Emerging Technology Integration Models

Royce Kimmons and Cassidy Hall

This chapter explores theoretical models of technology integration, which have emerged in response to new technologies, and the criteria we should use to evaluate them. In chapter 3, Anderson describes how theories “force us to look deeply at big picture issues and grapple with the reasons why our technology use is likely to enhance teaching and learning.” Focusing on what he terms “net-centric theories of learning,” he explains how emerging approaches to education, such as connectivism, have evolved in connection with the web and empowered educators and learners to exploit its new affordances. Just as theory is essential for understanding the interface between emerging technologies and learning, theoretical models are essential for guiding thoughtful technology integration practices in existing educational contexts. In recent years we have seen the birth of a number of models and frameworks intent upon guiding meaningful technology adoption in both K-12 and higher education settings. Yet, as a field, we have not maturely explored how to reconcile competing or conflicting models and frameworks with one another nor even considered the possibility of evaluating theoretical models on the basis of their utility in practice.

Practitioners and researchers commonly use technology integration models to guide their educational technology initiatives in face-to-face and online settings. Such models may be seen as lenses through which we interpret the role that technology plays in the learning process and the effects that it has upon learning experiences and outcomes.
As stated by Veletsianos in chapter 1, emerging technologies and emerging practices may not be strictly defined by newness, are evolving, are not yet fully understood, and are potentially disruptive but mostly unfulfilled. Technology integration models are frameworks that one can use to guide thinking around the use of emerging technologies in education and as such provide a way to examine the myriad ways stakeholders make decisions pertaining to technology use, adoption, and integration.

As theoretical constructs, technology integration models empower researchers and practitioners to ask certain questions and to understand technology integration in key ways. Much like the lens of a telescope, these models have great practical value for improving perceptions and guiding inquiry, and it is for this reason that various technology integration models have been posited in recent years as means for understanding technology integration phenomena. Some prominent examples include the Technological Pedagogical and Content Knowledge (TPACK) model, Substitution Augmentation Modification Redefinition (SAMR) model, Replacement Amplification Transformation (RAT) model, Technology Integration Matrix (TIM), Technology Acceptance Model (TAM), and Technology Integration Planning (TIP) model. Each provides different opportunities for understanding and interpreting technology integration efforts.

Within the educational literature, different models exhibit different levels of adoption. Some are widely adopted across geographic regions and content areas, while others have more isolated adoption. It is unclear from the literature why some groups adopt certain models over others, and throughout the literature there is typically little discussion about competing models and reasons for choosing one over another. Rather, it seems that technology integration models are adopted based on convenience and comfort on the part of adoptees without any clear explanation as to why. Furthermore, because the education field is permeated with a general sense of theoretical pluralism, which allows for competing and contradictory theoretical constructs to coexist and enjoy pragmatic use among practitioners and researchers, there does not seem to be a call for adoptees of different models to seek consensus or to reconcile models with one another. As a result, the educational literature does not contain a robust discussion of theory development in this regard, and it seems to be the norm that alternative theories need not compete with one another. Instead, they may be adopted and discarded based upon the current attitudes of the individual and trends in the field.
Researchers suggest that such theoretical concepts would benefit from ongoing development and critical discussion (Graham, 2011; Kimmons, 2015). The method by which discussion should occur is not clear, however, because theorists must reconcile the perceived value of theoretical pluralism with the clear need to create standardized conceptual understandings. Furthermore, there does not seem to be a general sense of urgency in this regard, because adoptees may view particular models as superior to alternatives without requiring clear and explicit criteria for doing so.

“GOOD” THEORETICAL CONSTRUCTS

Though we often quote Lewin’s (1951) famous statement that “there is nothing so practical as a good theory” (p. 169), we have not taken the step together as a field of considering what constitutes good theory nor considered the tautological implications of Lewin’s statement that the quality of theoretical concepts should be evaluated based upon their practicality. Rather, it seems that we have heretofore been content with assuming that the value of a theoretical concept, like beauty, lies in the eye of the beholder.

This general lack of theoretical discussion may have serious implications for the credibility and validity of the educational technology field as a site of serious academic endeavor (Selwyn, 2011) and has left us in a strange predicament: though we may believe that theoretical models are good insofar as they are practical, we have not as a field established methods for determining model practicality (and therefore value). Likewise, we have not maturely considered the possibility that some theoretical models may be more appropriate in certain contexts than others. Rather, the flavor of the educational literature in this regard seems to be highly subjective and uncritical, wherein a theoretical model may be adopted for a particular research study, but no justification is provided as to why the model was chosen over alternatives; models themselves are not critically evaluated based upon empirical outcomes. We seem to subjectively choose models and allow those models to dictate how we interpret our findings, rather than using our findings to drive theoretical model development and adoption.

In previous work, we and other authors have explored the affordances and limitations of specific models along with recognized needs for ongoing theory development (Brantley-Dias & Ertmer, 2014; Graham, 2011; Kimmons, 2015), but this has been done without standardized expectations of the function that theoretical models should fulfill, and we have typically done so with a single, monolithic perspective of educational context dictating how we interpret a given
model’s value. Yet it seems obvious that if theoretical models represent ways of perceiving technology integration, then the value of a model will be established upon the expectations and assumptions of those who wield it.

In our outreach and teaching efforts, we find the use of technology integration models to be extremely helpful for teaching various stakeholders about technology integration, but we also find that certain models are more appropriate for some situations than others. For this reason we do not believe that there is a single total package of theoretical concepts that serves all the needs represented by stakeholder groups, but we do believe that existing models may be effectively applied to address education needs as educators come to understand the value of each model and the criteria that make each model a good fit for some contexts and a poor fit for others.

As practitioners and researchers who have explored technology integration across a number of contexts, we believe that technology integration is a highly complex process that needs to include multiple considerations in order to be successful. For this reason, we embrace theoretical pluralism in the field and contend that various models are appropriate and valuable in different contexts. Technology integration models are very diverse and, like tools in the hands of a carpenter, should be applied in a manner that is contextually appropriate and that properly meshes the model with intended goals. We also believe that technology integration models should serve to guide and simplify, rather than confuse and obfuscate, the process of technology integration. We are therefore frustrated with a lack of clarity regarding model selection.

In this chapter, we propose a set of criteria that we believe to be important when weighing the value of any given model. Any model that would truly encompass all pieces and roles of technology integration would be far too complex to apply and remain valuable. Though we believe that no single theoretical model should reasonably be expected to be all things to all people, we also believe that there should be some general framework for model selection that allows us to match a model’s strengths to the value systems of potential adoptees.

SIX CRITERIA

Throughout this discussion, we hold that technology integration is a complex process that is influenced by nuances of context (chapters 1, 2, 7). For this reason, we anticipate that some models will be more valuable to some groups than others but also anticipate that these determinations of value are not purely arbitrary but are rather based in structured value systems representing
the beliefs, needs, desires, and intents of adoptees. As such, this chapter aims to provide a set of standardized criteria for establishing the value of one model over another. We propose that the following six criteria may be used to help individuals meaningfully match models to the needs and interests of diverse stakeholders: compatibility, scope, fruitfulness, role of technology, student outcomes, and, clarity.

We will now proceed by describing each criterion and discussing how each connects to technology integration models and adoption.

Compatibility

The notion of compatibility is derived from Rogers’ (2003) work on the diffusion of innovations and refers to the alignment between a technology integration model’s design and existing educational and pedagogical practices. Some models are created with practitioners in mind and seek to be easily applied, while others threaten to disrupt or alter practice or have no clear bearing on the day-to-day work of educators. This means that models exhibiting high compatibility will likely be welcomed by practitioners for their directedness and ease of implementation, while models with low compatibility would be rejected due to burden of implementation and lack of connection to existing goals and practices.

For example, the SAMR model (Puentedura, 2006) is widely used by practitioners, and this is likely due to the fact that the model is generally compatible with existing practices and guides educators through four phases or hierarchical stages of technology adoption. The SAMR model conceives of technology integration as a progression of four levels of impact (Substitution, Augmentation, Modification, and Redefinition), which are organized into two categories (Enhancement and Transformation). The first two levels (substitution and augmentation) fall under the enhancement category. Substitution applies to technology use as a direct tool substitute with no functional change, while augmentation refers to technology as a direct tool substitute with functional improvements. An example of this distinction would include utilizing a printed copy of a test (substitution) versus an electronic copy of a test (augmentation). Both examples utilize technology as a direct substitute for previous practice (typewritten tests), but the functional difference would be that the electronic copy could provide an improvement by cutting down on paper and providing immediate feedback to students. These two enhancement levels are transitional, with the goal to move to higher levels. The third and fourth levels (modification and redefinition), on the other hand, fall under the transformation category,
which means that technology is being used to change practice. In the modification level, the technology allows for significant task redesign, while in the redefinition stage, the technology allows for the creation of new tasks that were previously inconceivable. At both of these levels, technology transforms what is happening in the classroom, but modification emphasizes practices with technology (such as podcasts), while the redefinition stage treats technology as a catalyst for enacting new patterns in student learning (such as project creation through technology).

The author of the SAMR model maintains an active blog and encourages others to share and adapt the model. The blog promotes flexible adaptation of the model to a variety of educational contexts. This alignment makes the model valuable to those who are entrenched in educational systems and are looking for a way to guide phased approaches to technology integration. SAMR likely appeals to teachers because they can easily identify a method for progression within the model and gradually move toward integrating technology within their existing learning environments.

Such compatibility would not be important to innovators, however, who may view existing educational practices as being in need of reform; leaders who are removed from day-to-day processes of teaching and learning may also not find it useful. For those who seek to use technology as a catalyst for promoting change in the status quo, models that are compatible with existing systems may be viewed as ways to reinforce the status quo and to undermine technology’s potential as a social catalyst. For this reason, we anticipate that compatibility, as a valuable criterion for model selection, would be determined by stakeholders’ attitudes toward and perceptions of existing educational systems. As such, the model will likely be favored by educators, designers, and local administrators but be viewed less favorably by those who are situated further from practice.

**Scope**

The concept of scope emerges from the works of Kuhn (2013) and Papert (1987) and deals with the depth of questioning inherent in a model and the intended purposes for integration. Some models are developed to interrogate fundamental problems of teaching, learning, and educational practice, dealing with the “why” of integration and a global scope, while others take a more technocratic approach, dealing with the “how” of integration and a local scope. Models that exhibit a more global scope may seek to catalyze social reform through effective integration, while those that exhibit a more local scope may focus on...
improving a single lesson plan. Papert (1987) argues that technology can serve to accentuate existing rifts in educational theory and to encourage us to push forward theory and philosophy. However, he also explains that we can mistakenly view the field in a technocentric manner, wherein we ascribe causation to technology and focus only on application. Models that provide global scope lead us to reconsider and explore assumptions about teaching, learning, and social structures, while technocentric or local models lead us to think about how we can layer technology within existing practice.

For example, connectivism (Siemens, 2005) may be framed as a technology integration model that exhibits global scope and avoids technocentrism insofar as it seeks to propose an entirely new learning theory for the digital age. According to Siemens (2005), accepted learning theories such as behaviorism, cognitivism, and constructivism were developed before learning was affected by digital technologies, and the emerging digital world requires us to rethink the relationship between learners and knowledge and the contexts in which learning takes place. As argued in chapter 2, “born digital” versions of online education may need to be theorized under alternative perspectives. Within a connectivist framework, for example, knowledge is distributed between learners and nonhuman appliances (such as databases or websites), and the purpose of learning has shifted toward improving access between the learner and information sources. Unlike other models of technology integration that treat technology as an external component that must be merged into pre-existing practices of teaching and learning, connectivism holds that learning itself is fundamentally changing as a result of technology, and integration for educational institutions means to alter institutional processes and policies to align with these new and emerging standards of learning and knowing. As such, meaningful technology integration from a connectivist perspective considers issues of information flow and ownership, cycles of knowledge creation, and the development of literacies among learners for navigating and effectively utilizing information networks.

Based on this characterization, scope and compatibility may seem at odds with one another: models that excel in compatibility may be perceived as supporting the status quo, while models with global scope may be perceived as supporting sweeping change. It may be, though, that a model can exhibit both compatibility and global scope if we consider that compatibility may extend to beliefs and attitudes in addition to practice. For instance, teachers may find themselves operating in educational institutions that do not align with their beliefs about what constitutes effective practice. High-stakes testing and stan-
dardized curricula are examples of situations in which teachers may espouse one way of thinking but operate in a system that espouses another. In each case, certain technology integration models might be applied that are compatible with teacher beliefs but that seek to undermine artifacts of the institution (thereby exhibiting both compatibility and global scope).

Global scope may not be meaningful to stakeholders whose aim is to merely incorporate technology into existing systems, however. If the system is acceptable in its present state, the technology is not recognized as a potential catalyst for change, or the adopter has no interest in enacting sweeping reform, then global scope may not be valued. For instance, a teacher merely seeking to enhance a lesson through the introduction of a new technology may find little value in a model that encourages her to completely rethink the aims of educational institutions generally. Thus, models that exhibit global scope, like connectivism, may be more useful for those seeking to rethink educational institutions, while models with local scope, like TIP or TPACK, would be more valuable for those dealing with more focused or discrete problems of technology integration.

**Fruitfulness**

The concept of fruitfulness is derived from Kuhn (2013), who explains that a good theoretical model should “be fruitful of new research findings . . . [and] disclose new phenomena or previously unnoted relationships among those already known” (p. 75). In this sense, a fruitful technology integration model would be adopted by a diversity of users for diverse purposes and yield valuable results crossing disciplines and traditional silos of practice. In contrast, an unfruitful model would be generally ignored or only be adopted in a manner that promotes siloing and dissuades interdisciplinary practice.

TPACK is an example of a fruitful technology integration model. Proposed by Mishra and Koehler (2006, 2007), the TPACK model of technology integration asserts that teaching with technology is difficult to do well and requires a complex set of skills incorporating three domains of knowledge: technology, pedagogy, and content. Often using a Venn diagram to illustrate relationships between these three domains, TPACK holds that knowledge domains interact with one another to create additional domains (e.g., Shulman’s (1986) PCK or pedagogical content knowledge). These new domains are more than the sum of their parts, and TPACK represents the complex knowledge needed for a teacher to apply technology in educationally beneficial ways. Just as someone who
understands pedagogical theory and understands mathematical content might not be able to connect the two in a way that is educationally valuable for teaching elementary mathematics, for teachers to effectively integrate technology into teaching and learning, they must not only have necessary pedagogical, content, and technical knowledge but must also understand how these three constituent components interact with one another and can be applied effectively in a given situation to support deep, meaningful learning with technology.

TPACK exhibits fruitfulness in that it has been adopted by various researchers and practitioners spanning disciplines. Because TPACK recognizes the importance of content knowledge in technology integration, specialists in different fields may feel comfortable using it as a model, because it validates the importance of their areas of expertise. Numerous research studies have been conducted that connect the TPACK model to teacher beliefs and attitudes, and a wide array of professional organizations and journal special issues suggest that the model has been fruitful in creating and sustaining meaningful conversations about technology integration.

Adopters of technology integration models might find value in fruitful models for their potential to span disciplines and generate meaningful conversation in a common language. If a model represents a commonly accepted way of thinking about a phenomenon that spans disciplines, then researchers focused on improving practice will be drawn to that model. All else being equal, however, fruitfulness may have little value to practitioners and researchers that do not mind operating within the silo of a single discipline or institution or to those who are not seeking to contribute to larger conversations of effective technology integration.

**Role of technology**

Technology plays different roles in different models. As alluded to in the discussion of scope above, technology can be seen as a means to an end or as an end itself. Some models view technology as a means for achieving socially valuable ends or for improving learning, while other models may treat technology integration itself as the goal. Because technology integration occurs within social contexts wherein attempts at integration may be mandated or expected, some may feel compelled to integrate technology without having a firm understanding of how such integration will meaningfully influence the learning environment. This may compel such adopters to view technology integration as the goal, thereby adopting models that treat technology as an end.
CAST’s (2011) Universal Design for Learning (UDL) is an approach to technology integration that emphasizes the importance of addressing learners’ uniqueness, strengths, and needs in curricular decision-making, thereby formulating the role of technology as a means to support access and learning. UDL is comprised of three principles. Each principle contains three guidelines and each guideline contains several checkpoints. The three principles of UDL suggest that technology should be used to:

1. Provide multiple means of representation;
2. Provide multiple means of action and expression;
3. Provide multiple means for engagement.

Every guideline in UDL can be achieved via technology, and part of the strength of UDL as a model for technology integration lies in thinking about technology as a means for minimizing barriers to students while maximizing learning outcomes. In this way, technology integration is only valuable if it helps to achieve the three principles of UDL, and integration that does not achieve these principles is not seen as valuable.

Some groups view technology integration as an end, while others view integration as a means to some other end (such as, say, universal access). Because models are created with a specific role for technology in mind, technology integration models will treat technology as either a means or an end, and potential adopters will be drawn to those models that align with their views. For example, a practitioner who has been mandated to integrate technology in some manner into her curriculum would likely be drawn to models that treat technology as an end, because if technology adoption alone is the goal, then treating technology as an end seems to be the simplest way of achieving it. In contrast, a researcher that seeks to improve learning in a specific subject area would likely be drawn to models that treat technology as a means to another end (in this case, improving learning). In both cases, model selection would be driven by the vision of the adopter and how seamlessly potential models align with that vision.

**Student outcomes**

In our current culture of high-stakes testing and mandatory improvement, discernible student outcomes are of great interest (chapter 10), and much of the rhetoric surrounding technology integration focuses on improving student achievement. Yet not every technology integration model includes the incorporation of student outcomes or the expectation that integration will produce
a discernible impact. Similarly, though some models may allude to student outcomes, they may not give these outcomes a primary role in the technology integration process. On the other hand, some models incorporate student outcomes into their core formulations and encourage adopters to consider these outcomes prior to commencing technology integration.

The Technology Integration Planning (TIP) model is grounded on instructional design theory and consists of seven phases, which comprise three clusters of activity, to guide technology integration (Roblyer & Doering, 2013). The first cluster represents an analysis of learning and teaching needs and includes two phases: first, determine the relative advantage of the integration, and second, assess TPACK. This first cluster is the only cluster in the model that is not revisited later in the process, while all other clusters are recursive. The second cluster, planning for integration, consists of three phases: decide on objectives and assessments, design integration strategies, and prepare the instructional environment. And the third cluster, post-instruction analysis and revisions, includes the final phases: analyze results and make revisions. After determining outcomes, the third cluster cycles back to the second cluster, revisiting the planning stages in hopes of improving learning and allowing the adopter to solve problems and improve efficiencies.

A great strength of TIP is that it presents a need to plan prior to choosing a technology, thereby forcing adopters to clearly state intended student outcomes at the outset. These expectations are then revisited and evaluated, and the integration pattern is adjusted to address discrepancies between intended outcomes and actual results. It is expected that this type of approach would lead to thoughtful and impactful technology integration efforts that give primacy to student outcomes.

Models that meaningfully incorporate student outcomes would be of great value to those charged with improving achievement in a measurable manner. It may be, however, that not all benefits of technology integration are measurable or readily discernible (e.g., soft skills) and that not all technology integration efforts should be focused on students (e.g., improving institutional efficiencies). As a result, those who seek to achieve these types of results may find models that focus heavily on student outcomes to be burdensome or inappropriate.

**Clarity**

Finally, technology integration models vary in their clarity, in terms of both their formulation and their ongoing refinement. Clear models are simple and easy to
understand conceptually and in practice, while unclear models are confusing and may be misinterpreted. Reasons for variations in clarity may vary, but some models are clearer because they are simply stated and have limited scope. Others are unclear, because much has been written to refine and extend them. In general, clear models benefit from being easier to explain and utilize, while fuzzier or more confusing models are difficult to explain, or introduce uncertainty.

For example, the RAT (Replacement, Amplification, and Transformation) model of technology integration (Hughes, 2005) exhibits a high level of clarity when compared to some of its counterparts. This model proposes that technology integration in educational settings may be interpreted by considering the impact that the introduction of technology has upon educational activities and desired outcomes, and these impacts may be categorized in one of three (mutually exclusive) categories: replacement, amplification, or transformation. Instances of replacement would include situations wherein introduction of technology does not change the activity being performed but rather moves it into a new medium; amplification would include instances of technology integration wherein its introduction improved efficiencies of an existing practice; and transformation would include applications of technology that fundamentally change previous practices or empower participants to do things that they could not have done without technology. In its current form, the model does not suggest that the three classifications are hierarchical or that instances of technology integration should seek to be of a certain type, though replacement may likely be interpreted as inferior to the other two.

A major affordance of this model is that it empowers researchers and practitioners to ask concrete questions about technology integration, critically evaluating their reasons for incorporating technology. An example question might be: Does the use of social media in our online course merely replace an existing practice or is it empowering us to do something new? Because RAT treats all instances of technology integration as being amenable to classification in one of the three categories, it is fairly simple for educators to comprehend and use the model to analyze a particular case of technology integration. Also, since these classifications appeal to common sense and utilize definitions that may be applied with some level of certainty across contexts, the RAT model removes many difficulties of contextual interpretation and creates a generalizable standard.

Models that exhibit a high level of clarity would be valuable in helping to remove the interpretive guesswork that goes along with less clear models. Practi-
tioners need clear models to recognize how they should implement technologies across contexts, and researchers similarly need them for evaluation purposes. However, the use and integration of technology is a complex and nuanced process (chapter 1, 2), and clearer models may problematically lead to reductionist thinking by being overly simplistic. Thus, those focused on theory development or integration across diverse contexts may find less value in clear models due to their simplicity.

CONCLUSION

In this chapter, we argued that the field needs mechanisms to evaluate “good” theory when it comes to technology integration and we outlined six criteria for comparing theoretical models in a meaningful way. These criteria should not be used to universally evaluate models hierarchically. We believe, however, that they may be useful for aligning the strengths of particular models with the prioritized needs of potential adopters. For instance, an instructor who is being asked to teach online for the first time will likely need clear guidance on how to foster student outcomes, and would be drawn to a model that exhibits high marks in clarity and student outcomes, while a political leader intent on enacting large-scale social change using online education as a catalyst would be drawn to models that exhibit high marks in scope and role of technology.

To advance the use of technology integration models in online education, we must first create and validate mechanisms for evaluating models in accordance with adoptees’ prioritized needs. For this reason, future work should empirically identify the prioritized needs of various groups and evaluate emerging models in accordance with these criteria. This chapter has served as a first step in considering what some of these criteria may be, and we encourage practitioners and researchers alike to continue the conversation around technology integration so that we can collaboratively improve theory and practice. By initiating this conversation, we hope to elicit responses from the scholarly community to refine and adjust the proposed criteria to meaningfully account for the perspectives of all groups who may benefit from technology integration model adoption. Through this process, we hope to fulfill and actualize the promise of emerging technologies and emerging practices in education.

REFERENCES


