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"Grounded" Technology Integration: Instructional Planning Using Curriculum-Based Activity Type Taxonomies

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Technological pedagogical content knowledge (TPCK or TPACK) – the highly practical professional educational knowledge that enables and supports technology integration – is comprised of teachers' concurrent and interdependent curriculum content, general pedagogy, and technological understanding. Teachers' planning – which expresses teachers' professional knowledge (including TPACK) in pragmatic ways -- is situated, contextually sensitive, routinized, and activity-based. To assist with technology integration, therefore,

we suggest using what is understood from research about teachers' knowledge and instructional planning to form an approach to curriculum-based technology integration that is predicated upon teachers combining technologically supported learning activity types selected from content-keyed activity type taxonomies. In this article, we describe this approach to curriculum-based technology integration, illustrating it with overviews of and examples from six curriculum-based learning activity types taxonomies that have been developed to date. We invite our readers to vet and use these materials, which are available on the Activity Types Wiki (http://activitytypes.wmwikis.net/).

As Bruner, Dewey, and Schwab first noted decades ago, school curriculum content is knowledge from multiple disciplines that has been translated to and transformed within social contexts, especially schooling (Deng, 2007). Thinking – and therefore learning – differs quite dramatically by discipline (Donald, 2002). Given its disciplinary roots, knowledge for effective teaching within each curriculum-based content area is similarly differentiated; knowing how to teach high school-level history differs quite dramatically from knowing how to teach first-grade reading or middle-school algebra. This specialized professional knowledge is what Shulman (1986, 1987) termed *pedagogical content knowledge:* in part, the discipline-specific knowledge necessary to teach effectively in different content areas.

Mishra and Koehler (2006, 2008) have extended the construct of pedagogical content knowledge to include the technological knowledge necessary to teach effectively with digital tools and resources in different content areas. They note that knowledge of educational technologies' characteristics and operation is insufficient when planning to use the tools to assist students' learning. Instead, these authors argue, teachers' pedagogical content knowledge must expand to include how to select and use a broad range of educational technologies appropriately within different content areas and teaching approaches. This *technological pedagogical content knowledge* (TPACK) is complex, interdependent, situated, dynamic, and influenced by many contextual factors.

Planning for Technology Integration

During instructional planning, teachers' technological pedagogical knowledge is operationalized, in part, through the learning activities that they select, combine, sequence, and redesign (Harris, 2008). Learning activities are differentiated, in large measure, by content area (Stodolsky, 1988).

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.

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 (Tubin & Edri, 2004).

Given that educational technologies are not yet well-integrated into instruction in most K-12 classrooms (Levin & Wadmany, 2008; Russell, O'Dwyer, Bebell & Tao, 2007); that teachers' instructional planning tends to be activity-based and content-focused (John, 2006; Yinger, 1979); that learning activities are conceptualized and enacted differently in different disciplines (Shulman, 1986; Stodolsky, 1988); and that effective technology integration requires interdependent content, technological, and pedagogical knowledge (Mishra & Koehler, 2006, Koehler & Mishra, 2008); we suggest a that logical approach to helping teachers to better integrate technologies in their teaching is 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.

Note that the emphasis in this approach is upon content-based learning activities — the primary elements in teachers' instructional planning — rather than the affordances and constraints of educational technologies that can support learning activities for students (e.g., Freidhoff, 2008). Since teachers' planning is conceptualized around content goals and organized according to learning activities, technology integration methods should be similarly focused. Possibilities for technology use should be considered according to the types of learning activities that each digital tool or resource best supports.

Learning Activities Taxonomies

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

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. Since compatible technologies are suggested within these taxonomies for each type of learning activity, as teachers select learning activities (to match content goals, student needs and preferences, and pedagogical/contextual realities), they are concomitantly – and authentically – learning to integrate educational technologies into their instructional planning. We call this approach to technology integration "grounded," because the 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.

To our knowledge, comprehensive taxonomies of technology-integrated learning activity types within particular content areas do not yet exist, so we created, tested, and revised an initial set, with the expectation that we will continue to revise them with ongoing feedback and field testing. To date, we have developed learning activity type taxonomies in six curriculum areas: K-6 literacy, mathematics, science, secondary English language arts, social studies, and world languages. These taxonomies are accessible via a wiki with a stable URL (Hofer & Harris, 2011), where teachers and teacher educators are encouraged to vet the activity types by providing feedback on the contents of each taxonomy. These suggested revisions are used to refine the taxonomies, with successive versions posted on the wiki and offered for additional vetting.

The seven collaborators who participated in the development of the six content-based learning activity type taxonomies overviewed later in this article are university-based teacher educators and researchers with particular interest and expertise in curriculum-based technology integration. There is one technological pedagogical content knowledge specialist for each of the six curriculum areas represented in the group, plus a technology integration specialist with expertise in learning activity structures and their use in teacher professional development. The taxonomies were developed collaboratively in groups of two or three, with two authors participating in the development of each of the six taxonomies to maintain conceptual consistency. The taxonomies' components are based upon extensive review of the contents of curriculum journals and methods texts, plus national and international curriculum standards in each content area.

What follows is an introduction to the conceptual organization of each of the six learning activities taxonomies, along with brief descriptions of two sample learning activity types in each subcategory. A classroom-based lesson or project in each content area is offered to illustrate the ways in which learning activity types may be combined in practice, described according to the example's component activities. Complete taxonomies and additional examples of the activity types in practice are available for use and comment on the Learning Activity Types Wiki (Hofer & Harris, 2011).

K-6 LITERACY LEARNING ACTIVITY TYPES

We have identified 88 activity types to date in K-6 Literacy. These are divided into two broad categories: reading and writing. A brief description of each of the categories and subcategories follows, along with sample activity types and possible supporting technologies in each subcategory.

Reading Process Activity Types

Successful readers thoroughly understand the processes involved in reading. The reading process activity types offer a variety of ways to engage students in all the phases of the reading process. Of the 56 activity types that help students build their reading skills, six support pre-reading, 12 are used during reading, and nine facilitate post-reading. In addition, three activity types help students build their vocabulary, 16 support reading comprehension, and 10 enable students to build fluency in reading. Table 1 offers sample learning activity types in each of these subcategories.

Table 1
Sample Reading Process Activity Types

Activity Type	Brief Description	Example Technologies
Sample Pre-Reading Activity Types		
Develop Phonemic Awareness	Students hear, identify and manipulate sounds in words	Reader Rabbit, JumpStart Phonics, Living Books, podcasting, Gamequarium, Read•Write•Think
Activate Prior Knowledge	Students think about what they already know about the topic that is being read	PowerPoint, word processing, Inspiration, Kidspiration, Discovery Education Streaming, student response systems

Table 1 Continued

Activity Type	Brief Description	Example Technologies
Sample "During-Reading" Activity Types		
Directed Listening/Thinking Activity (DL-TA)	Students predict and respond to a story while the teacher reads	Storyline Online, BookFlix, e-books, WiggleWorks, podcasts, student response systems
Reader's Workshop	Students participate in mini-lessons to teach reading strategies, spend time reading independently, and then meet to share, discuss and reflect	Storyline Online, BookFlix, e-books, blogs, wikis, online discussion groups, podcasts
Sample Post-Reading Activity Types		
Visualizing	Students use images and visual imagery to recall what they remember about a story	Kid Pix, Pixie, Storybook Weaver Deluxe, ImageBlender, digital photography, Read•Write•Think, Comic Life
Discussing	Students discuss favorite parts or elements of a story	blogs, wikis, online discussion groups
Sample Vocabulary Activity Types		
Vocabulary Awareness	Students increase their knowledge of words by building sight vocabulary and understanding phonological and morphological patterns	Read•Write•Think, I Spy, Clifford the Big Red Dog Series, KidPix, Pixie, interactive whiteboard, Reading Pen
Vocabulary Analysis	Students build and sort words to study their patterns	word processing, Clifford the Big Red Dog series, Read•Write•Think, KidPix, Pixie, interactive whiteboard
Sample Comprehension Activity Types		
Graphic Organizers/ Charts	Students use visual and graphic organizers that illustrate relationships between facts, terms or ideas	Kidspiration, Inspiration, Bubblus, interactive whiteboard
Picture Walk	Teacher guides students through text by looking at and discussing the pictures before reading	PowerPoint, iPhoto, interactive whiteboard
Sample Fluency Activity Types		
Reader's Theater	Students perform an oral reading with an audience present using a script	voice recording (e.g., GarageBand, Audacity), digital video, podcasts
Storytelling	Students tell stories or narratives often by improvisation or embellishment	digital storytelling (e.g., iMovie, MovieMaker, PowerPoint, Frames)

Writing Process Activity Types

Good readers are good writers. Similar to the reading process activity types, 32 activity types support students throughout the writing process. They are divided into five sub-categories. Eight of the activity types focus on pre-reading, five facilitate learning during reading, and five support post-reading. Five activity types help students practice writing conventions, and nine challenge students to write in different genres. Table 2 offers sample writing process activity types in each of these subcategories.

Table 2
Sample Writing Process Activity Types

Activity Type	Brief Description	Example Technologies
Sample Pre-Writing Activity Types		
Storyboarding	Students develop a series of panels that outline the sequence of what pictures will be seen and what audio and/or voice will accompany them	Kidspiration, Inspiration, Bubblus, Timeliner XE, PowerPoint, interactive whiteboard
Journaling	Students write journal entries to brainstorm topics of personal interest, to note observations and to reflect upon their thinking	word processing, blogs, wikis,
Sample During Writing Activity Types		
Drafting/Composing	Students write draft of story, putting ideas into sentences and paragraphs	word processing, SubEthaEdit, Storybook Weaver Deluxe, KidPix, iMovie, MovieMaker,
Revising	Students improve their writing by adding details, rearranging information, deleting information, and/or replacing information	word processing, SubEthaEdit, Storybook Weaver Deluxe, KidPix, collaborative documents
Sample Post-Writing Activity Types		
Publishing	Students publish their writing for peers/others	word processing, SubEthaEdit, Storybook Weaver Deluxe, KidPix, podcasting, digital storytelling, Wiggle Works, Read•Write•Think
Evaluating	Students evaluate writing of peers and provide feedback	word processing, blogs, online discussion groups

Table 2 Continued

Activity Type	Brief Description	Example Technologies
Sample Writing Conventions Activity Types		
Letter/Word Formation	Students write/type lowercase and uppercase letters; Students write/type words (i.e., root, prefix, suffix)	Word Processing, KidPix, Pixie, Read•Write•Think, interactive whiteboard
Writing Sentences/ Paragraphs	Students construct complete sentences and combine sentences to compose a paragraph (topic sentence, supporting details, closing sentence)	word processing, SubEthaEdit, KidPix, Pixie, interactive whiteboard
Sample Writing Genres Activity Types		
Narrative	Students tell a story from a particular point of view	word processing, Read•Write•Think, KidPix, Pixie, Comic Life
Transactional	Students write to communicate ideas with each other	e-mail, blogs, wikis, online discussion groups, Read•Write•Think

K-6 Literacy Activity Types Classroom Example: The Writing Process

Mr. Smith uses a Writer's Workshop approach in his third-grade classroom to teach writing composition and skills. His third-grade students work independently, following each stage of the writing process – prewriting, drafting, revising, editing, and publishing – to compose numerous stories throughout the school year.

During the prewriting stage, students begin to brainstorm their story ideas using a word processor. Students type as many topics as they can think of to write about and save their documents, adding to their lists each week. Each student begins a new story by choosing a topic from that list, then creates a concept map using Inspiration. Each student's concept map helps her to visualize her ideas, illustrating various connections and relationships made while brainstorming the topic.

As drafting begins, the students use the concept maps to help them compose their first drafts using SubEthaEdit, which allows collaborative editing so stories can be shared online with others for the purpose of providing feedback and response. Once the first draft is complete, students partici-

pate in a recursive process that involves several online exchanges back and forth between peers and/or teachers while revising, editing, responding and re-drafting the stories. After students revise their stories, the collaborative revision process is replicated later by using SubEthaEdit during the editing stage, focusing on correcting mechanics, grammar and spelling.

Although publishing in Writer's Workshop can have multiple purposes and be implemented in a variety of ways, technology can play a significant role in completing the writing process cycle. Some students in Mr. Smith's class might publish their stories by printing them out from SubEthaEdit; while others might publish online. Mr. Smith encourages his students to post their stories on their classroom Web site or on an online publishing site like KidPub, Cyberkids, or Stories from the Web.

MATHEMATICS LEARNING ACTIVITY TYPES

To date, we have identified 31 learning activity types in mathematics that we have divided into seven categories derived from the National Council of Teachers of Mathematics' process standards. Each of the seven categories is introduced below.

The "Consider" Activity Types

When learning mathematics, students are often asked to thoughtfully consider new concepts or information. The six Consider activity types are important contributors to student understanding, and typically are manifested using a relatively direct presentation of foundational knowledge. Two samples of the Consider learning activity types are listed in Table 3.

Table 3
Sample "Consider" Mathematics Activity Types

Activity Type	Brief Description	Example Technologies
Attend to a Demonstration	The student gains information from a presentation, videoclip, animation, interactive whiteboard or other display media	PowerPoint, iMovie, YouTube, podcasts, videoconferencing, or other display media
Investigate a Concept	The student explores or investigates a concept (such as fractals), perhaps by use of the Internet or other research-related resources	Web searching, informational databases (Wikipedia), virtual worlds, simulations

The "Practice" Activity Types

In the learning of mathematics, it is often important for students to be able to practice computational techniques or other algorithm-based strategies in order to automate these skills for application in later and higher-level mathematical learning. Table 4 lists two of the three technology-supported learning activities that can assist these important student practice efforts.

Table 4
Sample "Practice" Mathematics Activity Types

Activity Type	Brief Description	Example Technologies
Do Computation	The student undertakes computation-based strategies using numeric or symbolic processing	Scientific calculators, graphing calculators, spreadsheets, Mathematica
Do Drill and Practice	The student rehearses a mathematical strategy or technique and perhaps uses computer-aided repetition and feedback in the practice process	Drill and practice software, textbook supplements, online homework help Web sites (e.g., WebMath).

The "Interpret" Activity Types

In the discipline of mathematics, individual concepts and the relationships among them can be quite abstract and at times, can even represent a bit of a mystery to students. Often students need to spend some time deducing and explaining these relationships in order to internalize them. Table 5 offers two examples of the six learning activity types that can support this thoughtful interpretation process.

Table 5
Sample "Interpret" Mathematics Activity Types

Activity Type	Brief Description	Example Technologies
Categorize	The student attempts to examine a concept or relationship in order to categorize it into a set of known categories	Database software (Microsoft Access), online databases, concept mapping software, drawing software
Interpret a Representation	The student explains the relationships apparent in a mathematical representation (table, formula, chart, diagram, graph, picture, model, animation, etc.)	Data visualization software (Inspire Data), 2D and 3D animations, video (iMovie), Global Positioning Devices (GPS), engineering visualization software (MathCad)

The "Produce" Activity Types

When students are actively engaged in the study of mathematics, they can become motivated producers of mathematical works, rather than merely passive consumers of prepared materials. We have identified five learning activity types that assist students in producing new mathematical knowledge. Table 6 offers two examples of how students may become "producers" of mathematics-related products.

Table 6
Sample "Produce" Mathematics Activity Types

Activity Type	Brief Description	Example Technologies
Do a Demonstration	The student makes a demonstration on some topic to show their understanding of a mathematical idea or process. Technology may assist in the development or presentation of the product.	Interactive whiteboard, video (YouTube), document camera, presentation software, podcasts
Produce a Representation	Using technology for production assistance if appropriate, the student develops a mathematical representation (table, formula, chart, diagram, graph, picture, model, animation, etc.).	Spreadsheet, virtual manipulatives (digital geoboard), spreadsheets, Inspire Data, concept mapping software, graphing calculator

The "Apply" Activity Types

The utility of mathematics in the world can be found in its authentic application. Table 7 lists two of the three learning activity types designed to enable students to link mathematical concepts to the realities in which they live.

Table 7
Sample "Apply" Mathematics Activity Types

Activity Type	Brief Description	Example Technologies
Choose a Strategy	The student reviews or selects a mathematics related strategy for a particular context or application.	Online help sites (WebMath, Math Forum), Inspire Data, dynamic geometry/algebra software (Geometry Expressions), Mathematica, MathCAD

Table 7 Continued

Activity Type	Brief Description	Example Technologies
Apply a Representation	The student applies a mathematical representation to a real life situation (table, formula, chart, diagram, graph, picture, model, animation, etc.).	Spreadsheet, robotics, graphing calculator, computer-aided laboratories, virtual manipulatives (algebra tiles)

The "Evaluate" Activity Types

When students evaluate the mathematical work of others, or of their own, they utilize a relatively sophisticated understanding of mathematical concepts and processes. Table 8 lists two of the four activity types focused on evaluating mathematical work.

Table 8
Sample "Evaluate" Mathematics Activity Types

Activity Type	Brief Description	Example Technologies
Compare and Contrast	The student compares and contrasts different mathematical strategies or concepts, to see which is more appropriate for a particular situation.	Inspiration, Web searches, Mathematica, MathCad
Test a Solution	The student systematically tests a solution and examines whether it makes sense based upon systematic feedback, which might be assisted by technology.	Scientific calculator, graphing calculator, spreadsheet, Mathematica, Geometry Expressions

The "Create" Activity Types

When students are involved in some of the highest levels of mathematics learning activities, they are often engaged in very creative and imaginative thinking processes. We have identified four such activity types. The sample activity types in Table 9 encourage these creative processes in students' mathematical learning and interaction.

Table 9
Sample "Create" Mathematics Activity Types

Activity Type	Brief Description	Example Technologies
Teach a Lesson	The student develops and delivers a lesson on a particular mathematics concept, strategy, or problem.	Presentation software, interactive video, video, podcasts
Create a Process	The student creates a mathematical process that others might use, test or replicate, essentially engaging in mathematical creativity.	Computer programming, robotics, Mathematica, MathCad, Inspire Data, iMovie

Math Activity Types Classroom Example: Selling Bricks

In middle school mathematics classes, an interesting activity in which students engage in divergent thinking and computation utilizes word processors, spreadsheets and the Internet. The lesson begins with the students divided into small groups and provided with a typical red brick that might be used in construction. Students measure and draw the brick to produce a representation and are then asked to use a word processing program to generate text that lists creative uses for the brick. Student lists often include items such as using the brick as a doorstop, a fitness weight, a bed warmer, or a desk organizer. After a period of brainstorming, students are then asked to compare and contrast the items on their list and to remove the items that might be on someone else's list, so that their list will be as unique as possible. Next, students are asked to compare and contrast the items on the groups' lists again, each narrowing their list to the "best" five items that could be advertised and sold in their community. The students are then asked by the teacher to use spreadsheet software to create a plan for selling the five items – more specifically, a business plan that includes a sales price for each item, estimated expenses for producing and marketing each item, discounted prices for volume sales, and various "package deals," in which items are sold in combination. Sales tax and shipping costs are also required for consideration within this student-authored business plan. Finally, students evaluate mathematical work by investigating possible competing products offered for sale on the Internet, and explaining whether and how their products would be competitive in today's market. This engaging lesson encourages productive discussions, especially concerning mathematical topics such as percent and formulas.

SCIENCE LEARNING ACTIVITY TYPES

Of the 38 science activity types that have been identified to date, 30 are focused upon helping students build their knowledge of science concepts and procedures. Seventeen of the knowledge-building activity types emphasize conceptual learning, and 10 of these involve the procedural knowledge employed in science learning. Eleven of the activity types describe learning activities that demonstrate students' knowledge expression.

Conceptual Knowledge Building Activity Types

Helping students to build their conceptual knowledge of science is a key focal area for science teachers. Table 10 offers three examples of the 17 learning activity types that assist students in building science conceptual knowledge.

Table 10
Sample Conceptual Knowledge Building Science Activity Types

Activity Type	Brief Description	Possible Technologies
View Presentation/ Demonstration	Students gain information from teachers, guest speakers, and peers; synchronous/asynchronous, oral or multimedia	Presentation software, document camera, video
Organize/Classify Data	Students create a structure to organize data collected	Database, spreadsheet, Inspiration
Analyze Data	Students describe relationships, understand cause-and-effect, prioritize evidence, determine possible sources of error/discrepancies, etc.	Spreadsheet, TinkerPlots, InspireData, graphing calculator, statistical software

Procedural Knowledge Building Activity Types

In science classrooms, building conceptual knowledge frequently requires that students use materials and "process" skills (Millar & Driver, 1987) as they develop scientific knowledge. We use the term "procedural knowledge" to describe this kind of understanding. Table 11 offers samples of the 10 learning activities with a focus upon procedural knowledge.

Table 11
Sample Procedural Knowledge Building Science Activity Types

Activity Type	Brief Description	Possible Technologies
Practice	Students practice using equipment, software, measuring, testing what they have designed, etc.	Web-based software or software tutorials
Collect Data	Students collect data with physical objects or simulations	Graphing calculators, video, audio, digital cameras, digital microscopes, web-based data sheets
Observe	Students make observations from physical or digital experiences	Document camera, WebCams, digital/video cameras, digital microscopes

Knowledge Expression Activity Types

While in many cases teachers may want their students to express similar understanding of course content, at other times they will want to encourage students to develop and express their own constructions of a given topic. The 11 science knowledge expression activity types afford students opportunities to share and further develop current understanding of science concepts, procedures, and relationships. Three samples can be found in Table 12.

Table 12
Sample Knowledge Expression Science Activity Types

Activity Type	Brief Description	Possible Technologies
Do a Presentation or Demonstration	Students present or demonstrate laboratory or research findings, or other course learning (e.g. a system of the human body)	Presentation software, video, document camera, moviemaking software
Draw/Create Images	Students physically or digitally draw or create images (from labs, observations, etc.)	Drawing software, digital camera, image editing software
Concept Mapping	Students participate in or develop graphic organizers, semantic maps, etc.	Inspiration/Kidspiration, interactive whiteboards, drawing software

Science Activity Types Classroom Example: The Car Labs

The Car Labs, a unit developed for middle school teachers in the SMART for Teachers Project (http://21ctl.fi.ncsu.edu/msms/autolabs.html), engages students in a multi-day investigation of physical science concepts underlying an automotive theme. Teams of three or four students start by building a rubber band-powered car for drag race competitions, then rotate through investigations at four laboratory stations (focused upon piston pressure, headlight color, distance, and a radiator simulation) during several subsequent sessions. The purpose of these labs is to engage students in data collection and analysis keyed to science content standards about energy and states of matter (Blanchard, Sharp & Grable, 2009).

On the first day of the laboratory, students design and construct a rubber band-powered car from cardboard, skewers, rubber bands, and tape. They compete in drag races to see whose car goes the farthest and/or the fastest by collecting, recording, and computing data. On the third and fourth days, student teams work through the following four learning stations.

At the Going the Distance station, student teams run three-second trials with a motion sensor attached to a graphing calculator to measure how far and how fast their cars travel. They use a calculator to create distance-versus-time graphs that students then analyze. At the Piston Pressure station, students follow procedures to record the pressure exerted from a syringe (simulated piston) into an Erlenmeyer flask, measuring changes in pressure and volume. The Color of Headlights station asks students to observe and compare light intensity differences between different colored headlights using a light sensor. At the Soda Can Radiator station, students generate data by measuring the change in water temperature as simulated fuel (a cheese puff) is burned under a simulated radiator (a soda can with water in it). A temperature probe inserted into the water and connected to a graphing calculator collects data tracing the change in temperature over time. A balance connected to the calculator records the change in mass of the cheese puff, indicating the energy used in the process. As students complete work at each of the stations, their teacher uses a "State Inspection Station" sheet for summative evaluation of their work.

SECONDARY ENGLISH LANGUAGE ARTS LEARNING ACTIVITY TYPES

We have identified 65 secondary-level English language arts learning activity types to date. We divided them into five categories of English lan-

guage arts learning processes: reading, writing, language, oral speaking/performing, and listening/watching.

Reading Process Activity Types

Within the reading category, two pre-reading activity types help students to frontload meaning, 14 during-reading activity types assist students with constructing meaning, and seven post-reading activity types help students to extend meaning. Sample reading process learning activity types can be found in Table 13.

Table 13

Sample Reading Process Secondary English language arts Activity Types

Activity Type	Brief Description	Example Technologies
Sample Pre-Reading Activity Types		
Activating / Generating Prior Knowledge	Students activate or generate prior knowledge and experience to help them frontload meaning and forge connections with their reading.	Wikis for interactive K-W-L charts; clicker technology to complete Anticipation Guides
Making Predictions	As a means of drawing upon existing knowledge and generating new connections with a text, students make predictions about texts.	Digital camera to take pictures of various parts of a book, individual or group blog responses
Sample During-Reading Activity Types		
Literature Circles / Book Clubs	Students are organized in smaller groups and read multiple books at the same time. Selections may vary based on interest, ability, theme, content focus, etc.	Online discussion groups, digital video for recording literature circle roles and related discussions
Critical Analysis / Reflection	Students engage in activities focused on higher level critical analysis.	Participatory media for representing critical literary perspectives of a text; digital audio and video for recorded reflections and analysis

Table 13 Continued

Activity Type	Brief Description	Example Technologies
Sample Post-Reading Activity Types		
Sharing / Collaborating	Students extend their understanding of texts by sharing and collaborating with others about their reading experience and what they learned/gained.	Participatory media for creating and posting book talks and book reviews; online discussion groups; digital video; podcasts
Creating Text-Related Artifacts	Students demonstrate understanding of text by creating various artifacts related to the content of the reading ranging from literary essays to a collage, mobile, diorama, bulletin board, Web site, etc.	Web-design software; graphic design software; MS Paint

The Writing Process Activity Types

The four subcategories of writing process activity types assist learning before, during, and after writing. Three prewriting activity types help students to generate ideas and build fluency (e.g., brainstorming; free writing); four activity types help students to organize their ideas for writing (e.g., storyboarding; identifying purpose and audience), eight activity types assist students' writing (e.g., conferencing; revising; editing), and three activity types help students to share, publish, and/or perform their writing. Sample activity types from each of these four subcategories are listed below.

Table 14

Sample Writing Process Secondary English Language Arts Activity Types

Activity Type	Brief Description	Example Technologies
Sample Pre-Writing Activity Types		
Brainstorming / Listing	Students write down ideas as they pop into their heads—sometimes done on their own, sometimes in response to a prompt.	Word processor
Webbing / Clustering / Semantic Mapping	Students use "webs" or "clusters" to create visual representations of brainstorming efforts.	Concept mapping software

Table 14 Continued

Activity Type	Brief Description	Example Technologies
Sample Organizing Ideas for Writing Activity Types		
Sequencing / Outlining / Storyboarding	Students organize ideas for writing by creating sequences, outlines, or storyboards.	MS Word (bullets and outline features); ComicLife storyboard feature; other storyboarding software
Identifying Purpose / Audience	Students further organize ideas for writing by identifying a purpose for writing and a target audience.	Consult online examples of genre pieces and various writing formats
Sample During Writing Activity Types		
Revising	Students revise the content of their writing based on feedback from peers and the instructor, as well as their own ideas regarding purpose, audience, and format.	Word processor; wiki
Consulting Resources	Students explore and consult resources that might inform their writing in some meaningful way (e.g., content, research, format, etc.)	Web searching; online writing models; Purdue University Online Writing Lab (OWL)

Language-Focused Activity Types

Language-focused learning activity types are subdivided into five categories. There are three activity types that address language exploration, inquiry, and awareness; two activity types that help students with language practice, four activity types that assist with language analysis; five activity types that help students with language conventions, such as mechanics, grammar, and spelling; and three activity types that help students to develop vocabulary awareness, use, and analysis skills.

Table 15

Sample Language-Focused Secondary English Language Arts Activity Types

Activity Type	Brief Description	Example Technologies
Sample Language Exploration, Awareness, and Inquiry Activity Types		
Language Exploration	Students explore origins and history of language.	Web searching; video

Table 15 Continued

Activity Type	Brief Description	Example Technologies
Language Awareness	Students engage in activities to develop awareness and understanding of language variation and dialect; language as symbol; language in context.	Web searching
Sample Language Composing Activity Types		
Sentence Composing	Students build sentences using sentence composing resulting in syntactic growth.	Word processor; screencasts
Code Switching	Students practice code switching in oral and written language, developing a better understanding of informal and formal speech varieties and the contexts in which each is most appropriately used.	Word processor; digital audio and video recordings; podcasts and vodcasts; participatory media
Sample Language Analysis Activity Types		
Word Analysis	Students analyze words in a variety of ways, including origins, parts (e.g., roots, affixes, etc.), formations, functions (i.e., parts of speech).	Web searching; online dictionaries and language resources
Semantic Analysis	Students engage in semantic analysis in a variety of ways to better understand simple and complex meaning in language.	Web searching; online dictionary; digital images; online advertisements
Sample Language Conventions Activity Types		
Mechanics	Students develop an understanding of mechanics in the context of language, specifically reading and writing, and an ability to apply it.	MS Word grammar and spell check; grammar practice Web sites
Usage	Students develop an understanding of language use in the context of reading, writing, and speaking. They also learn and apply rules of Standard English language arts language usage in applicable contexts.	MS Word grammar and spell check

Oral Speaking / Performance Activity Types

Oral language serves as the foundation for English language arts and for all other forms of communication; therefore, it requires keen instructional focus and attention. Performance can serve as a natural extension of oral language instruction and activities. Together, they provide opportunities for students to speak more competently, cogently, and confidently. Three learning activity types support oral speaking and performance. Two samples are included in Table 16 below.

Table 16
Sample Oral Speaking/Performance Secondary English language arts Activity Types

Activity Type	Brief Description	Example Technologies
Speaking / Speech	Individual students produce oral language in a variety of contexts.	Microphone and speakers; camera and projector; digital audio and video recording; podcasts, vodcasts, etc.
Evaluating / Critiquing Speech / Performance / Production	Students will build the skills for developing evaluation tools and engage in assessing and critiquing speeches / performances.	Online rubric generators; digital audio and digital video recorders and players, Web searching

Listening / Watching Activity Types

Listening and watching are complements to oral speaking and performance, except that listening and watching involve reception, rather than production. A key component of listening and watching, however, is the active nature of taking in information and stimuli, then thinking about and processing it in order to make sense of and respond effectively to it. Two samples of the three learning activity types that promote active learning can be found in Table 17.

Table 17

Sample Listening/Watching Secondary English Language Arts Activity Types

Activity Type	Brief Description	Example Technologies
Watching / Viewing Actively	Students watch or view actively and process visual images (still or moving, silent or audio enhanced) in order to create memories, learn from them, respond to them, act on or apply information gained from them.	Online image and photography sites; online video sites; digital video recordings; online art sites; online demonstrations and simulations
Multimodal / Multimedia Interaction	Students listen, watch /view, and interact with or participate in multimodal and multimedia texts.	Participatory media; digital audio and video devices for recording and playing files

Secondary English Language Arts Activity Types Classroom Example: Laugh & Learn with Satire

In "The Laugh and Learn with Satire and Technology" lesson plan (Brown-Parker & Young, 2008), English language arts teacher Allyson Young and media specialist Kerri Brown-Parker engage high school seniors in determining what satire and parody are, as well as understanding the important distinctions between the two literary terms. The teachers divided this lesson into four phases: reading, researching, analysis, and writing / publication.

To begin the lesson, students activate prior knowledge about satire and parody by discussing Jon Scieszka's *The True Story of the 3 Little Pigs*, a parody of the children's story, told in this case from the perspective of the wolf. In addition, the teachers have students reference their prior reading of Jonathan Swift's *A Modest Proposal* and reread selections from this classic satire.

Next, in order to distinguish between the two literary terms and determine the characteristics of each, the teachers ask students to view digital video examples of parody and satire, using a satire evaluation handout. The examples they show, Weird Al Yankovic's "Don't Download this Song" and "The eBay Song," are freely available via Google Video. The teachers have students share their responses to questions about the examples in a class blog. After responding to the teachers' questions, students then can respond to each other's postings. The teachers then use the blog postings to facilitate a class discussion in which the students reach consensus about whether the songs/videos are satire, parody, or both, along with identifying the characteristics, features, and purposes of each literary device.

Afterwards, each student conducts Web research to find two examples of online satire in two different media formats for analyis and evaluation. Students complete the satire evaluation worksheets for these as well, and then they share at least one of their online examples in small groups. Students also post entries about their online examples to the class blog, including links.

As a bridge from the discussion of examples to having students plan, write, and produce their own multimedia satire, the teachers ask the students to listen, view, and interact with a VoiceThread presentation about satire, including opportunities for the students to post reactions or responses (as either text or audiorecordings) directly in the presentation. The teachers then provide students with guidelines for creating online satire proposals, and students collaborate in small groups to propose a multimedia satire. Students then draft, storyboard, and produce multimedia satires using VoiceThread, MovieMaker, iMovie, or other commercial or noncommercial digital video applications. As a culminating activity, students then present their completed satires to their classes.

SOCIAL STUDIES LEARNING ACTIVITY TYPES

Of the 44 social studies learning activity types that have been identified to date, 17 are focused upon helping students build their knowledge of social studies content, concepts, and processes. Twenty-seven provide students with opportunities to express their understanding in a variety of ways. Six of these knowledge expression activity types emphasize convergent learning and 21 offer students opportunities to express their understanding in divergent ways.

Knowledge Building Activity Types

To actively engage in learning key concepts in the social studies, students must build their background knowledge in a variety of areas. Samples of the 17 learning activity types designed to help students build knowledge are offered in Table 18, below.

Table 18
Sample Knowledge Building Social Studies Activity Types

Activity Type	Brief Description	Possible Technologies
Read Text	Students extract information from textbooks, historical documents, census data, etc.; both print-based and digital formats	Digital archives, Web sites, electronic books, audiobooks
Engage in Data-Based Inquiry	Using print-based and digital data available online students pursue original lines of inquiry	CIA World Factbook, Thomas, census data, Excel, Inspire Data

Knowledge Expression Activity Types

Teachers are able to determine what students have learned during a unit of study by analyzing their expressions of knowledge. At times, social studies teachers deem it appropriate for all students to come to a similar understanding of a course topic. This kind of understanding is expressed by engaging in convergent knowledge expression activities, as illustrated below.

Table 19
Sample Convergent Knowledge Expression Social Studies Activity Types

Activity Type	Brief Description	Possible Technologies
Create a Timeline	Students sequence events on a printed or electronic timeline or through a Web page or multimedia presentation	Timeline creation software, presentation software, concept mapping software, word processor
Complete a Review Activity	Students engage in some form of question and answer to review content; paper-based to game-show format using multimedia presentation tools	Student response systems (SRS), interactive whiteboard review games (e.g., Jeopardy), survey tools

While in many cases teachers may want their students to express similar understanding of course content, at other times they will want to encourage students to develop and express their own understandings of a given topic. Twenty-one divergent knowledge expression learning activity types afford students opportunities to share their unique understanding of a topic or concept. They are subdivided into learning activities that are written, visual, conceptual, product-oriented, and participatory. Table 20 provides samples of activity types in each subcategory.

Table 20

Sample Divergent Knowledge Expression Social Studies Activity Types

Activity Type	Brief Description	Possible Technologies
Sample Written Knowledge Expression Activity Types		
Generate a Narrative	Using primary documents and secondary source information, students develop their own story of the past	Word processor, wiki or collaborative word processor (to track contributions from multiple authors), blog
Create a Diary	Students write from a first-hand perspective about an event from the past; paper and pencil or digital format	Blog, word processor
Sample Visual Divergent Knowledge Expression Activity Types		
Create an Illustrated Map	Students use pictures, symbols and/or graphics to highlight key features in creating an illustrated map	Outline maps available online, Google Earth, presentation software,scanner
Draw a Cartoon	Students create a drawing or caricature using a paper and pencil or digital format	Comic creation software, drawing software, scanner
Sample Conceptual Divergent Knowledge Expression Activity Types		
Develop a Knowledge Web	Using teacher or student created webs, students organize information in a visual/spatial manner; written or digital format	Concept mapping software, presentation software, word processor
Generate Questions	Students develop questions related to course material/concepts	Word processor, wiki
Sample Product-Oriented Divergent Knowledge Expression Activity Types		
Design an Exhibit	Students synthesize key elements of a topic in a physical or virtual exhibit	Wikis, presentation software, video creation software (e.g., Movie Maker, iMovie)
Create a Film	Using some combination of still images, motion video, music and narration students produce their own movies	Video creation software (e.g., Movie Maker, iMovie), digital video camera
Sample Participatory Divergent Knowledge Expression Activity Types		
Roleplay	Students take on a character, role, or persona to experience or experiment with a concept or event, live, videotaped, or recorded	Video creation software (Movie Maker, iMovie), digital video camera
Engage in Civic Action	Students write government representatives or engage in some other form of civic action	Blog, email, videoconferencing, ThinkQuest

Social Studies Activity Types Classroom Example: Civil War Voice Wall

In the Civil War Voice Wall project (Bray, Russell & Hofer, 2006) teachers Julie Bray and Darlene Russell challenged their sixth grade history students to develop short documentary films about a person or key event from the U.S. Civil War. The purpose of the project was to engage students more deeply in their study of this war, enabling them not only to learn key factual content, but also to understand the multiple perspectives of different people who lived through the experience. The teachers agreed that having the students develop a story about a chosen person narratively (as opposed to using a standard report format) might be more engaging for the students, encouraging them to go beyond creating an "electronic encyclopedia entry."

The teachers divided the project into three phases: research, writing, and production. During the research phase, students read a range of print materials as well as selected Web sites that the teacher had bookmarked prior to beginning project work. The students collected appropriate images for their documentaries, both by scanning pictures from books and via image searches online. They answered a set of questions to capture their research notes.

During the writing phase, students essentially wove together their research in order to create a diary in the form of a movie script. The students received feedback on each section of the script from their parents, in addition to in-class feedback from the teachers. At the end of this phase, each student had developed a complete script for a film.

During the production phase of the project, the students paired their scripts with images to develop a paper-copy storyboard for their films. During this process, they also identified any music, sound effects, titles, and transitions that they wanted to incorporate. Once complete, they used the storyboards as blueprints to create their films using Microsoft's Moviemaker software. They used the scripts to record their narration in an historical role play format, and arranged the images and other elements into a complete Ken Burns-style film. They then "screened" all of the films in class to prepare for their exam on the Civil War.

WORLD LANGUAGES LEARNING ACTIVITY TYPES

The 56 learning activity types for world languages overviewed below are linked closely to the American Council on the Teaching of Foreign Languages (ACTFL) Standards for Foreign Language Learning (1998), which state that communication in the target language ("L2") is understood as a

process that involves three modes: interpersonal, interpretive, and presentational. Because these communication modes require students to work on different skills as they develop their communicative competence, we have conceptualized and organized the world languages activity types into five genres that address different abilities: listening, speaking, reading, writing, and viewing.

Listening Activity Types

Listening skills may seem more passive or less demanding than other language skills. However, when students are engaged in listening activities, they must not only comprehend and interpret a message; they also need to know morphology, syntax, vocabulary, the social and cultural expectations of native speakers in the language studied, how to use pronouns and conjunctions in a cohesive and coherent manner, and how to make educated guesses to compensate for gaps in their knowledge. The seven learning activity types which support students' active listening are illustrated with two samples in Table 21, below.

Table 21
Sample Listening World Languages Activity Types

Activity Type	Brief Description	Possible Technologies
Listen to a conversation	Students listen to a conversation in L2, either live or recorded (e.g., from a textbook supplement, radio broadcast, skit, guest speakers).	CD; Web audio site
Listen to a broadcast	Students listen to a broadcast in L2 (e.g., radio, television, news, performance).	Web radio

Speaking Activity Types

When learning a foreign language, speaking skills are crucial to students' engagement and sustained language development. The 13 speaking activity types are appropriate for students with different levels of language proficiency within the continuum described in the ACTFL Guidelines (1998). Two samples are listed in Table 22.

Table 22
Sample Speaking World Languages Activity Types

Activity Type	Brief Description	Possible Technologies
Have a conversation with a partner/small group	Students converse with a limited number of others in L2 (improvised or with prompts).	Audioconference/ videoconference; telephone
Perform role plays	Students speak in L2 in character in a simulated situation (e.g., ordering dinner in a restaurant; checking in at the airport; skit, play, impersonation, puppet show).	Video camera

Writing Activity Types

Writing in the target language focuses on both process and the product. When working with writing skills, students can engage in all three modes of communication: interpersonal, interpretive, and presentational. The 21 writing activity types, with two samples listed below in Table 23, address both expository and creative writing skills.

Table 23
Sample Writing World Languages Activity Types

Activity Type	Brief Description	Possible Technologies
Define terms in written form	Students use new and old vocabulary to compose a glossary of terms (e.g., glossary of terms for textbook chapter, literary piece read in class or as a homework)	Word processor; concept mapping software
Create a comic	Students create a comic strip to apply functions, culture, grammar, and/or vocabulary related to a given topic.	Word processor; drawing program; comic creation software; Photoshop

Reading Activity Types

The cognitive processes involved in reading in a foreign language are similar to those described for listening skills. Students bring into play grammatical, discursive, sociolinguistic, and strategic competencies when at-

tempting to comprehend and interpret a written message. The 10 reading activity types may be done either silently or aloud. Examples can be found below.

Table 24

Sample Reading World Languages Activity Types

Activity Type	Brief Description	Possible Technologies
Read a story	Students read and analyze stories by relevant authors from their target language to get acquainted with different literary styles (e.g., J. Borges, A. Matute, H. Quiroga).	Web; ebook reader
Read a newspaper/ magazine	Students read and extract information from newspapers and magazines from different countries where their target language is spoken.	Web

Viewing Activity Types

Viewing abilities are critical for "zooming into" the target language culture. Through viewing activities, students can observe authentic interactions among native speakers, and learn about differences among dialects, accents, registers, and body language without leaving their classrooms. The five viewing activity types are exemplified by the samples in Table 25 below.

Table 25

Sample Viewing World Languages Activity Types

Activity Type	**Brief Description**	**Possible Technologies**
Watch a video	Students watch contemporary or classic movies, video clips of commercials, documentaries, to enhance comprehension of course topics.	Web; DVD; YouTube
View an exhibit	Students take physical or virtual field trips (e.g., to an art museum, cultural artifacts, other students' works, school exhibition).	Web; Web-based virtual fieldtrip; videoconference

World Languages Activity Types Classroom Example: Peninsular Writers - Antonio Machado

Advanced Spanish language students are required to read texts written by both Latin American and Peninsular (from Spain) writers, analyze and contextualize their work, and carry out presentations. Due to the complexity of these writers' works, students need to attain a high level of language proficiency as well as a deep cultural understanding to attempt these readings. These requirements can be overwhelming for the average student with no experiences studying abroad. Consequently, advanced students without such immersion experience may disengage and become less efficient learners. Careful planning of learning activity type combinations can help to address this instructional challenge.

Consider Spanish author Antonio Machado's poems — or any literary works written originally in the target language — to illustrate combining and sequencing 12 activity types into a project that culminates with a group presentation in the format of a documentary about his work. Students first get acquainted with the author and collect information. To do so, the teacher guides students to listen to his poems (via CD or iTunes), read his poems (via textbook or e-book), engage in question-and-answer activities with the teacher and peers about his works and the historic and socio-political contexts of his writings (synchronously and asynchronously), read articles (via the Web or magazines), and take notes. They then organize their information (using a word processor or concept mapping software), and collect images (by scanning photos from books or doing online searches) and write a sentence or paragraph to describe each one.

In the second phase of the project, students work with their groups to organize all of their materials and then begin the production of their presentations. At this point, students write and help their peers to edit their scripts using a word processor or wikis, record narration, and rearrange images to develop the documentaries using Microsoft's Moviemaker software. In the third and final phase of the project, students deliver their presentations orally by introducing, then showing, their movies to their classmates.

ACTIVITY TYPES IN TEACHER EDUCATION

As explained above, we have endeavored to create comprehensive taxonomies of learning activity types in each curriculum content area, each of which is available in full on the Learning Activity Types Wiki (Hofer &

Harris, 2011). To do so, we decided that all teaching approaches – not only the ones that we individually recommend as teacher educators – ought to be represented in each taxonomy. In including all types of learning activities in our taxonomies without evaluation or comment, we acknowledge that we are separating technology integration goals from educational reform goals (Harris, 2005). In this work, we seek to help all teachers to integrate educational technologies into their teaching, regardless of teaching philosophy or approach, or instructional planning model used. Given teachers' (and teacher educators') vastly different opinions about methods for effective planning and instruction, we feel that such a pedagogically inclusive approach to technology integration is warranted at this time.

Should teacher educators wish to use the learning activity types presented here to forward particular pedagogical reforms, we recommend purposively selecting subsets of learning activity types (and accompanying project examples) that are most often used in the instructional approaches being recommended. For example, to support science education professional development in inquiry-based teaching and learning, activity types such as develop predictions, hypotheses, questions, and variables; select procedures; sequence procedures; organize/classify data; analyze data; compare findings with predictions/hypotheses and make connections between findings and science concepts/knowledge could be emphasized, while activity types such as view presentation/demonstration, take a quiz or test, and read text could be de-emphasized.

Our pedagogically neutral stance emphasizes the primacy of pedagogical content knowledge in both instructional planning and technology integration processes as we have conceptualized them. In addition to improving technology integration by linking it more directly with curriculum and pedagogical practice, we suspect that creating awareness of all possible learning activity types in a particular content area may lead indirectly to greater varieties of instructional strategies being planned and used, resulting in more possibilities for instruction to accommodate the learning styles and preferences of students. This, in fact, was one of the primary findings of a recent descriptive study (Harris & Hofer, 2011) about the nature of experienced secondary social studies teachers' instructional planning before and after being taught to use the activity types approach to technology integration.

The importance and use of pedagogical content knowledge in technologically integrated instructional planning with learning activity types, however, also highlights an important question that we are currently researching. Though we suspect that access to comprehensive collections of curriculum-keyed learning activity types is helpful to people learning to be teachers, as

it is to their more experienced colleagues (albeit in different ways and for different reasons), we cannot be sure that a learning activity types approach can be used as effectively by professionals who have had fewer (or no) opportunities to teach with different types of learning activities, and less familiarity overall with matching types of learning activities to students' demonstrated learning needs and preferences. To whatever degree selecting the most appropriate combinations of learning activity types to help students address particular curriculum-based learning goals is a function of experience-based expertise is the extent to which preservice teachers' activity selections will need to be scaffolded. We suggest, therefore, that technologically supported learning activity types be introduced during or immediately following the completion of curriculum-based methods courses. Optimally, use of the activity types should be integrated throughout methods courses.

Our vetting and testing of both the activity types taxonomies and their use in preservice and inservice teacher development continues. Preliminary results, as described above, are encouraging. At a minimum, we expect that more teachers may more seamlessly integrate a greater variety of educational technologies into their teaching when using the taxonomies introduced here, due to their pedagogical, rather than technological, emphasis and organization. We invite you to participate with us in exploring and refining this new approach to the development and use of technological pedagogical content knowledge (TPACK).

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