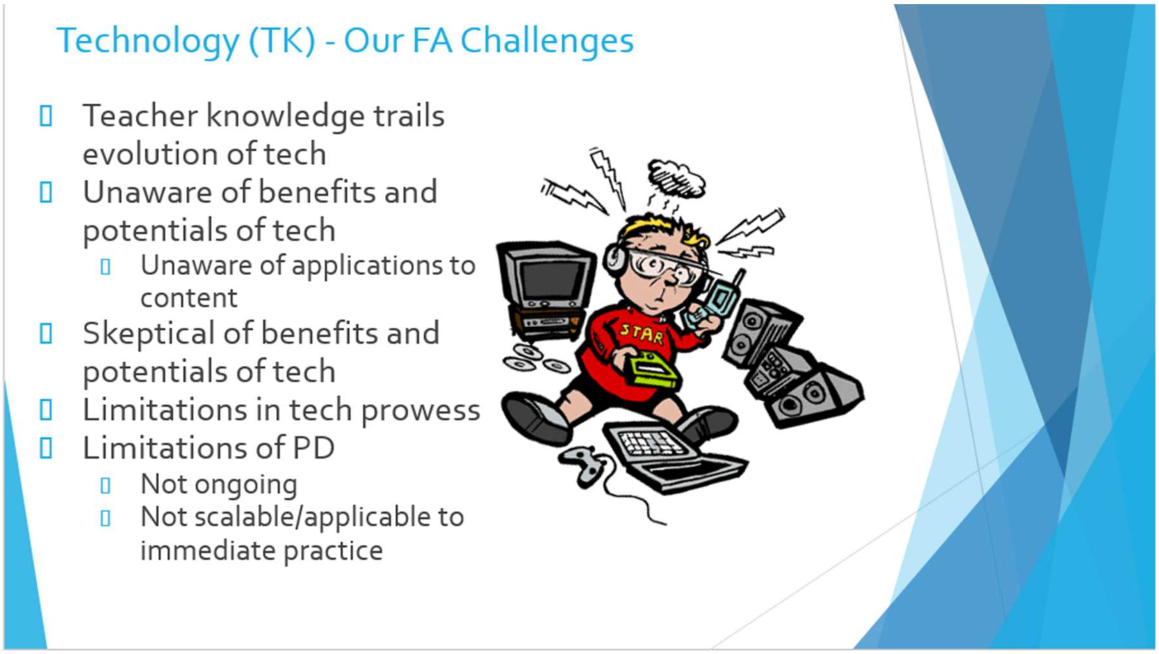


Our challenges generally are not unique! There is a body of research that has explored some of the specific challenges that teachers have with regard to their TPACK knowledge. As we explore those, see if any of these resonate with you and consider what strategies might help you to tackle them. We will attempt to mitigate some of these challenges through the course of these 3 days.

Teacher understanding of the myriad of ways that digitals tools can be used to collect and analyze data has failed to evolve as quickly as technology has (Bugaj & Poss, 2016; De Witte et al., 2015). Sweeney et al. (2017) found that teachers simply did not understand the nuances of technology and how the tools could be applied to positively affect teaching and learning. Lost in the nuance were the benefits and the full potential possible when using technology to facilitate formative assessments and use the resulting feedback to inform subsequent instruction (Sweeney et al., 2017). Even as technology quickly moved into the educational arena, researchers found that teachers continued to be resistant to integrating technology (Barana & Marchisio, 2016; Elmahdi et al., 2018). Reasons for this reluctance included perceived limitations in the ability to use the technology, skepticism as to the efficacy of the technology, and inadequate professional development (Soto & Ambrose, 2016).

As technologies to facilitate formative assessment continued to emerge and become more powerful, the need for adapting professional development for educators to accommodate the changes may be necessary (Spector et al., 2016). Barana and Marchisio (2016) noted that most teachers were the recipients of “traditional” education and therefore lacked not only the confidence but the suitable training to integrate technology effectively. Shifting the paradigm from analog to digital formative assessments may require practice and training in the form of professional development (Bugaj & Poss, 2016; Zhan & So, 2017). Romero-Martín et al. (2017) reflected that this change in teaching and learning, like other changes before it, required a significant commitment to “proper training and professional development” (p. 65). The researchers echoed Spector et al. (2016) in calling for ongoing professional development opportunities to operationalize these emerging technologies to “scale up and achieve sustained success” (Romero-Martín et al., 2017, p. 65). Professional development was identified as a research recommended strategy to help overcome the challenges faced by teachers to use digital tools to facilitate formative assessment and use the resulting feedback to inform instruction.

Successful integration of technology in practice requires teachers to understand the complexities of technology, content, and pedagogy, both in isolation and in relationship to one another (Mishra & Koehler, 2006). TPACK knowledge results from teachers’ understanding of content, pedagogy, and technology - independently and simultaneously, within their own learning contexts.

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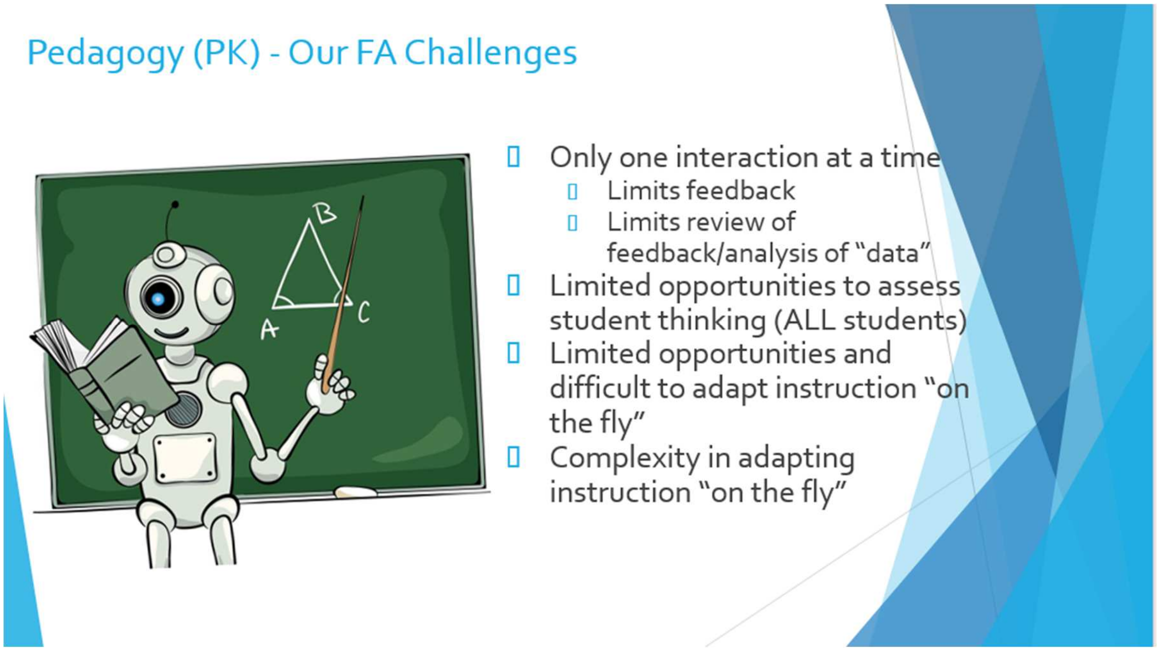


Chanpet et al. (2018) suggested that there are characteristics inherent in traditional face-to-face classrooms that contribute to problematic pedagogy. Teachers can participate in only one interaction at a time, thereby limiting the teacher or student feedback. This feedback also cannot be reviewed later by either teacher or student for subsequent action (Chanpet et al., 2018). Face-to-face classrooms are also ripe with inefficiencies given the need to communicate similar messages in different contexts with multiple combinations of individuals and groups of students. Teacher lecture is a common strategy meant to create efficiency by maximizing content coverage; however, this strategy provides minimal opportunity for teachers to formatively assess student thinking or for students to formatively adapt their understanding and learning behaviors (Alt, 2018; Irving, 2015). This same strategy, however, creates a logistical challenge to collecting, aggregating, and analyzing data during real-time instruction. Performing data analysis while instruction is ongoing and providing subsequent feedback is both challenging and demanding to classroom teachers (Abrams et al., 2016; Irving, 2015; Yilmaz, 2017). The complexity of facilitating formative assessment and using the resulting feedback requires a repertoire of instructional tools and strategies to meet the learning needs of students.

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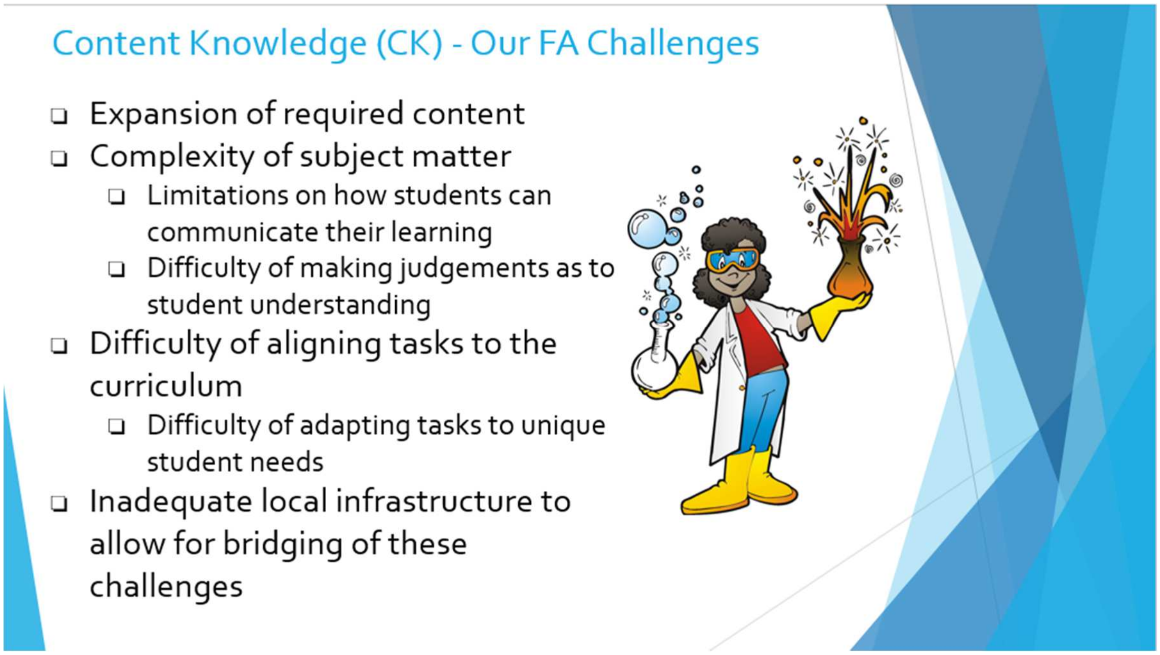


Much of the difficulty of planning such activities lies in the difficulty of aligning assessment tasks to the curriculum (Zhan & So, 2017). Learning tasks are designed and implemented differently given classroom context and disciplinary area. Learning activities such as science laboratory experiments or sentence structure analysis are specific to the content area (Harris & Hofer, 2011). Abrams et al. (2016) reported teacher inadequacy of locally developed formative assessments. Teachers developed formative assessments that yielded student learning data insufficient to determine subsequent instructional strategies and to address common learning misconceptions (Abrams et al.). Teachers mentioned other difficulties specific to aligning formative assessment to curriculum, namely the expansion of content in state curriculum requiring a higher level of student cognitive demand, coupled with an inadequate local infrastructure to support the synthesis of formative assessment data (Abrams et al., 2016).

The complexity of the subject matter also presents a unique challenge to teachers. Subject matter that includes complex problem solving or project-based learning (PBL) may present limitations by how students are relegated to communicate. Mathematical explanations, articulation of laboratory reports, or learning gleaned from projects or other large-scale activities require students to articulate their thoughts or actions in nontraditional ways (Soto & Ambrose, 2016). Relying on the written work of students to communicate the intricacies of their learning in these types of formative assessments can lead to inaccurate judgments from teachers as to the level of student understanding.

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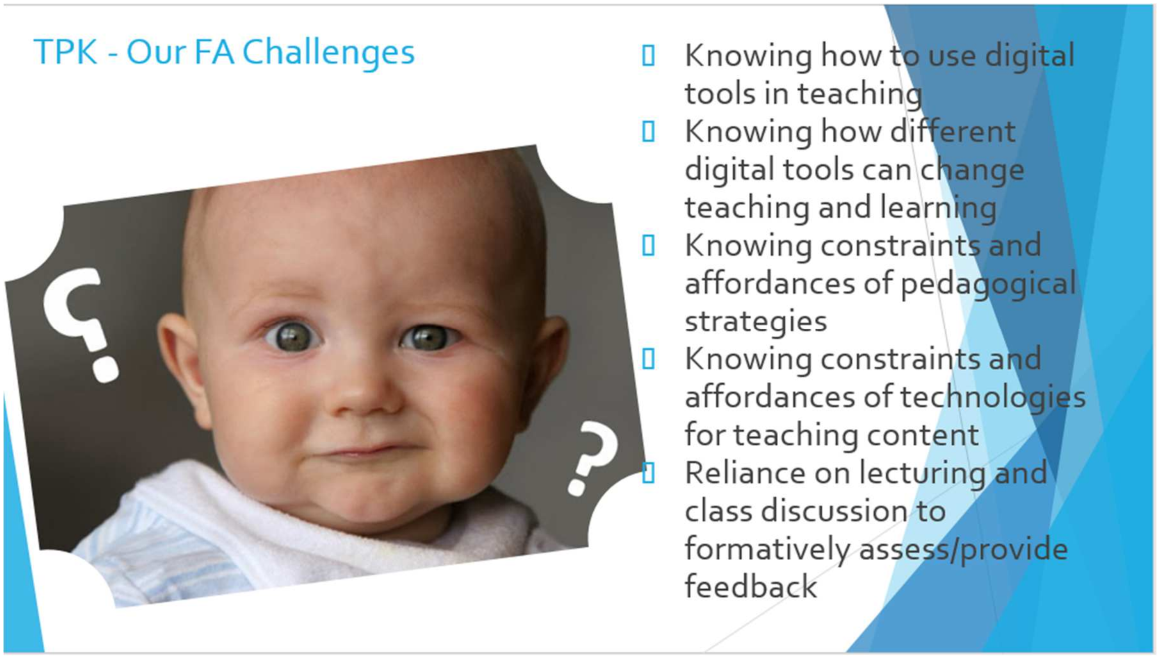


Teachers were challenged to know how to use particular digital tools in teaching. TPK required that teachers understood how the application of different technologies could change teaching and learning (Harris & Hofer, 2011; Koehler & Mishra, 2009). This knowledge component required that teachers build a more complete understanding of both the pedagogical and technological constraints and affordances of their discipline (Koehler & Mishra, 2009). Studies of K-12 teachers' application of digital tools in practice demonstrated a lack of pedagogical sophistication (Harris et al., 2009). Teachers typically relied on lecturing and class discussion to stimulate learning as well as to formatively assess and provide feedback rather than use digital tools to facilitate such interactions (Egelandsdal & Krumsvik, 2017; Elmahdi et al., 2018; Romero-Martín et al., 2017).

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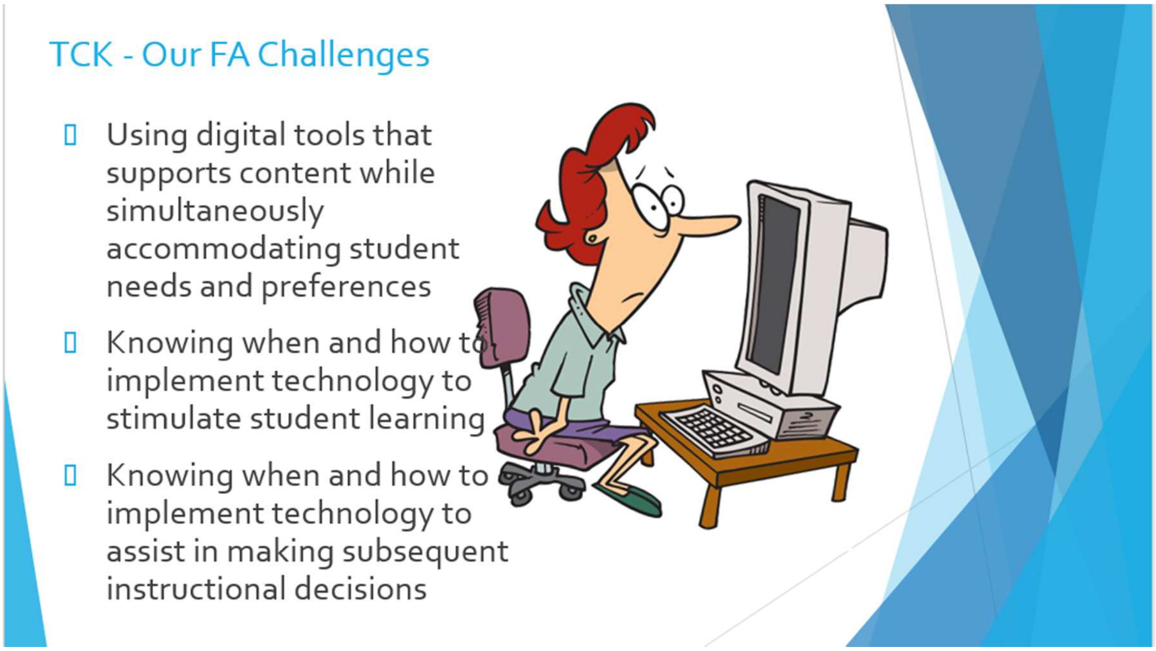


Teachers were challenged to teach content using digital tools that best supported their content and simultaneously addressed the needs and preferences of students (Harris & Hofer, 2011). Shirley and Irving (2015) argued that “teachers need to be equipped with the necessary skills to implement the technology on a routine basis and train students in how to use it for learning. Similarly, teachers need support in developing the pedagogical skills to know when and how to implement technology to promote student learning as well as in making appropriate subsequent instructional decisions” (p. 65). TPACK knowledge components were not well understood by teachers. The requirements for teachers to develop the multifaceted and nuanced knowledge components to integrate technology successfully continued to be a challenge. The challenges that have been outlined contributed to inconsistent technology integration (Harris & Hofer, 2011; Harris et al., 2009), and by extension to inconsistent digital tool integration to facilitate formative assessment and use the resulting feedback to inform subsequent instruction.

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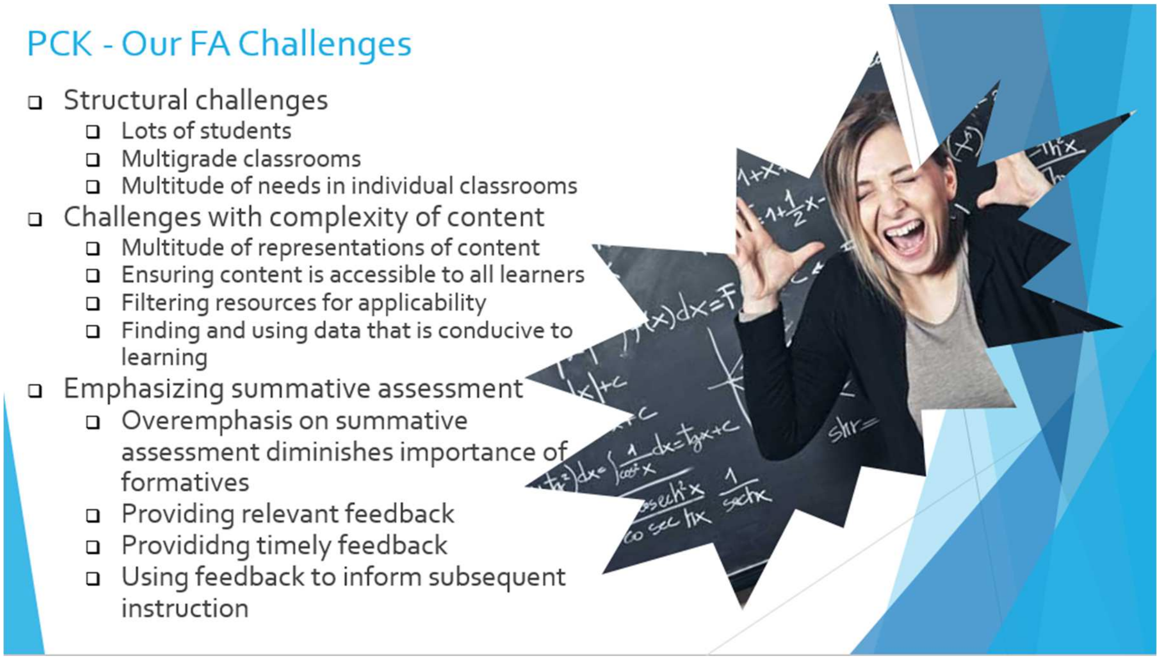


Facilitating formative assessment and using the resulting feedback to inform subsequent instruction is a complex process. Focusing on either teacher pedagogy or content knowledge components independently is insufficient to understand teacher knowledge (Shulman, 1986). Focusing on the overlap of pedagogy and content knowledge (PCK) allows for a more complete characterization of the complexities of teaching in general and in facilitating formative assessment and feedback specifically (Koehler & Mishra, 2009). In this overlap, teachers are continually challenged to interpret their subject matter and find a multitude of manners in which the content can be represented and made accessible to all learners (Mishra & Koehler, 2006). While Spector et al. (2016) reported concerns regarding “potentials, concerns and issues with regard to the role of technology” in formative assessment, these same concerns are widely applicable to the overlap of pedagogical and content challenges inherent in formative assessment and feedback (p. 58). The authors lamented the challenges of classes with high numbers of students, multi-grade classrooms, and a combination of these environments across the educational landscape. Spector et al. (2016) argued that additional challenges exist in the form of developing complex formative assessment tasks, filtering and synthesizing the voluminous resources and data that result, providing relevant and timely feedback to learners that is individualized and conducive to learning, and emphasizing formative assessments rather than overemphasizing summative assessments. These challenges are clear barriers to the ability of teachers to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. Only by tackling these challenges can educators master the inextricable combination of pedagogical knowledge and content knowledge that are the basis for successful teaching practice (Shulman, 1986).

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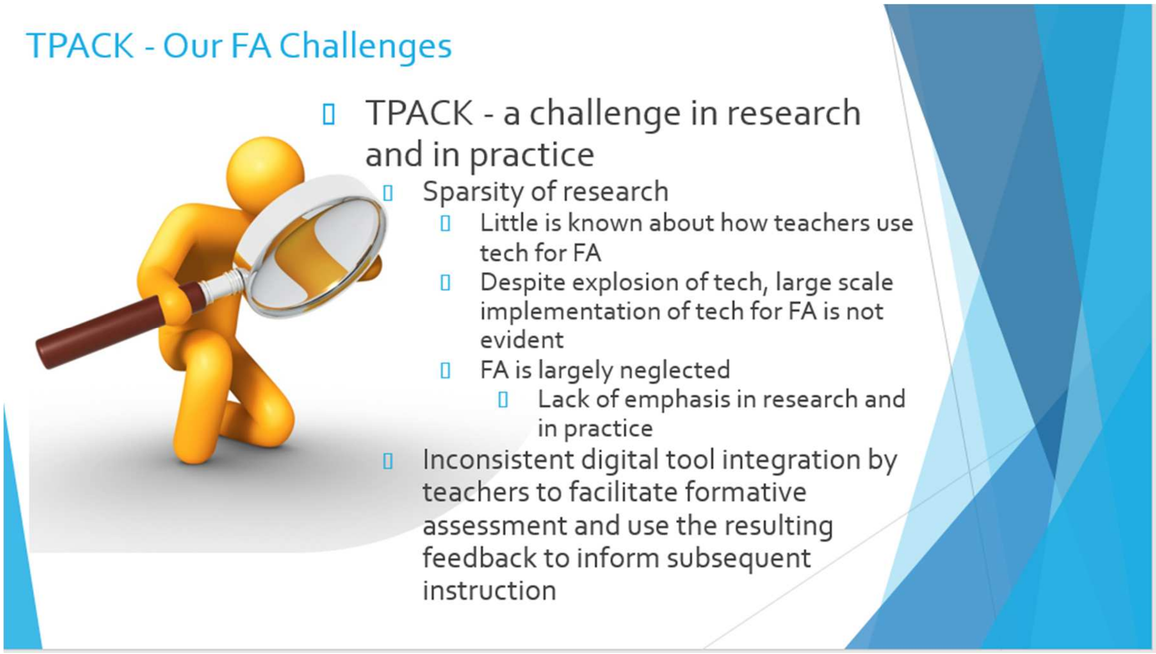


While teacher integration of technology in education has proven to be an inconsistent endeavor for teachers, researchers have also found this inconsistency in digital tool integration to facilitate formative assessment and use the resulting feedback to inform subsequent instruction (Bhagat & Spector, 2017; Mohamadi, 2018; Spector et al., 2016; Zhan & So, 2017). This is a gap that exists both in research and in practice. As to the gap in research, Zhan and So (2017) testified that little is known of how teachers view and experience digital formative assessment in the classroom. The sparsity of research that does exist rarely targeted how technology was used by teachers to support their facilitation of formative assessment and feedback (Zhan & So, 2017). Mohamadi (2018) concurred by observing a lack of research that outlines how ICT has been integrated into the classroom to advance assessment. In a review of earlier research, Bhagat and Spector (2017) found that the recent explosion of digital tools in the educational arena had not translated into any large-scale implementation of digital tool integration to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. On the contrary, much of the technology integration was used by students to simply access learning resources (Bhagat & Spector, 2017). Bhagat and Spector testified that formative assessment has been largely neglected and despite the potential power of using digital tools to facilitate formative assessment, little evidence exists to support the occurrence. Also lacking in the body of research are explorations of strategies used by teachers to provide instructional feedback as a result of digital formative assessments (Spector et al., 2016).

Although referring specifically to higher education, Sweeney et al. (2017) pointed to the existing gap in teacher practice. Despite the ready availability of technology-enhanced assessments (TEAs) in higher education settings, the shift to digital formative assessment and feedback methods has been slow to evolve (Sweeney et al., 2017). The findings of Faber et al. (2017) aligned with Sweeney et al. despite being conducted in a grade three classroom. Faber et al. testified that teachers do not primarily use digital tools to improve their instructional activities, thereby limiting the knowledge of the contributions possible from formative assessment activities conducted by digital means. Maier et al. (2016) found that inconsistent digital tool integration is also prevalent in secondary classrooms, where commonly applicable technology is available but not widely applied. A study conducted by Hooley and Thorpe (2017) in a high school government class found that activities used to formatively assess reading comprehension progress are largely conducted using analog strategies. Bugaj and Poss (2016) also noted the same reliance on analog strategies when teachers and specialists work with students with disabilities. The potential capacity of digital tools to operationalize student learning data to enhance student learning remains elusive (Luckin et al., 2017). Consequently, a problem of inconsistent digital tool integration by teachers to facilitate formative assessment and use the resulting feedback to inform subsequent instruction has been identified.

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Digitizing the formative assessment and feedback loop amplifies the possibilities for beneficial application in classroom settings by increasing the timeliness in which these processes can occur and the real-time data that can be procured. In a synthesis of digital formative assessment literature, Spector et al. (2016) emphasized that the influx of technology in the field of education has placed an even greater emphasis on formative assessments. The researchers noted that as reliance on technology has increased, so has the need for timely feedback. The need for meaningful and timely feedback that is necessary for effective formative assessments is not conceivable without using technology (Spector et al., 2016). Spector et al. specifically identified the tremendous benefit that can result from the data that is collected and aggregated by digital formative assessment tools. Conducting formative assessments using technology allows teachers to facilitate numerous and ongoing data collection aimed at understanding how student learning is progressing. The data generated can subsequently be used to make adjustments tailored to differentiated student needs (Spector et al., 2016). Barana and Marchisio (2016) echoed the overarching benefits of digital formative assessments found by Spector et al. (2016). In developing an educational model for automating formative assessment, the researchers stressed the advantage of meaningful and timely feedback. Barana and Marchisio also emphasized that the immediate availability of data when automating formative assessments fosters immediate feedback and adaptivity to inform future improvements for both teachers and students. In promoting the use of technology for administering formative assessments, Bhagat and Spector (2017) also recognized the potential advantages of increasing the use of technology to conduct digital formative assessments. Like Barana and Marchisio (2016), Bhagat and Spector (2017) noted the potential time savings in automating formative assessment processes rather than performing manual corrections. Additionally, Bhagat and Spector (2017) viewed digital formative assessments as a means to aid complex problem-solving tasks, providing a more complete record of the learner processes.

### Connected Classroom Technology

Several studies relating to using digital tools to facilitate formative assessment and use the resulting feedback to inform subsequent instruction focused on specific digital tools and their implementation. While touting technological advancements as supportive to formative assessment practices, Irving et al. (2016) emphasized potential benefits in using connected classroom technology (CCT). Irving et al. (2016) saw CCTs as critical to the formative assessment process, specifically in terms of the assistance these technologies can provide to the feedback process. Likewise, Varier et al. (2017) echoed the benefits of CCT in their qualitative research that examined the integration of one-to-one technological devices in a large mid-Atlantic school district. In this study, teachers and students in elementary, middle, and high school attributed increased opportunities to give and receive feedback to the presence of the technological device (Varier et al., 2017). Such modern technologies supported immediate electronic response capabilities, providing teachers with increased and enhanced opportunities to provide feedback throughout the learning process (Varier et al., 2017) and allowing for teachers and students to make classroom decisions based on timely feedback (Irving et al., 2016). Based on the results of their longitudinal study in a national trial of Algebra 1 students and teachers, Irving et al. (2016) posited that classrooms facilitated with CCT and the immediate feedback loop made possible in this technological environment fostered positive effects on student achievement. Similarly, Shirley and Irving (2015) explored the experiences of four middle and high school science teachers, focusing on their integration of connected classroom technology (CCT) as a strategy to facilitate effective formative assessments. The researchers found that CCT facilitated instructional tasks helped both teachers and students better understand the extent to which learning was occurring and subsequently influenced ongoing instructional decision-making (Shirley & Irving, 2015). The use of connected classroom technology provided teachers with timely and accurate learning data. Basing subsequent instructional decisions on timely and accurate data improved the formative feedback loop (Varier et al., 2017) and benefited the teaching and learning process (Irving et al., 2016; Shirley & Irving, 2015).

### Student Response Systems

Student response systems (SRS) or clicker systems are also becoming more prevalent in classroom settings thanks to advances in technology. Fuller and Dawson (2017) examined how an integration specialist helped district middle school teachers combine literature-based strategies and SRS technology to perform digital formative assessments, then adjust subsequent instruction. Through this examination, the researchers found benefits for both teachers and students (Fuller & Dawson, 2017). Using the SRS technology, teachers were able to collect data, monitor student progress, and make adjustments during the learning process, while students were reflective and exhibited engaged behavior (Fuller & Dawson, 2017).

Research conducted using SRSs as a means of facilitating formative assessment during classroom lectures has also shown to be beneficial for both teachers and students. During instructional delivery in a one-to-one Chromebook environment, teachers reported that the availability of a technological device increased and enhanced opportunities for feedback (Varier et al., 2017). Teachers also testified that the immediacy of feedback enabled by the presence of technology allowed for mitigation of misconceptions or other student errors earlier in the learning process (Varier et al.). By shortening the feedback loop, instructional adjustments were possible throughout the learning process rather than waiting for the summative exam. Students reported benefits inherent in clicker-based student response systems during classroom lectures. Egelandsdal and Krumsvik (2017) found that students perceived an increased ability to self-monitor their learning. Students also expressed that they were more aware of their level of understanding and on what they should focus on to further their learning (Egelandsdal & Krumsvik). Likewise, Yilmaz (2017) found that the use of a clicker system was effective in supporting immediate feedback to students while assisting them in ongoing self-assessment and self-regulation. Students testified that the immediate feedback helped them to see their level of accuracy and to compare it to others in the course (Yilmaz). Additionally, students reported higher levels of engagement and the ability to more clearly identify misconceptions they had relating to the course material (Yilmaz). Dobbins and Denton (2017) echoed the use of mobile technology in lectures to facilitate engagement. Students found the student response system Textwall™ enabled them to become more involved in-class lectures and encouraged a level of comfort to communicate not present absent the technology (Dobbins & Denton, 2017). Student response systems provided significant benefits to both teachers and students in facilitating formative assessment and using the resulting feedback to inform subsequent instruction.

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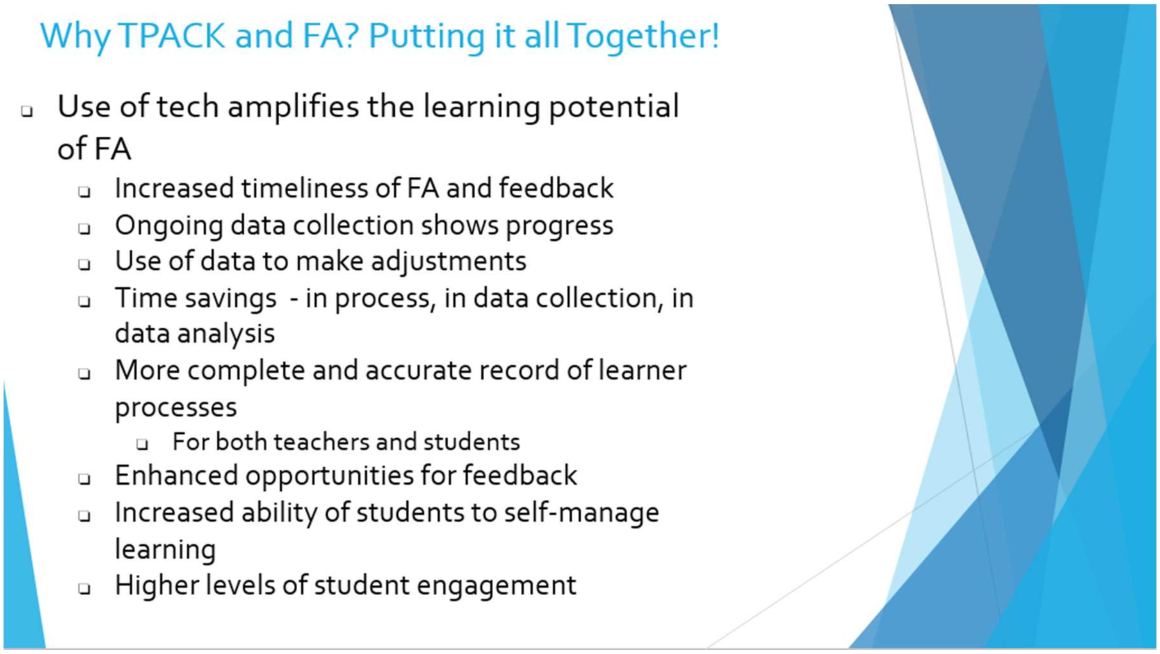


Digitizing the formative assessment and feedback loop amplifies the possibilities for beneficial application in classroom settings by increasing the timeliness in which these processes can occur and the real-time data that can be procured. In a synthesis of digital formative assessment literature, Spector et al. (2016) emphasized that the influx of technology in the field of education has placed an even greater emphasis on formative assessments. The researchers noted that as reliance on technology has increased, so has the need for timely feedback. The need for meaningful and timely feedback that is necessary for effective formative assessments is not conceivable without using technology (Spector et al., 2016). Spector et al. specifically identified the tremendous benefit that can result from the data that is collected and aggregated by digital formative assessment tools. Conducting formative assessments using technology allows teachers to facilitate numerous and ongoing data collection aimed at understanding how student learning is progressing. The data generated can subsequently be used to make adjustments tailored to differentiated student needs (Spector et al., 2016). Barana and Marchisio (2016) echoed the overarching benefits of digital formative assessments found by Spector et al. (2016). In developing an educational model for automating formative assessment, the researchers stressed the advantage of meaningful and timely feedback. Barana and Marchisio also emphasized that the immediate availability of data when automating formative assessments fosters immediate feedback and adaptivity to inform future improvements for both teachers and students. In promoting the use of technology for administering formative assessments, Bhagat and Spector (2017) also recognized the potential advantages of increasing the use of technology to conduct digital formative assessments. Like Barana and Marchisio (2016), Bhagat and Spector (2017) noted the potential time savings in automating formative assessment processes rather than performing manual corrections. Additionally, Bhagat and Spector (2017) viewed digital formative assessments as a means to aid complex problem-solving tasks, providing a more complete record of the learner processes.

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Student Response Systems

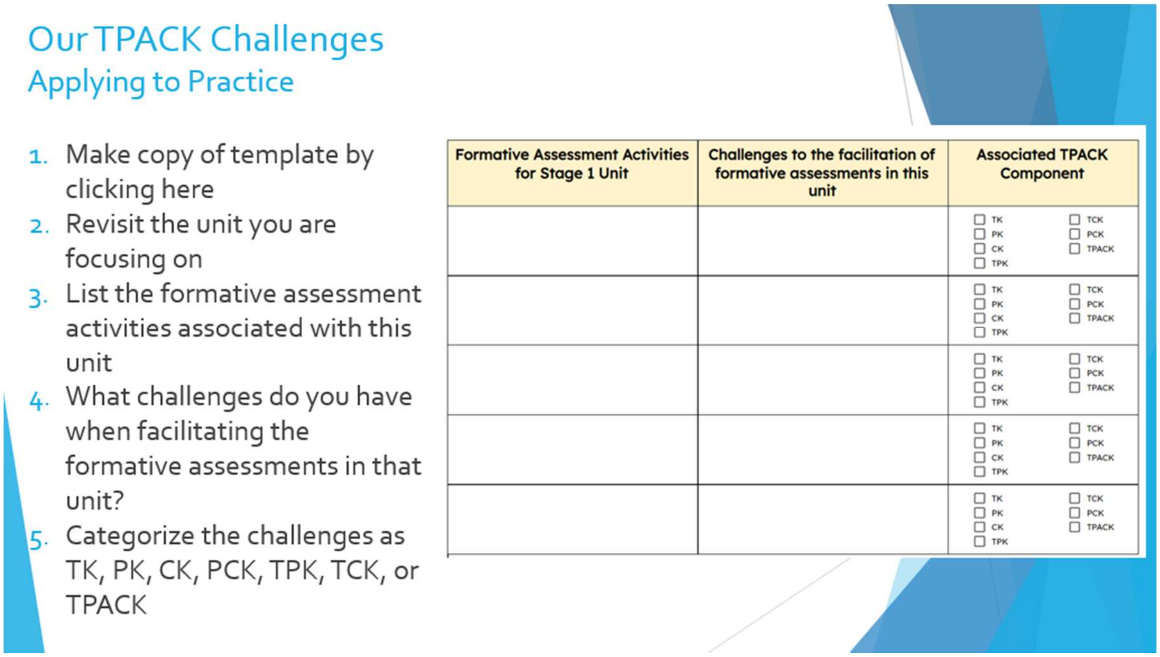
Student response systems (SRS) or clicker systems are also becoming more prevalent in classroom settings thanks to advances in technology. Fuller and Dawson (2017) examined how an integration specialist helped district middle school teachers combine literature-based strategies and SRS technology to perform digital formative assessments, then adjust subsequent instruction. Through this examination, the researchers found benefits for both teachers and students (Fuller & Dawson, 2017). Using the SRS technology, teachers were able to collect data, monitor student progress, and make adjustments during the learning process, while students were reflective and exhibited engaged behavior (Fuller & Dawson, 2017).

Research conducted using SRSs as a means of facilitating formative assessment during classroom lectures has also shown to be beneficial for both teachers and students. During instructional delivery in a one-to-one Chromebook environment, teachers reported that the availability of a technological device increased and enhanced opportunities for feedback (Varier et al., 2017). Teachers also testified that the immediacy of feedback enabled by the presence of technology allowed for mitigation of misconceptions or other student errors earlier in the learning process (Varier et al.). By shortening the feedback loop, instructional adjustments were possible throughout the learning process rather than waiting for the summative exam. Students reported benefits inherent in clicker-based student response systems during classroom lectures. Egelandsdal and Krumsvik (2017) found that students perceived an increased ability to self-monitor their learning. Students also expressed that they were more aware of their level of understanding and on what they should focus on to further their learning (Egelandsdal & Krumsvik). Likewise, Yilmaz (2017) found that the use of a clicker system was effective in supporting immediate feedback to students while assisting them in ongoing self-assessment and self-regulation. Students testified that the immediate feedback helped them to see their level of accuracy and to compare it to others in the course (Yilmaz). Additionally, students reported higher levels of engagement and the ability to more clearly identify misconceptions they had relating to the course material (Yilmaz). Dobbins and Denton (2017) echoed the use of mobile technology in lectures to facilitate engagement. Students found the student response system Textwall™ enabled them to become more involved in-class lectures and encouraged a level of comfort to communicate not present absent the technology (Dobbins & Denton, 2017). Student response systems provided significant benefits to both teachers and students in facilitating formative assessment and using the resulting feedback to inform subsequent instruction.

Slide 24

Slide 25

Slide 26




So what are your TPACK challenges?

Make a copy of this template, then take a few minutes to revisit the unit that you are working on with your content group. List the formative assessments that you use in this unit to meet the content learning goals that you established (competencies/standards/understandings/essential questions). Consider, when you are creating formative assessments for this unit, what challenges do you have?  Also, try to nail down which TPACK knowledge component that you are struggling with. Keep in mind that you could be struggling with multiple knowledge components at once - and that’s ok!

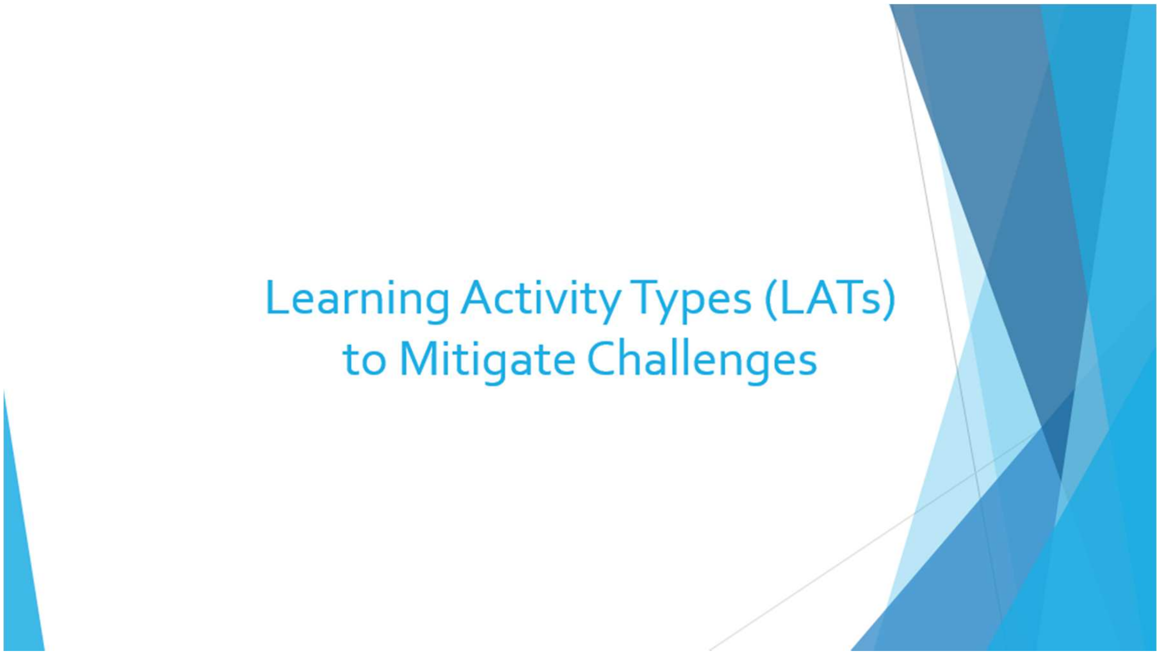
Slide 27


What challenges did your group identify as being present specific to the formative assessments that you have in this unit.

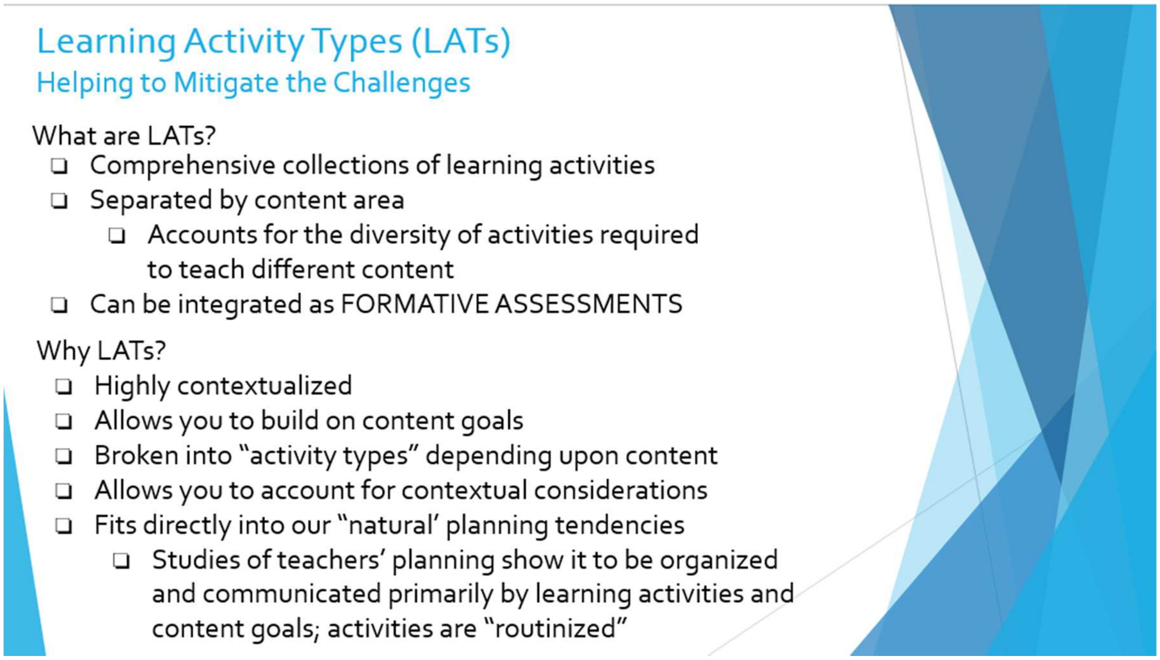
TPACK is highly contextualized. Given this, could you identify whether the challenge was specific to the content being taught, to the teacher, to the student group? Other?

[PD participants report out so that other groups can hear/see varying thought processes and strategies]

Slide 28



Slide 29




Our work has shown that to plan technology-integrated, content-based learning activities in a maximally efficient way, comprehensive collections of learning activities in each curriculum area can be offered for teachers' use, with suggested educational technologies indicated for each type of activity included. Since the numbers of possible learning activity types – even 576 Harris, Hofer, Schmidt, Blanchard, Young, Grandgenett, and Olphen within a single content area – can be large, these collections should be organized into functional subcategories. Such learning activity taxonomies can then serve as organized collections of options for teachers to consider, once content goals are selected, contextual constraints are acknowledged, and student learning styles and preferences are noted.

Technologies selected for use are based in content-specific pedagogy. Technological selections are based upon teachers' practical decisions to use particular content-based learning activities that are pedagogically and contextually appropriate, rather than any intentions to integrate specific technologies into instruction.

Studies of teachers' planning show it to be organized and communicated primarily by learning activities and content goals (John, 2006; Yinger, 1979). Learning activities are "routinized" by teachers over time to simplify the planning and coordinating of classroom activity (Yinger, p. 165), allowing greater flexibility and responsiveness to students in the highly situated and contextualized classroom environment (John, 2006). Little is known, however, about how digital educational technologies are integrated into teachers' planning

Though there are some activities that are used in multiple content areas – such as independent reading, class discussion, or presentation, for example – they are interpreted and implemented quite differently in different disciplinary (and classroom) contexts. Other learning activities, such as science labs, geometric proofs, and readers' theater, are content area-specific

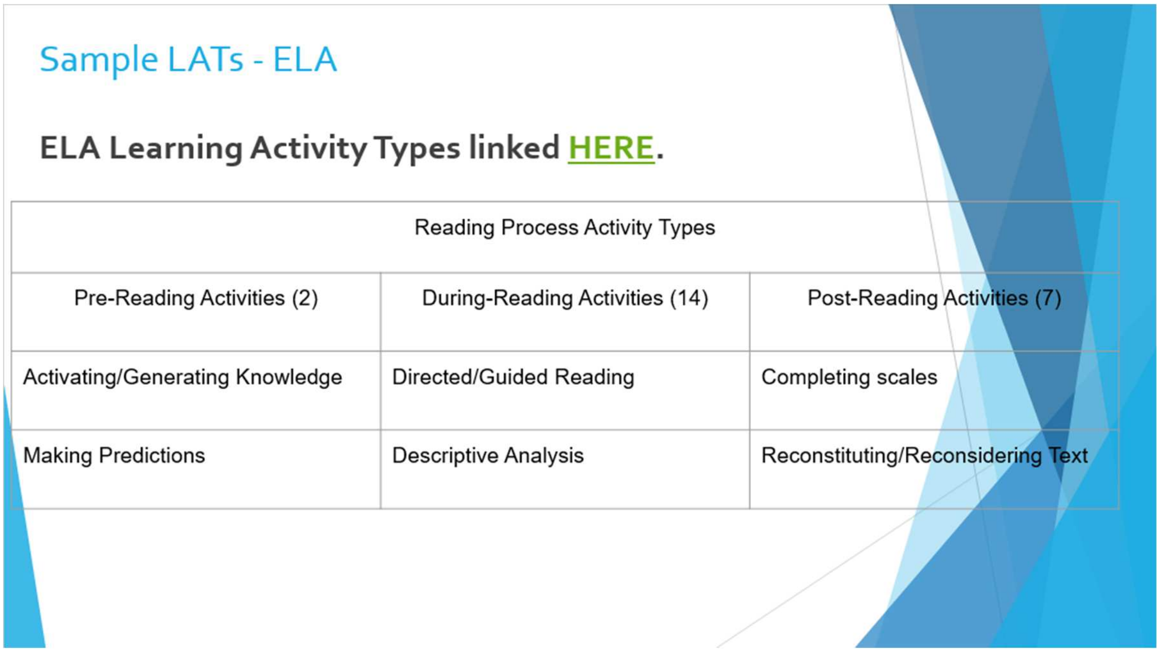
Slide 30


The sample LATs that we are going to take a look at are incredibly wide-ranging. There is something here for everyone! And given that so much of teacher instruction is routinized, it could be incredibly advantageous to see other activity types that ones that you've been routinely integrating in your practice. Let's take a look at the breakdown of activity types for ONLY ELA. [Discuss activity types listed]

The sample LATs also include potential technologies that can be used for each LAT. The LATs were developed in 2011, so since the technologies are more than a decade old at this point, we will integrate our own current technologies later in the PD.

LAT attribution: http://creativecommons.org/licenses/by-sa/4.0/

Slide 31



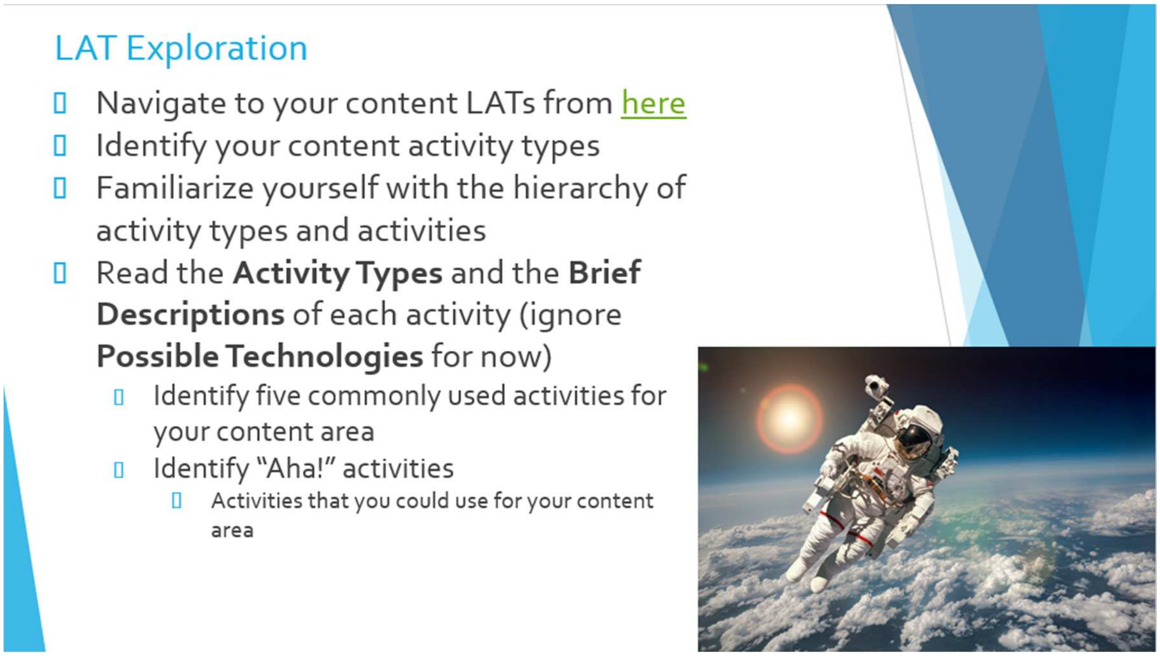

| Reading Process Activity Types | | |
|---|---|---|
| Pre-Reading Activities (2) | During-Reading Activities (14) | Post-Reading Activities (7) |
| Activating/Generating Knowledge | Directed/Guided Reading | Completing scales |
| Making Predictions | Descriptive Analysis | Reconstituting/Reconsidering Text |

To continue the example, let’s look at the ELA Learning Activity Types. Note the breakdown in the types of activities that may be facilitated in an ELA classroom. Additionally, note that each of these activity types lend themselves to being integrated into the classroom as FORMATIVE ASSESSMENT activities. [Allow for exploration of the ELA LATs] Note that each activity type provides a brief description of the activity, in the event it’s a new concept to you.

[Questions for the group] What activites do you recognize?  Are these activities that you routinely implement?  Are there other activities that look feasible for you and your contextualized content needs?

Slide 32

Slide 33

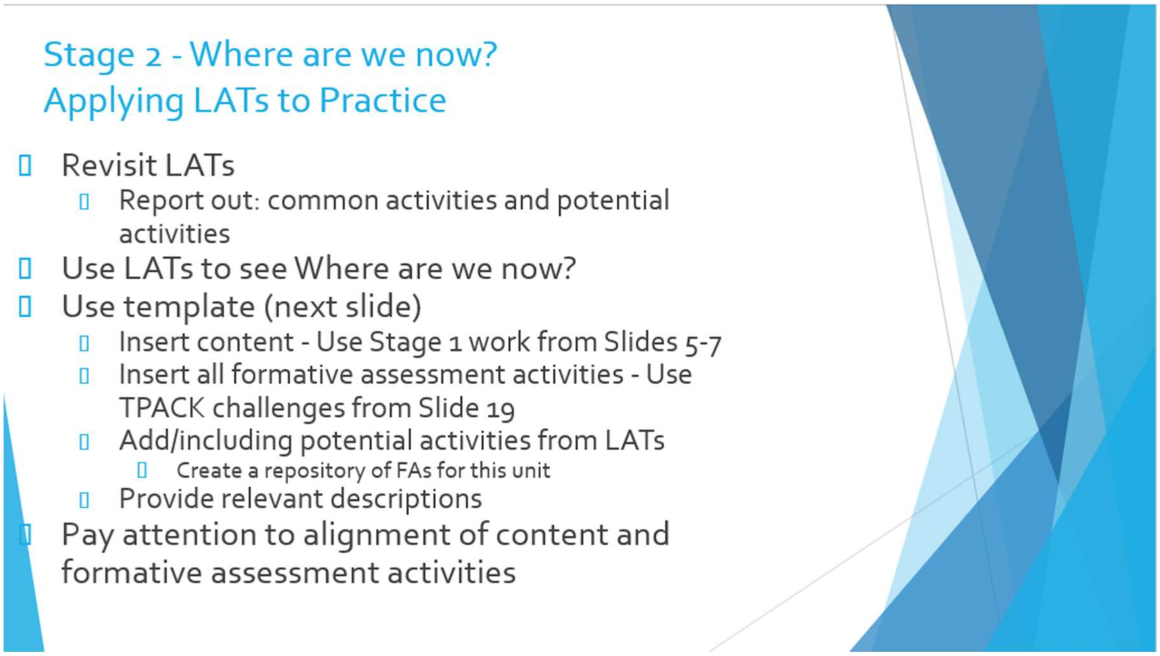



Now let's take a look at the LATs for your content area. Navigate to the link on the slide, then spend some time exploring the activities for your content area. Focus on the activity types and the descriptions of the activities. Do you see activities that you use now? Do you see activities that you'd never thought of but think may be applicable to your content? Find five commonly used activities for your content area. Then begin identifying activities that have potential for implementation.

Slide 34

Slide 35

Slide 36




Revisit LATs - Groups report out on their analysis of their content level LATs so that other groups can hear/see varying thought processes and strategies.

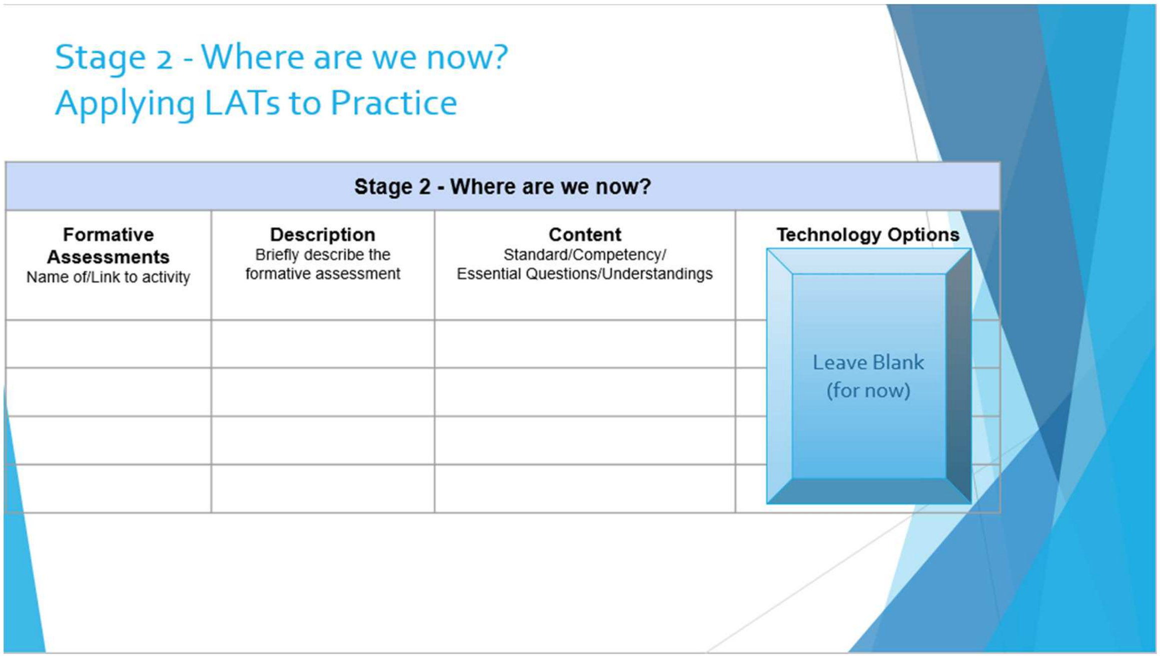
This morning, you identified one unit to center all of your learning and planning around. During your Stage 1 planning, you identified the standards/competencies/essential questions/understandings that are the learning goals for this unit. During our TPACK Challenges activity, you also listed the formative assessment activities that you provide for student learning. Find both of those documents.

We will now use the LATs to build on our Stage 1 unit choice and move to Stage 2 - Where are we now?

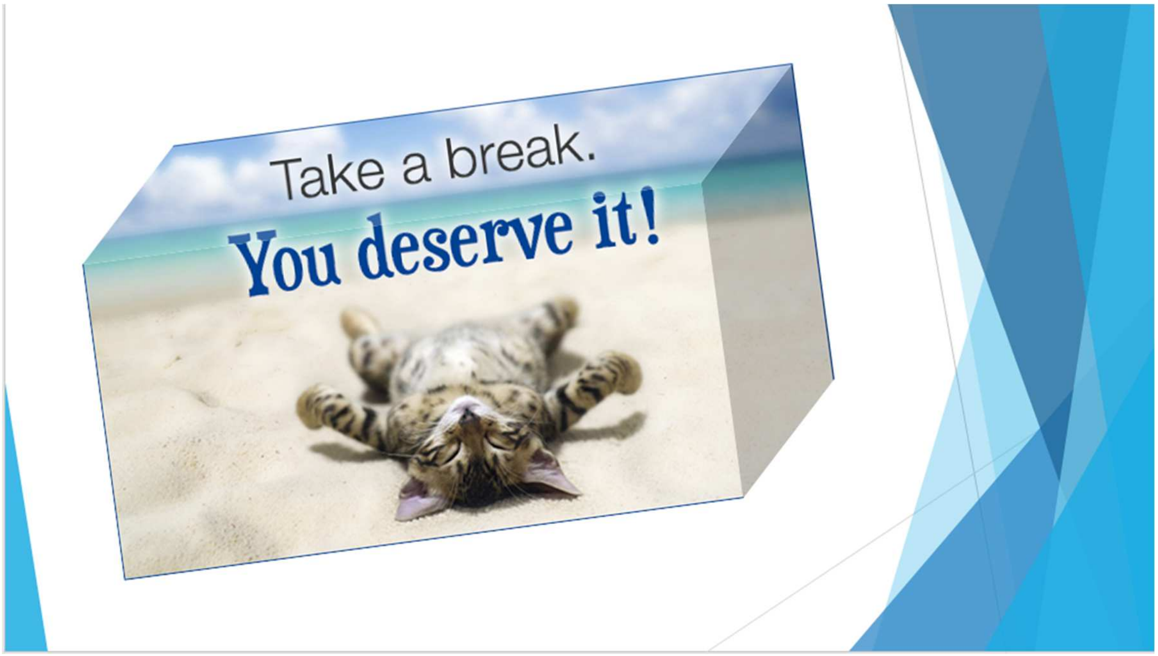
The Stage 2 template is on the next slide and is linked on that slide. Using your Stage 1 work as your guide for the content column by entering the content that you are teaching in the unit. Then use your TPACK challenges activity to list the formative assessments that you use in this unit. Add any potential activities that you discovered while exploring the LATs. Do you need to revamp your formative assessments list based on seeing new selections in the LAT list? Make those additions/changes. We are making a repository of potential formative assessments in Stage 2. (We are also working to align our TPACK). Keep in mind that different teachers in different contexts with different student groups may need different formative assessment activities to facilitate content learning, so add as many formative assessment activities as you wish. Then provide your own relevant descriptions for the formative assessment activities. As you are working through these activities, pay particular attention to the alignment of your content (CK) and your formative assessment activities (PK) (PCK). Do your activities provide a way for students to learn the content?  You may need to tweak as you go.

Leave the last column blank. We will add our technologies at a later time. We first need to center on the content we are teaching and the pedagogical means of facilitate that learning through the LATs.

Slide 37


Stage 2 - Where are we now?
Applying LATs to Practice
Stage 2 - Where are we now?
Formative Assessments
Name of/Link to activity
Description
Briefly describe the formative assessment
Content
Standard/Competency/
Essential Questions/Understandings
Technology Options
Leave Blank
(for now)

Slide 38

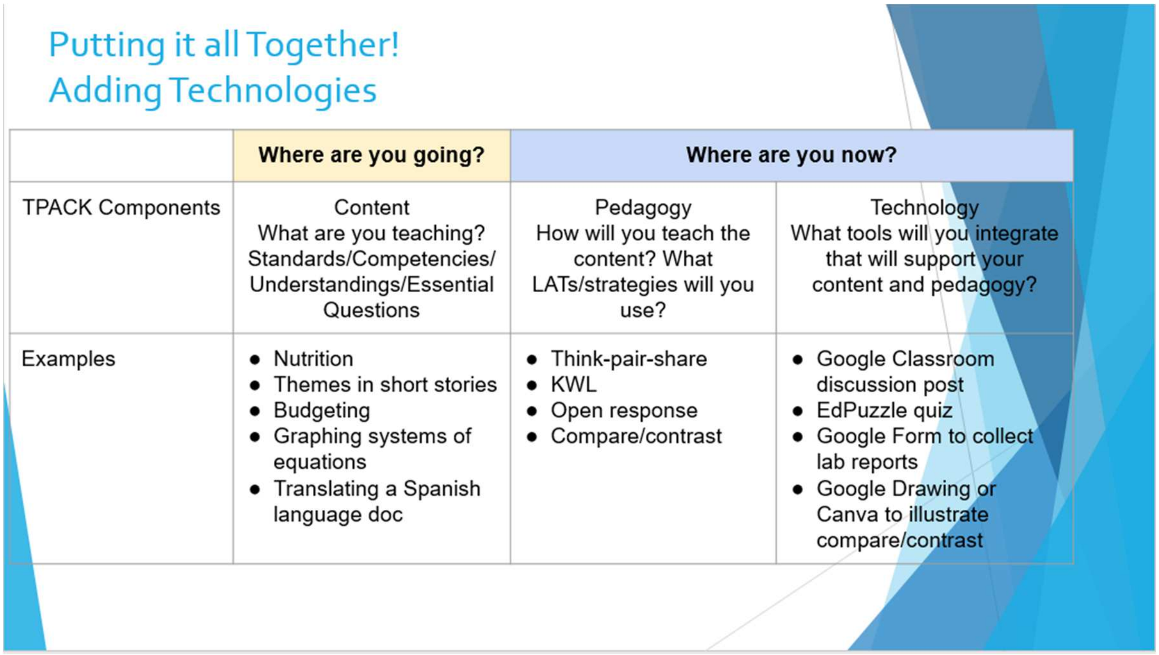


Slide 39

Slide 40


So far we've used our Stage 1 planning tool to choose our unit and to define the content that we want students to learn. (CK)
We have used part of our Stage 2 planning tool to align our content to our formative assessment activities (CK) (PK) (PCK). We've basically built two legs of a three legged stool, but we need that third leg of the stool so that our instruction will "stand." The interplay of all three TPACK knowledge components in critical to tech integration and student learning. So now we are ready to add technology as a means of facilitate our formative assessments.

Slide 41



Putting it all Together!
Adding Technologies

| | Where are you going? | Where are you now? | |
|---|---|---|---|
| TPACK Components | Content<br>What are you teaching? Standards/Competencies/ Understandings/Essential Questions | Pedagogy<br>How will you teach the content? What LATs/strategies will you use? | Technology<br>What tools will you integrate that will support your content and pedagogy? |
| Examples | • Nutrition<br>• Themes in short stories<br>• Budgeting<br>• Graphing systems of equations<br>• Translating a Spanish language doc | • Think-pair-share<br>• KWL<br>• Open response<br>• Compare/contrast | • Google Classroom discussion post<br>• EdPuzzle quiz<br>• Google Form to collect lab reports<br>• Google Drawing or Canva to illustrate compare/contrast |

By asking ‘Where are you going?’ we have established and planned out the content learning that we are seeking to facilitate. By asking ‘Where are you now?’ we’ve begun to construct a plan for understanding what students know and can do right now in an effort to figure out where we go from here.

One piece we haven’t spent much time on is the technology piece. We will touch on this tomorrow in much more detail, but tech can be pivotal to helping students learn and to helping us to pinpoint where students are in their learning and in informing subsequent instruction. For now, let’s consider how technology can be coordinated to the plans we have already. For the content and formative assessments that we are teaching in our unit, what technologies can we/do we integrate that will support the content and pedagogy in our contexts?

[Walk through this exemplar as to the interplay of the stages (Where are you going? and Where are you now?) and the coordination of TPACK] [Allow groups to present their own examples]

Slide 42

## Putting it all Together!
## Continuing Stage 2 - Adding Technologies

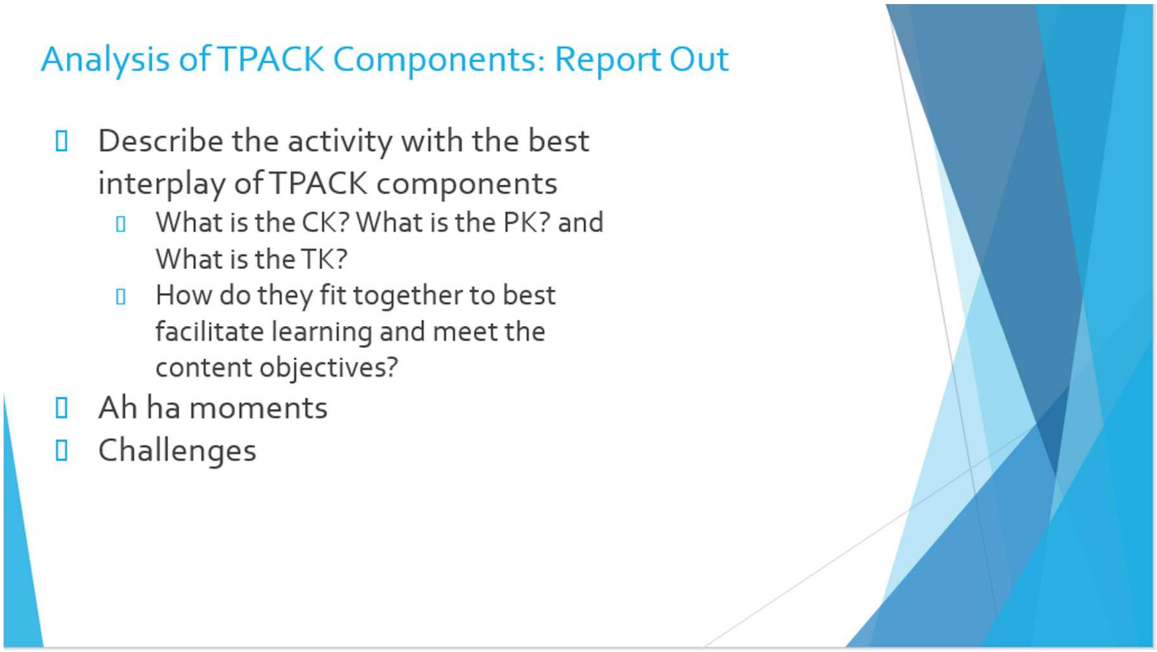
| **Stage 2 - Where are we now?** | | | |
|---|---|---|---|
| **Formative Assessments** Name of/Link to activity | **Description** Briefly describe the formative assessment | **Content** Standard/Competency/ Essential Questions/Understandings | **Technology Options** What tool(s) will be used to facilitate the formative assessment? |
| | | | |
| | | | |
| | | | |
| | | | |

[Provide hyperlink on this slide to the district-approved technologies. I have not done so here to account for confidentiality of the study site.]

Due to COPPA, FERPA, and state law, the school district has provided us with a list of approved technologies that can be used with students. That link is included on the slide.

In your groups, reexamine the content and formative assessments that you will be teaching in your unit. Then decide what technologies you either currently use or can potentially use to support the facilitation of the formative assessments given your content, pedagogy, and student contexts.

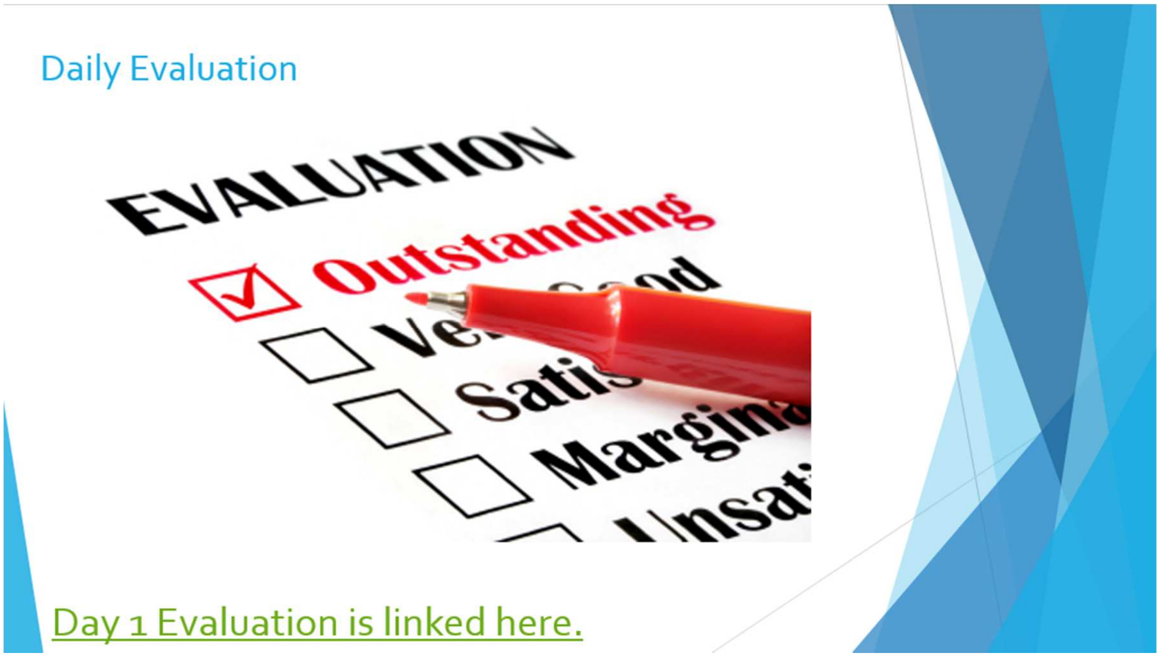
Slide 43




[PD participants report out so that other groups can hear/see varying thought processes and strategies]

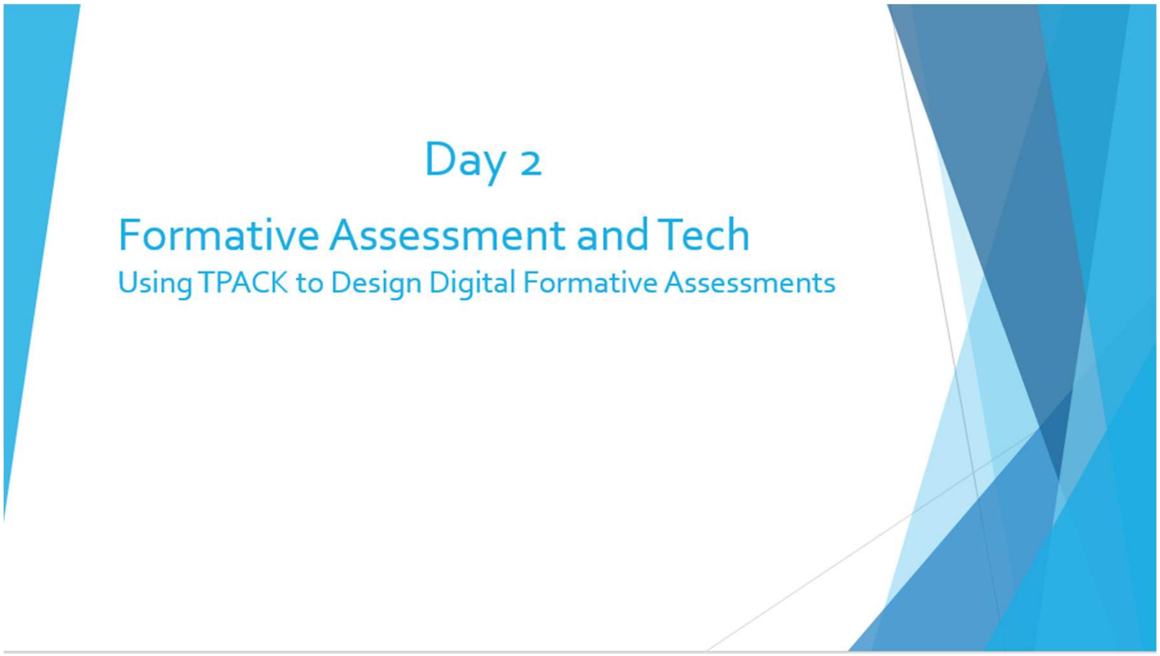
Slide 44

Slide 45




Thank you for all of your hard work and participation today! I hope that you have found this PD to be a worthwhile experience that will feed forward into your practice. Please fill out the daily evaluation. This will provide your trainers with FORMATIVE FEEDBACK to be used to feed forward into our subsequent instruction!

Slide 46


Day 2
Formative Assessment and Tech
Using TPACK to Design Digital Formative Assessments

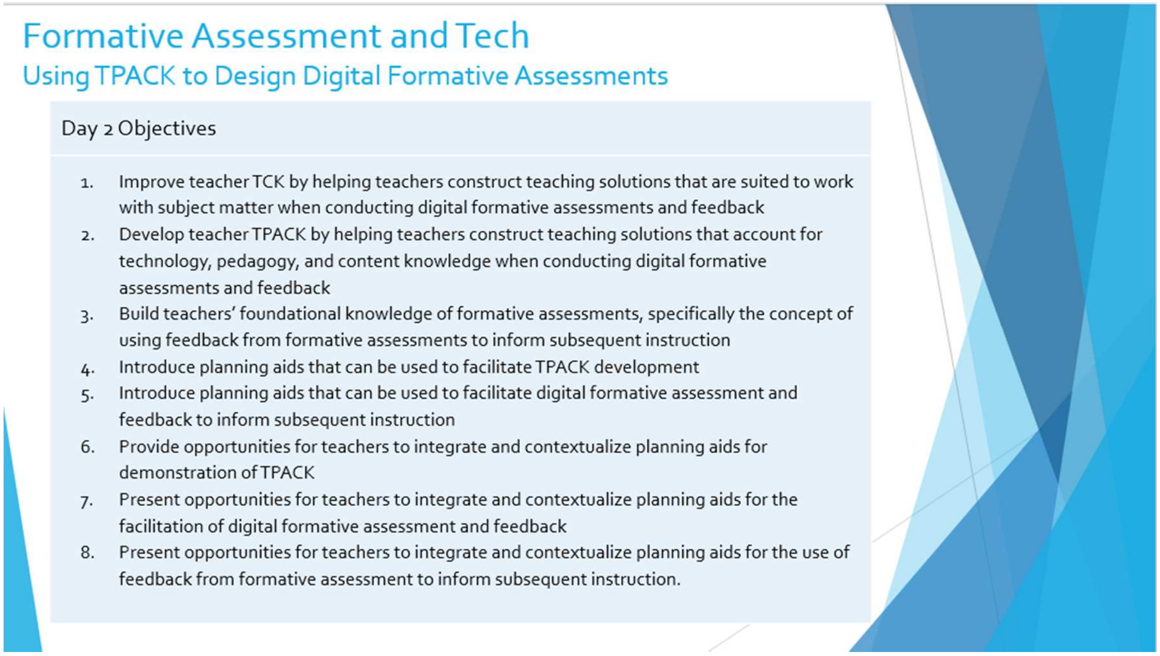
Slide 47

Agenda

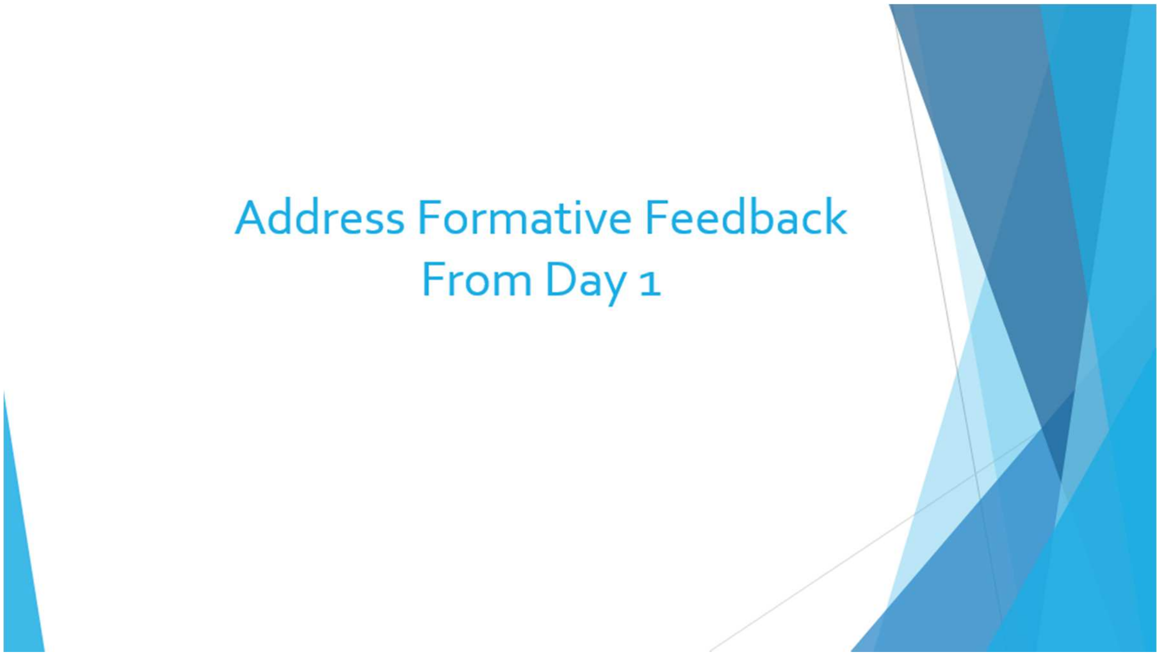
| | |
|---|---|
| 8:00-8:30 | Address Formative Feedback from Day 1<br>Objectives for today |
| 8:30-9:00 | Introduction to formative assessment and feedback |
| 9:00-9:45 | Stage 2 Planning - Where are we now?<br>Are our Formatives Formative? |
| 9:45-10:00 | Break |
| 10:00-11:30 | Stage 2 Planning - Where are we now?<br>Are our Formatives Formative?<br>Groups Report and Evaluate Formatives |
| 11:30-12:30 | Lunch |
| 12:30-1:30 | Technology and Formative Assessments - Inconsistencies, Challenges, Benefits, Effective Strategies<br>Stage 3 Planning - How do we get there?<br>Analysis of Evidence From Formative Assessments |
| 1:30-1:45 | Break |
| 1:45-2:45 | Stage 3 Planning - How do we get there?<br>Planning for Subsequent Instruction |
| 2:45-3:00 | Daily Evaluation |

Slide 48

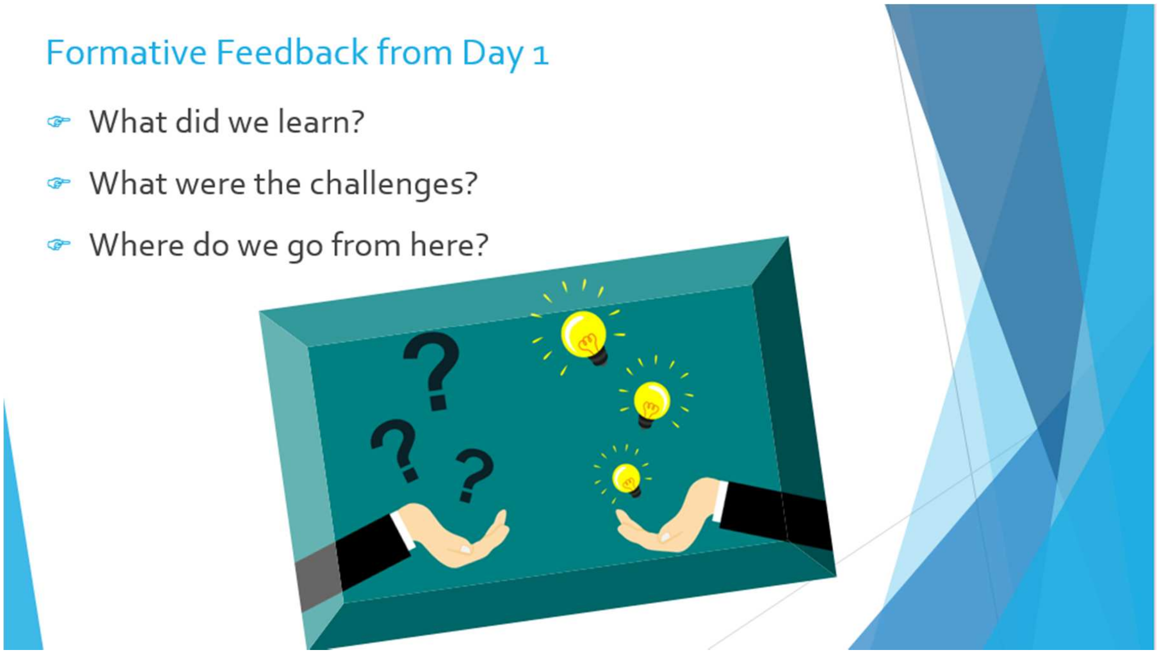
Slide 49


Formative Assessment and Tech
Using TPACK to Design Digital Formative Assessments
Day 2 Objectives
1. Improve teacher TCK by helping teachers construct teaching solutions that are suited to work with subject matter when conducting digital formative assessments and feedback
2. Develop teacher TPACK by helping teachers construct teaching solutions that account for technology, pedagogy, and content knowledge when conducting digital formative assessments and feedback
3. Build teachers' foundational knowledge of formative assessments, specifically the concept of using feedback from formative assessments to inform subsequent instruction
4. Introduce planning aids that can be used to facilitate TPACK development
5. Introduce planning aids that can be used to facilitate digital formative assessment and feedback to inform subsequent instruction
6. Provide opportunities for teachers to integrate and contextualize planning aids for demonstration of TPACK
7. Present opportunities for teachers to integrate and contextualize planning aids for the facilitation of digital formative assessment and feedback
8. Present opportunities for teachers to integrate and contextualize planning aids for the use of feedback from formative assessment to inform subsequent instruction.

Slide 50



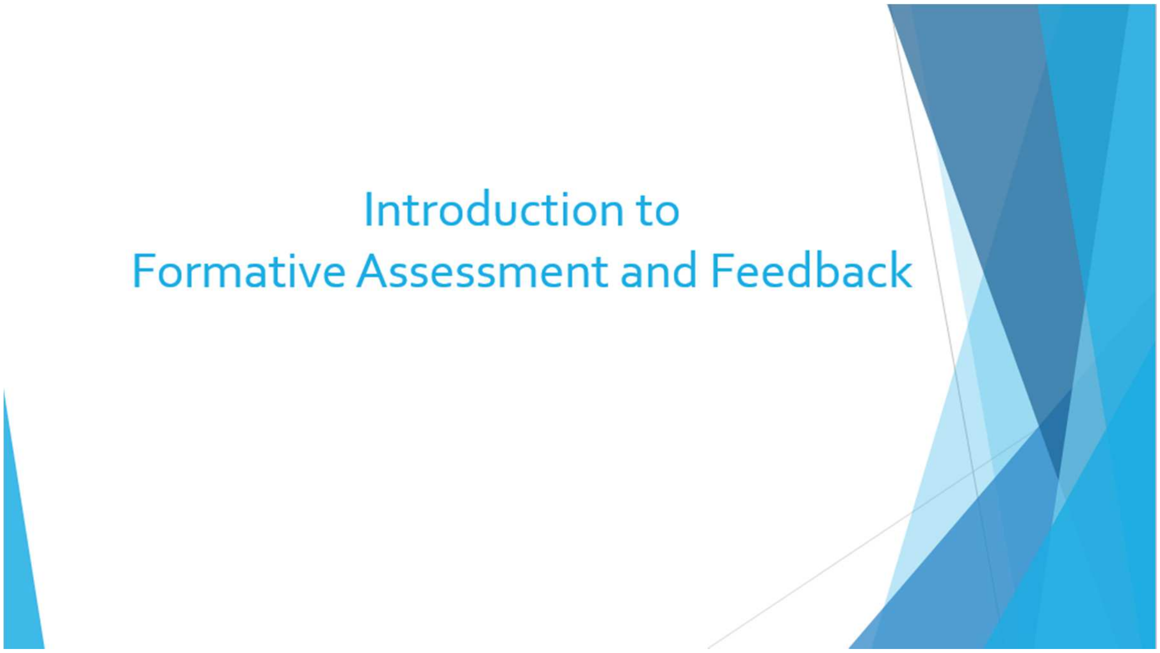
Slide 51



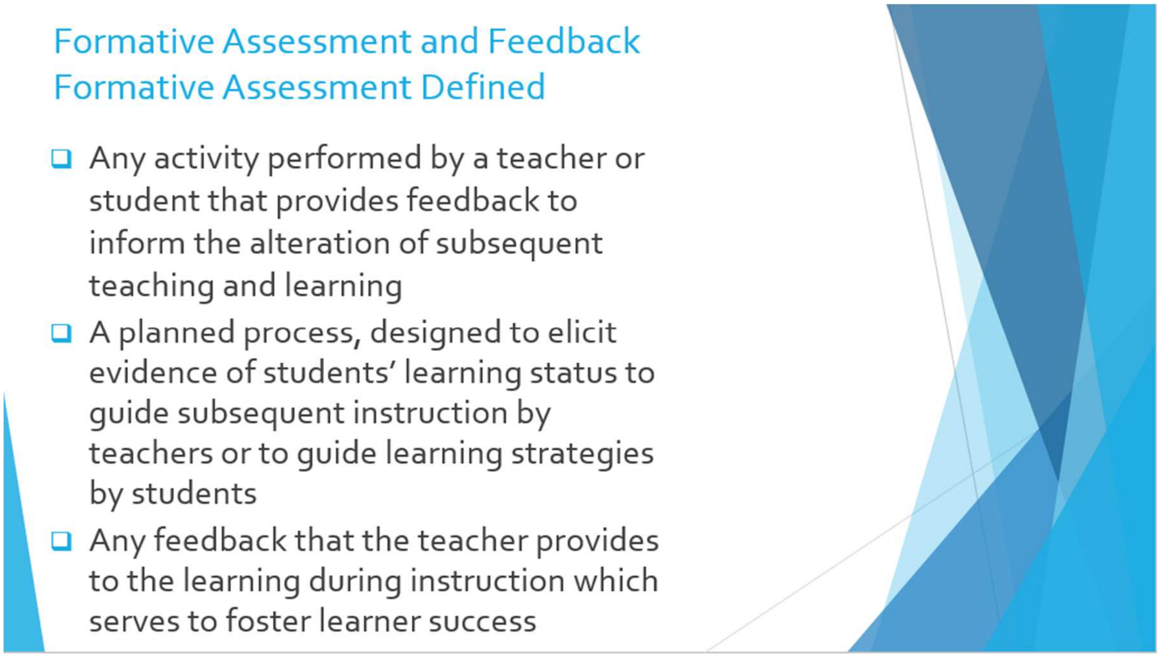

First two questions will be based on formative feedback provided on the day 1 daily evaluation. I will invite the audience to add their own takeaways.

“Where do we go from here?” will be used to transition to the day 2 objectives.

Slide 52

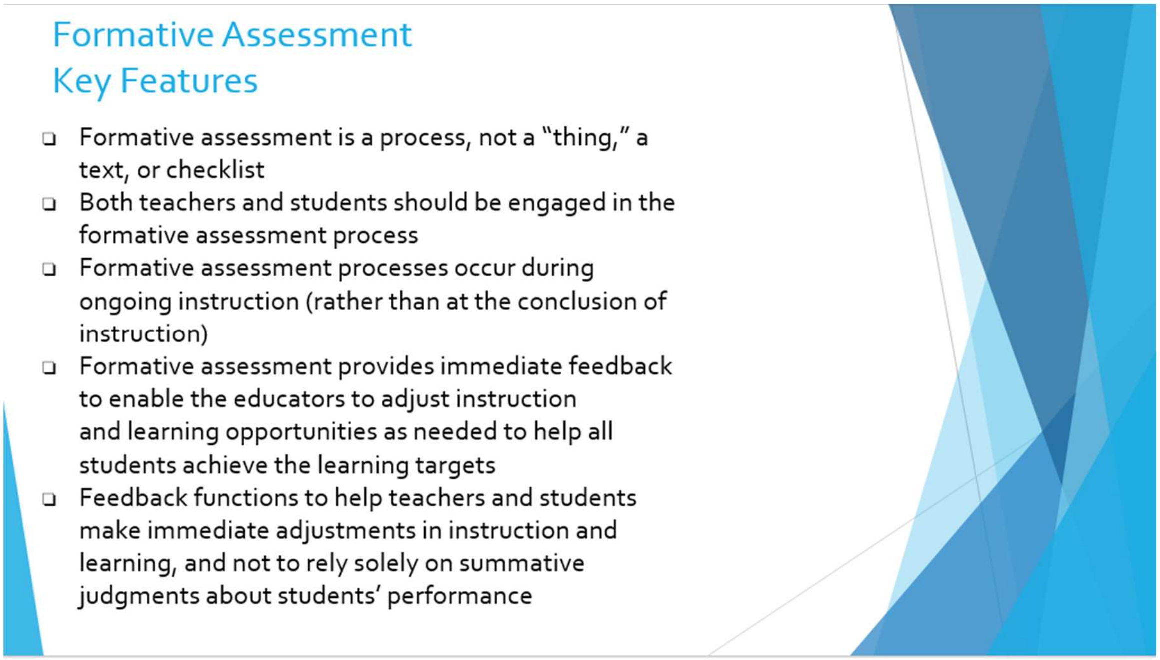


Slide 53




The formative assessment theory developed by Black and Wiliam (1998a) provided the foundation for defining both formative assessment and feedback for this project study. The researchers declared that formative assessment encompasses any activity performed by a teacher or student that informs feedback to alter subsequent teaching and learning. Other researchers, however, noted some general distinctions in their definitions of formative assessments. Irving (2015) and Elmahdi et al. (2018) defined formative assessment as a planned process, designed to elicit evidence of students' learning status to guide subsequent instruction by teachers or to guide learning strategies by students. Not identifying formative assessment as a planned process, Bhagat and Spector (2017) limited formative assessment to any feedback that the teacher provides to the learning during instruction which serves to foster learner success. While there are minor distinctions in how researchers define formative assessment, a critical point of agreement is that formative assessment functions to inform subsequent instruction.

Slide 54

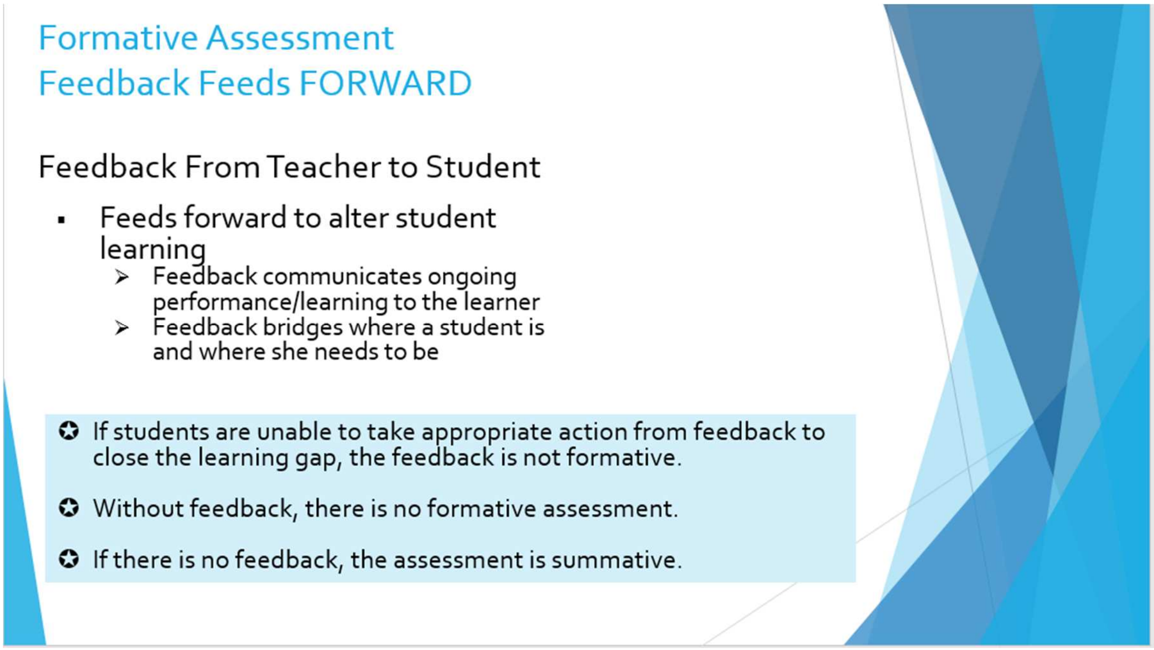



Formative assessment is a process that is, "...used by teachers and students during instruction that pro-
vides feedback to adjust ongoing teaching and learning to improve students' achievement of intended instructional outcomes" (CCSSO, 2008, p.3). The key features are that:

1. Formative assessment is a process, not a "thing," a text, or checklist;
2. Both teachers and students should be engaged in the formative assessment process;
3. Formative assessment processes occur during ongoing instruction;
4. Formative assessment provides immediate feedback to enable the educators to adjust instruction and learning opportunities as needed to help all students achieve the learning targets;
5. Feedback functions to help teachers and students make immediate adjustments in instruction and learning, and not to rely solely on summative judgments about students' performance.

(Cisterna et al., 2016)

Slide 55

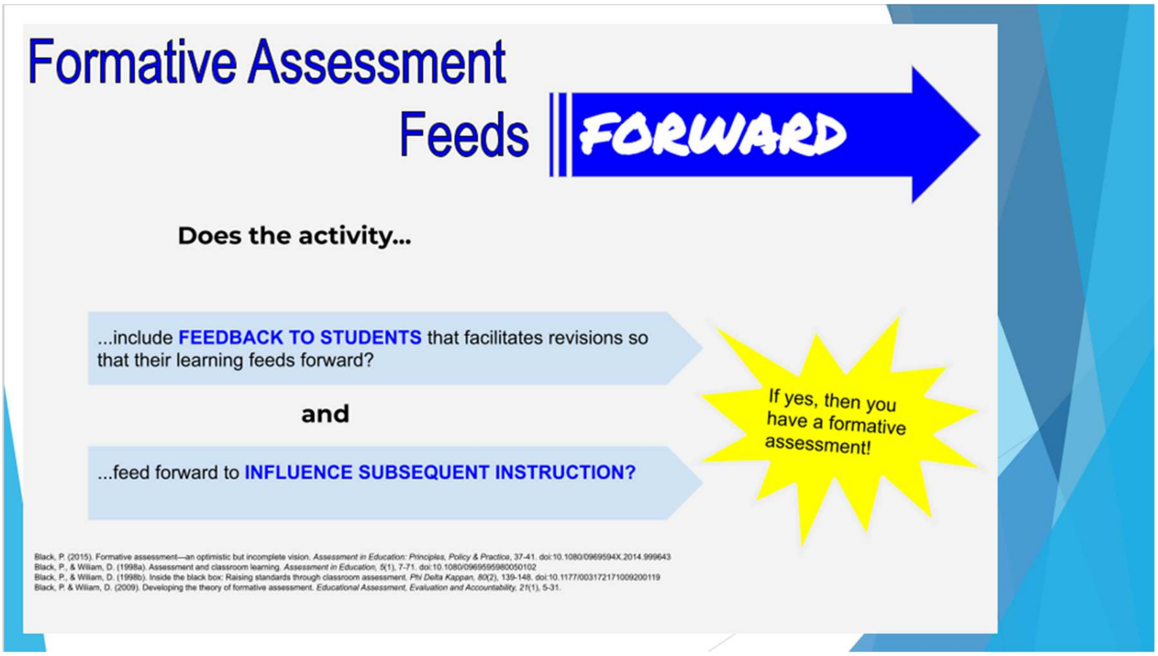



Feedback is viewed as the vehicle to inform subsequent instruction. Formative feedback is considered to be any information communicated to the learner about an ongoing performance intended to bridge the level of learning required by the task (Black & Wiliam, 1998a, 1998b, 2009; Shute, 2008). In their seminal work on feedback, Sadler (1989) testified that feedback is the bridge between where a student is in her learning and where she needs to be.

Sadler warned, however, that if students are unable to take appropriate action from feedback to close the learning gap, the formative feedback loop to facilitate learning will not be closed. As formative assessment and the subsequent feedback are designed to inform adjustments to teaching and learning, the concepts of formative assessment and feedback are inextricably linked. Without feedback, there is no formative assessment (Black & Wiliam, 1998a).

If there is no feedback, then it’s a SUMMATIVE assessment

Slide 56

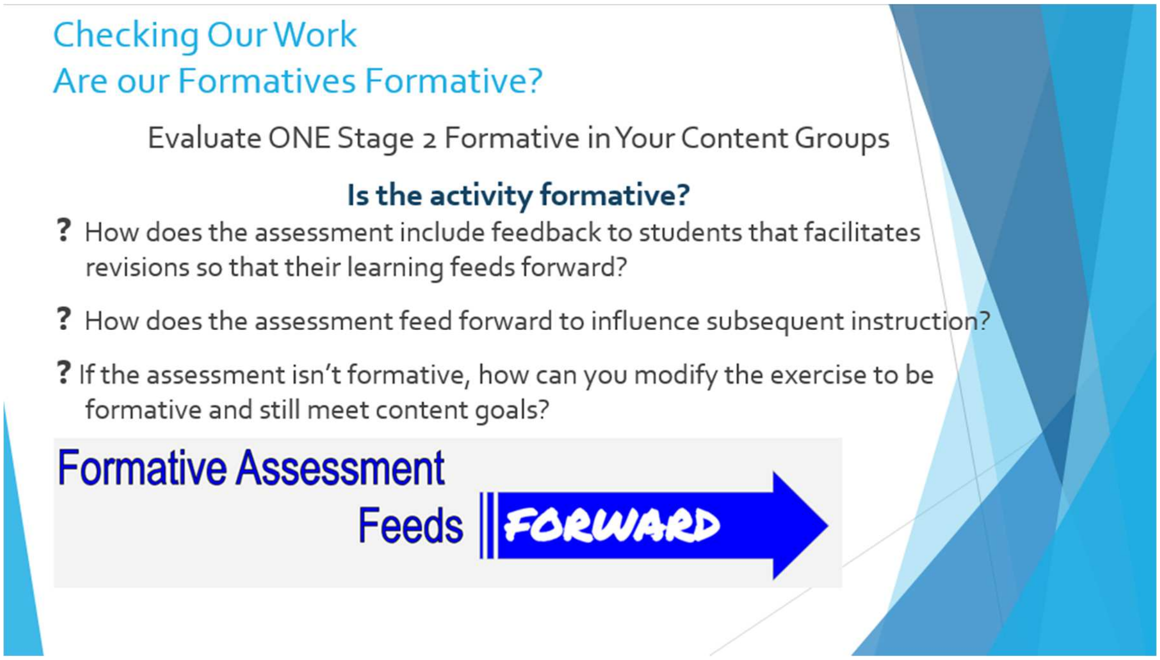



This graphic summarizes how formative assessments feed FORWARD into student learning and can be used as a quick guide for teachers to assess whether their activity is truly a formative assessment.

Slide 57


Stage 2 Planning - Where are we now?
Are Our Formatives Formative?

Slide 58




Given the definition of formative assessments, we sometimes find that activities we were engaging our students with aren't necessarily formative. Using the previous graphic can help us do a quick formative assessment of our formative assessments! Let's spend a few minutes doing just that!

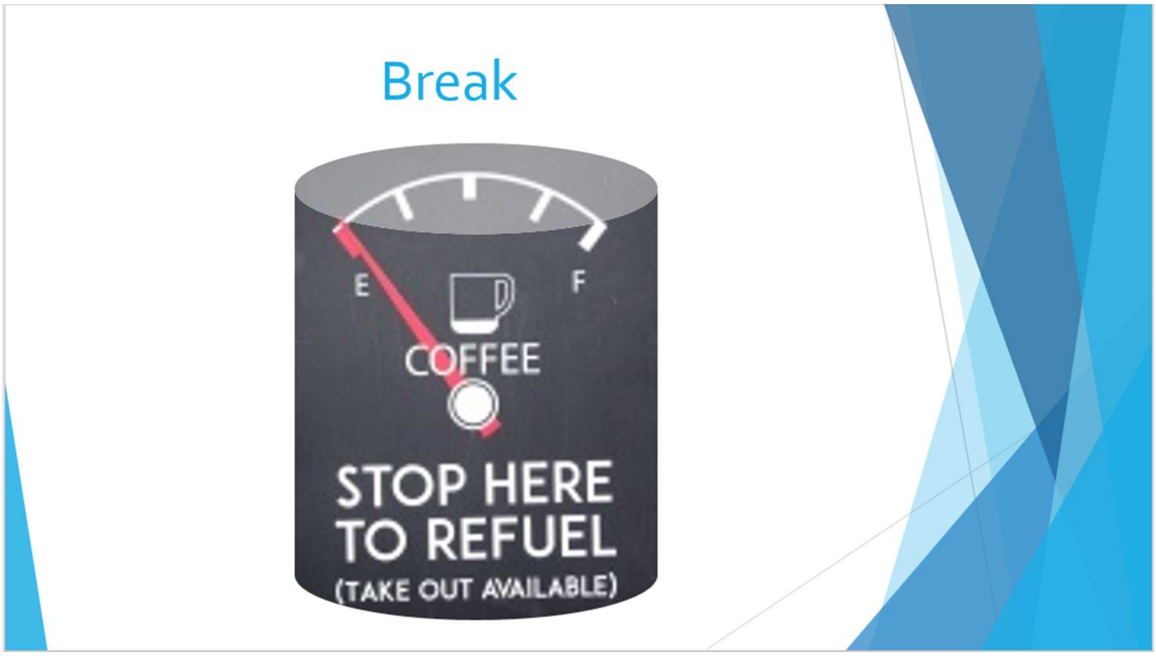
Access the work that your group did on Stage 2 yesterday. In your groups, assess ONE formative assessment by discussing the two questions that are "checked" on the slide. You can also use the graphic in the previous slide as a guide.

If your assessment isn't formative, modify the exercise to make it formative while still meeting content goals. Make these alterations on your Stage 2 document (shown on next slide as a reminder).

Slide 59

| Stage 2 - Where are we now? | | | |
|---|---|---|---|
| **Formative Assessments**<br>Name of/Link to activity | **Description**<br>Briefly describe the formative assessment | **Content**<br>Standard/Competency/<br>Essential Questions/Understandings | **Technology Options**<br>What tool(s) will be used to facilitate the formative assessment? |
| | | | |
| | | | |
| | | | |
| | | | |

Slide 60



Slide 61


Stage 2 Planning - Where are we now?
Are Our Formatives Formative?

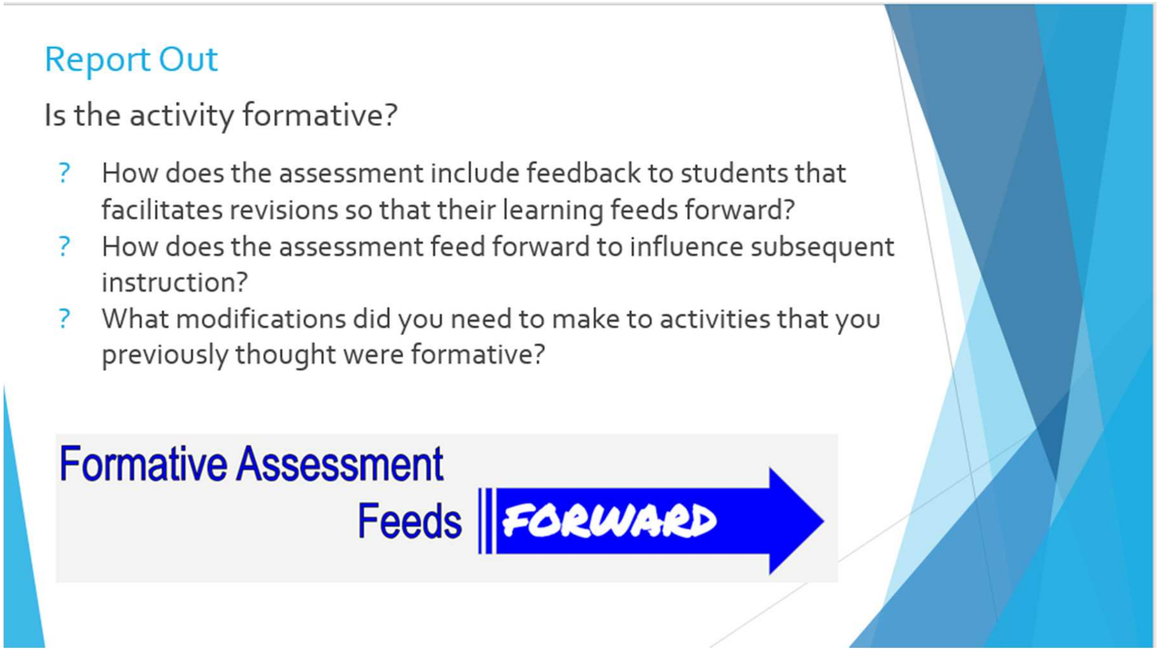
Slide 62


Access the work that your group did on Stage 2 yesterday. In your groups, assess the rest of the formative assessments in your unit by discussing the two questions that are "checked" on the slide. You can also use the "Formative Assessment Feeds Forward" graphic as a guide.

If your assessment isn't formative, modify the exercise to make it formative while still meeting content goals. Make these alterations on your Stage 2 planning document.

Slide 63

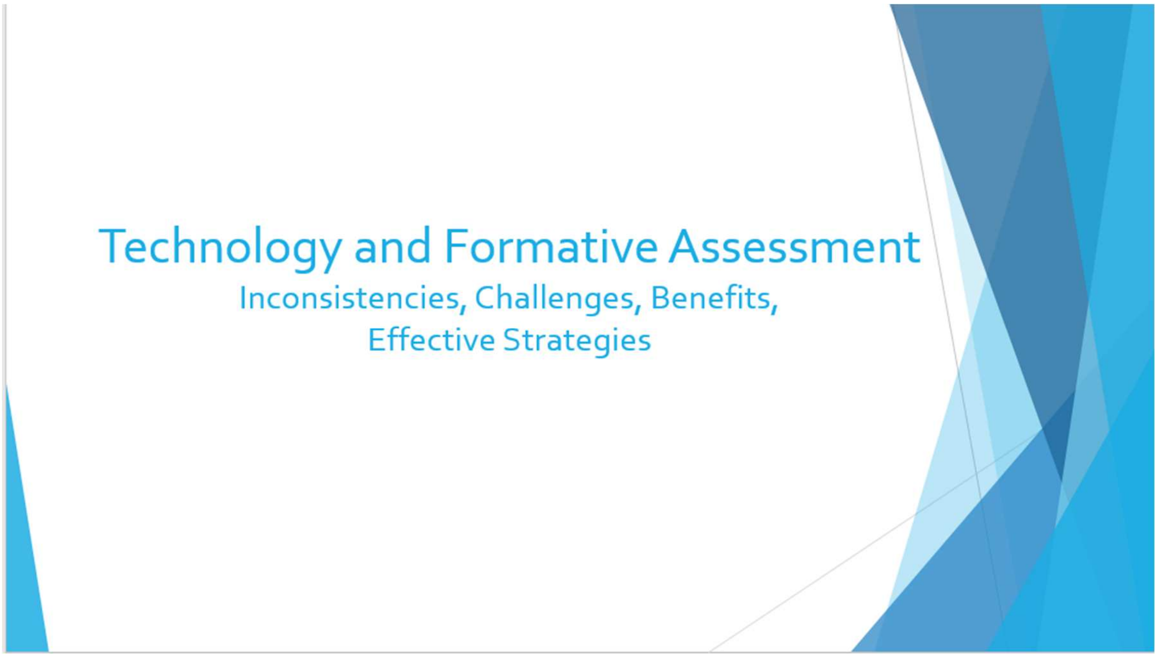
Slide 64



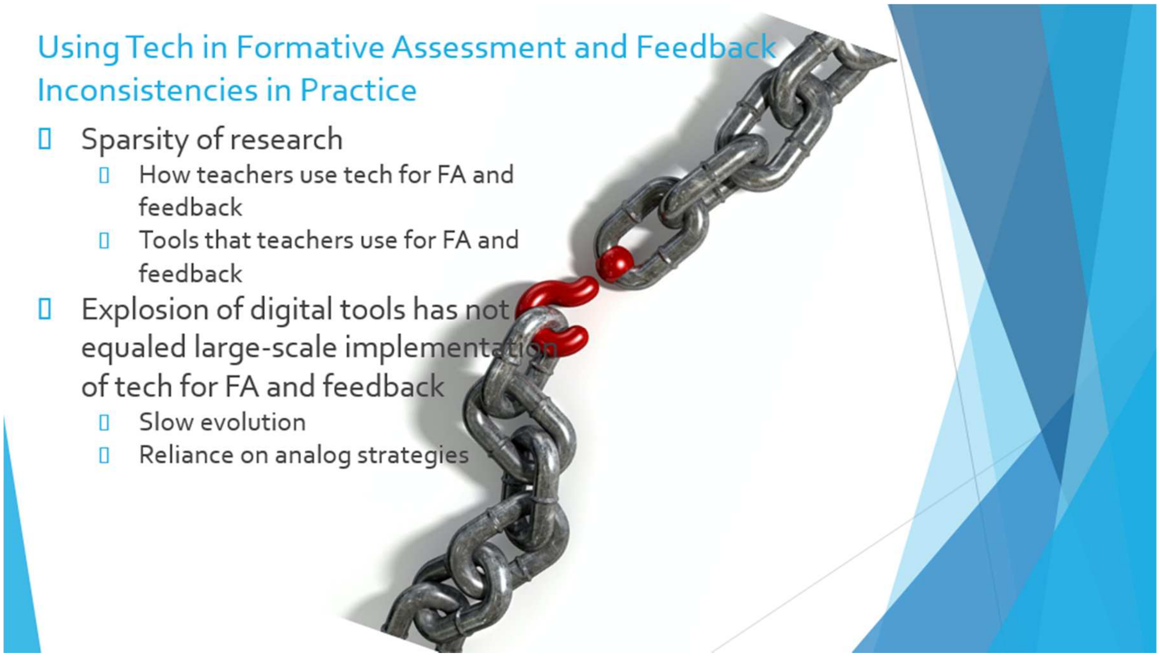

[PD participants report out their assessment of their formative assessment so that other groups can hear/see varying thought processes and strategies]
[Groups provide feedback regarding whether formatives are formative}

Slide 65

Slide 66


Technology and Formative Assessment
Inconsistencies, Challenges, Benefits,
Effective Strategies

Slide 67

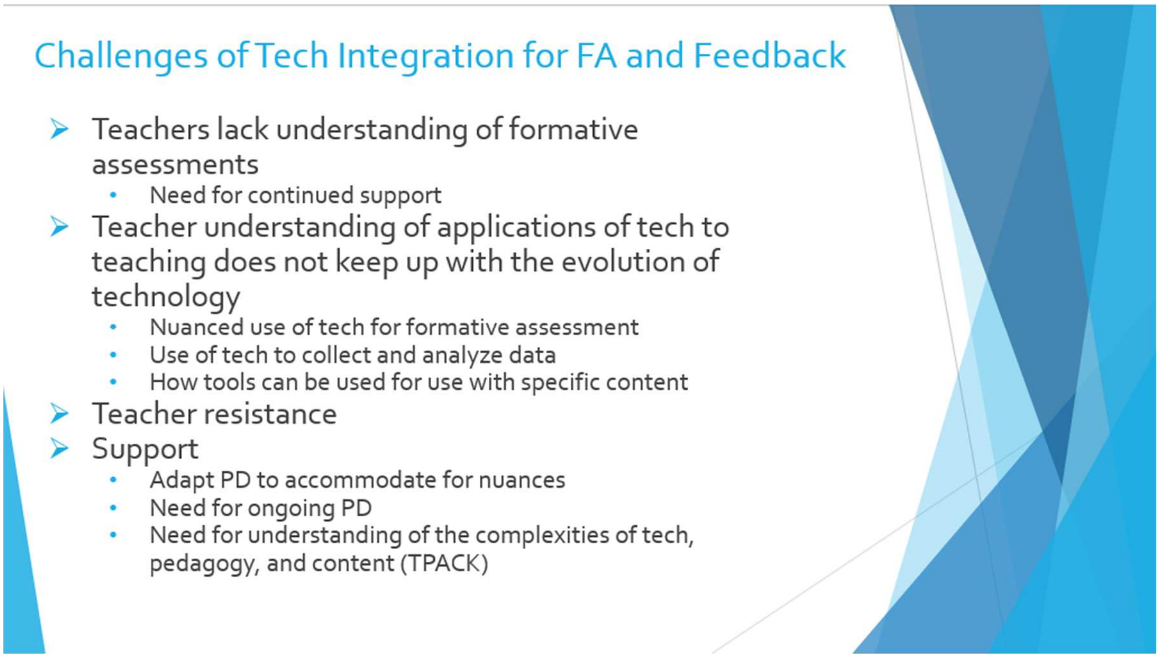



Formative assessment alignment and creation can be a bit tricky. Adding technology to the mix can make it a bit trickier. This is not unique to us here in this district!

While teacher integration of technology in education has proven to be an inconsistent endeavor for teachers, researchers have also found this inconsistency in digital tool integration to facilitate formative assessment and use the resulting feedback to inform subsequent instruction (Bhagat & Spector, 2017; Mohamadi, 2018; Spector et al., 2016; Zhan & So, 2017). This is a gap that exists both in research and in practice. As to the gap in research, Zhan and So (2017) testified that little is known of how teachers view and experience digital formative assessment in the classroom. The sparsity of research that does exist rarely targeted how technology was used by teachers to support their facilitation of formative assessment and feedback (Zhan & So, 2017). Mohamadi (2018) concurred by observing a lack of research that outlines how ICT has been integrated into the classroom to advance assessment. In a review of earlier research, Bhagat and Spector (2017) found that the recent explosion of digital tools in the educational arena had not translated into any large-scale implementation of digital tool integration to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. On the contrary, much of the technology integration was used by students to simply access learning resources (Bhagat & Spector, 2017). Bhagat and Spector testified that formative assessment has been largely neglected and despite the potential power of using digital tools to facilitate formative assessment, little evidence

exists to support the occurrence. Also lacking in the body of research are explorations of strategies used by teachers to provide instructional feedback as a result of digital formative assessments (Spector et al., 2016).
Although referring specifically to higher education, Sweeney et al. (2017) pointed to the existing gap in teacher practice. Despite the ready availability of technology-enhanced assessments (TEAs) in higher education settings, the shift to digital formative assessment and feedback methods has been slow to evolve (Sweeney et al., 2017). The findings of Faber et al. (2017) aligned with Sweeney et al. despite being conducted in a grade three classroom. Faber et al. testified that teachers do not primarily use digital tools to improve their instructional activities, thereby limiting the knowledge of the contributions possible from formative assessment activities conducted by digital means. Maier et al. (2016) found that inconsistent digital tool integration is also prevalent in secondary classrooms, where commonly applicable technology is available but not widely applied. A study conducted by Hooley and Thorpe (2017) in a high school government class found that activities used to formatively assess reading comprehension progress are largely conducted using analog strategies. Bugaj and Poss (2016) also noted the same reliance on analog strategies when teachers and specialists work with students with disabilities. The potential capacity of digital tools to operationalize student learning data to enhance student learning remains elusive (Luckin et al., 2017). Consequently, a problem of inconsistent digital tool integration by teachers to facilitate formative assessment and use the resulting feedback to inform subsequent instruction has been identified.

Slide 68




As you likely already know, it can be challenging to integrate technology in general, and specifically it can be difficult to integrate technology when facilitating formative assessments. Again, this is not an issue that is unique to us. The challenges are outlined clearly in the literature:

Teachers face significant challenges to integrate digital tools to facilitate formative assessment and use the resulting feedback to inform subsequent instruction. Black and Wiliam (1998a) argued that formative assessments were not well understood by teachers, resulting in weak practice. Black (2015) stressed a need for the continued support of teachers from both practitioners and researchers to assist in developing formative assessment practices. More current research indicated that a lack of basic understanding, as well as a need for continued supports, existed relative to digital formative assessments and feedback.
Teacher understanding of the myriad of ways that digitals tools can be used to collect and analyze data has failed to evolve as quickly as technology has (Bugaj & Poss, 2016; De Witte et al., 2015). Sweeney et al. (2017) found that teachers simply did not understand the nuances of technology and how the tools could be applied to positively affect teaching and learning. Lost in the nuance were the benefits and the full potential possible when using technology to facilitate formative assessments and use the resulting feedback to inform subsequent instruction (Sweeney et al., 2017). Even as technology quickly moved into the educational arena, researchers found that teachers continued to be resistant to

integrating technology (Barana & Marchisio, 2016; Elmahdi et al., 2018). Reasons for this reluctance included perceived limitations in the ability to use the technology, skepticism as to the efficacy of the technology, and inadequate professional development (Soto & Ambrose, 2016).

As technologies to facilitate formative assessment continued to emerge and become more powerful, the need for adapting professional development for educators to accommodate the changes may be necessary (Spector et al., 2016). Barana and Marchisio (2016) noted that most teachers were the recipients of “traditional” education and therefore lacked not only the confidence but the suitable training to integrate technology effectively. Shifting the paradigm from analog to digital formative assessments may require practice and training in the form of professional development (Bugaj & Poss, 2016; Zhan & So, 2017). Romero-Martín et al. (2017) reflected that this change in teaching and learning, like other changes before it, required a significant commitment to “proper training and professional development” (p. 65). The researchers echoed Spector et al. (2016) in calling for ongoing professional development opportunities to operationalize these emerging technologies to “scale up and achieve sustained success” (Romero-Martín et al., 2017, p. 65). Professional development was identified as a research recommended strategy to help overcome the challenges faced by teachers to use digital tools to facilitate formative assessment and use the resulting feedback to inform instruction.

Successful integration of technology in practice required teachers to understand the complexities of technology, content, and pedagogy, both in isolation and in relationship to one another (Mishra & Koehler, 2006). This TPACK knowledge results from “teachers’ concurrent and interdependent understanding of content, general pedagogy, technology, and learning contexts” (Harris & Hofer, 2011, p. 212) and was informed by the intersections of four knowledge types: pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPACK). There were challenges to integrating technology that related to each of the four knowledge types.

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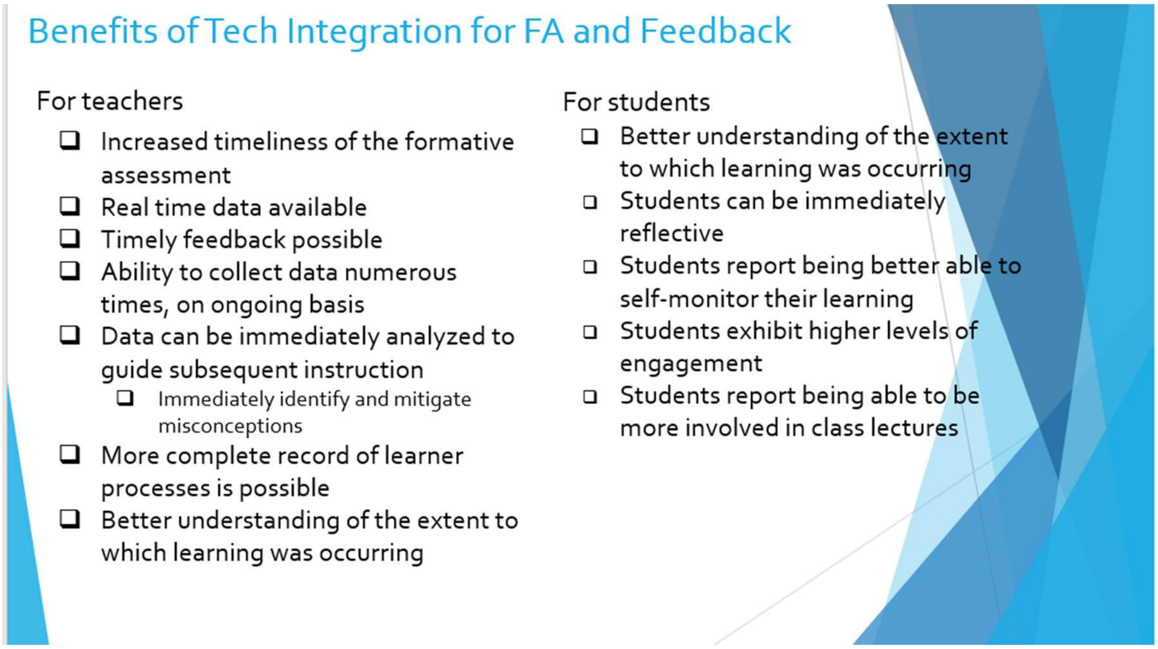



The benefits of using technology when conducting formative assessments and providing feedback are numerous and are supported by a treasure trove of literature:

There is significant research that supports that formative assessment and feedback can be beneficial when applied in the classroom. These benefits have been demonstrated both in terms of conceptual understanding as well as in established learning gains demonstrated through student achievement measures. Digitizing the formative assessment and feedback loop amplifies the possibilities for beneficial application in classroom settings by increasing the timeliness in which these processes can occur and the real-time data that can be procured. In a synthesis of digital formative assessment literature, Spector et al. (2016) emphasized that the influx of technology in the field of education has placed an even greater emphasis on formative assessments. The researchers noted that as reliance on technology has increased, so has the need for timely feedback. The need for meaningful and timely feedback that is necessary for effective formative assessments is not conceivable without using technology (Spector et al., 2016). Spector et al. specifically identified the tremendous benefit that can result from the data that is collected and aggregated by digital formative assessment tools. Conducting formative assessments using technology allows teachers to facilitate numerous and ongoing data collection aimed at understanding how student learning is progressing. The data generated can subsequently be used to make adjustments tailored to differentiated student needs (Spector et al., 2016).

Barana and Marchisio (2016) echoed the overarching benefits of digital formative assessments found by Spector et al. (2016). In developing an educational model for automating formative assessment, the researchers stressed the advantage of meaningful and timely feedback. Barana and Marchisio also emphasized that the immediate availability of data when automating formative assessments fosters immediate feedback and adaptivity to inform future improvements for both teachers and students. In promoting the use of technology for administering formative assessments, Bhagat and Spector (2017) also recognized the potential advantages of increasing the use of technology to conduct digital formative assessments. Like Barana and Marchisio (2016), Bhagat and Spector (2017) noted the potential time savings in automating formative assessment processes rather than performing manual corrections. Additionally, Bhagat and Spector (2017) viewed digital formative assessments as a means to aid complex problem-solving tasks, providing a more complete record of the learner processes.

Several studies relating to using digital tools to facilitate formative assessment and use the resulting feedback to inform subsequent instruction focused on specific digital tools and their implementation. While touting technological advancements as supportive to formative assessment practices, Irving et al. (2016) emphasized potential benefits in using connected classroom technology (CCT). Irving et al. (2016) saw CCTs as critical to the formative assessment process, specifically in terms of the assistance these technologies can provide to the feedback process. Likewise, Varier et al. (2017) echoed the benefits of CCT in their qualitative research that examined the integration of one-to-one technological devices in a large mid-Atlantic school district. In this study, teachers and students in elementary, middle, and high school attributed increased opportunities to give and receive feedback to the presence of the technological device (Varier et al., 2017). Such modern technologies supported immediate electronic response capabilities, providing teachers with increased and enhanced opportunities to provide feedback throughout the learning process (Varier et al., 2017) and allowing for teachers and students to make classroom decisions based on timely feedback (Irving et al., 2016). Based on the results of their longitudinal study in a national trial of Algebra 1 students and teachers, Irving et al. (2016) posited that classrooms facilitated with CCT and the immediate feedback loop made possible in this technological environment fostered positive effects on student achievement. Similarly, Shirley and Irving (2015) explored the experiences of four middle and high school science teachers, focusing on their integration of connected classroom technology (CCT) as a strategy to facilitate effective formative assessments. The researchers found that CCT facilitated instructional tasks helped both teachers and students better understand the extent to which learning was occurring and subsequently influenced ongoing instructional decision-making (Shirley & Irving, 2015). The use of connected classroom technology provided teachers with timely and accurate learning data. Basing subsequent instructional decisions on timely and accurate data improved the formative feedback loop (Varier et al., 2017) and benefited the teaching and learning process (Irving et al., 2016; Shirley & Irving, 2015).

Student response systems (SRS) or clicker systems are also becoming more prevalent in classroom settings thanks to advances in technology. Fuller and Dawson (2017) examined how an integration specialist helped district middle school teachers combine literature-based strategies and SRS technology to perform digital formative assessments, then adjust subsequent instruction. Through this examination, the researchers found benefits for both teachers and students (Fuller & Dawson, 2017). Using the SRS technology, teachers were able to collect data, monitor student progress, and make adjustments during the learning process, while students were reflective and exhibited engaged behavior (Fuller & Dawson, 2017).

Research conducted using SRSs as a means of facilitating formative assessment during classroom lectures has also shown to be beneficial for both teachers and students. During instructional delivery in a one-to-one Chromebook environment, teachers reported that the availability of a technological device increased and enhanced opportunities for feedback (Varier et al., 2017). Teachers also testified that the immediacy of feedback enabled by the presence of technology allowed for mitigation of misconceptions or other student errors earlier in the learning process (Varier et al.). By shortening the feedback loop, instructional adjustments were possible throughout the learning process rather than waiting for the summative exam. Students reported benefits inherent in clicker-based student response systems during classroom lectures. Egelandsdal and Krumsvik (2017) found that students perceived an increased ability to self-monitor their learning. Students also expressed that they were more aware of their level of understanding and on what they should focus on to further their learning (Egelandsdal & Krumsvik). Likewise, Yilmaz (2017) found that the use of a clicker system was effective in supporting immediate feedback to students while assisting them in ongoing self-assessment and self-regulation. Students testified that the immediate feedback helped them to see their level of accuracy and to compare it to others in the course (Yilmaz). Additionally, students reported higher levels of engagement and the ability to more clearly identify misconceptions they had relating to the course material (Yilmaz). Dobbins and Denton (2017) echoed the use of mobile technology in lectures to facilitate engagement. Students found the student response system Textwall™ enabled them to become more involved in-class lectures and encouraged a level of comfort to communicate not present absent the technology (Dobbins & Denton, 2017). Student response systems provided significant benefits to both teachers and students in facilitating formative assessment and using the resulting feedback to inform subsequent instruction.

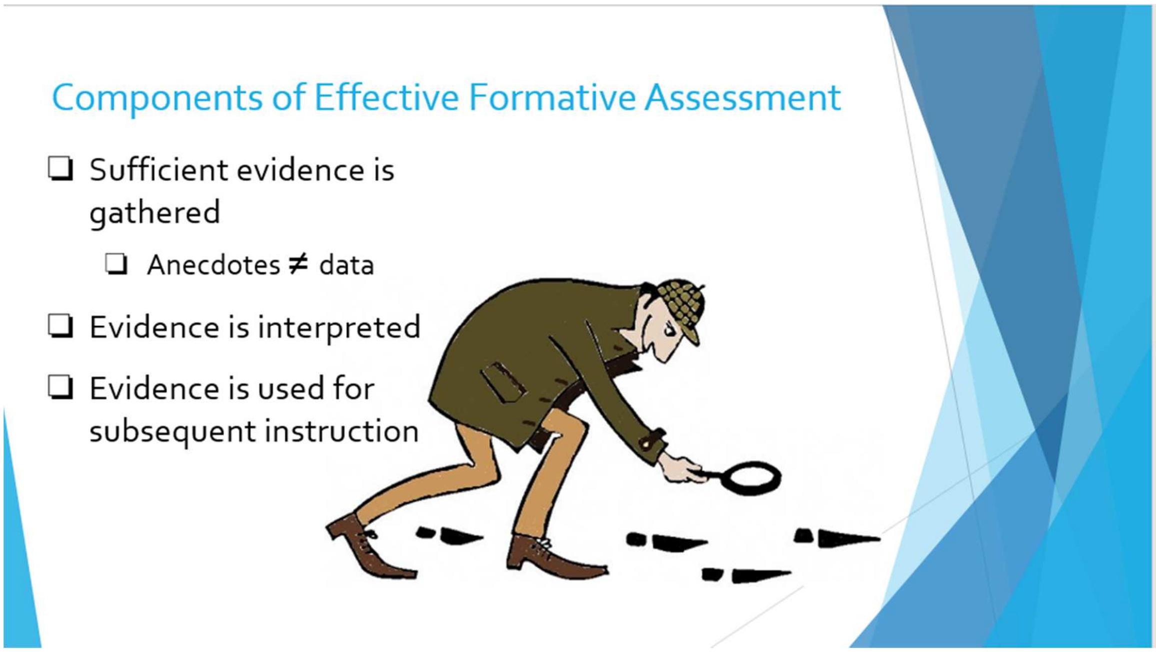
Slide 70


The benefits of formative assessment and feedback are well documented. We also know that there are effective strategies when conducting formative assessments and giving feedback.

Feedback should be timely, giving the students an opportunity to revise and make adjustments given your feedback.
Feedback should be ongoing and continuous, occurring throughout the learning process.
Feedback should be directly related to the competency/standard/essential questions/understandings that are being addressed in the content. Saying “good job” is nice but it is NOT feedback. Giving a check mark is nice, but it is NOT feedback.

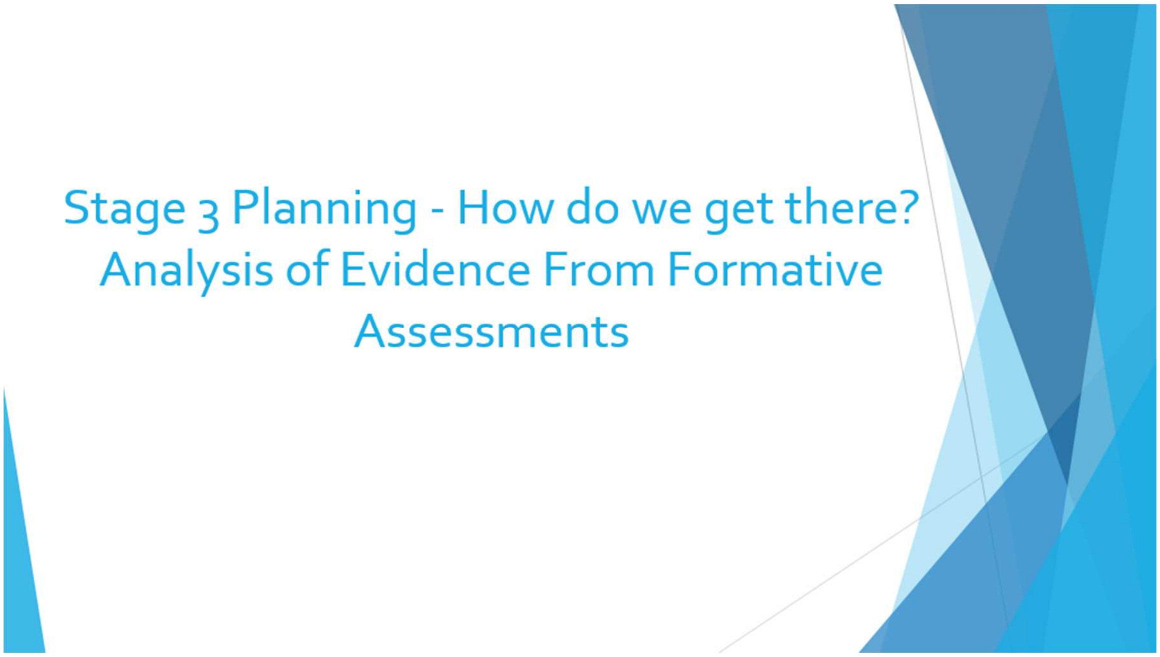
(Black & William, 1998; Black & William, 2006; Black & William, 2009; Clark, 2012)

Slide 71

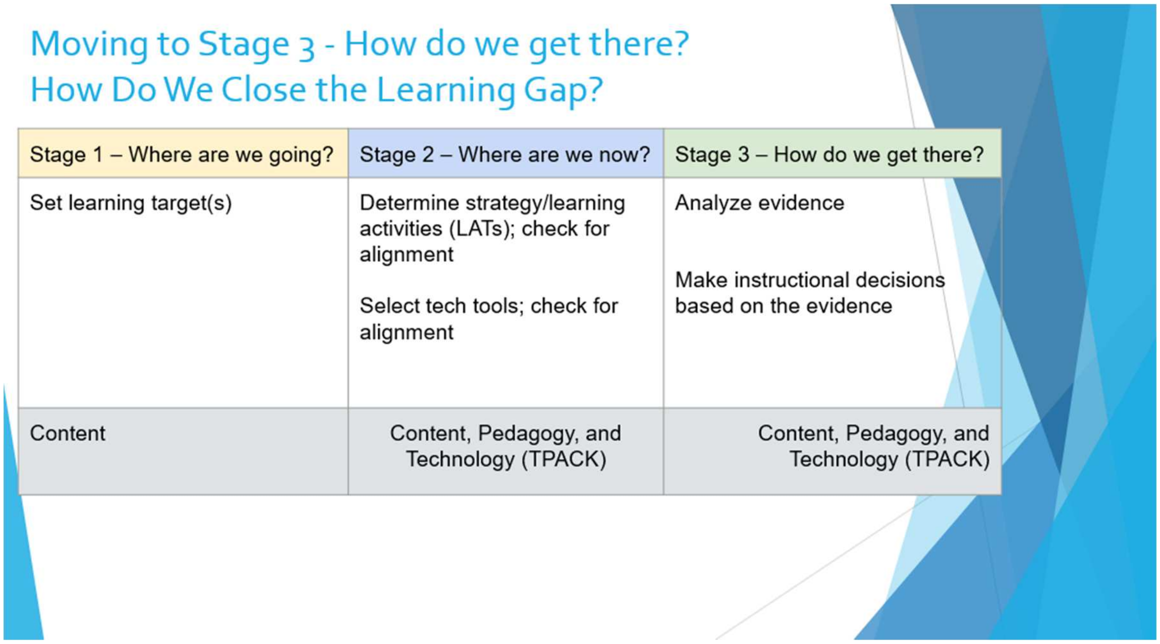



The benefits of formative assessment and feedback are well documented. We also know, based on the literature, that there are some effective strategies that you should consider when conducting formative assessments and giving feedback. In terms of the assessment itself, consider:
Are you gathering sufficient evidence to gauge student learning?  Anecdotes do not equal data?
Are you interpreting the evidence that you are gathering?
Are you using the evidence that you gather to guide subsequent instruction?  If not, you're not really giving a formative assessment.
(Black & William, 1998; Black & William, 2006; Black & William, 2009; Clark, 2012)
This brings us to Stage 3 - How do we get there? (How do we close the learning gap?)

Slide 72

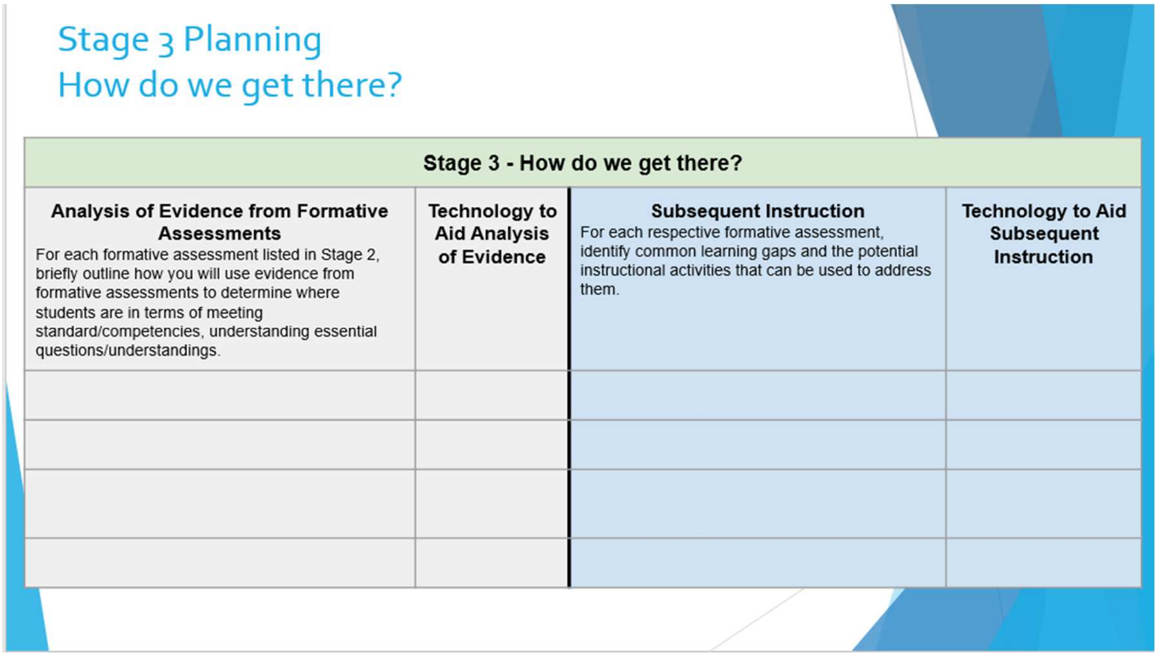

Stage 3 Planning - How do we get there?
Analysis of Evidence From Formative
Assessments

Slide 73




So far, we have moved through stages 1 and 2. [Recap our work in stage 1 and 2]
Now we are ready for the third and final stage: planning for “How do we get there?” This third stage is aimed at helping you plan for/anticipate how you will analyze the evidence gathered from the formative assessments and to plan for potential subsequent instructional decisions based on your formative assessment analysis. We are now going to focus on FEEDING THE LEARNING FORWARD!

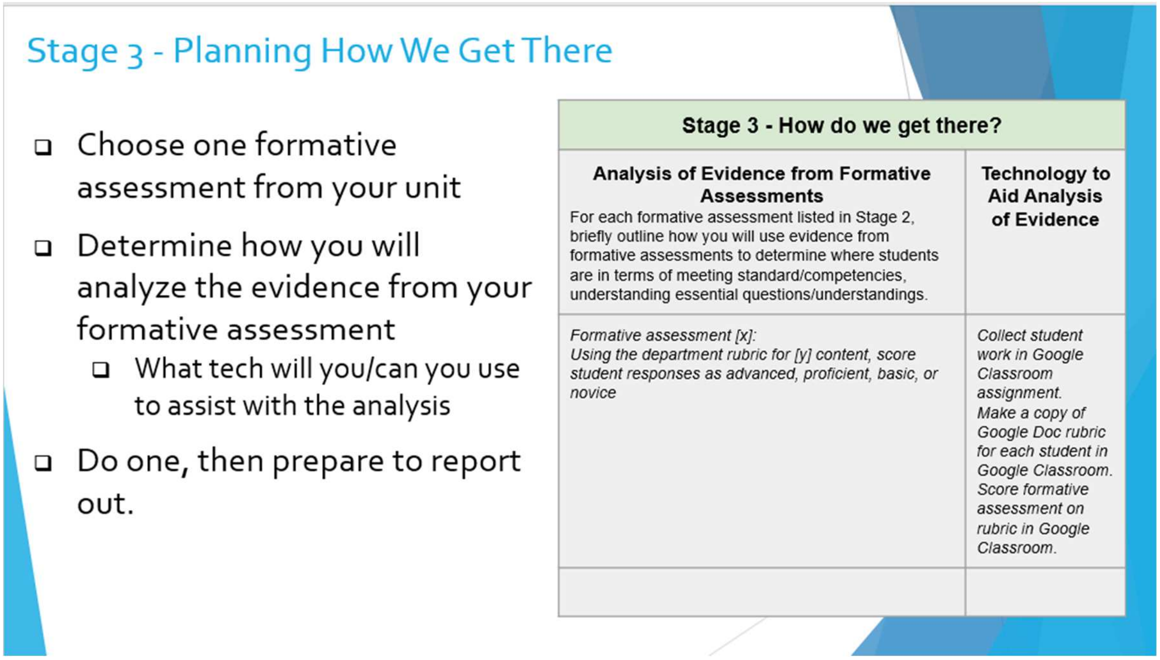
Slide 74




| Stage 3 - How do we get there? | | | |
|---|---|---|---|
| **Analysis of Evidence from Formative Assessments** For each formative assessment listed in Stage 2, briefly outline how you will use evidence from formative assessments to determine where students are in terms of meeting standard/competencies, understanding essential questions/understandings. | **Technology to Aid Analysis of Evidence** | **Subsequent Instruction** For each respective formative assessment, identify common learning gaps and the potential instructional activities that can be used to address them. | **Technology to Aid Subsequent Instruction** |
| | | | |
| | | | |
| | | | |
| | | | |

How do we get there??? We feed the learning FORWARD. In order to feed the learning forward, we have to PLAN how we will feed the learning forward. Our planning template is designed to help you consider your decision-making processes when analyzing the evidence gathered from formative assessments, in planning for possible subsequent instructional strategies, and considering technological options to assist you in these processes. Notice that in the planning template, the analysis of evidence is delineated from the planning for subsequent instruction. We will tackle these tasks in two separate pieces in order to exclusively focus on one at a time.

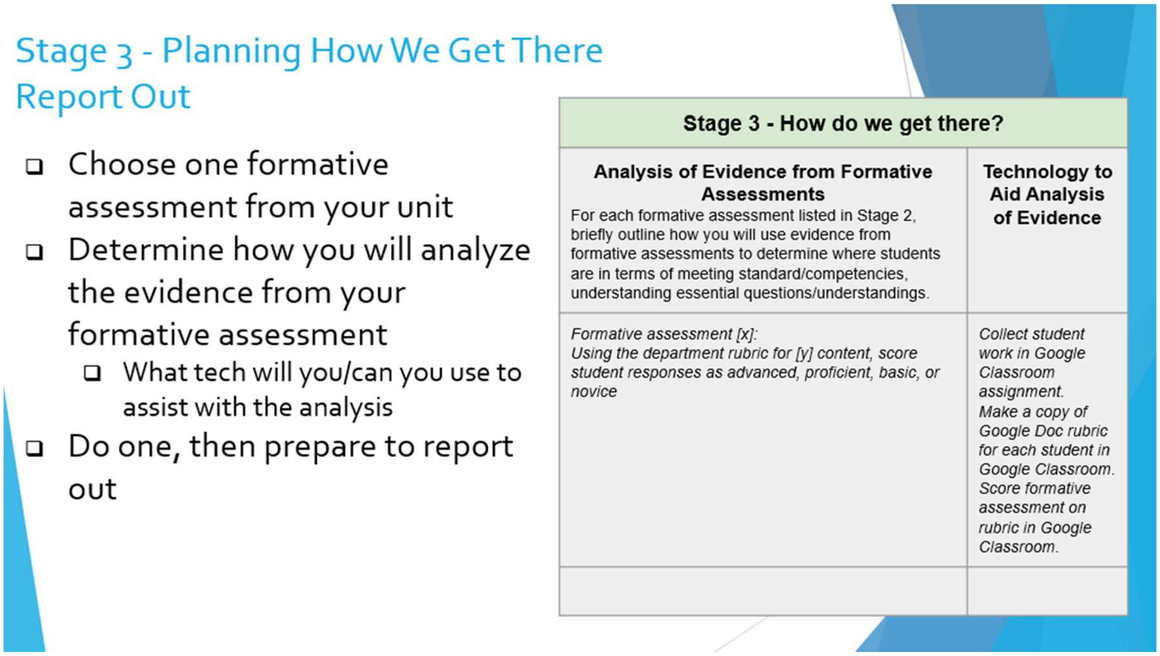
Slide 75




We are going to do Stage 3 in two planning chunks. The first planning chunk is designed to have you consider how you will analyze the evidence gathered from the formative assessments and what technologies may be able to aid you in the process. In analyzing the evidence from formative assessments, you may outline your thresholds for engaging in subsequent activities. For example, you could outline how the analysis of evidence will allow you to determine whether students are currently advanced/proficient/basic/novice. Then note which technologies can be used to aid in the analysis of the evidence.

[Walk participants through the italicized example]
You will do one of these on your own. Then, each content group will report out so that you can all benefit from the knowledge in the room.

Slide 76




PD participants report out so that other groups can hear/see varying thought processes and strategies

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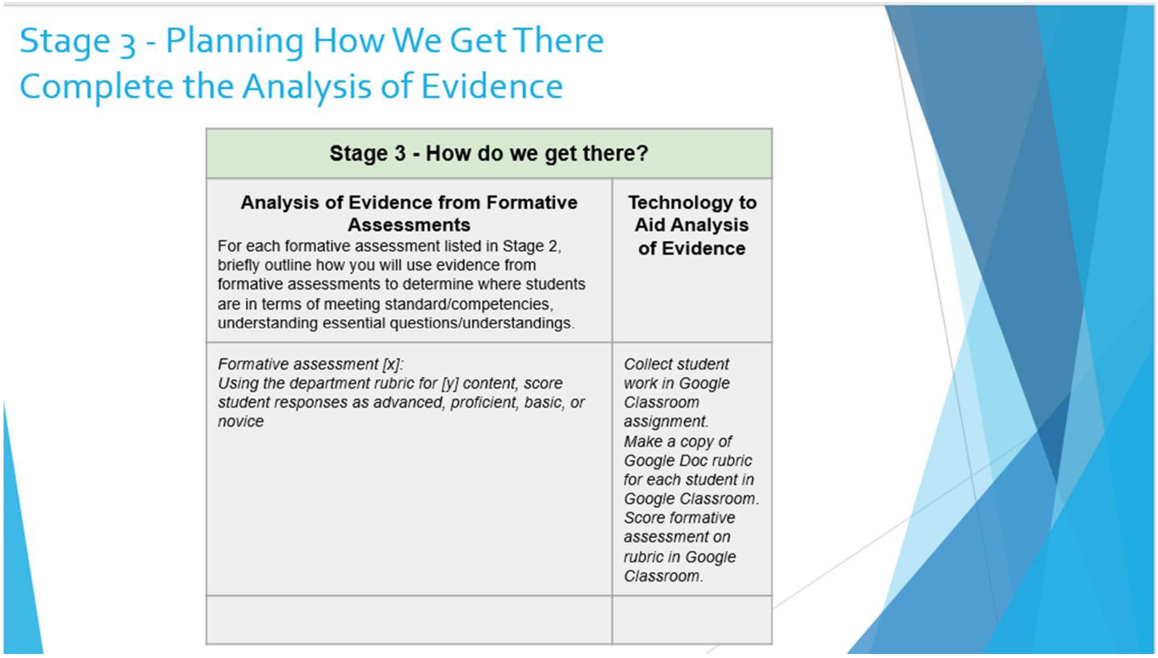
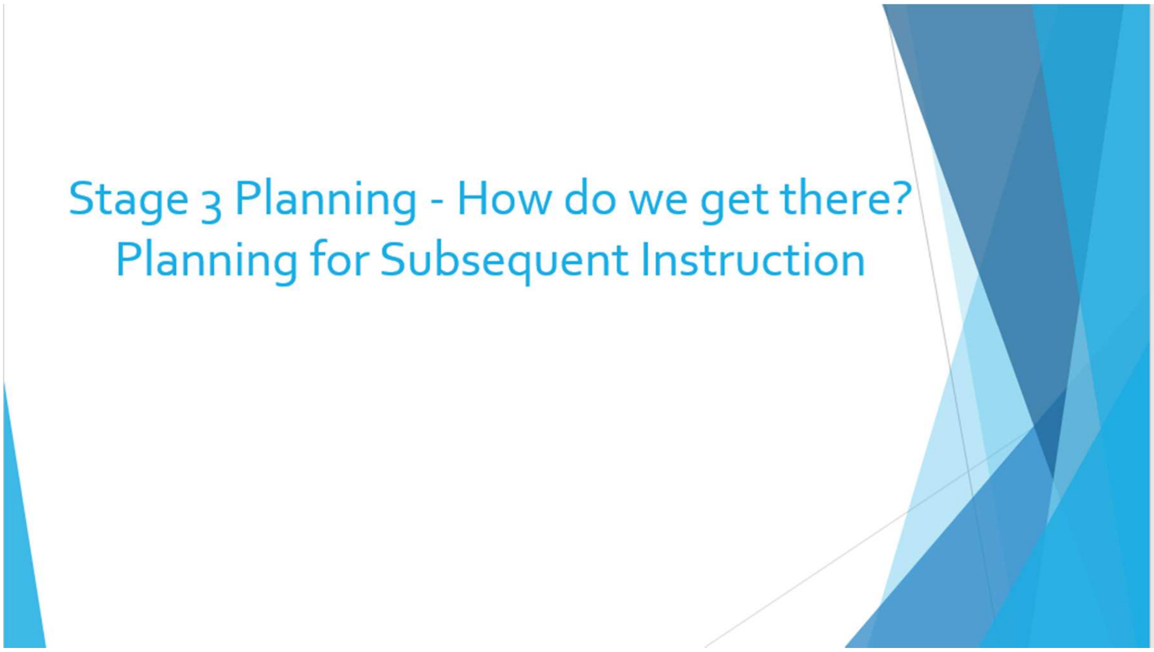



| Stage 3 - How do we get there? | |
|---|---|
| **Analysis of Evidence from Formative Assessments**<br>For each formative assessment listed in Stage 2, briefly outline how you will use evidence from formative assessments to determine where students are in terms of meeting standard/competencies, understanding essential questions/understandings. | **Technology to Aid Analysis of Evidence** |
| *Formative assessment [x]:*<br>*Using the department rubric for [y] content, score student responses as advanced, proficient, basic, or novice* | *Collect student work in Google Classroom assignment.*<br>*Make a copy of Google Doc rubric for each student in Google Classroom.*<br>*Score formative assessment on rubric in Google Classroom.* |
| | |

Complete this section of stage 3 by using the planning tool to record your analysis of evidence and technology aids for ALL of your formative assessments.

Slide 78

Slide 79


Stage 3 Planning - How do we get there?
Planning for Subsequent Instruction

Slide 80

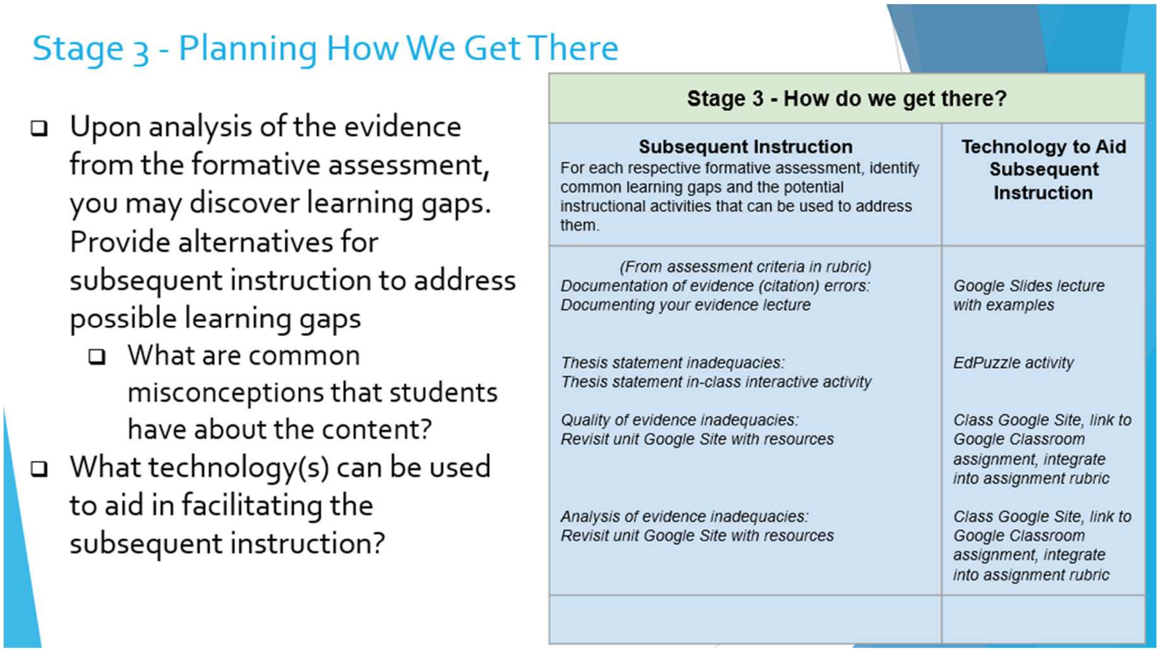
## Stage 3 - Planning How We Get There

| Stage 3 - How do we get there? | | | |
|---|---|---|---|
| **Analysis of Evidence from Formative Assessments**<br>For each formative assessment listed in Stage 2, briefly outline how you will use evidence from formative assessments to determine where students are in terms of meeting standard/competencies, understanding essential questions/understandings. | **Technology to Aid Analysis of Evidence** | **Subsequent Instruction**<br>For each respective formative assessment, identify common learning gaps and the potential instructional activities that can be used to address them. | **Technology to Aid Subsequent Instruction** |
| *Formative assessment [x]:*<br>*Using the department rubric for [y] content, score student responses as advanced, proficient, basic, or novice* | *Collect student work in Google Classroom assignment. Make a copy of Google Doc rubric for each student in Google Classroom. Score formative assessment on rubric in Google Classroom.* | *(From assessment criteria in rubric)*<br>*Documentation of evidence (citation) errors: Documenting your evidence lecture*<br><br>*Thesis statement inadequacies: Thesis statement in-class interactive activity*<br><br>*Quality of evidence inadequacies: Revisit unit Google Site with resources*<br><br>*Analysis of evidence inadequacies: Revisit unit Google Site with resources* | *Google Slides lecture with examples*<br><br>*EdPuzzle activity*<br><br>*Class Google Site, link to Google Classroom assignment, integrate into assignment rubric*<br><br>*Class Google Site, link to Google Classroom assignment, integrate into assignment rubric* |

Once you've analyzed the evidence from your formative assessments and determined which technologies can aid in the process, consider how learning gaps will be addressed in subsequent instruction. What instructional activities can you use to address the learning gaps? Consider and plan for common misconceptions that students may have about the content. Then plan for use of technologies that can be used to aid in the planned subsequent instruction. Note that we are planning for the subsequent instruction of each of our respective formative assessments.

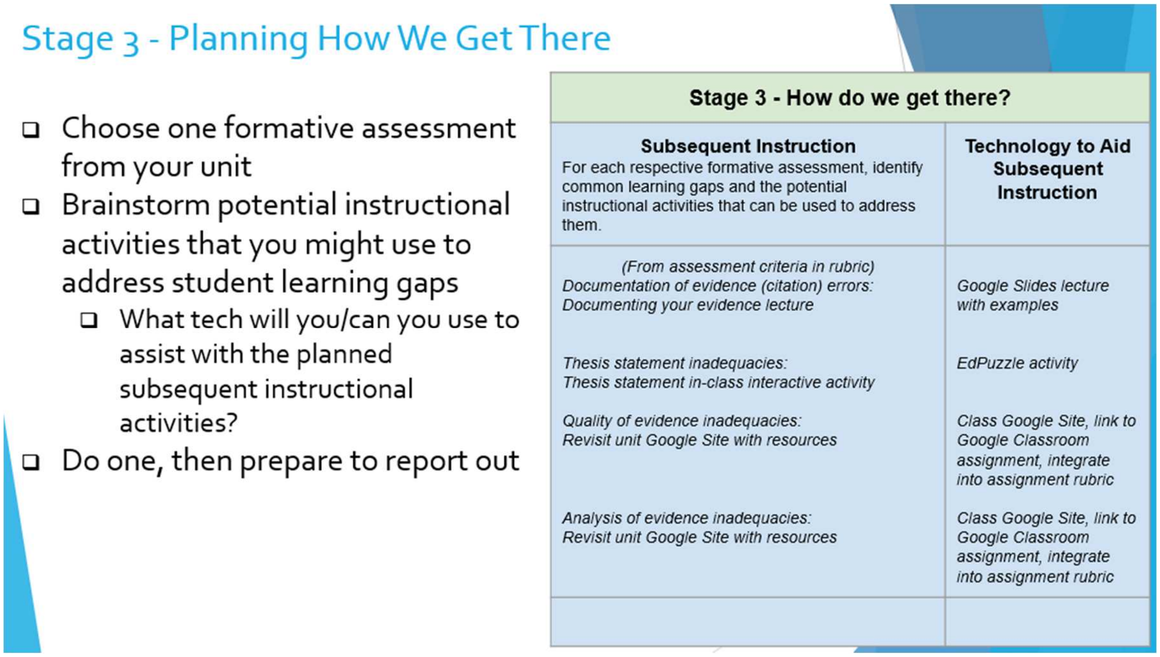
[Walk teachers through the example] [Note that we are carrying FORWARD the planning strategies from the "Analysis of Evidence" section of Stage 3]

Slide 81



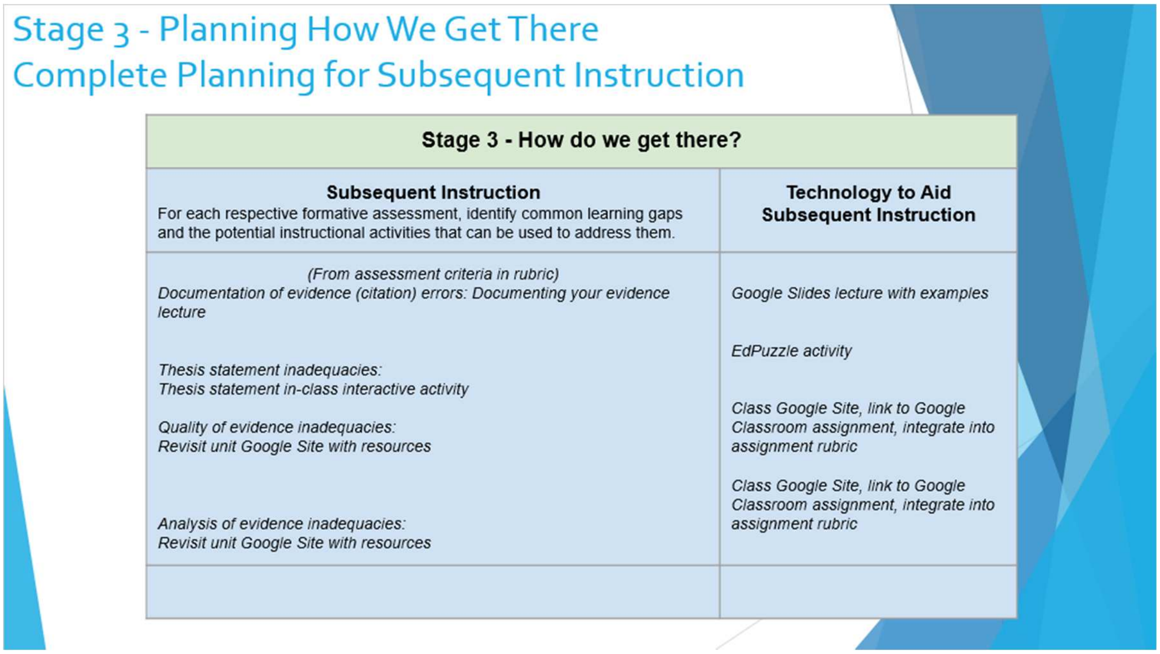

Once you've analyzed the evidence from your formative assessments and determined which technologies can aid in the process, consider how learning gaps will be addressed in subsequent instruction. What instructional activities can you use to address the learning gaps? Consider and plan for common misconceptions that students may have about the content. Then plan for use of technologies that can be used to aid in the planned subsequent instruction. Note that we are planning for the subsequent instruction of each of our respective formative assessments.
[Walk teachers through the example]

Slide 82




| Stage 3 - How do we get there? | |
|---|---|
| **Subsequent Instruction** For each respective formative assessment, identify common learning gaps and the potential instructional activities that can be used to address them. | **Technology to Aid Subsequent Instruction** |
| *(From assessment criteria in rubric)* *Documentation of evidence (citation) errors: Documenting your evidence lecture* | *Google Slides lecture with examples* |
| *Thesis statement inadequacies: Thesis statement in-class interactive activity* | *EdPuzzle activity* |
| *Quality of evidence inadequacies: Revisit unit Google Site with resources* | *Class Google Site, link to Google Classroom assignment, integrate into assignment rubric* |
| *Analysis of evidence inadequacies: Revisit unit Google Site with resources* | *Class Google Site, link to Google Classroom assignment, integrate into assignment rubric* |
| | |

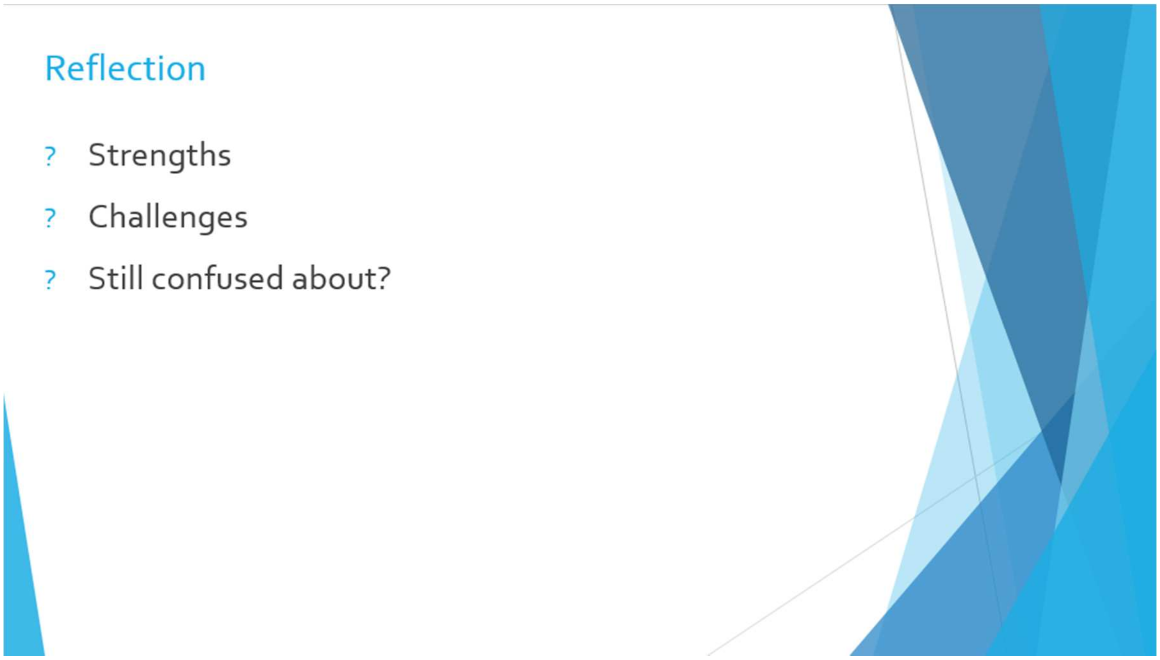
Slide 83




| Stage 3 - How do we get there? | |
|---|---|
| **Subsequent Instruction**<br>For each respective formative assessment, identify common learning gaps and the potential instructional activities that can be used to address them. | **Technology to Aid Subsequent Instruction** |
| *(From assessment criteria in rubric)*<br>*Documentation of evidence (citation) errors: Documenting your evidence lecture*<br><br>*Thesis statement inadequacies:*<br>*Thesis statement in-class interactive activity*<br><br>*Quality of evidence inadequacies:*<br>*Revisit unit Google Site with resources*<br><br>*Analysis of evidence inadequacies:*<br>*Revisit unit Google Site with resources* | *Google Slides lecture with examples*<br><br>*EdPuzzle activity*<br><br>*Class Google Site, link to Google Classroom assignment, integrate into assignment rubric*<br><br>*Class Google Site, link to Google Classroom assignment, integrate into assignment rubric* |
| | |

Complete this section of stage 3 by using the planning tool to record potential subsequent instructional activities and technology aids for each of your formative assessments.

Slide 84




[Discussion of these reflections. Formative data will be collected in the daily evaluation]

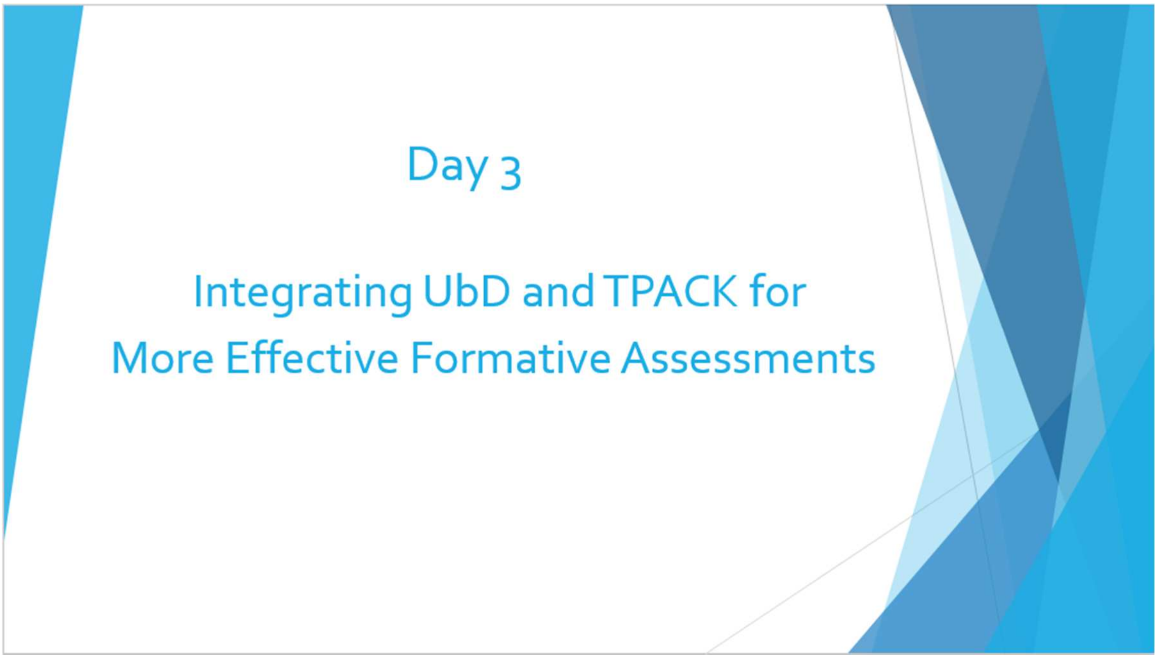
Slide 85


Thank you for all of your hard work and participation today!  I hope that you have found this PD to be a worthwhile experience that will feed forward into your practice. Please fill out the daily evaluation. This will provide your trainers with FORMATIVE FEEDBACK to be used to feed forward into our subsequent instruction!

Slide 86


Thank you for all of your hard work and participation today! I hope that you have found this PD to be a worthwhile experience that will feed forward into your practice. Please fill out the daily evaluation. This will provide your trainers with FORMATIVE FEEDBACK to be used to feed forward into our subsequent instruction!

Slide 87


Day 3
Integrating UbD and TPACK for
More Effective Formative Assessments

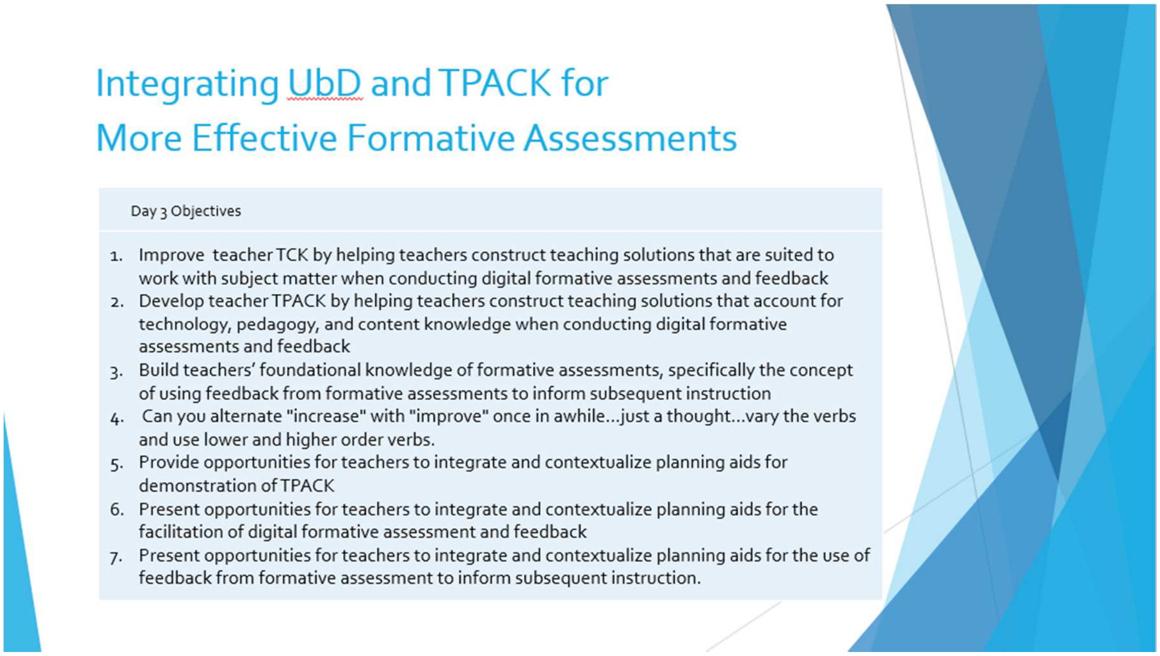
Slide 88

## Agenda

| | |
|---|---|
| 8:00-8:30 | Address Formative Feedback from Day 2<br><br>Objectives for today |
| 8:30-9:30 | Stage 1 - Where are we going?<br>Reminders and Suggestions; Use Template to Plan Unit |
| 9:30-9:45 | Break |
| 9:45-11:30 | Stage 2 - Where are we now?<br>Reminders and Suggestions; Use Template to Plan Unit |
| 11:30-12:30 | Lunch |
| 12:30-1:30 | Stage 3 - How do we get there?<br>Reminders and Suggestions; Use Template to Plan Unit |
| 1:30-1:45 | Break |
| 1:45-2:45 | Presentation of Unit Plans |
| 2:45-3:00 | Final evaluation |

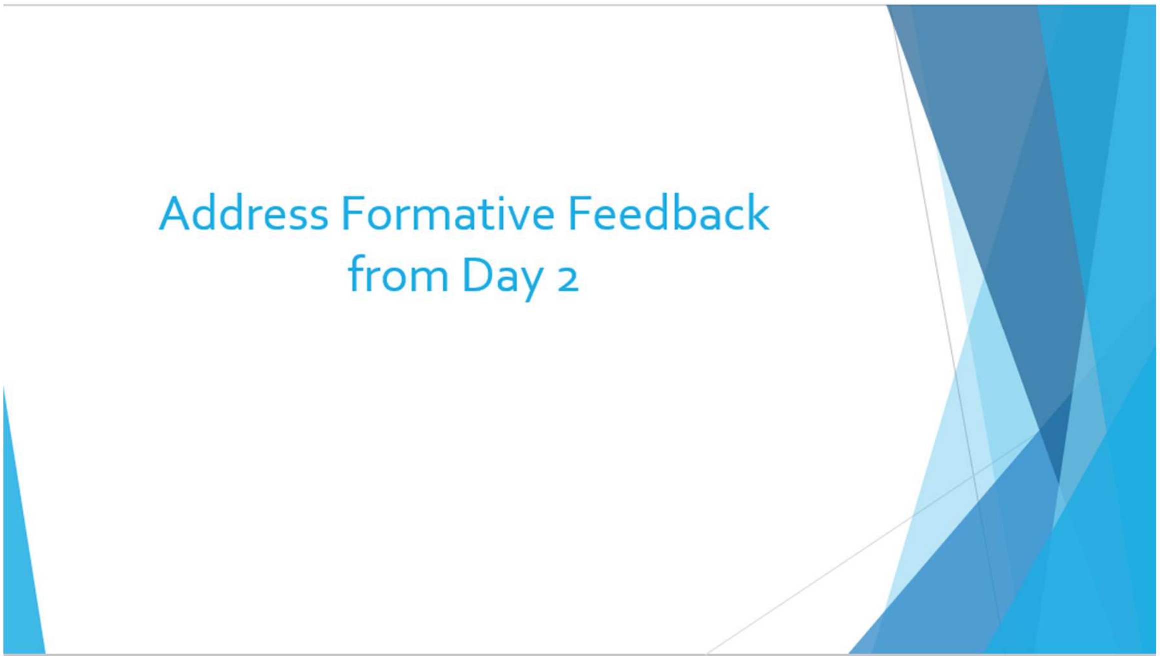
Slide 89

Slide 90




Today centers on test running the planning template on a different unit. Professional development opportunities should be active, actionable, and ongoing. By allowing you to immediately implement your learning and feed it forward to a different unit, we are attempting to employ these best practices and to give you a jumping off point when you move to using the template on your own or in your PLCs.

Slide 91



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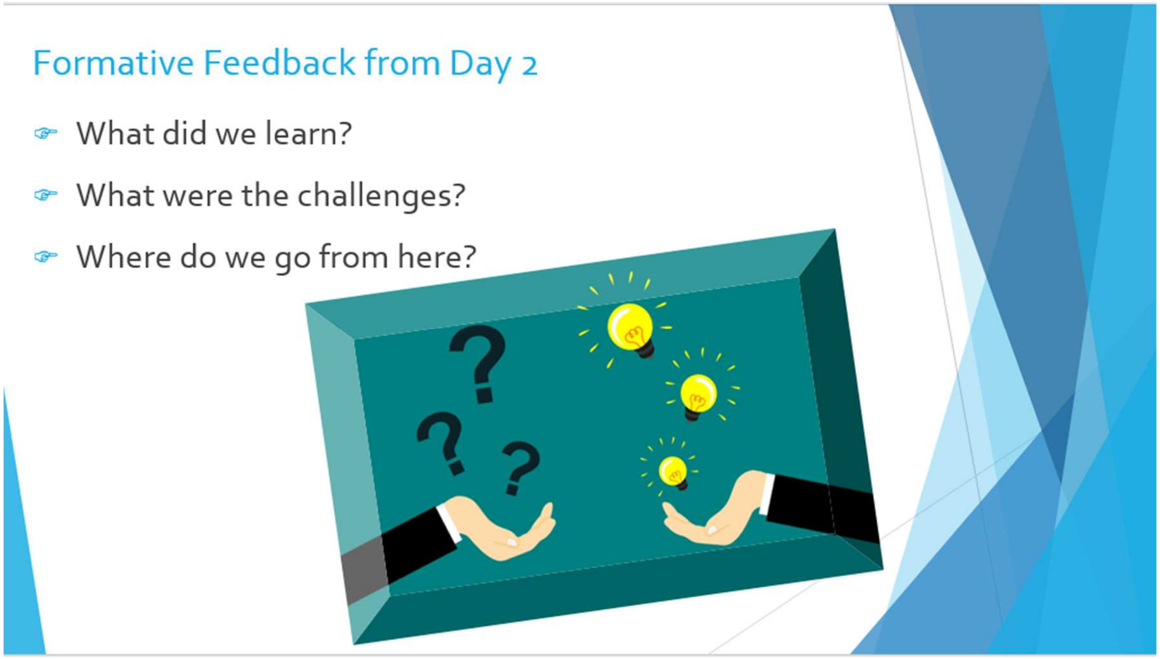
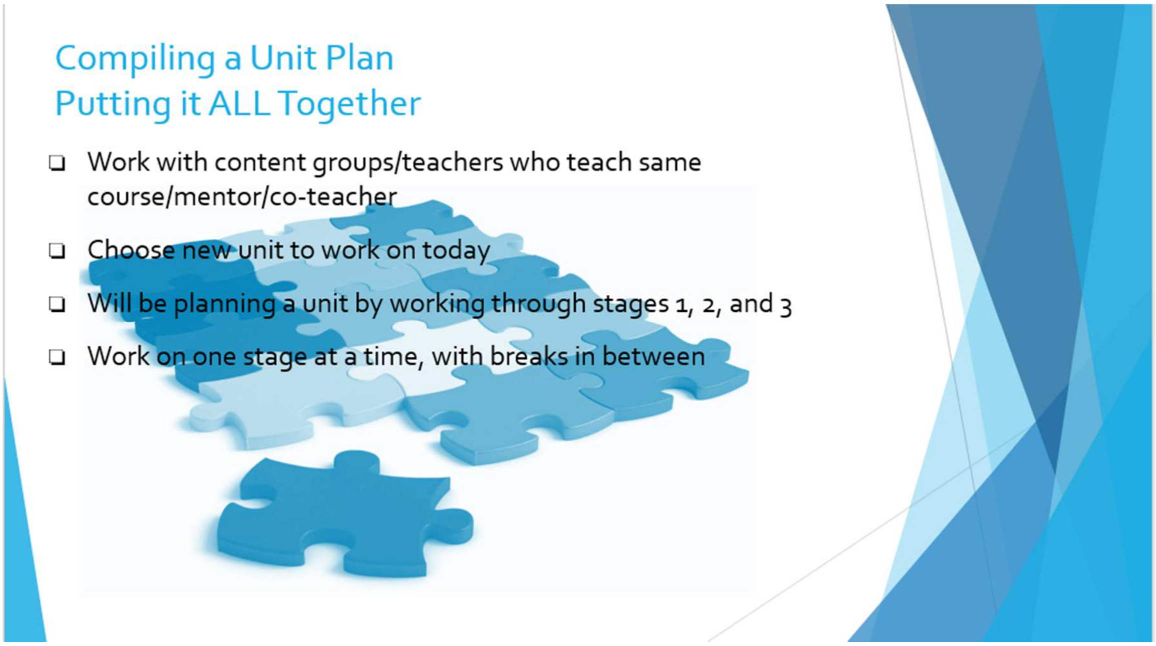



First two questions will be based on formative feedback provided on the day 2 daily evaluation. I will invite the audience to add their own takeaways.

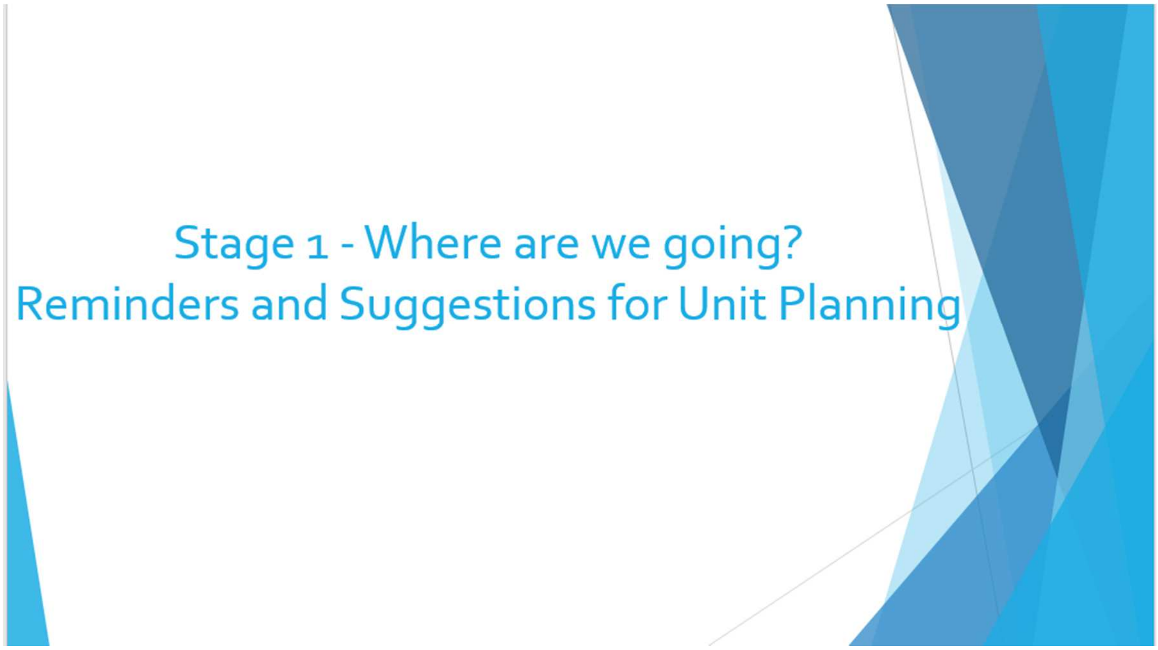
“Where do we go from here?” will be used to transition to the day 2 objectives.

Slide 93

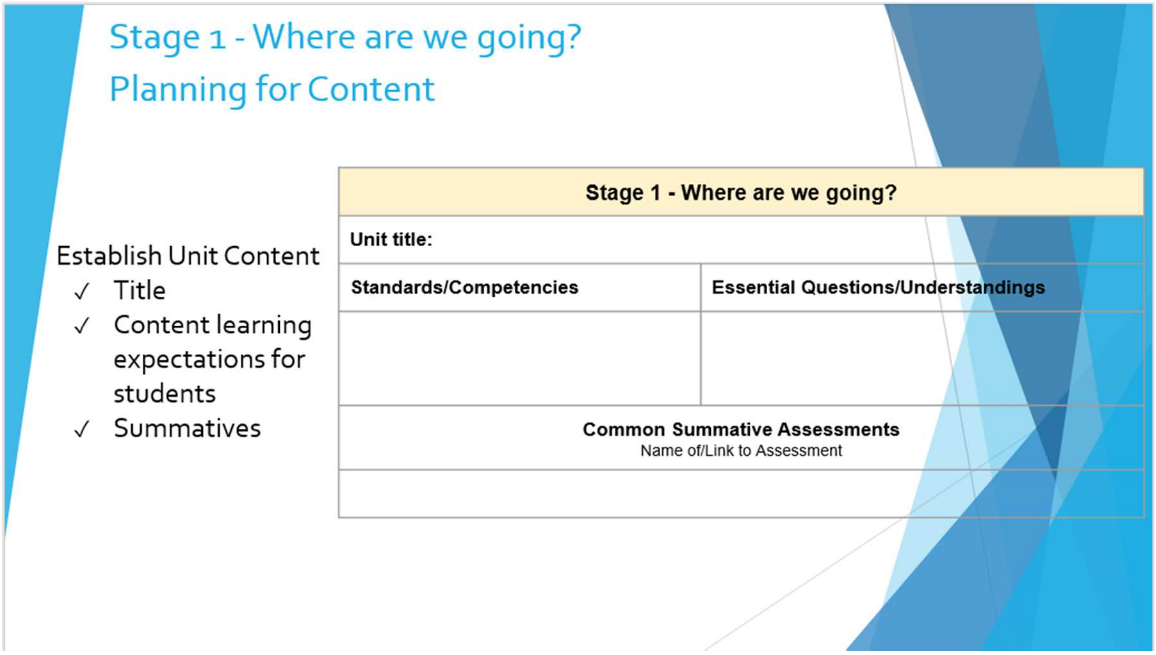



So, here is our charge for today. We are going to continue to work in content groups, but if you want to switch into smaller groups within your content groups, feel free to do so. For those of you who teach the same course, you may want to consider teaming up to tackle a unit plan in that common course. Also, feel free to bounce between groups if you teach multiple units.

Slide 94


Stage 1 - Where are we going?
Reminders and Suggestions for Unit Planning

Slide 95




Work through the checklist to complete Stage 1.

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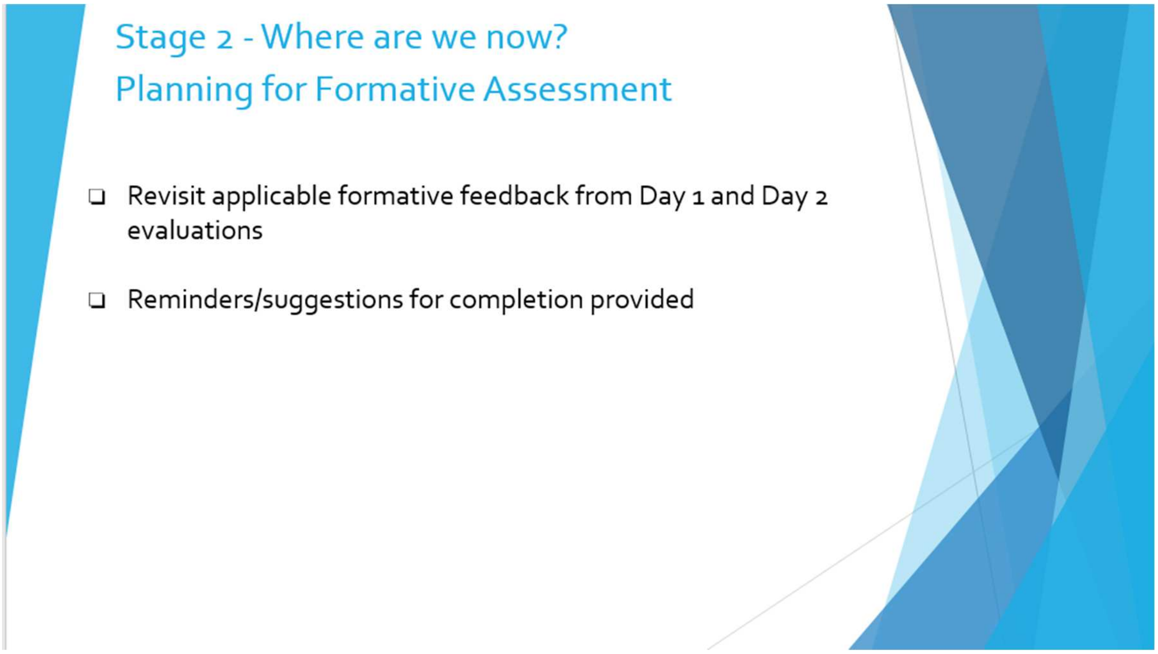
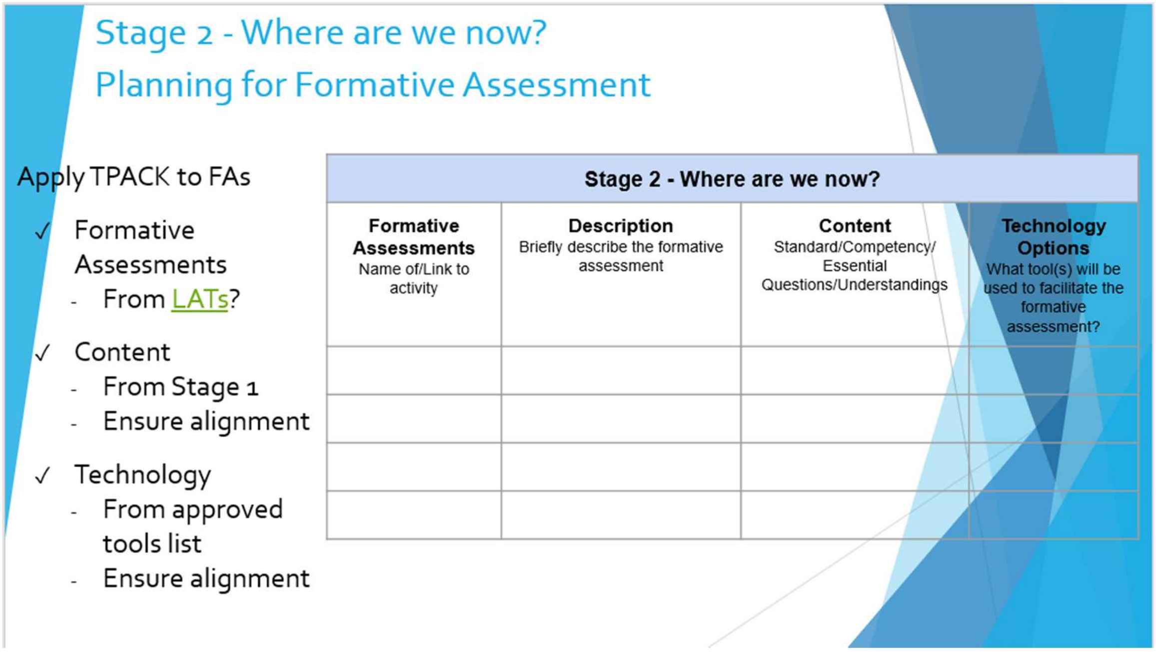
Stage 2 - Where are we now?
Reminders and Suggestions for Unit Planning

Slide 98




[Revisit applicable feedback from Day 1 and Day 2 evaluation]
[Reference reminders/suggestions that are included on the next slide|

Slide 99



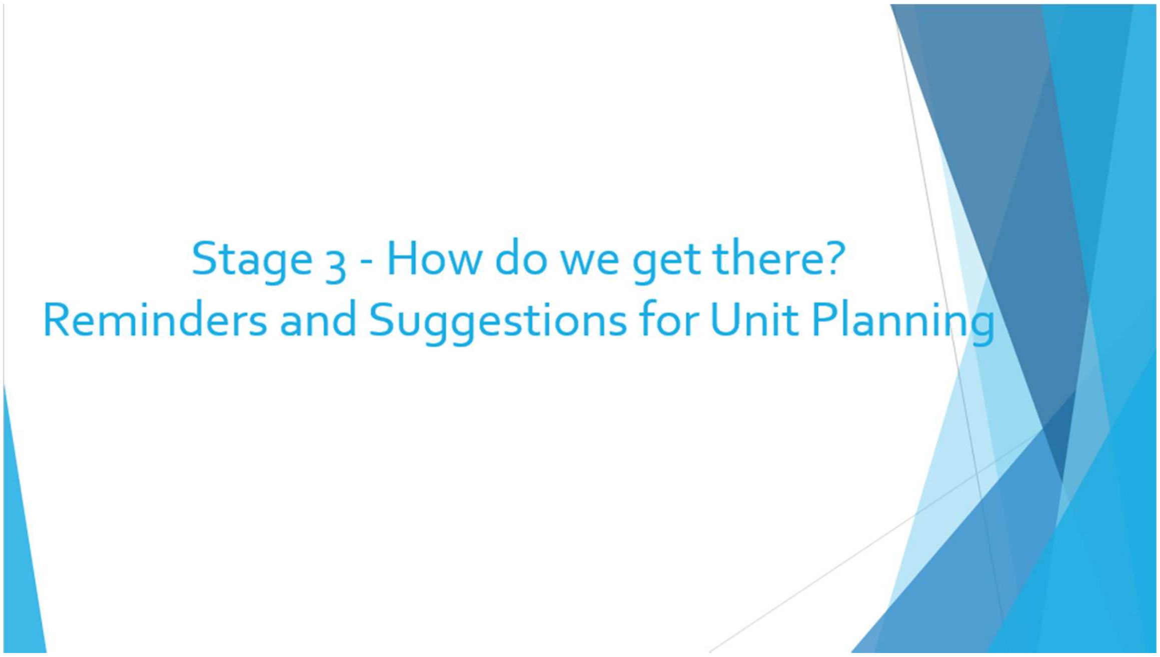

A few reminders about this stage. We are attempting to assess where are students' learning is now and we are planning for all of the potential tools to use: content, pedagogy, and technology and the interaction of the three.

When listing your FAs, remember that you can peak at the list of content LATs to see if there are choices that are applicable and appropriate to support the teaching of your content. I have provided a link to the LATs.
Your content will be taken from Stage 1: competencies/standards/understandings/essential questions.

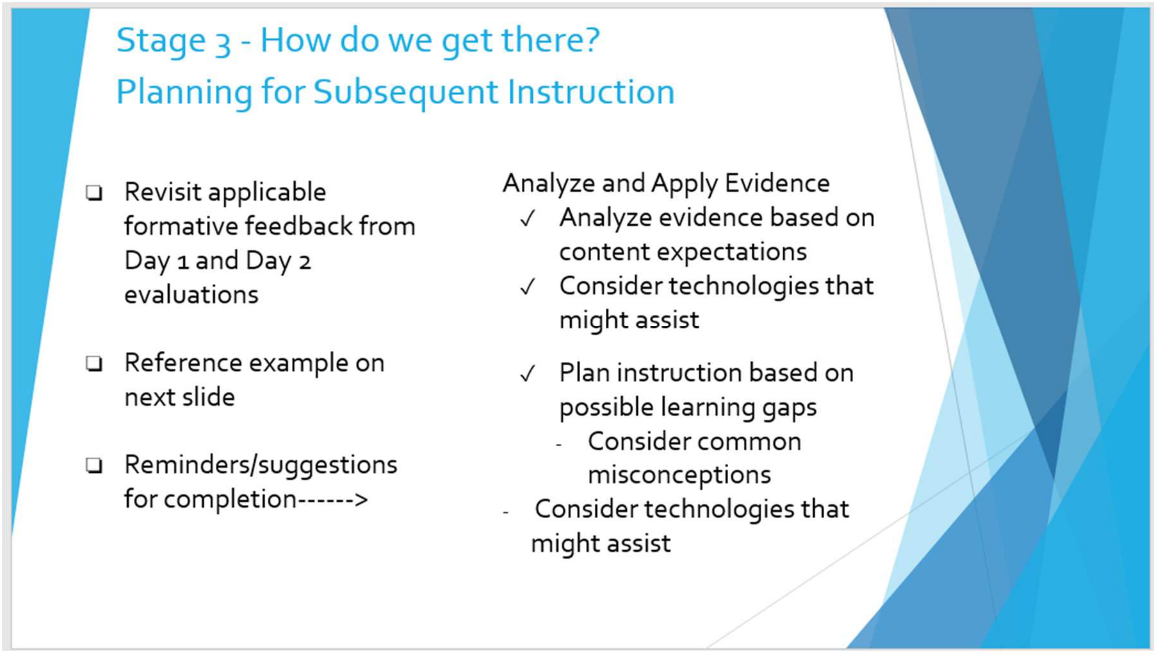
Your potential technologies should be taken from the district approved tools list [link this list to the slide]. Consider the affordances and constraints of your technology to support the learning goals of your formative assessment.

Slide 100

Slide 101


Stage 3 - How do we get there?
Reminders and Suggestions for Unit Planning

Slide 102




[Revisit applicable feedback from Day 1 and Day 2 evaluation]
[Reference reminders/suggestions that are included here|

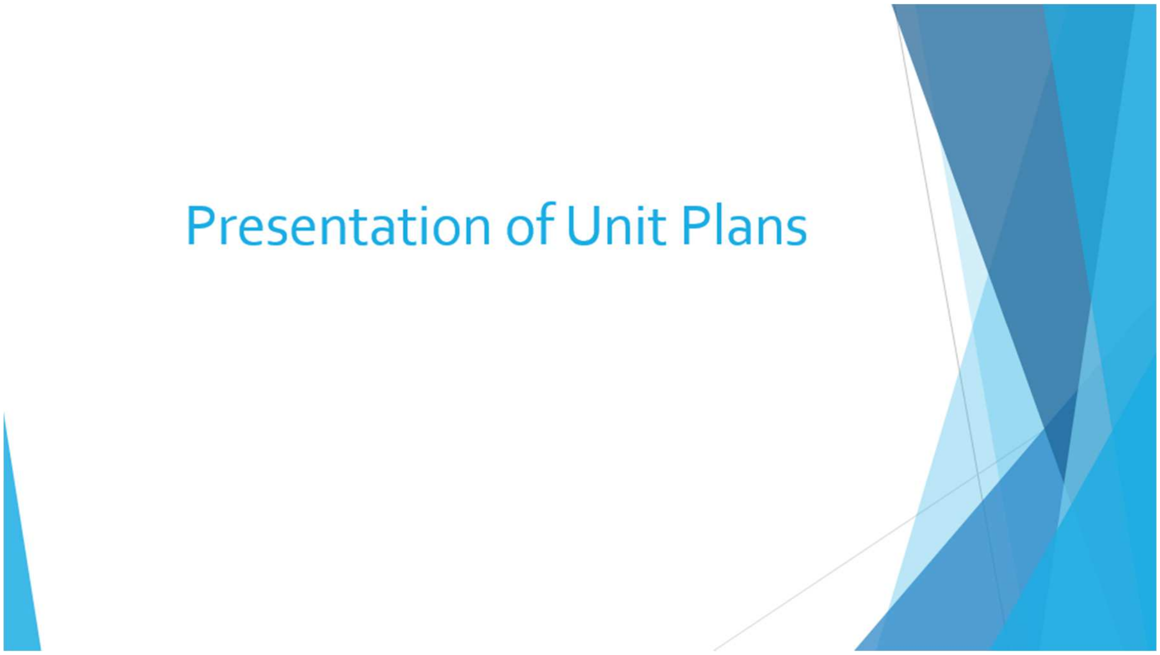
Slide 103

## Stage 3 - How do we get there?
## Planning for Subsequent Instruction

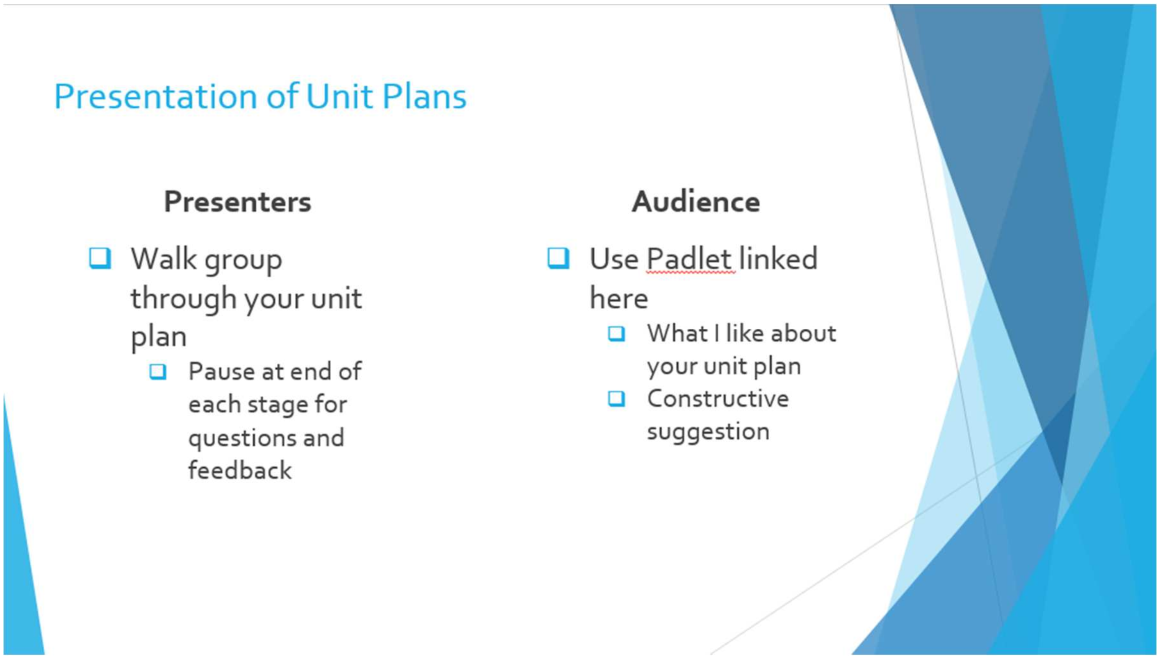
| Stage 3 - How do we get there? | | | |
|---|---|---|---|
| **Analysis of Evidence from Formative Assessments**<br>For each formative assessment listed in Stage 2, briefly outline how you will use evidence from formative assessments to determine where students are in terms of meeting standard/competencies, understanding essential questions/understandings. | **Technology to Aid Analysis of Evidence** | **Subsequent Instruction**<br>For each respective formative assessment, identify common learning gaps and the potential instructional activities that can be used to address them. | **Technology to Aid Subsequent Instruction** |
| *Formative assessment [x]:*<br>*Using the department rubric for [y] content, score student responses as advanced, proficient, basic, or novice* | *Collect student work in Google Classroom assignment.*<br>*Make a copy of Google Doc rubric for each student in Google Classroom.*<br>*Score formative assessment on rubric in Google Classroom.* | *(From assessment criteria in rubric)*<br>*Documentation of evidence (citation) errors: Documenting your evidence lecture*<br><br>*Thesis statement inadequacies: Thesis statement in-class interactive activity*<br><br>*Quality of evidence inadequacies: Revisit unit Google Site with resources*<br><br>*Analysis of evidence inadequacies: Revisit unit Google Site with resources* | *Google Slides lecture with examples*<br><br>*EdPuzzle activity*<br><br>*Class Google Site, link to Google Classroom assignment, integrate into assignment rubric*<br><br>*Class Google Site, link to Google Classroom assignment, integrate into assignment rubric* |

Slide 104

Slide 105



Slide 106

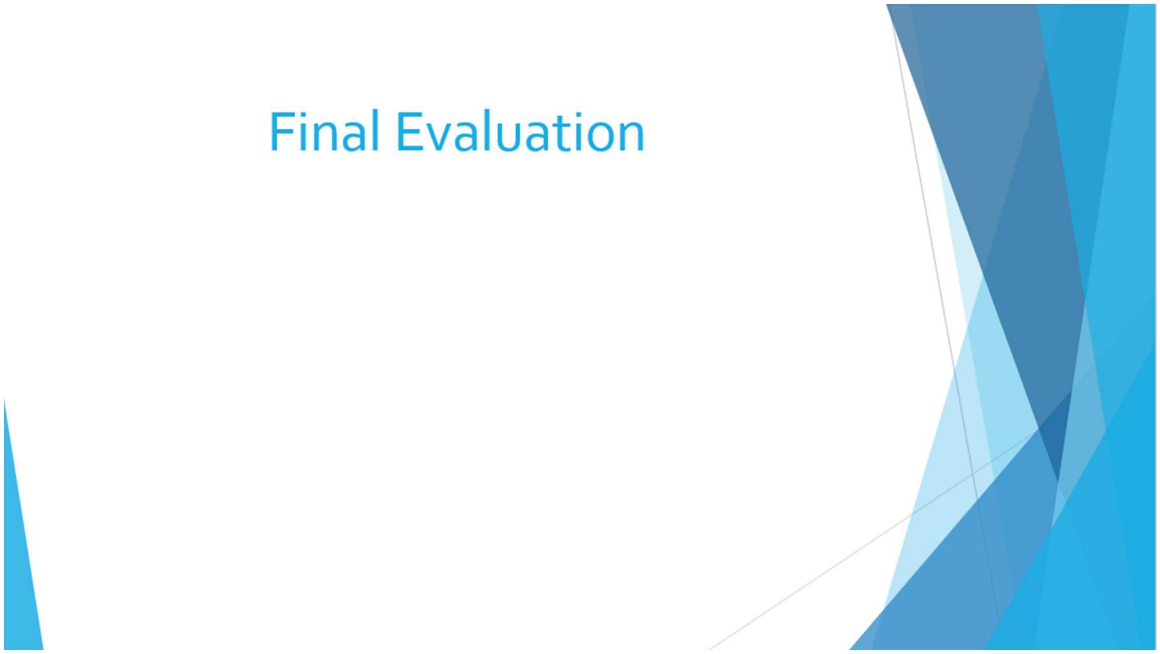



So that each group is able to get constructive feedback from the educational knowledge in the room, each group will present their unit plan, pausing at the end of each stage so that the group can ask questions and provide feedback. At the conclusion of each unit presentation, please visit the Padlet [digital wall for posting] and provide one thing that you like about the unit presented and a constructive suggestion for that group. This way, all the groups have access to the assessments and can use them to reflect on their own practice.

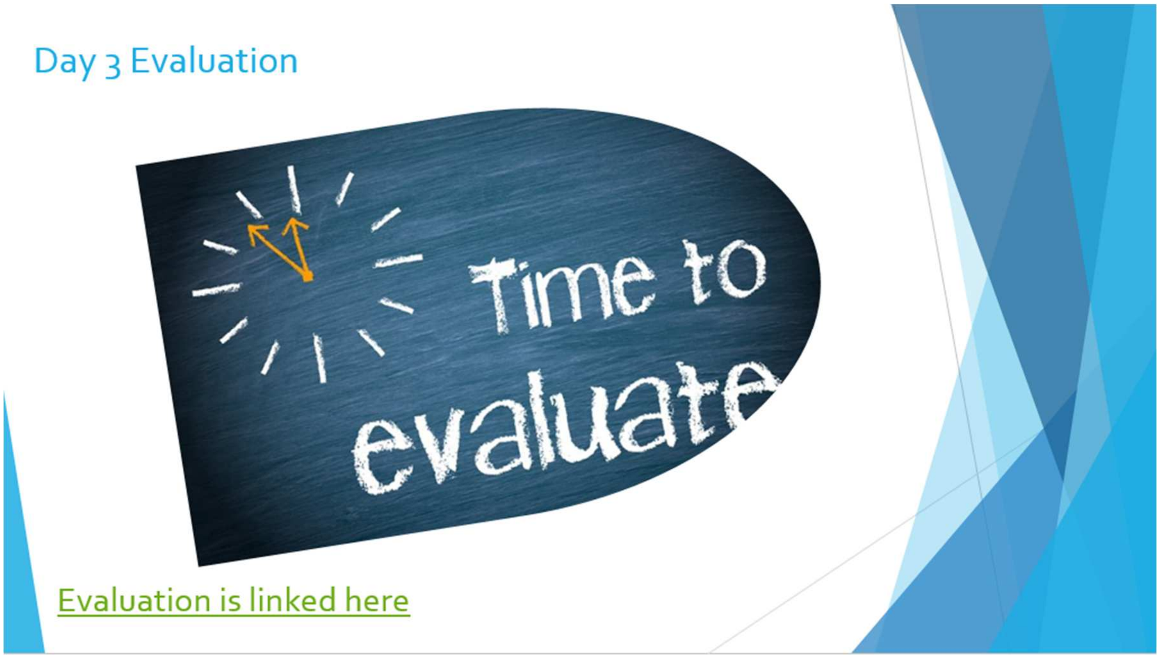
Slide 107


Much like for our students, in order for our learning to feed forward, it helps for our learning to be immediately applicable and for the process to apply the learning to be ongoing. To that end, the professional development has been constructed so that you can use the newly designed UBD planning template for use in your PLC or for individual planning purposes. The template can be constructed in small chunks if time is short but also can be used in totality to see the connection of each piece of instruction.

Slide 108



Slide 109




Thank you for all your hard work and participation over the course of this 3-day PD! I hope that you have a few nuggets to take with you to immediately feed forward into your practice. Please fill out the daily evaluation. This will provide your trainers with FORMATIVE FEEDBACK to be used in future PD opportunities.

# Appendix B: Prestudy Survey

## Pre-Study Survey - Digital Formative Assessment and Feedback

**Thank you for your interest in participating in my study. Please complete the following survey so that I might further ascertain your viability as a study participant. Thank you, again.**

1. Name

   ______________________________

2. Grade level that you currently teach

   *Check all that apply.*

   - [ ] Grade 6
   - [ ] Grade 7
   - [ ] Grade 8

3. Content that you currently teach

   *Check all that apply.*

   - [ ] English
   - [ ] Math
   - [ ] Social Studies
   - [ ] Science
   - [ ] Special Education
   - [ ] World Language
   - [ ] Health
   - [ ] Physical Education
   - [ ] Music

   Other: [ ] ______________________________

4. In your current teaching, do you integrate digital tools to facilitate formative assessment?

   *Mark only one oval.*

   - ( ) Never
   - ( ) Rarely
   - ( ) Sometimes
   - ( ) Often

5. In your current teaching, do you integrate digital tools to use feedback resulting from formative assessment to inform subsequent instruction?

   *Mark only one oval.*

   - ( ) Never
   - ( ) Rarely
   - ( ) Sometimes
   - ( ) Often

# Appendix C: Interview Protocol

## Introductory Narrative

Good afternoon. Thank you for agreeing to be interviewed for this study. I am incredibly grateful for the time that you are committing to assist me in my study. A reminder that this study is being conducted as part of the fulfillment of a doctoral degree that I am pursuing in educational technology through Walden University. My study is about how teachers perceive the use of digital tools for the purpose of facilitating formative assessment and using the resulting feedback to inform subsequent instruction. This interview is to help me gather data to explore how teachers perceive the use of digital tools for formative assessment and feedback. This interview is considered to be a semistructured interview, so I will be asking you open ended questions that may be followed by probing, follow-up questions. I wanted to confirm that you are ok with allowing me to record our interview? Do you have any questions? Ok, we will begin.

1. [TK] Talk about your knowledge of digital formative assessment tools. How do you develop the technological knowledge necessary to use digital tools to facilitate formative assessment?
   a. What supports help in this process?
   b. What barriers exist in this process?
2. [TPK] Talk about your formative assessment planning process. In designing and planning for formative assessments, how do you determine whether to implement technology? (RQ1, RQ2)
   a. In designing and planning for formative assessments, how do you determine which, if any, digital tools to use? (RQ1, RQ2)
3. [TCK] In your classroom teaching, how are digital tools used during formative assessment to help students understand concepts specific to your content area? (RQ1)
   a. When formative assessment is administered and feedback is collected, how are the digital tool(s) then used to inform subsequent instruction? (RQ2)
4. [TPACK] Talk about some classroom experiences with digital formative assessments when the learning process has been most positively affected. In your

discussion, include how you knew the learning process was positively affected. (RQ1, RQ2)

a. How do you think lesson design helped to facilitate the results?
b. What specific resources helped to facilitate the results?
c. How did the resource(s) help to facilitate the results?
d. What supports helped to make this possible?
e. What barriers impeded the experience?

# Appendix D: Lesson Plan Protocol

## Requirements for Participants: Q&A

On the day of the participant interview, I will collect two lesson plans from lessons conducted in the traditional classroom setting prior to the transition to remote learning necessitated by the COVID-19 pandemic. Please email lesson plans to my personal email address, XXXXXXXX prior to the scheduled interview. These lessons should include the use of digital tools to facilitate formative assessment and feedback.

Q1: What is required for submission?

A1: Participants are expected to submit digital copies of two lesson plans from lessons conducted in the traditional classroom setting prior to the transition to remote learning necessitated by the COVID-19 pandemic. Teachers will be asked to choose plans from lessons that include the use of digital tools to facilitate formative assessment and feedback.

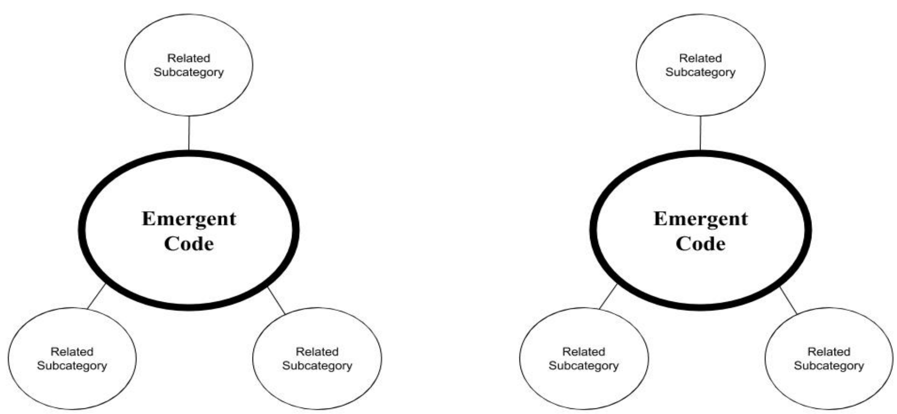
Q2: What type of content do you expect in participant lesson plans?

A2: Minimally, the expectation for the content of participant lesson plans is to include information regarding formative assessment activities that are being taught/facilitated, data analysis procedures, feedback procedures, and digital tools used.

Q3: In what format should the lesson plan be submitted?

A3: Please email a digital copy of the lesson plan to Jeanna Wagner's personal email account, XXXXXXXX.

Appendix E: Coding Procedures

<table>
<tr><td colspan="4">Open Coding<br>Items will be grouped by their similarities and differences to find emergent codes within each a priori category.</td></tr>
<tr><td>TK</td><td>TPK</td><td>TCK</td><td>TPACK</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">A Priori Coding<br>A priori coding will be used to categorize data from interview transcripts, reflective notes taken during interviews, and lesson plan documentation. Transcript data will be listed in black, lesson plan documentation data will be listed in blue, and reflective notes will be listed in red.</td></tr>
<tr><td>TK</td><td>TPK</td><td>TCK</td><td>TPACK</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">Axial Coding<br>Data will be reassembled via axial coding to determine dominant overall data including overarching themes and their related subcategories (Saldaña, 2016).</td></tr>
<tr><td colspan="4">
</td></tr>
</table>

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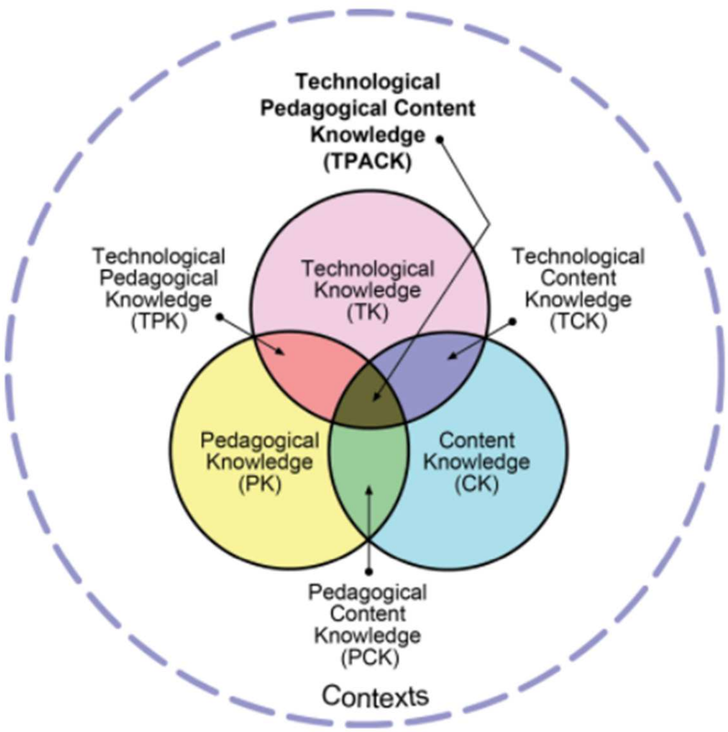
Published on May 11, 2011 by mkoehler

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