INTEGRATING TECHNOLOGY IN THE CLASSROOM

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HANOVER RESEARCH

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INTRODUCTION

Many school districts throughout the country have needed to adapt to changing classroom technology needs. This adaptation requires districts to provide guidance to school leadership and instructional staff as they work closely with students and evolving technology.

Hanover Research (Hanover) has prepared the following report to assist member districts in researching best practices around technology integration in the classroom. This report includes research-based tools and resources to assist in building capacity and understanding around the use of classroom technology. The report also focuses on best practice strategies that support technology integration.

This report is comprised of two sections:

- **Section I: Best Practices for Integrating Technology in the Classroom** reviews best practices for technology integration, including relevant frameworks, instructional design, and classroom practices.
- **Section II: Supporting Instructional Staff in Technology Integration** examines how school districts can support instructional staff in technology integration, reviewing best practices for professional development, coaching, and evaluation.

RECOMMENDATIONS

Based on our findings, Hanover Research suggests that districts consider the following recommendations.

Survey current state of technology use and access in the district. Plan and implement a survey for a variety of stakeholders to assess areas for support or improvement based on existing structures and access. Having knowledge of the current state of technology use can help determine areas for improvement – such as bolstering professional learning opportunities, restructuring instructional design, or providing guidance for student technology use.

Define or refine district wide technology integration mission. Gather district stakeholders from all levels, including teachers, students, as well as administrative staff and board members, to outline goals for technology integration and steps to meet these goals. Outline processes like instructional design, steps for student access, and professional development opportunities for educators, and establish a yearly evaluation plan. Build the finalized plan into a larger district-wide strategic initiative.

Partner with Hanover to create an instructional planning toolkit to aid teachers in implementing technology into their classrooms. The toolkit should provide practical guidelines, program suggestions, and best practices that align with the district's integration plan. The toolkit would benefit both instructors as well as district and school leaders. Using tools like this, school leaders should be encouraged to build ongoing professional development opportunities for instructional staff that incorporate practical strategies around technology integration.

KEY FINDINGS

To integrate technology into the classroom effectively, educators should be aware of the frameworks and standards of technology integration. These frameworks and standards

contextualize the value and roles of technology in the classroom and can be used to improve and evaluate technology use. Popular frameworks include SAMR (Substitution Augmentation Modification Redefinition), TPACK (Technological Pedagogical Content Knowledge), and TIM (Technology Integration Matrix), while the International Society for Technology in Education (ISTE) provides internationally recognized standards.

- **Studies show that comprehensive instructional design is crucial to the effective integration of technology.** Technological tools are most effective when they are used intentionally to enhance student learning, rather than simply serve as a replacement to traditional pedagogy. Teachers should employ instructional planning toolkits to integrate technology deliberately and intentionally into their lessons, in ways which support the content students are expected to learn.

- **Ongoing and consistent professional development is crucial for supporting teachers in technology integration**. Research indicates that professional learning for teachers should be interactive, ongoing, interest-driven, relevant to teachers' needs and provide opportunities for collaboration. Districts and schools need to provide comprehensive professional learning plans for their teachers and ensure the ongoing availability of trainings. Professional learning can be provided in a variety of ways, including certification courses, online courses, or by embedding technology trainings into existing professional learning communities.

- **Research supports the use of coaching and peer collaboration alongside professional development strategies to support technology integration.** Instructional coaching can be an important factor in technology integration by providing on-going and personalized support to educators. Coaching also allows teachers to receive live feedback from classroom observations. Research finds that coaches who bring technological skills as well as expertise with their mentee's content area are most successful as they are able to not only train teachers in using technology but are able to recommend specific tools that aid a particular content area.

- **Successful technological integration relies on the effective use of materials and practices within the classroom to support curricular and pedagogical goals.** Alongside instructional planning, positive student engagement is crucial to the success of technology integration. Establishing access to internet and digital tools and devices is a first step districts can make to ensure the success of a technology integration program. Districts should conduct a survey of students' use of technology and their access to the internet and digital devices to determine an action plan to increase access. Students also need to be taught digital citizenship boundaries and skills to use digital resources in constructive and safe ways.

- **Periodic system evaluations can help support teachers and students, identify needs and/or gaps, and help school leaders improve their program.** Research suggests three steps for evaluating a program: identify criteria to measure the program's success, collect data from students and teachers, and analyze data against set criteria.

SECTION I: BEST PRACTICES FOR INTEGRATING TECHNOLOGY IN THE CLASSROOM

The National Center for Education Statistics defines technology integration as "the incorporation of technology resources and technology-based practices into the daily routines, work, and management of schools."[1] In this section, Hanover first provides an overview of technology integration frameworks and technology use standards, and then reviews relevant classroom practices and tools that support effective technology integration.

FRAMEWORKS FOR TECHNOLOGICAL INTEGRATION

A variety of frameworks aim to assess and guide the integration of technology into the classroom and educators' instructional practices. Technology integration frameworks offer comprehensive goals and guidance for schools and districts and provide the appropriate structures to support technology use in the classroom. Without these strong and supportive leadership structures, educational technologies can fall into the status quo of existing beliefs and practices, rather than being a catalyst for more effective instruction.[2] Frameworks vary from focusing on the broad relationships between technology, pedagogy, and content, to offering prescriptive approaches for integrating technology at a series of hierarchical levels.

This subsection provides an overview of three common integration frameworks – SAMR, TPACK, TIM. These programs were conceptualized early in the 2000s but continue to adapt and remain at the forefront of cutting-edge research today.[3]

TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPACK)

TPACK is a theoretical framework for guiding technology integration into classroom teaching. The TPACK framework is a combination of three knowledge areas for instructors to carry out technological integration, these areas being: 1) **Content,** 2) **Pedagogy,** and 3) **Technology** (Figure 1.1).[4] The model operates under the assumption that traditional technological training is too isolated from the classroom and calls for the integration of technological pedagogy.[5] Therefore, the framework encourages teacher development not just in these separate areas, but in the overlap of all three together.

[1] "Technology in Schools." National Center for Education Statistics, 2002. chap. 7. https://nces.ed.gov/pubs2003/tech_schools/chapter7.asp#4

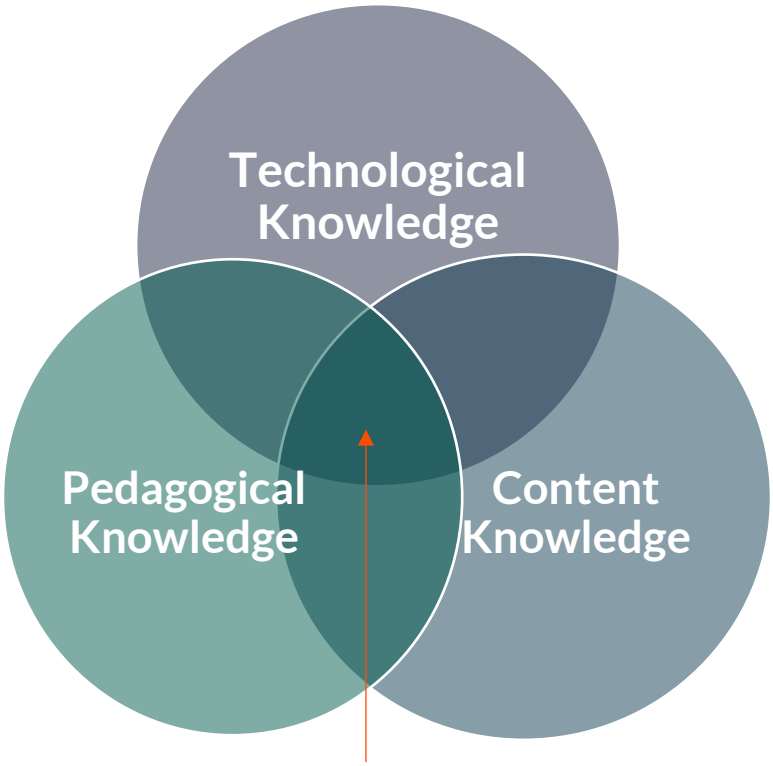
[2] Davies, R.S. and R.E. West. "Technology Integration in Schools." *Foundations of Learning and Instructional Design Technology*, 2018. https://open.byu.edu/lidtfoundations/tech_integration_in_schools

[3] Ray, K. "Is SAMR Dead?" Tech & Learning, April 26, 2021. https://www.techlearning.com/news/is-samr-dead

[4] Bajracharya, J.R. "Technology Integration Models and Frameworks in Teaching and Training." *Journal of Training and Development*, 6:01, December 28, 2021. p. 6. https://www.nepjol.info/index.php/JTD/article/view/41674 [2] Mishra, P. and M.J. Koehler. "Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge." *Teachers College Record*, :6, June 2006. https://journals.sagepub.com/doi/abs/10.1111/j.1467-9620.2006.00684.x

[5] Mishra and Koehler, Op. cit., p. 1024.

Figure 1.1: TPACK Framework



Source: EDTech[6]

Teachers can use the TPACK model as a guide to see the interdisciplinary nature of technological integration rather than treating technology separately from teaching and learning. Traditionally, as teachers teach, they combine knowledge of content (subject or material) with their knowledge of pedagogy (how to teach); as technology becomes more important in the classroom, technology must be added equally into this mix. [7]

School leaders and educators alike can track the success of TPACK integration in their schools by using the Technology Integration Assessment Rubric, shown in Table 1. 1.

Table 1.1: TPACK Assessment Rubric[8]

CRITERIA	4	3	2	1
Curriculum Goals & Technologies	Technologies selected for use in the instructional plan are strongly aligned with one or more curriculum goals	Technologies selected for use in the instructional plan are aligned with one or more curriculum goals	Technologies selected for use in the instructional plan are partially aligned with one or more curriculum goals	Technologies selected for use in the instructional plan are partially aligned with one or more curriculum goals

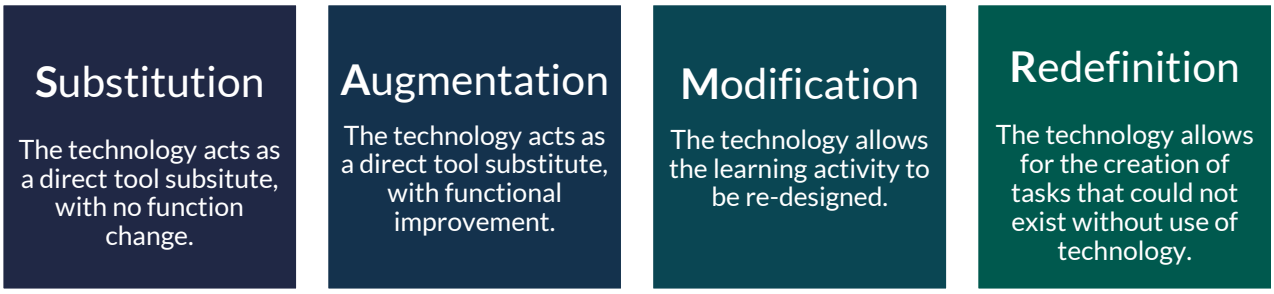
[6] "All About TPACK: A Teacher's Guide to the TPACK Tech Integration Model." EdTech Classroom, June 30, 2021. https://edtech-class.com/2021/06/30/all-about-tpack-a-teachers-guide-to-the-tpack-tech-integration-model/
[7] Ibid.
[8] Table taken verbatim from: "Technology Integration Assessment Rubric." College of William & Mary School of Education. https://activitytypes.wm.edu/Assessments/assessmentsindex.html

Instructional Strategies & Technologies (Using technology in teaching/ learning)	Technology use optimally supports instructional strategies	Technology use supports instructional strategies	Technology use minimally supports instructional strategies	Technology use does not support instructional strategies
Technology Selection(s) (Compatibility with curriculum goals & instructional strategies	Technology selection(s) are exemplary, given curriculum goal(s) and instructional strategies	Technology selection(s) are appropriate, but not exemplary, given curriculum goal(s) and instructional strategies	Technology selection(s) are marginally appropriate, given curriculum goal(s) and instructional strategies	Technology selection(s) are inappropriate, given curriculum goal(s) and instructional strategies
"Fit" (Content, pedagogy and technology together)	Content, instructional strategies and technology fit together strongly within the instructional plan	Content, instructional strategies and technology fit together within the instructional plan	Content, instructional strategies and technology fit together somewhat within the instructional plan	Content, instructional strategies and technology do not fit together within the instructional plan

SAMR

The SAMR model, developed in 2010 by education researcher Ruben Puentedura, similarly provides a theoretical framework for technology integration in the classroom. The model is built around four main levels which make up its' acronym: Substitution, Augmentation, Modification, and Redefinition. Each of these steps represent advancement in technological implementation in the classroom, while providing guidance for teachers in creating a lesson plan that utilizes technological tools. The goals for each level are outlined in Figure 1.2 (below).

Figure 1.2: SAMR Framework



Source: The SAMR Model[9]

[9] Four elements adapted with minor language changes from: Hamilton, E., J. Rosenberg, and M. Akcaoglu. "The Substitution Augmentation Modification Redefinition (SAMR) Model: A Critical Review and Suggestions for Its Use." *TechTrends*, 60, 2016. https://link.springer.com/article/10.1007/s11528-016-0091-y

While the framework is arranged in steps, the SAMR model really exists as a spectrum: each step can exist in the same classroom. For example, some classroom exercises work best within step one (Substitution), while others may require step four (Redefinition).[10] The SAMR model serves as a guide for teachers in thinking about the best ways to integrate technological tools into instruction and into student assignments.[11]

Below are some examples of these steps in action in the classroom:[12]

Substitution	• Students may use Keynote or PowerPoint to present information for an assignment. • Lessons and worksheets are converted to PDFs and posted online in a file-sharing service. • Classroom resources – schedules, lists, rules – are similarly converted to digital formats. • Asynchronous versions of class materials or discussions are provided.
Augmentation	• Students use video supplements or interactive links to fill in parts of their presentation. • Students create digital portfolios or multimedia presentations. • Students take gamified quizzes. • Teacher creates and uses virtual bulletin boards.
Modification	• Students collaborate through online platforms, shared documents or email. • Teacher uses a classroom utilized learning management system such as Google Classroom, Moodle, or Canvas to centralize logistics of classroom. • Teacher provides alternative methods for participation including online peer-to-peer exercises, discussion boards, or learning forums.
Redefinition	• Students are provided real-time peer feedback or can interact with others directly about their projects. • Students participate in virtual learning activities such as virtual field trips, virtual pen-pals, or virtual webinars. • Students create digital projects and interact virtually with other members of their communities or other classrooms around the world.

THE TECHNOLOGY INTEGRATION MATRIX (TIM)

TIM also provides a framework for describing and targeting the use of technology to enhance learning and instruction.[13] TIM outlines five interdependent characteristics of meaningful learning environments, which it

[10] M, K. "SAMR Model: A Practical Guide for K-12 Classroom Technology Integration." PowerSchool, April 13, 2021. https://www.powerschool.com/blog/samr-model-a-practical-guide-for-k-12-classroom-technology-integration/
[11] Terada, Y. "A Powerful Model for Understanding Good Tech Integration." Edutopia, May 4, 2020. https://www.edutopia.org/article/powerful-model-understanding-good-tech-integration
[12] Examples summarized from: Ibid.
[13] "The Technology Integration Matrix." The Technology Integration Matrix: A Project of the Florida Center for Instructional Technology, 2005-2021. https://fcit.usf.edu/matrix/matrix/

aligns with five levels of technology integration. Developed by the Florida Center for Instructional Technology (FCIT) in 2005, the TIM is now in its third edition (2019).[14]

The five characteristics of meaningful learning environments are: **active, collaborative, constructive, authentic, and goal-directed.** The five characteristics of technology integration are**: entry, adoption, adaptation, infusion, and transformation.** Together, the five characteristics of meaningful learning environments and five levels of technology integration create a matrix of 25 cells, as illustrated below (Table 1.2).

Table 1.2: TIM – Table of Teacher Descriptors

	ENTRY	ADOPTION	ADAPTATION	INFUSION	TRANSFORMATION
ACTIVE	The teacher may be the only one actively using technology. This may include using presentation software to support delivery of a lecture. The teacher may also have the students complete "drill and practice" activities on computers to practice basic skills, such as typing.	The teacher controls the type of technology and how it is used. The teacher may be pacing the students through a project, making sure that they each complete every step in the same sequence with the same tool. Although the students are more active than students at the Entry level in their use of technology, the teacher still strongly regulates activities.	The teacher allows for some student choice and exploration of technology tools. Because the students are developing a conceptual and procedural knowledge of the technology tools, the teacher does not need to guide students step-by-step through activities. Instead, the teacher acts as a facilitator toward learning, allowing for greater student engagement with technology tools.	The teacher guides, informs, and contextualizes student choices of technology tools and is flexible and open to student ideas. Lessons are structured so that student use of technology is self-directed.	The teacher serves as a guide, mentor, and model in the use of technology. The teacher encourages and supports the active engagement of students with technology resources. The teacher facilitates lessons in which students are engaged in higher order learning activities that may not have been possible without the use of technology tools. The teacher helps students locate appropriate resources to support student choices.
COLLABORATIVE	The teacher directs students to work alone on tasks involving technology.	The teacher directs students in the conventional use of technology tools for working with others.	The teacher provides opportunities for students to use technology to work with others. The teacher selects and provides technology tools for students to use in collaborative ways, and encourages students to begin exploring the use of these tools.	The teacher fosters a collaborative learning environment and supports students' meaningful choices in their selection of technology tools for collaboration.	The teacher seeks partnerships outside of the setting to allow students to access experts and peers in other locations and encourages students to extend the use of collaborative technology tools in higher-order learning activities that may not be possible without the use of technology tools.

[14] "Florida Center for Instructional Technology." https://fcit.usf.edu/

CONSTRUCTIVE	The teacher uses technology to deliver information to students.	The teacher provides some opportunities for students to use technology in conventional ways to build knowledge and experience. The students construct meaning about the relationships between prior knowledge and new learning, but the teacher makes the choices regarding technology use.	The teacher creates instruction in which students' use of technology tools is integral to building an understanding of a concept. The teacher gives the students access to technology tools and guides them in exploring and choosing appropriate resources.	The teacher consistently allows students to select technology tools to use in building an understanding of a concept. The teacher provides a context in which technology tools are seamlessly integrated into a lesson and is supportive of student autonomy in choosing the tools and when they can best be used to accomplish the desired outcomes.	The teacher facilitates higher-order learning opportunities in which students regularly engage in activities that may be impossible to achieve without the use of technology tools. The teacher encourages students to explore the use of technology in unconventional ways and to use the full capacity of multiple tools in order to build knowledge.
AUTHENTIC	The teacher assigns work based on a predetermined curriculum unrelated to the students or issues beyond the instructional setting.	The teacher directs students in the conventional use of technology tools for learning activities that are sometimes related to the students or issues beyond the instructional setting.	The teacher creates instruction that purposefully integrates technology tools and provides access to information on community and world issues. The teacher directs the choice of technology tools but students use the tools on their own, and may begin to explore other capabilities of the tools.	The teacher encourages students to use technology tools to make connections to the world outside of the instructional setting, and to their lives and interests. The teacher provides a learning context in which students regularly use technology tools and have the freedom to choose the tools that, for each student, best match the task.	The teacher encourages innovative use of technology tools in higher-order learning activities that support connections to the lives of the students and the world beyond the instructional setting.
GOAL-DIRECTED	The teacher gives students directions and monitors step by-step completion of tasks. The teacher sets goals for students and monitors their progress.	The teacher directs students step by step in the conventional use of technology tools to set goals, plan, monitor, evaluate an activity, or reflect upon learning activities.	The teacher selects the technology tools and clearly integrates them into the lesson. The teacher facilitates students' independent use of the technology tools to set goals, plan, monitor progress, evaluate outcomes, and reflect upon learning activities. The teacher may provide guidance in breaking down tasks.	The teacher creates a learning context in which students regularly use technology tools to set goals, plan, monitor, evaluate outcomes, and reflect upon learning activities. The teacher facilitates students' choice and independent use of technology tools to accomplish these tasks.	The teacher creates a rich learning environment in which students regularly engage in higher-order planning, monitoring, evaluative, and reflective activities that may be impossible to achieve without technology. The teacher sets a context in which students are encouraged to use technology tools in innovative ways to direct and reflect on their own learning.

Source: The Technology Integration Matrix[15]

APPLICATION STANDARDS

Technology standards are building blocks for the implementation, improvement, and evaluation of technology integration in classrooms. The International Society of Technology in Education provides standards that have been used for over 20 years in all 50 states and many countries throughout the world, meant to provide a comprehensive roadmap for the effective use of technology in schools.[16]

[15] "The Technology Integration Matrix," Op. cit.
[16] "ISTE Standards." International Society for Technology in Education. https://www.iste.org/iste-standards

The ISTE standards "consist of five sets of standards and provide a framework for amplifying — or even transforming — digital age learning, teaching, and leading."[17] The ISTE provides publicly available sets of standards for students, teachers, administrators, coaches, and computer science educators. Figure 1.3 below depicts possible uses of the ISTE standards.

Figure 1.3: ISTE Standards Use

THE STUDENT STANDARDS...	THE EDUCATOR STANDARDS...
▪ Inform lesson and curriculum planning. ▪ Help schools, districts, and states create technology plans. ▪ Aid academic researchers in their work. ▪ Guide forward-thinking companies in developing products, services, and resources.	▪ Guide educators in their professional development. ▪ Help leaders and systems personnel define job roles and assess systems, curriculum, learning, and staff. ▪ Assist higher education faculty in research and teacher preparation.

Source: ISTE Standards[18]

ISTE also outlines seven essential conditions that must be in place before a school or district can achieve meaningful technology integration, shown in Figure 1.4.

Figure 1.4: Essential Conditions for Effective Tech Use in Schools

SHARED VISION
Create a shared vision for transforming student learning through the effective use of technology with participation from all stakeholders (including teachers, support staff, administrators, students, parents, teacher-preparation programs, policy makers and members of the community) and align that vision to established frameworks or standards.
IMPLEMENTATION PLANNING
Develop a comprehensive plan for building and sustaining technology infrastructure, evaluating and selecting digital learning resources, and providing and sustaining professional learning and coaching.
EQUITABLE ACCESS
Ensure robust and reliable access to digital devices, internet connectivity, capable teachers and technology platforms required to support the learning vision for all students (including language learners, students with physical or learning disabilities, foster or homeless youth, etc.).
PREPARED EDUCATORS
Ensure educators and education leaders know how to use technology in appropriate ways, aligned to learning research and the school system's vision for learning.
SKILLED AND SUFFICIENT TECHNICAL SUPPORT
Ensure technology leadership and sufficient technical support staff capable of maintaining the learning infrastructure and providing technical support for learning.
HIGH QUALITY LEARNING ACTIVIES AND CONTENT
Select effective digital learning activities and content aligned to standards, and create authentic and creative learning experiences that support the school system's vision for learning.
ONGOING EVAULATION
Continually evaluate learning experiences in partnership with all stakeholders identified in Condition #1.

[17] "ISTE Standards FAQ." International Society for Technology in Education. https://www.iste.org/standards/standards/iste-standards-2016-faq
[18] "ISTE Standards," Op. cit.

Source: ISTE Essential Conditions[19]

INSTRUCTIONAL DESIGN

Studies show that comprehensive instructional design is crucial to the effective integration of technology.[20] Access to technological resources and even trainings are proven to be not sufficient conditions for technology integration: comprehensive lesson planning and deliberate use of tools are needed to carry out technology integration in the classroom.[21] This section first reviews digital tools that aid instruction and then second, reviews methods for instructional design planning.

INSTRUCTIONAL TOOLS

While technology has been used in classroom setting for a substantial amount of time, the use of technology took on a new role during the COVID-19 global pandemic. Instead of instruction informing technology use, technology framed and structured instruction. As in-person instruction returned and regained its place as the central mode of instruction for educators and students, instructional methods from the pandemic that successful integrate technology remain useful. **Below are several instructional tools and methods which intentionally maximize the use of technology in course design, the first section looking at how technology can help teachers provide resources for their classes, and the second reviewing types of tools for instruction.**

DIGITAL RESOURCES

Technology can help teachers provide additional resources to their students in a straightforward and organized manner. Providing resources digitally allows students consistent access to materials that can boost their understanding of class materials and topics. These materials can range from multimedia formats such as aural and visual materials, to web sources and other text-based sources. Teachers should seek to create digital resources with a goal or set of goals in mind – what do these resources provide to my students? Such goals might include providing background information or context, introducing parallel ideas or concepts, or marking connections with class materials.[22] Updating these materials throughout the school year also allows teachers to continually connect and engage their students outside of the classroom.

In providing digital resources, teachers should ensure the materials are well-organized and accessible to all students. Providing resources in a singular or uniform site, such as platforms like Google Classroom or a Schoology collection, can help organize and provide access to content. [23]

DIGITAL TOOLS

The pandemic rapidly accelerated the spread and use of digital tools in schools, and experts say it's unlikely this will end with the pandemic.[24] Platforms like Zoom, Google Classroom, Nearpod, and Newsela provided space for students and teachers to interact and collaborate, which can be used alongside in-person instruction. Beyond these larger instructional platforms, a significant number of educators reported that math (and STEM more broadly) is well-suited to digital instruction.[25] New tools can allow students to work together in groups, as well as digitally show and share their work. For mathematics, students using digital

[19] Figure text taken verbatim from: "Essential Conditions for Effective Tech Use in Schools." International Society for Technology in Education. https://www.iste.org/standards/iste-essential-conditions
[20] Bajracharya, Op. cit.
[21] Ibid., p. 4.
[22] Burns, M. "Planning Technology Integration for In-Person Instruction." *ASCD*, 78:9, July 2021. https://www.ascd.org/el/articles/planning-technology-integration-for-in-person-instruction
[23] "How to Keep Students Organized and Thriving in a Digital Classroom." EdSurge, October 14, 2019. https://www.edsurge.com/news/2019-10-14-how-to-keep-students-organized-and-thriving-in-a-digital-classroom
[24] Singer, N. "Learning Apps Have Boomed in the Pandemic. Now Comes the Real Test." *The New York Times*, March 17, 2021. https://www.nytimes.com/2021/03/17/technology/learning-apps-students.html
[25] Herold, B. "Pandemic Tech Tools That Are Here to Stay." *Education Week*, March 8, 2022. https://www.edweek.org/technology/pandemic-tech-tools-that-are-here-to-stay/2022/03

tools can easily capture and collect data, communicate with peers or other users, consume media, and can easily generate results.[26] A recent study from 2021 found that COVID-19 allowed for the positive potential of digital technology use in mathematics, as digital instruction was previously viewed as second-rate.[27]

Educators have realized the potential for technology to enhance learning in STEM fields, and a variety of new digital tools and resources emerge every year.[28] The US Office of Education Technology has developed a research-based guide for supporting STEM learning with technology, its nine dimensions outlined in Figure 1.5 below:

Figure 1.5: Nine Dimensions of Powerful STEM Learning

	**Dynamic Representations.** Students learn or master STEM concepts through interacting with digital models, simulations, and dynamic representations of mathematical, scientific, and engineering systems.
	**Collaborative Reasoning.** Technology tools support students' collaborative reasoning around STEM concepts, equalizing participation among group members, and helping individuals and groups improve their ideas.
	**Immediate and Individualized Feedback.** Digital tools provide students practicing or learning STEM skills or concepts with immediate and individualized feedback beyond right or wrong.
	**Science Argumentation Skills.** Students use technology that supports science argumentation skills including presenting and evaluating evidence about scientific or mathematical claims.
	**Engineering Design Processes**. Students plan, revise, implement, and test problem solutions using engineering design processes and appropriate technologies.
	**Computational Thinking.** Students use technology to problem-solve using algorithms, data, and simulations to investigate questions and develop new understandings about phenomena.
	**Project-based Interdisciplinary Learning.** Students use digital technology tools in the context of projector challenge-based learning activities that integrate multiple STEM fields (e.g., science and mathematics).
	**Embedded Assessments.** Digital assessments are embedded in STEM instruction to prompt students' reflection on the quality of their explanations, models, or problem solutions.
	**Evidence-based Models.** Students use technology to develop models based on data and evidence.

[26] This conclusion reached in: Alabdulaziz, M.S. "COVID-19 and the Use of Digital Technology in Mathematics Education." *Education and Information Technologies*, 26:6, November 1, 2021. https://link.springer.com/content/pdf/10.1007/s10639-021-10602-3.pdf
[27] Ibid.
[28] Vahidy, J. "Enhancing STEM Learning Through Technology." July 12, 2019. https://pressbooks.pub/techandcurr2019/chapter/enhancingstem/

Source: Office of Education Technology[29]

School Spotlight - Greene Central High School (NC)

At Green Central High Schools, students receive individualized and immediate feedback while learning mathematics. Student's instructional time is centered around video material of their teacher working through a problem set. Each student is supplied a tablet and can watch and re-watch their teacher's work and work through the problem on their own. This technology also allows the teacher to oversee each student's work in real time and provide immediate feedback or assistance. The technology allows the teacher to provide individualized support for more students, extending their capacity beyond what is possible in a traditional instructional setting. The technology also allows the teacher to collect student and class data to track progress over the semester or year. [30]

INSTRUCTIONAL PLANNING TOOLS

Many frameworks are available for educators to use to aid instructional planning that integrates technology.

The TPAC framework offers the Technology Integration Planning Cycle (TIPC) for instructional planning shown below in Figure 1.6. Hutchison and Woodward (2014)[31] assert that teachers that use the cycle must have the ability to: (1) identify and adhere to a clear instructional goal when integrating digital technology; (2) identify an appropriate instructional approach for the instructional goal; (3) select appropriate digital or non-digital tools to support instruction; (4) foresee how the selected tool can contribute to the instructional goal; (5) identify the potential constraints of using the tool to determine whether they can be overcome; (6) understand how the instruction will need to be delivered or altered due to the use of the selected tool; and (7) reflect on the resulting instruction and make changes/learn more about the instructional tools as needed.[32]

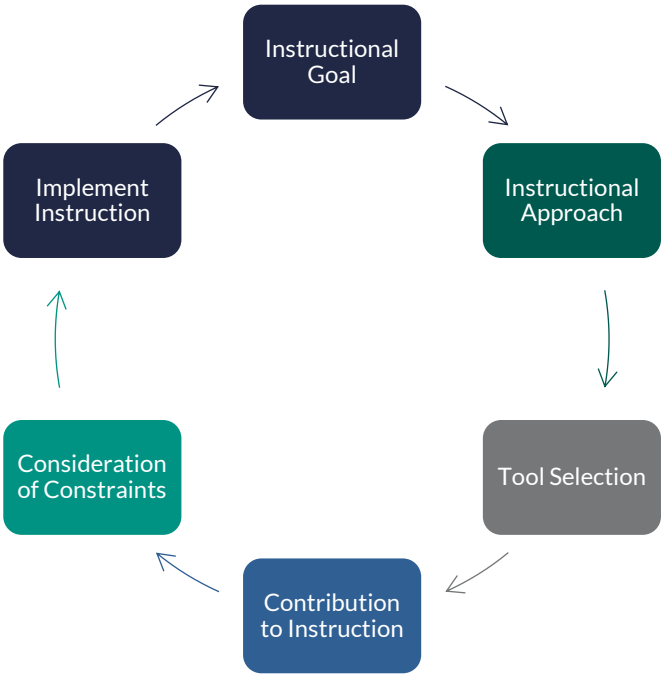
[29] "STEM Innovation Spotlights." Office of Educational Technology. https://tech.ed.gov/files/2019/10/stem-innovation-spotlights-research-synthesis.pdf

[30] School spotlight summarized from Ibid., p. 10.

[31] Hutchison, A. and L. Woodward. "A Planning Cycle for Integrating Digital Technology Into Literacy Instruction." *The Reading Teacher*, 67:6, 2014. https://www.academia.edu/5151373/A_Planning_Cycle_for_Integrating_Digital_Technology_Into_Literacy_Instruction

[32] Citation and description of TIPC taken verbatim from: Bergeson, K. and B. Beschorner. "Modeling and Scaffolding the Technology Integration Planning Cycle for Pre-Service Teachers: A Case Study." *International Journal of Education in Mathematics, Science and Technology*, 8:4, 2020. pp. 331–332. https://files.eric.ed.gov/fulltext/EJ1268803.pdf

Figure 1.6: Technology Integration Planning Cycle



Source: International Journal of Education in Mathematics, Science, Technology[33]

Under this umbrella of instructional goal setting, teachers can implement the lessons learned from the TPACK model in the classroom in a variety of ways. Harris et. al. in 2010 demonstrated how the TPACK model should change daily lesson planning; this research outlined potential categories of instruction and matched them with potential technologies. Figure 1.7 shows one of these tables for social studies exercises:

Figure 1.7: Social Studies Activities

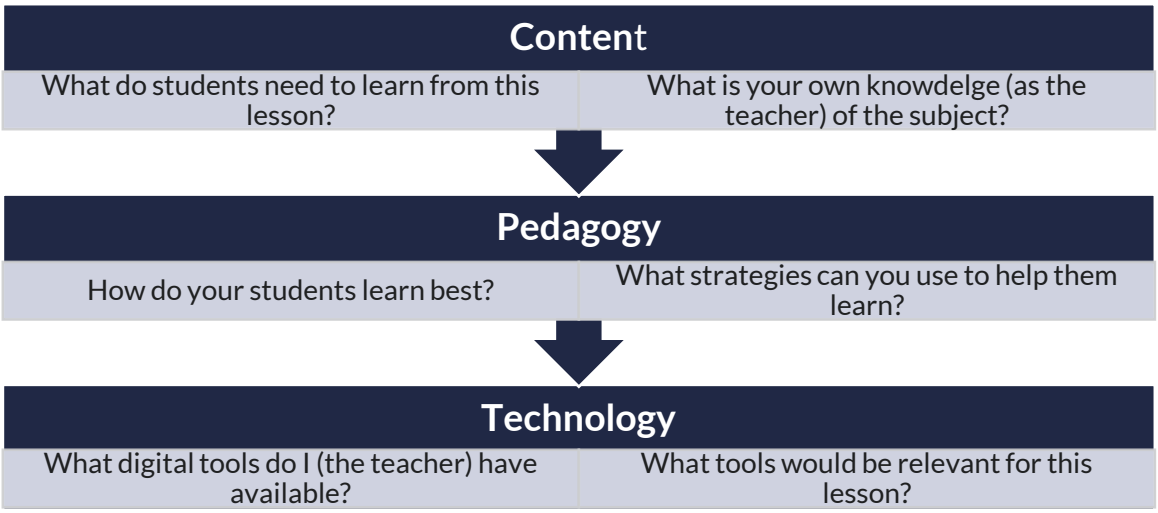
ACTIVITY TYPE	DESCRIPTION	POSSIBLE TECHNOLOGIES
Read Text	Students extract information from textbooks, historical documents, census data, etc.	Digital archives, web sites, electronic books, audiobooks
Create a Timeline	Students sequence events on a printed or electronic timeline	Timeline creation software, presentation software, concept mapping software, word processor
Review Activity	Students engage in some form of question and answer to review content	Student response systems (SRS), interactive whiteboard games, survey tools

Source: Harris et. al.[34]

More broadly in individual lesson planning, teachers using the TPACK model can follow a three-step framework (Figure 1.8).

[33] Taken with slight modifications from: Ibid., p. 332.
[34] Table taken with modifications from: Harris, J.B. and M.J. Hofer. "'Grounded' Technology Integration: Instructional Planning Using Curriculum-Based Activity Type Taxonomies." *Journal of Technology and Teacher Education*, 18:4, 2010. pp. 596–7. https://activitytypes.wm.edu/HarrisHofer&Others-InstructionalPlanningUsingLATsTaxonomies.pdf

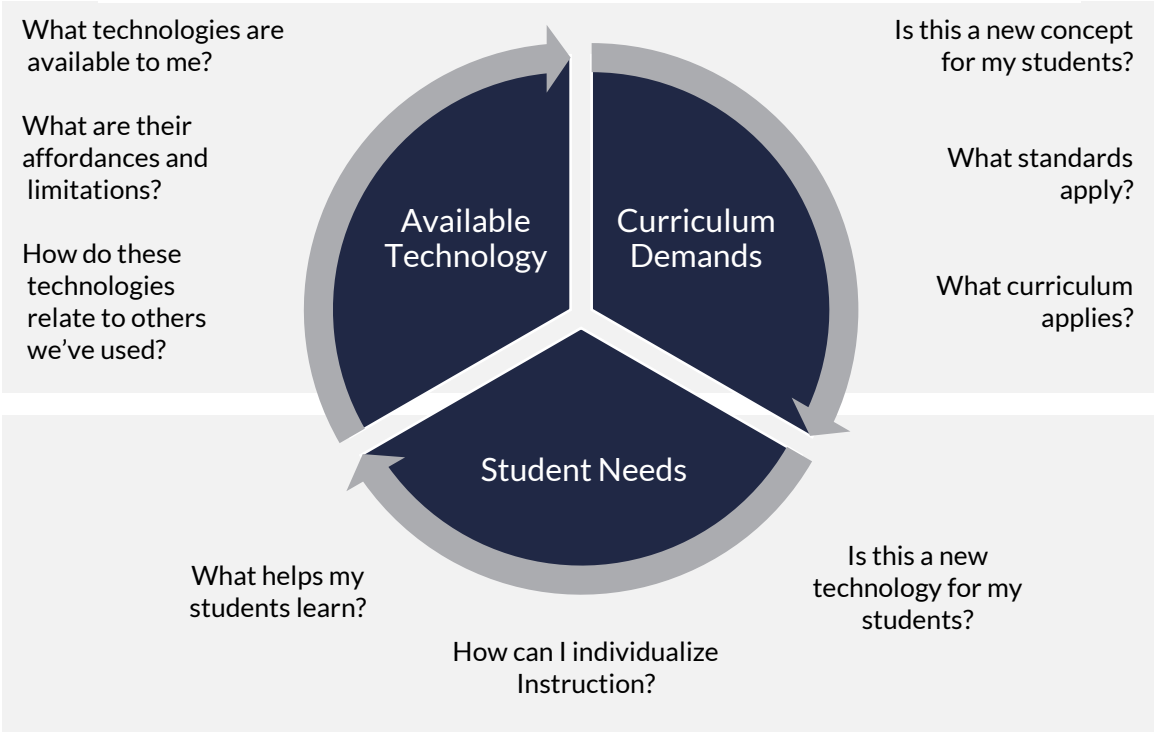
Figure 1.8: TPACK Lesson Planning



Source: PowerSchool[35]

The TIM framework simiarly provides guidance for integrating technology into classroom planning. Figure 1.9 illustrates a instructional planning model that supports the goals of TIM.

Figure 1.9: TIM Instructional Planning Model

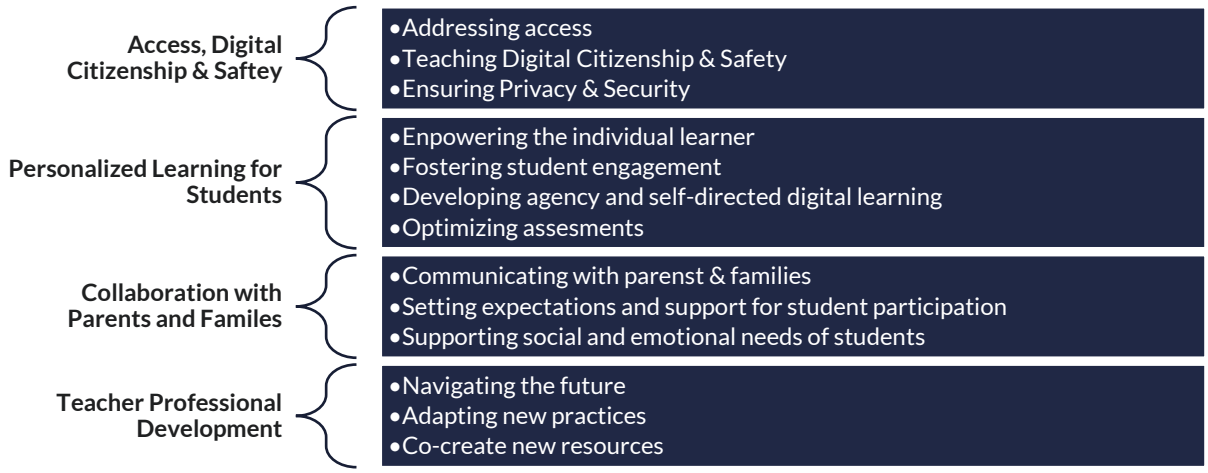


Source: Technology Integration Matrix[36]

[35] Falasz, B. "The TPACK Framework Explained." PowerSchool, April 20, 2022. https://www.powerschool.com/blog/the-tpack-framework-explained-with-classroom-examples/
[36] "Instructional Planning Model." Technology Integration Matrix. https://fcit.usf.edu/matrix/project/instructional-planning-model-pdf/

The Office of Education Technology also offers a free-access Teacher Digital Learning Guide which aids teachers in implementing digital learning.[37] This Guide provides a holistic overview of how to implement digital learning into the classroom and provides additional resources and tools.[38] Figure 1.10 shows the four main areas of the guide.

Figure 1.10: Teacher Digital Learning Guide



Source: Office of Educational Technology[39]

District Technology Plans

Some schools and districts outline individual instructional planning toolkits for integrating technology into the classroom which helps promote the even spread of technological use across the school or district.

District Spotlight – Clarkstown Central School District

Clarkstown Central School district, located in upstate New York, launched a district-wide technology plan for 2022-2025. The plan is centered around dual principals; to prepare their students to be productive members of an evolving global society and to support the District's curricular goals to shape students into well-rounded critical thinkers.[40] In order to implement this plan, the district created a technology committee, comprised of stakeholders representing all relevant parties (parents, students, trustees, teachers, administration, and board members).[41] The plan includes a comprehensive professional development plan for instructors based on the TPACK model, sets standards for digital content, and set plans to expand the district's technology infrastructure. The plan also includes action steps and an evaluation tool to measure progress.[42]

[37] "Teacher Digital Learning Guide." Office of Educational Technology. https://tech.ed.gov/publications/digital-learning-guide/teacher/
[38] "Tech Resources for Teachers." Office of Educational Technology. https://tech.ed.gov/teachers/
[39] "Teacher Digital Learning Guide," Op. cit.
[40] "Clarkstown Central School District NYSED Technology Plan 2022-2025." Clarkstown Central School District School Board. p. 2. https://go.boarddocs.com/ny/clarkcsd/Board.nsf/files/CF2QC26895C4/$file/District%20Tech%20Plan%202022-2025.pdf
[41] Ibid.
[42] Ibid., pp. 6–12.

CLASSROOM PRACTICES

Successful technological integration relies on the effective use of materials and practices within the classroom to support curricular and pedagogical goals. Positive student engagement, as well as guidance on the proper use of technology and tools, can determine outcomes for a school or district.[43] This section examines how students and teachers can best use technology in the classroom together: through daily learning, with equal access, and with proper practices.

DAILY LEARNING

Student engagement with technology largely depends on how effectively teachers integrate technology into learning. Research indicates that teachers are "slow to transform the ways they teach, despite the influx of new technology into their classrooms."[44] Providing students with devices does not automatically result in achievement gains, nor enable students to engage with technology in ways that support learning.[45]

Consequently, despite widespread access to technology, students often do not consistently engage technology to advance their learning, either in school or at home. School leaders can mitigate this first by determining student's actual technology use.

Student Technology Use Survey

To determine how students currently use technology at school and at home, as well as what factors would increase their technology use for educational purposes, districts or schools may wish to conduct a technology use survey.

Sample questions might include:

- How often do you use computers in class?
- Do you have internet access at home?
- How often do the majority of your teachers ask you to write online, collaborate online, collect and analyze data using technology, etc.?
- What technology would you like to have in your classroom or have more access to?

Source: SurveyMonkey, Shaler Area School District[46]

To encourage student's engagement in technology in learning, teachers should integrate technology into daily learning. Integration means that technology serves as a method for consistent and enhanced learning, not simply as a random or occasional platform for learning. Figure 1.11 lists recommended strategies for educators to move from *using* technology to *integrating* technology into daily instruction.

[43] Ferlazzo, L. "Technology 'Doesn't Replace Good Teaching.'" *Education Week*, November 10, 2019. https://www.edweek.org/teaching-learning/opinion-technology-doesnt-replace-good-teaching/2019/11

[44] Herold, B. "Technology in Education: An Overview." *Education Week*, February 5, 2016. https://www.edweek.org/technology/technology-in-education-an-overview/2016/02

[45] Ferlazzo, L. "Technology Is the Tool, Not the Teacher." *Education Week*, July 15, 2022. https://www.edweek.org/technology/opinion-technology-is-the-tool-not-the-teacher/2022/07

[46] Figure content adapted and quoted verbatim from: [1] "FISD Technology Use Student Survey." Surveymonkey. https://www.surveymonkey.com/r/FMS37RD [2] "Clarity High School Student Survey." Shaler Area School District. http://www.sasd.k12.pa.us/Downloads/BrightBytes%20High%20School%20Student%20Qs%20for%20v34.pdf

Figure 1.11: Technology *Use* Verses Technology *Integration*

TECHNOLOGY USE	TECHNOLOGY INTEGRATION
Technology use is random, arbitrary, and often an afterthought	Technology usage is planned and purposeful
Technology is rarely or sporadically used in the classroom	Technology is a routine part of the classroom environment
Technology is used purely for the sake of using technology	Technology is used to support curricular goals and learning objectives
Technology is used to instruct students on content	Technology is used to engage students with content
Technology is mostly being used by the instructor	Technology is being used mostly by the students
Focus on simply using technology	Focus on using technologies to create and develop new thinking processes
More instructional time is spent learning the technology	More instructional time is spent using the technology to learn
Technology is used to facilitate activities that are feasible or easier without technology	Technology is used to facilitate activities that would otherwise be difficult or impossible

Source: Distance Learning[47]

STUDENT ACCESS

The use of technology alone will not improve equitable access to learning: educators must take additional steps in ensuring the effective use of technology and the accessibility of their materials. Access to stable internet, usable equipment, and guidelines for internet and digital safety are crucial to the success of technology in the classroom.[48]

According to a survey conducted by the Pew Research Center in 2021, assessing American internet use during the pandemic,[49] 70 percent of parents of K-12 students reported that it was very or somewhat easy to help their children use technology for online instruction.[50] However, 30 percent reported that it has been very or somewhat difficult to help their children use technology. The survey indicates that children from lower income households are more likely to encounter tech-related obstacles to completing their schoolwork.[51]

[47] Content shortened and modified from: Harris, C . "The Effective Integration of Technology Into School's Curriculum." Distance Learning, 13, (2), 2016. https://www.proquest.com/docview/1822357068?accountid=132487&fromopenview=true&pq-origsite=gscholar
[48] "K-12 Leaders' Guide to Successful Technology Integration." Verizon Innovative Learning Schools. https://verizon.digitalpromise.org/elements-of-success/
[49] Survey included 4,623 U.S. adults in April of 2021. From: Mcclain, C. et al. "The Internet and the Pandemic." Pew Research Center: Internet, Science & Tech, September 1, 2021. https://www.pewresearch.org/internet/2021/09/01/the-internet-and-the-pandemic/
[50] Ibid.
[51] Ibid.

While schools have now re-adjusted back to in-person instruction, these obstacles to using technology in the classroom will remain for some students.[52] **In order to recognize and mitigate these risks, schools must ensure, to the best of their ability, equal access both at home and in school for all students.** On campus, school leaders should monitor school equipment and internet capabilities, and identify missing devices or those in need of repair. Likewise, leaders should work with IT to set up a system for replacing missing or damaged devices quickly. To monitor student access at home, school leaders should seek to gather information on internet connectivity from school district families as part of the general school registration process. Leaders can also survey teachers about home connectivity in a similar manner. Once data is compiled, leaders can analyze solutions for connectivity for those who indicate they do not have internet access. Possible solutions could include, checking out hotspots or LTE-enabled devices to those in need so they can have access at home, identifying nearby public Wi-Fi networks, or installing external Wi-Fi in school outdoor areas like parking lots. [53]

DIGITAL CITIZENSHIP

Promoting responsible internet use is key to the successful use of technology in the classroom. Students should be taught to use technology and the internet critically, in a safe manner, and in a way that respects the human rights of others.[54] These skills are crucial for students to be able to participate fully in digital learning, but also are crucial for their own safety and wellness.

Digital citizenship has become increasingly important in recent years in education, and a large body of research exists in both defining what digital citizenship means, and how it can be taught.[55] Experts agree that there are nine main elements of digital citizenship, which are shown in Figure 1.12.

Figure 1.12: Nine Elements of Digital Citizenship

RESPECT (YOURSELF AND OTHERS)	**Etiquette**. Understanding appropriate code of conduct and procedures when using digital devices.
	Access. Understanding who has access to technology and the limitations and consequences to those who have limited access to technology.
	Law. Understanding legal rights and restrictions related to the online world (e.g., copyright laws).
EDUCATE (YOURSELF/CONNECT WITH OTHERS)	**Digital Literacy.** Teaching and learning how to use technology in its many forms.
	Commerce. Making safe and informed decisions when purchasing or downloading materials online.
	Communication. Making appropriate decisions when communicating through the different modes and mediums of digital technology.
PROTECT (YOURSELF/PROTECT OTHERS)	**Security.** Understanding and being aware of malware attacks and how to prevent them.
	Digital Health and Welfare. Maintaining technological practices to promote physical and psychological wellness (e.g., balancing screen time and screen use).

[52] Lieberman, M. "Most Students Now Have Home Internet Access. But What About the Ones Who Don't?" *Education Week*, April 20, 2021. https://www.edweek.org/technology/most-students-now-have-home-internet-access-but-what-about-the-ones-who-dont/2021/04
[53] Suggestions taken with slight modifications from "K-12 Leaders' Guide to Successful Technology Integration," Op. cit.
[54] Farmer, L. "Teaching Digital Citizenship." Association for the Advancement of Computing in Education (AACE), 2011. https://www.learntechlib.org/primary/p/37093/
[55] Frau-Meigs, D. et al. *Digital Citizenship Education: Overview and New Perspectives.* Council of Europe, 2017, 2021. https://rm.coe.int/168077bc6a

	Rights and Responsibility. Understanding of the requirements and freedoms extended to everyone in a digital world.

Source: Digital Citizenship in Schools[56]

Educators can help children develop digital citizenship skills by setting boundaries and expectations around classroom technologies and also by using open access resources such as Common Sense Education's Digital Citizenship Curriculum[57] and the Student Technology Standards from the ISTE.[58]

[56] Figure text taken verbatim from: Ribble, M. *Digital Citizenship in Schools: Nine Elements All Students Should Know*. International Society for Technology in Education, 2015.
[57] Common Sense Education. "Digital Citizenship." Common Sense Education, February 14, 2017. https://www.commonsense.org/education/digital-citizenship
[58] "The ISTE Standards." International Society for Technology in Education, 2022. https://www.iste.org/iste-standards

SECTION II: SUPPORTING INSTRUCTIONAL STAFF IN TECHNOLOGY INTEGRATION

In this section, Hanover reviews professional development strategies to support teachers in implementing technology in the classroom. The section is broken down into three areas of support: professional development, coaching and collaboration, and evaluation.

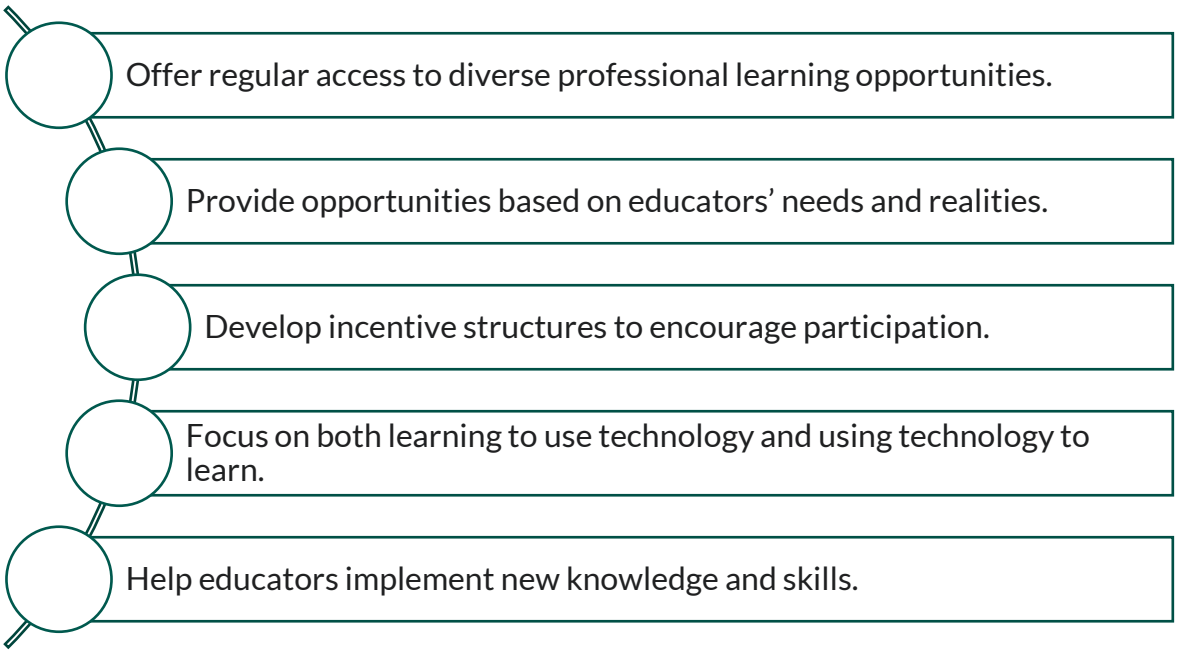
PROFESSIONAL LEARNING

To implement technology successfully in the classroom, teachers need themselves to have a firm grasp on the technologies and have a clear understanding of best practices for technological pedagogy. This can be attained through various forms of professional learning. Research indicates that professional learning for teachers should be interactive, ongoing, interest-driven, relevant to teachers' needs and provide opportunities for collaboration.[59] Districts and schools should therefore provide comprehensive professional learning plans for the teachers and ensure the ongoing availability of trainings.

FRAMEWORKS AND GUIDELINES

The ISTE offers guidelines for administrators in how to support professional learning specifically for technological integration. While school administrators can implement professional learning plans in a variety of different ways, depending on needs and resources, ISTE recommends a series of principles to order professional learning efforts (Figure 2.1).

Figure 2.1: ISTE Principals for Supporting Professional Learning

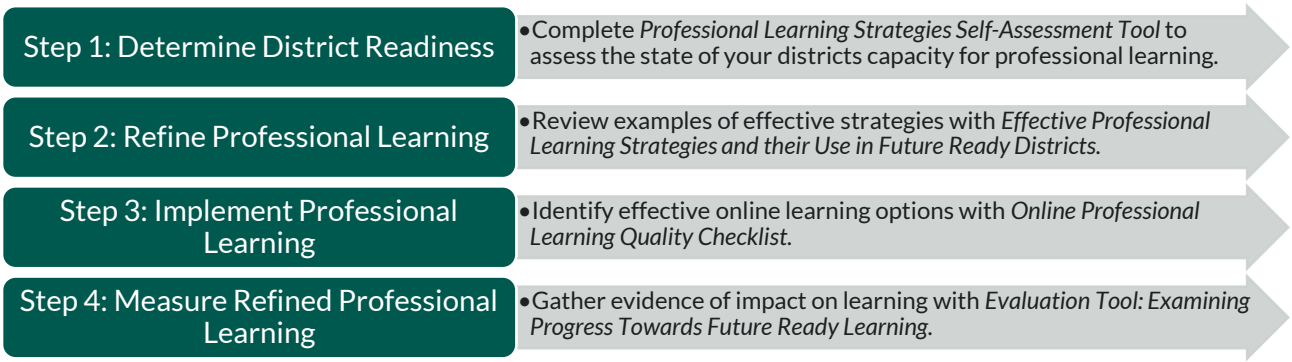


Source: ISTE[60]

[59] Elliott, J.C. "The Evolution From Traditional to Online Professional Development: A Review." *Journal of Digital Learning in Teacher Education*, 33:3, July 3, 2017. https://doi.org/10.1080/21532974.2017.1305304
[60] "Ongoing Professional Learning." International Society for Technology in Education. https://www.iste.org/standards/essential-conditions/ongoing-professional-learning

In a similar direction, the Office of Educational Technology offers a step-by-step process for evaluating current professional learning programs and implementing effective professional learning strategies that utilize current technologies. This program offers steps aligned with provided toolkits for implementing a digital professional learning strategy, shown in Figure 2.2.

Figure 2.2: Office of Educational Technology Toolkit for Professional Learning



Source: Office of Educational Technology[61]

ONLINE PROFESSIONAL LEARNING (OPL)

The outbreak of the COVID-19 Pandemic caused the unprecedented scale of digitally supported learning – this was also true for professional learning (PL) of teachers. In the scramble to move everything online, PL during the pandemic focused on preparing teachers to use new digital tools and applications to support their student's learning.[62] As the digital landscape in education expanded during the pandemic, it is unlikely this will fade with the return to in-person instruction; likewise many of the effective OPL programs that assisted teachers in using digital tools and pedagogy will remain relevant.[63] In addition, a benefit of OPL is that these opportunities can fit into a teacher's busy schedule and offer more personalized learning options.[64]

Because of the flexibility of an online format, opportunities for OPL can be found in many different areas. **Districts can often integrate the use of OPL through state or federally provided resources.** For example, Fort Worth Independent School District in Texas partnered with Eduphoria to provide OPL in technology integration for its educators.[65] The district also hosts an annual technology conference which "aims to innovate, integrate, and motivate educators."[66]

Other OPL opportunities can be provided by third-party organizations. For example, the International Society for Technology in Education (ISTE) offers a membership for educators and schools, and provides peer-driven professional learning opportunities in the form of resources, webinars, or book studies.[67] ISTE also

[61] Steps modified from 5 to 4 for simplicity. Step 2 combined with Step 1 from original toolkit. Information synthesized from: "Future Ready Schools: Empowering Educators through Professional Learning Toolkit - Office of Educational Technology." https://tech.ed.gov/futureready/professional-learning/
[62] Bragg, L.A., C. Walsh, and M. Heyeres. "Successful Design and Delivery of Online Professional Development for Teachers: A Systematic Review of the Literature." *Computers & Education*, 166, June 1, 2021. https://www.sciencedirect.com/science/article/pii/S036013152100035X
[63] Ibid.
[64] ul Haq, F. "Five Reasons Online Learning Is The Future Of Professional Development." Forbes. https://www.forbes.com/sites/forbestechcouncil/2021/03/26/five-reasons-online-learning-is-the-future-of-professional-development/
[65] "District Professional Learning Guidance Document." Fort Worth Independent School District. https://www.fwisd.org/Page/28535
[66] "Annual Fort Worth Technology Conference Aims to Innovate, Integrate, Motivate Educators." McLean Middle School. https://www.fwisd.org/site/default.aspx?PageType=3&DomainID=39&ModuleInstanceID=1326&ViewID=6446EE88-D30C-497E-9316-3F8874B3E108&RenderLoc=0&FlexDataID=79643&PageID=71
[67] "ISTE's Professional Learning Network." International Society for Technology in Education. https://www.iste.org/membership/professional-learning-network-for-teachers

offers a Certification for Educators which is the only vendor-neutral and internationally recognized credential for educators which focuses on education practice and technology. The certification process includes fourteen weeks of professional learning and participants can apply to earn graduate credit from the course.[68] iTeach also offers their own professional learning courses for integrating technology, with options for self-paced courses and group instruction.[69]

Some universities or community college often offer certificate courses in technology integration. Fresno Pacific University offers technology courses where teachers can also earn graduate level credit. The program includes courses such as "The Chromebook Classroom," "The Flipped Classroom," and "Teaching with Immersive Technology."[70] In addition to technology education courses, Fresno Pacific also offers certificate programs in technology.[71] Districts can choose from a variety of such programs available to offer OPL for their teachers.

COMMUNITIES OF PRACTICE AND EDUCATIONAL TECHNOLOGY

Critics have long argued that professional training on the use of technology in the classroom if often too far divorced from actual classroom practice and application [72] **However, current research indicates that integrating professional education on technology within pre-existing professional learning environments may have more success and be more applicable to classroom instruction**. [73] Professional Learning Communities (PLCs), also known as Communities of Practice (CoPs), which may already be in place in schools, can provide situated professional learning, ongoing engagement, and appropriate social context for ongoing involvement and pedagogical development.[74]

Spotlight: 21st Century Learning Collaborative Initiative – Technological Integration

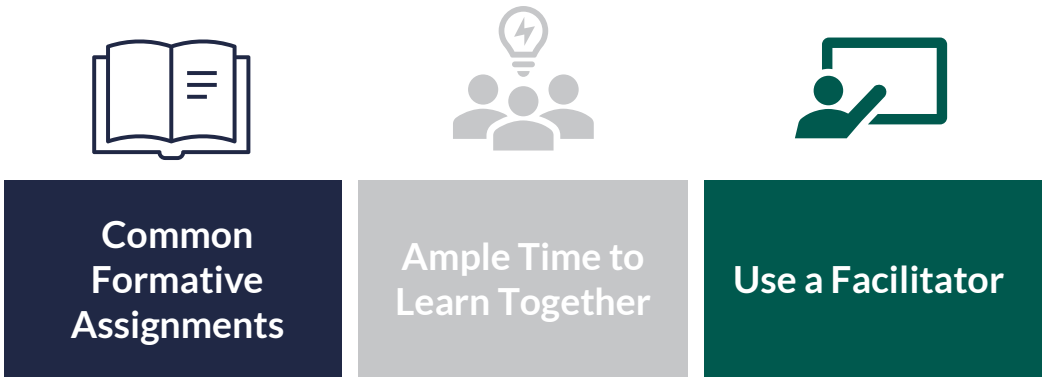
In 2018, the 21st Century Learning Collaborative Initiative was launched in collaboration between a large Mid-Western University and area K-12 Catholic schools. [75] The program provided a six-week period of instructional sessions for representative teachers from the participating schools to provide technological integration training. The teachers were introduced to flipped classrooms and blended learning and received training on technology tools to integrate into the classroom. After the six-week session, teachers were groups by school location to create smaller learning communities at their schools. Within these learning communities throughout the year, the representative teachers would implement technological and other skill training and conduct ongoing classroom visits. [76] Evaluation at the end of the project concluded that collaboration with peers is an essential component of implementing technology and indicated the project's success in preparing teachers to use tech in their classrooms.[77]

[68] "ISTE Certification." International Society for Technology in Education. https://www.iste.org/professional-development/iste-certification
[69] "ITeach Technology Integration Courses." ITeach. https://iteach.usf.edu/browse-courses/
[70] "Technology Courses for Teachers." Fresno Pacific University. https://ce.fresno.edu/technology-courses/
[71] "Classroom Technology Integration Certificate." Fresno Pacific University. https://ce.fresno.edu/classroom-technology-integration-certificate/
[72] Thorvaldsen, S. and S.S. Madsen. "Perspectives on the Tensions in Teaching with Technology in Norwegian Teacher Education Analysed Using Argyris and Schön's Theory of Action." *Education and Information Technologies*, 25:6, November 1, 2020. https://link.springer.com/content/pdf/10.1007/s10639-020-10221-4.pdf
[73] Smith, C. and S. Becker. "Using Communities of Practice to Facilitate Technology Integration among K-12 Educators: A Qualitative Meta-Synthesis." *Journal of Technology and Teacher Education*, 29:4, December 2021. https://www.learntechlib.org/primary/p/219900/
[74] Ibid., p. 575.
[75] Rieckhoff, B., R. Owens, and B. Kraber. "Teaching in the 21st Century: Perspectives from a Catholic University Partnership." *Journal of Catholic Education*, 21:2, June 13, 2018. p. 182. https://digitalcommons.lmu.edu/ce/vol21/iss2/14
[76] Ibid., pp. 188–190.
[77] Ibid., p. 196.

PLCs are particularly well suited for helping teachers learn new technologies and implement them into their classrooms because PLCs naturally allow for shared resources and ongoing discourse, as well as help teachers make clear goals around technological use.[78]

A recent study analyzed how fifth-grade teachers worked within their PLCs to use the Technology Integration Planning Cycle (surveyed in Section 1: Figure 1.6).[79] The study found that the steps outlined in the TIPC helped teachers work together through brainstorming practices that would help them reach their instructional goals in terms of technology. **The study concluded in recommending three practices for PLCs to support effective technology integration, outlined in Figure 2.3 below**.

Figure 2.3: Three Practices for PLCs



Source: The Reading Teacher[80]

Based on these three areas, the study recommended an action plan for PLCs: [81]

ACTION STEPS	
1.	As a PLC, determine what your instructional outcomes for students for a unit will be. Limit this to a few learning standards that you will examine closely.
2.	Create a common formative assessment to determine whether students have achieved the standards.
3.	If your PLC is not tech-savvy, consider bringing in a third party (such as a media specialist, technology coach, or another teacher) who can help you determine which tools will best support students in reaching literacy goals.
4.	Decide whether the tools you have chosen will help or hinder instruction. Are there work-arounds for any potential barriers?
5.	Teach your unit. At certain points, check in with your team and show student work to determine how students are reaching their literacy goals.
6.	Reflect on the process. Did students reach their intended literacy goals? What helped this process? What hindered this process?

COACHING AND COLLABORATION

This section examines the importance of instructional coaching and institutional support to technology integration efforts. Coaching and leadership support can be crucial to supporting teachers in tandem with professional learning opportunities.

[78] Thoma, J. et al. "Planning for Technology Integration in a Professional Learning Community." *The Reading Teacher*, 71:2, 2017. https://onlinelibrary.wiley.com/doi/abs/10.1002/trtr.1604
[79] Ibid.
[80] Thoma et al., Op. cit., pp. 7–8.
[81] Action steps taken verbatim from: Ibid., p. 8.

INSTRUCTIONAL COACHING

Research has shown that instructional coaching supports good instructional practices; similarly, instructional coaching can be critical for technology integration.[82] For technology integration, coaching, rather than singular workshops or professional learning courses, can more effectively help teacher integrate technology into their classes consistently throughout the school year.[83] The US National Educational Technology Plan in 2017 recommended the need to have a common set of technological competencies for instructional coaches meant to prepare teachers for technology integration.[84] Following this lead, four researchers in 2017 comprised a project to identify and recommend a set number of twelve technology competencies, using a wide variety of collected data.[85] These competencies are outlined in Table 2.1.

Table 2.1: Core Competencies for Teacher Educators in Technology

1. TEACHER EDUCATORS WILL DESIGN INSTRUCTION THAT UTILIZES CONTENT-SPECIFIC TECHNOLOGIES TO ENHANCE TEACHING AND LEARNING.
a) **Evaluate content-specific technology for teaching and learning.** b) Align content with pedagogical approaches and appropriate technology. c) Model approaches for aligning the content being taught with appropriate pedagogy and technology
2. TEACHER EDUCATORS WILL INCORPORATE PEDAGOGICAL APPROACHES THAT PREPARE TEACHER CANDIDATES TO EFFECTIVELY USE TECHNOLOGY.
a) Model using technology for accessing, analyzing, creating, and evaluating information. b) Assist teacher candidates with evaluating the affordances of content-specific technologies to support student learning. c) Assist teacher candidates with the selection and use of content-specific technologies to support student learning. d) Facilitate opportunities for teacher candidates to practice teaching with technology
3. TEACHER EDUCATORS WILL SUPPORT THE DEVELOPMENT OF THE KNOWLEDGE, SKILLS, AND ATTITUDES OF TEACHER CANDIDATES AS RELATED TO TEACHING WITH TECHNOLOGY IN THEIR CONTENT AREA.
a) Support teacher candidates' alignment of content with pedagogy and appropriate technology. b) Provide opportunities for teacher candidates to reflect on their attitudes about using technology for teaching and for their own learning. c) Provide opportunities to develop teacher candidates' efficacy about using technology in teaching.
4. TEACHER EDUCATORS WILL USE ONLINE TOOLS TO ENHANCE TEACHING AND LEARNING.
a) Communicate using online tools. b) Collaborate using online tools. c) Design instruction using online tools. d) Assess teacher candidates using online tools.

[82] Salas, S.D. de, C. Rohlfs, and C. Spannagel. "Coaching Teachers in Using Technology." presented at the EdMedia + Innovate Learning, Association for the Advancement of Computing in Education (AACE), 2016. https://www.learntechlib.org/primary/p/173060/ [2] Jackson, N.M. "How Coaches Help Teachers Get the Most from Ed Tech." District Administration, January 24, 2020. https://districtadministration.com/tech-coaches/

[83] Ehsanipour, T. and F. Gomez Zaccarelli. "Exploring Coaching for Powerful Technology Use in Education." Digital Promise, 2017. p. 10. https://digitalpromise.dspacedirect.org/bitstream/handle/20.500.12265/47/Exploring-Coaching-DLP-2017.pdf?sequence=1&isAllowed=y

[84] "National Educational Technology Plan." Office of Educational Technology. p. 44. https://tech.ed.gov/netp/

[85] Foulger, T.S. et al. "Teacher Educator Technology Competencies." *Journal of Technology and Teacher Education*, 25:4, October 2017. https://www.learntechlib.org/primary/p/181966/

5. TEACHER EDUCATORS WILL USE TECHNOLOGY TO DIFFERENTIATE INSTRUCTION TO MEET DIVERSE LEARNING NEEDS

a) Design instruction using technology to meet the needs of diverse learners.
b) Demonstrate using assistive technologies to maximize learning for individual student needs.
c) Model using technology to differentiate learning in teaching and learning.
d) Provide opportunities for teacher candidates to create learning activities using technology to differentiate instruction.

6. TEACHER EDUCATORS WILL USE APPROPRIATE TECHNOLOGY TOOLS FOR ASSESSMENT

a) Use technology to assess teacher candidates' competence and knowledge.
b) Model a variety of assessment practices that use technology.
c) Provide opportunities for teacher candidates to use appropriate technology for assessment.

7. TEACHER EDUCATORS WILL USE EFFECTIVE STRATEGIES FOR TEACHING ONLINE AND/OR BLENDED/HYBRID LEARNING ENVIRONMENTS.

a) Model online and blended learning methods and strategies.
b) Provide opportunities for teacher candidates to practice teaching online and/or in blended/hybrid learning environments.

8. TEACHER EDUCATORS WILL USE TECHNOLOGY TO CONNECT GLOBALLY WITH A VARIETY OF REGIONS AND CULTURES.

a) Model global engagement using technologies to connect teacher candidates with other cultures and locations.
b) Design instruction in which teacher candidates use technology to collaborate with learners from a variety of backgrounds and cultures.
c) Address strategies needed for cultures and regions having different levels of technological connectivity.

9. TEACHER EDUCATORS WILL ADDRESS THE LEGAL, ETHICAL, AND SOCIALLY-RESPONSIBLE USE OF TECHNOLOGY IN EDUCATION.

a) Model the legal, ethical, and socially-responsible use of technology for teaching and learning.
b) Guide teacher candidates' use of technology in legal, ethical, and socially-responsible ways.
c) Provide opportunities for teacher candidates to design curriculum following legal, ethical, and socially-responsible uses of technology.

10. TEACHER EDUCATORS WILL ENGAGE IN ONGOING PROFESSIONAL DEVELOPMENT AND NETWORKING ACTIVITIES TO IMPROVE THE INTEGRATION OF TECHNOLOGY IN TEACHING.

a) Define goals for personal growth in using technology.
b) Engage in continuous professional development and networking activities promoting technology knowledge and skills.
c) Support teacher candidates' continuous participation in networking activities to increase their knowledge of technology.

11. TEACHER EDUCATORS WILL ENGAGE IN LEADERSHIP AND ADVOCACY FOR USING TECHNOLOGY

a) Share a vision for teaching and learning with technology.
b) Engage with professional organizations that advocate technology use in education.
c) Seek to influence the opinions and decisions of others regarding technology integration.
d) Assist teacher candidates in becoming advocates for using technology to enhance teaching and learning.
e) Support teacher candidates in understanding local, state, and national technology policies in education.

12. TEACHER EDUCATORS WILL APPLY BASIC TROUBLESHOOTING SKILLS TO RESOLVE TECHNOLOGY ISSUES.

a) Configure digital devices for teaching.
b) Operate digital devices during teaching.
c) Model basic troubleshooting skills during teaching.
d) Find solutions to problems related to technology using a variety of resources.

Source: Journal of Technology and Teacher Education[86]

These core competencies, and related criteria, mean to serve as guidelines for the depth of knowledge, skills, and attitudes needed for successful technology integration coaching.[87] This can serve as a model for preparing coaches as well as for selecting candidates for coaching positions.

For implementing coaching, the Technology Integration Matrix System also a offers a phase framework for coaching technology integration, shown in Figure 2. 4.

Figure 2.4: TIM Coaching Tool

	**Phase 1: Set Goals** ▪ Base goals on data collection/analysis or national/professional standard
	**Phase 2: Plan Activities** ▪ Relate activities to each goal ▪ Set duration or number of activities
	**Phase 3: Monitor Progress** ▪ Conduct check-ins, ask questions, problem solve obstacles
	**Phase 4: Record Outcomes** ▪ Record meeting set goals
	**Phase 5: Reflect on the Coaching Cycle** ▪ Identify success and areas for reevaluation

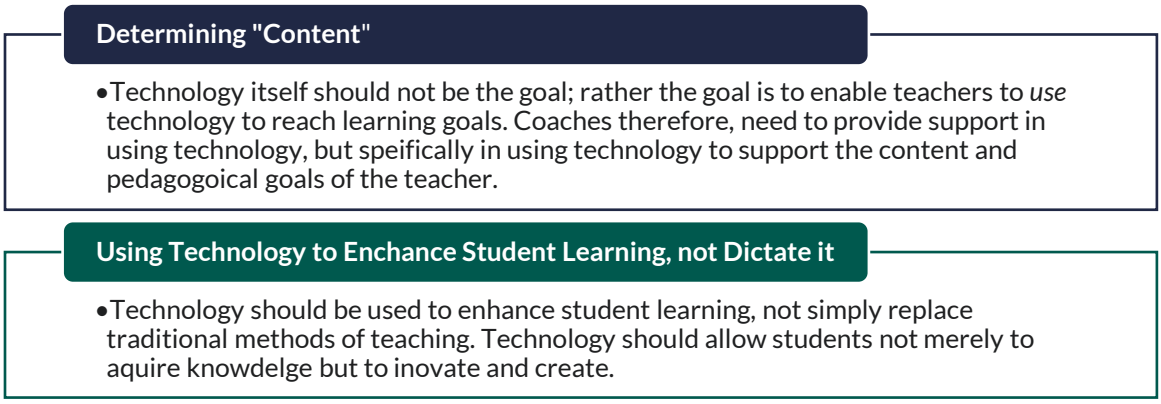
Source: The Technology Integration Matrix[88]

[86] Ibid., pp. 432–433.
[87] Ibid., p. 437.
[88] Winkelman, R. "Using the TIM-C Coaching Tool." *Teaching and Learning with Technology*, September 25, 2019. https://fcit.usf.edu/matrix/using-the-tim-c-coaching-tool/

TIM experts note that this phase cycle can be used across content areas, and while it provides a general framework, the coach and teacher/group of teachers must customize it to meet their needs.[89] This coaching model may be guided by the twelve competencies, reviewed above, or by goals set forth by an individual school or district.

As coaches prepare to work with their teachers based on these principles of coaching technology, there are two main obstacles both coaches and teachers will face, found in Figure 2.5.

Figure 2.5: Obstacles to Technology Integration Coaching



Source: Digital Promise[90]

There are a number of coaching approaches which can help coaches and teachers to overcome these obstacles to using technology in the classroom. A study conducted in 2019 indicated the success of a **co-constructed coaching model for integrating technology**.[91] In this model, both the coach and the teacher bring specific knowledge to the table – the coach, technological tools and methods, and the teacher, content and pedagogical tools. Teachers from all content areas in the study attended a summer institute where they were introduced to methods of technology integration, and they then worked weekly or bi-weekly with an instructional coach. The year-long sessions built on the foundation created during the summer institute. The study found that coaching was most effective when coaches worked with groups of teachers within the same discipline, so the group could collaborate on best practices to serve the needs of their content area.[92] Likewise, as the coach modeled technological skills and tools for the teachers, the evaluation at the end of the study indicated that coaches with similar pedagogical backgrounds to their mentees were more helpful.[93]

Coaches can also personalize coaching sessions around the very technology that teachers wish to integrate into their classrooms. This sort of personalized training allows teachers to actively work together with coaches to create classroom practices, rather than simply inserting technology into their teaching equations. This model also allows for coaches to help troubleshoot and provide in-class support for teachers.[94] Likewise, as coaches typically conduct classroom observations, observing a teacher's live practice can allow coaches to suggest relevant technologies to enhance instruction.[95]

[89] Ibid.
[90] Figure content synthesized from: Ehsanipour and Gomez Zaccarelli, Op. cit., p. 11.
[91] Bergeson and Beschorner, Op. cit. [2] Dillon, D. et al. "Teacher Educator Technology Integration Initiative: Addressing the Technology Preparation Gap." *Journal of Technology and Teacher Education*, 27:4, October 2019. https://www.learntechlib.org/primary/p/208214/
[92] Dillon et al., Op. cit., p. 550.
[93] Ibid., p. 551.
[94] Ottenbreit-Leftwich, A. et al. "Year-Long Implementation of a Research-Based Technology Integration Professional Development Coaching Model in an Elementary School." *Journal of Digital Learning in Teacher Education*, 36:4, October 1, 2020. p. 212. https://doi.org/10.1080/21532974.2020.1804494
[95] Ibid., pp. 212–213.

District Spotlight: Prince William County Schools (VA)

Prince William County Schools in Virginia provide an instructional technology coach for each school building. These coaches are meant to serve as on-site resources for instructional staff and to create different opportunities for learning.[96]

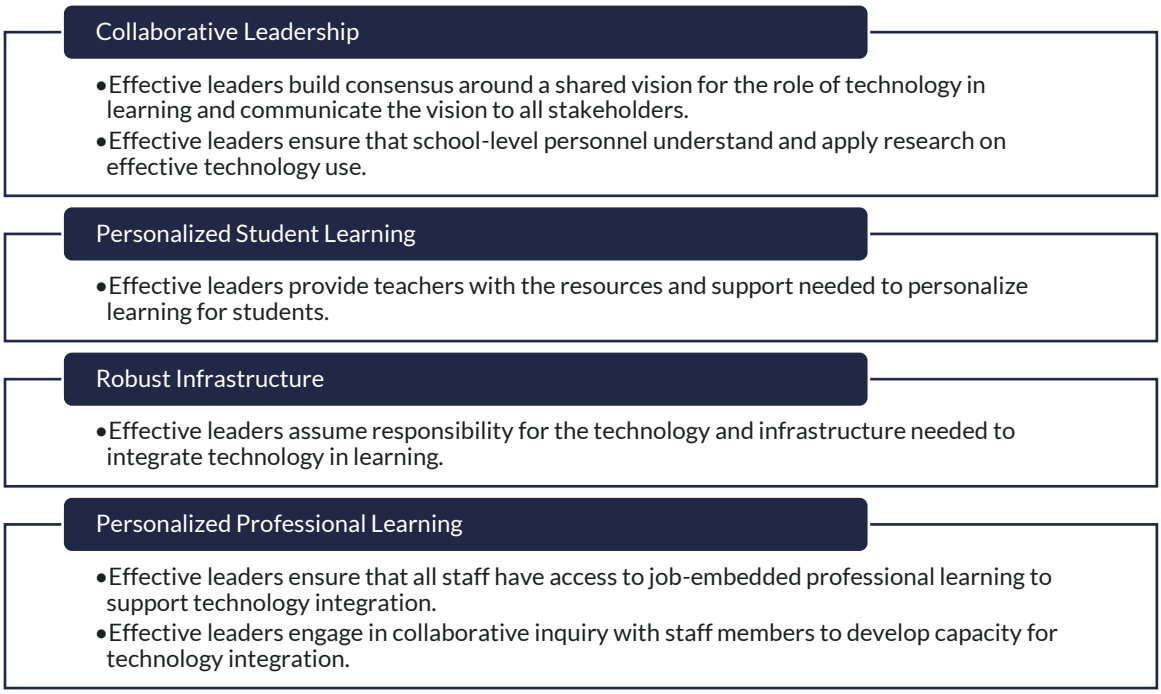
The responsibilities of these coaches include:[97]

- Providing instructional technology leadership.
- Identifying and providing technology trainings.
- Collaborating and planning with teachers to provide lessons and resources for integrating technology.
- Developing, modeling, and co-teaching appropriate curriculum-based technology-rich lessons with teachers and students.

SUPPORT FROM LEADERSHIP

Visible support from school and district leadership is crucial to the success of instructional coaching program as well as to technology integration. Leaders across roles should be in agreement with the coaching or professional development model and provide support for coaches and teachers.[98] Effective leaders should strive to engage in the principles outlined in Figure 2.6.

Figure 2.6: Leadership Characteristics for Technology Integration



[96] "Instructional Technology Coaches Leading the Way." Prince William County Public Schools. https://www.pwcs.edu/departments/Instructional_technology/instructional_technology_coaches_leading_the_way_
[97] These responsibilities are taken verbatim from: Ibid.
[98] Thomas, S. "Reimagining the Role of Technology in Education: 2017 National Education Technology Plan Update." Office of Educational Technology, US Department of Education, January 2017. p. 42. https://tech.ed.gov/files/2017/01/NETP17.pdf

Source: Office of Educational Technology, U.S. Department of Education[99]

While coaching and collaboration efforts are crucial to any technology integration plan, one obstacle many teachers face is lack of time to participate in coaching or collaboration. **There are several ways district and school leaders can schedule collaborative planning times to ensure all teachers have the ability to engage in these activities, outlined in Table 2.2.**[100]

Table 2.2: Strategies to Schedule Collaborative Planning Time

STRATEGY	DESCRIPTION	CONSIDERATIONS
Back-to Back	Stack two blocks of planning time together	▪ May mean teachers do not have a planning block one day a week ▪ Schools must ensure teachers have duty-free lunch or other noninstructional time every day
Banking Time	Reduce planning time on a few days to increase time on another day	▪ Useful when teachers have at least 40 minutes of planning time per day, to ensure shortened blocks are still useful
Beginning and End of Day	Reorganize time that teachers have at the beginning and end of the day into more team planning time	▪ Useful when teachers are mandated to arrive before and depart after students ▪ Staff may need to arrive earlier or stay later on certain days under this model
Recess and Lunch	Schedule noninstructional blocks like recess and lunch next to planning time, and cover those activities with other adults	▪ Schools must have staff to cover recess/lunch ▪ Schools must ensure that teachers still have sufficient time for eating lunch
Larger Specials	Create larger specials classes so that fewer specials classes can cover more core teachers' time	▪ Works best when specials are not already at or near class-size limit
Enrichment Periods	Create enrichment or intervention periods, covered by other adults, to allow teachers to plan	▪ Useful when schools have staff or community partners to cover enrichment periods effectively —i.e., as an academic benefit, not a time filler

Source: Education Resource Strategies[101]

In particular, principals can be crucial support points for instructional coaching and collaboration opportunities. As instructional leaders, it is the job of the principal to not only be aware of technology use in their school, but to have a deep understanding of practice and of obstacles their teachers may face in using technology.[102] Principals should designate a school-level leadership team to collect data on technology use and identify supports needed for teachers at the school level.[103] Similarly, some studies have suggested that principals can also benefit from instructional coaching in technology integration to strengthen their own leadership skills in the area.[104]

[99] Chart contents adapted from: Thomas, Op. cit., pp. 43–45.
[100] Rosenberg, D., R. Daigneau, and M. Galvez. "Finding Time for Collaborative Planning." *Education Resource Strategies*, 2018.
[101] Chart taken verbatim from: Ibid., p. 4.
[102] "Leading the Way on Technology Integration." Edutopia. https://www.edutopia.org/article/leading-way-technology-integration
[103] "Technology Implementation Practice Guide." *American Institutes for Research*, 2014. https://powerupwhatworks.org/sites/default/files/PowerUp%20WHAT%20WORKS%20Technology%20Implementation%20Practice%20Guide.pdf
[104] Bakhshaei, M. et al. "Fostering Powerful Use of Technology Through Instructional Coaching." Digital Promise, 2018. http://hdl.handle.net/20.500.12265/48

Principals and school leadership should also be responsible for the follow-through and fidelity of a coaching program. The principal must serve as a liaison between their teachers and the coaches, ensure that the coach neve plays an evaluative role, and ensure teachers have time and capacity to engage in coaching activities.[105]

EVALUATING SUCCESS OF TECHNOLOGY INTEGRATION

To ensure the success and evolution of a technology integration plan, schools must have a system in place to evaluate and survey teacher and student responses. A few of these evaluation tools offered by programs such as TPACK and TIM have already been reviewed in Section I (Table 1.1, Table 1.2), but this section will cover several other tools and frameworks for evaluating a program.

To gauge the progress and success of technology integration, school leaders need to continually investigate and monitor the effectiveness of their strategies at all levels. **Evaluation of technology integration initiatives can produce positive outcomes in three important ways, outlined in Figure 2.7.[106]**

Figure 2.7: Positive Outcomes of Evaluations

DEFINING CLEAR GOALS	IDENTIFYING ELEMENTS OF SUCCESS	SUPPORTING ONGOING IMPROVEMENTS
Evaluation requires clear and explicit statement of the goals for a technology integration initiative, encouraging discussion that moves beyond general aspirations to specify concrete outcomes. While any technology integration can have multiple outcomes, evaluation helps prioritize and target those that are the most desirable.	Evaluation helps stakeholders better understand how to get to intended outcomes by specifying elements needed along the way and identifying indicators of short-, medium-, and long-term success. If improving local capacity for entrepreneurship is a high priority, for example, an evaluation might focus on whether appropriate software tools are made available to participants, how these tools get used, and what new businesses have begun to use them.	Perhaps the most important use of evaluation is systematically learning from what has been done in order to refine, strengthen, and plan for next phases of the initiative. Evaluation is the backbone of an ongoing process of examination that gives project leaders the data, analysis, and other information they need to make decisions for the future.

Source: Intel Education Research[107]

In implementing an evaluation, school leaders should cover the following areas:[108]

The technology itself

- How are digital technologies and resources applied in the classroom?
- Are they useful for achieving educational goals and learning objectives?

Those who use the technology:

- Are teachers successfully applying technology in the classroom?

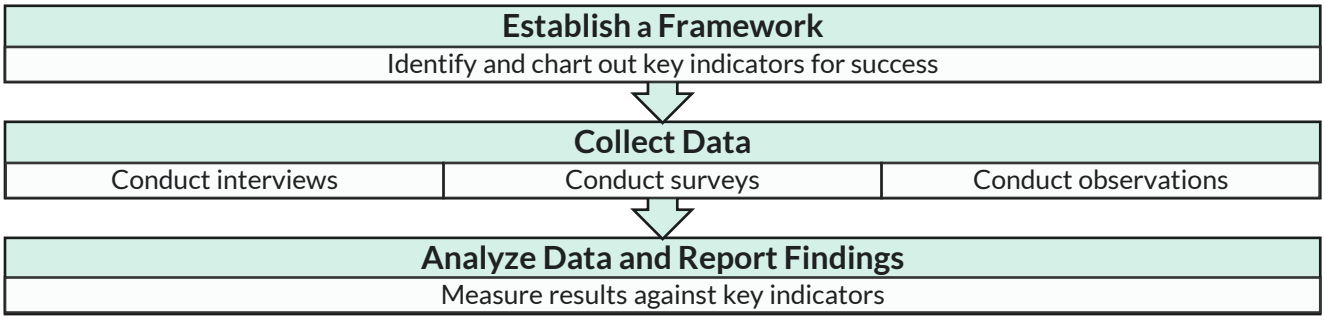
[105] Ibid., p. 12.
[106] "Evaluating Your Technology Integration Initiative: Pointers for Success." Intel Education Research. https://www.intel.com/content/dam/www/program/education/us/en/documents/evaluating-tech-integration-initiative.pdf
[107] Text taken with minor modifications from: Ibid.
[108] Bulleted points taken verbatim from: "Assessment and Evaluations." International Society for Technology in Education. https://www.iste.org/standards/essential-conditions/assessment-and-evaluation

- Are students able to use technology to enhance their learning?
- Are leaders successfully using technology and supporting its use in the classroom?

When evaluating the success of technology integration, school leaders should also be focused on student outcomes, not singularly on the success of technological tools. The ISTE indicates that a successful program means that technology transforms learning and prompts students' ability to master content.[109]

All these components make up effective evaluation processes for monitoring the success of technology integration. **When creating an evaluation tool, school leaders need to take three steps:**

Figure 2.8: Steps for Creating an Evaluation



Source: Intel Education Research[110]

At the end of an evaluation, evaluators should ask the questions in the following areas:[111]

- **The baseline status of that indicator:** What is in place at the start of the initiative?
- **Change over time from baseline status to the current status**: How does what is in place now compare with what existed or what was happening previously?
- **Implications of having or not having the key indicators in place as described:** What impact does the current situation have for project participants?
- **Correlation between a given indicator and other relevant factors:** How is this outcome affected by other conditions or activities that may be taking place?

[109] Joyner, D. "So, You Want to Evaluate a Technology Tool?" International Society for Technology in Education, April 22, 2019. https://www.iste.org/explore/tools-devices-and-apps/so-you-want-evaluate-technology-tool
[110] Text taken with minor modifications from: "Evaluating Your Technology Integration Initiative: Pointers for Success," Op. cit., p. 9.
[111] Ibid., p. 10.

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