FOREWORD

A Systems View of Technology Infusion

PUNYA MISHRA
MELISSA WARR
ARIZONA STATE UNIVERSITY

Let us begin with a story, a story about a car factory in Fremont, California, and how it changed over time. In the beginning, this factory, run by General Motors (GM), was one of the worst factories in their lineup—inefficient and sloppy. As reported by Adler (1993) and Glass and Langfitt (2010), nobody associated with the factory was happy—not the workers, not the managers, and not even those who would eventually drive the cars. Factory workers were so unhappy that they purposely messed up cars—scratching them, adding extra bolts to make the doors rattle, even putting the engines in backward. The union made it almost impossible for employees to be fired. Absenteeism was high, and drug and alcohol abuse ran rampant. The result was a whole lot of wasted time, energy, and money. Eventually, GM closed the factory (Adler, 1993).

A year later, the factory was reopened, the result of a collaboration between GM and Toyota, and it was a completely different story. The plant ended up becoming one of their most profitable and efficient car factories, and within a couple of years, it was meeting and exceeding every industry standard in terms of quality and efficiency. So, what changed? Well, let's start with what did *not* change. The workforce did not change. The new factory included 85% of the previous employees, including the same union leaders. The brand did not change. For the first four years after the factory reopened, it continued to produce Chevrolets.

What had changed were the systems and culture. In addition to financial investment, Toyota brought their team-based production system to the factory. Toyota had a record of consistently turning out high-quality cars, and they believed their production system was key. To start the project, Toyota brought GM employees to Japan, where they worked in Toyota factories next to Toyota employees. In the Toyota production system, workers were put into teams of four or five employees. They rotated assignments to stave off boredom. When workers were behind, others offered assistance. Whereas in Fremont the assembly line never stopped, at Toyota, if a team had a problem, they could pull a cord and a team-chosen tune would play,

informing a manager that help was needed. If necessary, workers could stop the production line to fix problems. The focus was on quality, not quantity. Employees received bonuses for finding ways to make their work more efficient, resulting in new innovations such as special tools and processes. This was a new kind of factory culture—one where managers and laborers worked together and respected one another to create a product they could all be proud of.

The results were astounding. The new factory's quality met the same high standards as the Japanese factories. Workers enjoyed coming to work, absenteeism dropped, and overall production increased. Finally, according to the Consumer Report Reliability Index, the quality of the cars themselves improved (Adler, 1993).

This is the difference that the thoughtful design of systems and culture can make.

The obvious question that readers of this foreword must be asking is, What does the story of the turn-around of a car company have to do with technology infusion, the topic of this book? Essentially, we argue that most teacher preparation programs have seen technology integration as being "somebody else's problem" (Koehler, Mishra, Hershey, & Peruski, 2004). Technology and teaching are domains ruled by different groups of people—teacher educators, who are in charge of pedagogy and learning; and technologists, who are in charge of technology. The solution that emerges from this division is often that of providing a stand-alone technology course to teacher candidates who are taught by technology faculty. In contrast, a framework for technology infusion suggests technology integration should be a concern of the *entire* teacher preparation program, not only that of educational technology faculty. What is needed is a programmatic and systemic approach where the charge is a shared responsibility among all teacher preparation faculty.

There are complex historical precedents that have led to the "somebody else's problem" situation. Scholars have commonly labeled applying technology to teaching and learning as technology integration. Early attempts at integration laudably focused on learners and how they could harness new digital tools for new kinds of learning. For example, Jonassen's mindtools placed technology as a knowledge construction tool, emphasizing that students should be learning with, not from, technology (Jonassen, Carr, & Yueh, 1998). Others have emphasized that technology integration must focus not on the technology itself, but on the teaching and learning the technology enables (Knezek, Christensen, Miyashita,

& Ropp, 2000; Mills & Tincher, 2003; Norum, Grabinger, & Duffield, 1999). Teachers and teacher educators became the focus of attention with the advent of the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006). The TPACK framework described the need for teachers (and teacher candidates) to simultaneously call on their knowledge of technology, pedagogy, and subject matter content. Though the focus on teachers and teacher knowledge was a valuable insight provided by TPACK, the framework does not address how best to develop that knowledge in a teacher preparation program.

We argue that perhaps there has been an inordinate focus on the teacher as the central adopter and agent of change, and we have neglected the role of systems and culture in technology integration efforts. We do not argue that the research has completely neglected the impacts of external barriers, systems, and culture on technology integration. Indeed, much research has considered both internal and external barriers (Ertmer & Ottenbreit-Leftwich, 2013; Rogers 2000), compared the impact of individual versus systemic factors on technology integration (Reid, 2014; Teo, 2015), and emphasized the need for systemic change (Ellsworth, 2000; Fullan, 2007). However, most of this work has focused on studying how the *current* system interacts with and affects teacher actions and beliefs, not on the type of influence a *new* system might have on technology use in education. And *this* is the lesson of the car factory in Fremont, California, with which we began our foreword—that *one can thoughtfully design not just tools and experiences but also systems and culture.*

We argue that it is productive to see tools, processes, experiences, systems, and culture as overlapping spaces of design, what we have called the Five Spaces for Design in Education (Figure F.1).

Each circle in the model depicted in Figure F.1 represents a space for design activity. Although design occurs across all the spaces, in each space the outcome of design is focused on a particular category of product: artifacts, processes, experiences, systems, or culture.

Although technology is not distinctly mentioned in the diagram, one can easily see how technology fits within each of these spaces. For instance, artifacts could be digital artifacts such as apps or websites, while processes could be technology-assisted lesson plans, and so on. It is also important to note that the complexity of the design spaces increases as we go from artifacts to culture. This is not to say that creating a good educational app is easy—rather that it is a relatively tame problem

compared to changing systems and culture. These spaces, though they appear nested within each other, do influence meaning-making bidirectionally. Thus, effective design in any design space requires an awareness of all design spaces.

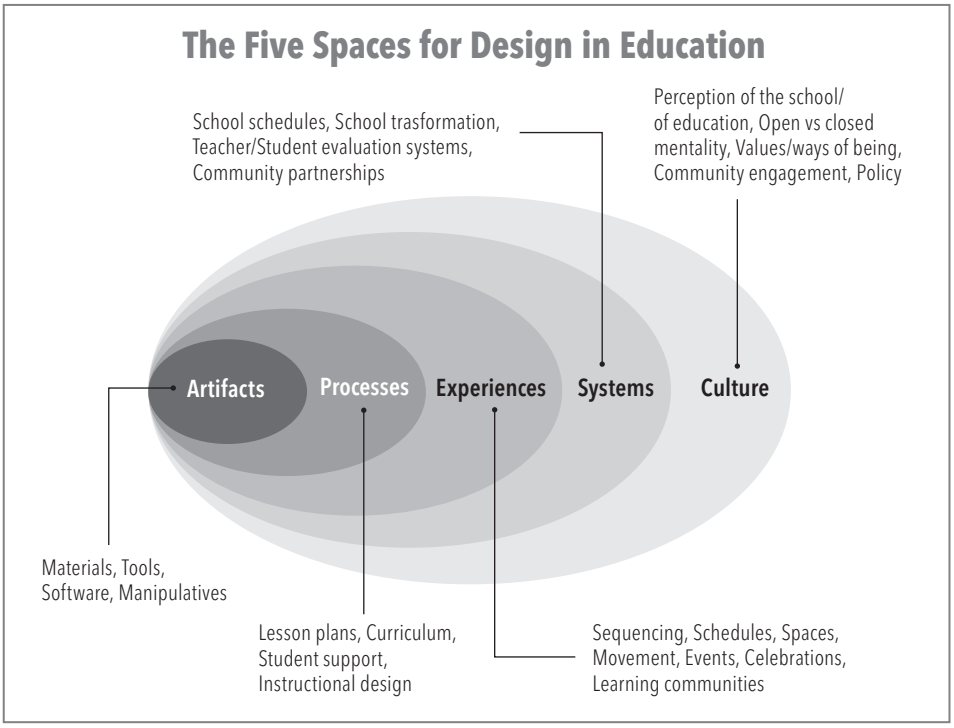

Figure F.1 The Five Spaces for Design in Education (see Warr, Mishra, & Scragg, 2019). Image property of Punya Mishra, Ben Scragg, and Melissa Warr.

We believe that the Five Spaces for Design in Education provides a broad vision of technology in education and emphasizes the importance of designing systems and culture. Most research on technology in education has focused on knowledge needed to design artifacts and processes, and sometimes experiences, but has at times ignored systems and culture which, as we saw in the Fremont factory, can entirely change how artifacts, processes, and experiences gain meaning and are used. Systematic, sustainable change requires attention to all five spaces of design: artifacts, processes, experiences, systems, and culture. This brings us to what we mean by technology infusion. *Whereas technology integration typically focuses on*

a particular instance when technology is used for teaching or learning, technology infusion is a program-deep and program-wide effort in teacher preparation programs to help teacher candidates learn how to effectively teach with technology. It emphasizes redesigning experiences, systems, and cultures of teacher education systems rather than focusing on stand-alone technology integration courses and tool-specific applications. It infuses technology into the culture of the teacher preparation program, enabling rich experiences for teaching and learning with technology.

The chapters in this book explore elements of a technology infusion framework. Teacher education is a complex system, consisting of multilayered and deeply contextual environments that provide students with a range of experiences to help them prepare for the future. Clearly, creating a coherent learning experience for teacher candidates (even when not considering technology) in complex contexts such as these requires thinking at the level of systems and culture. Additionally, teacher education does not work within a vacuum but is driven by structures, visions, and policy constraints that can be both internal to the organization (such as existing regulations, conventions, etc.) and external (such as the needs for certification, and so on). Making sustainable change in these types of situations is often fraught with ambiguity. In this context, teacher preparation programs that seek to make technology a key component of teacher education need to be seen as learning organizations—they are organizational structures adapted to a purpose. Change efforts need to consider relevant situations, constraints, and contexts. This is just a roundabout way of suggesting that the task the authors of these chapters have taken on is not an easy one.

Establishing a technology infusion framework is hemmed in by multiple social, organizational, interpersonal, and structural constraints. Thus, technology infusion is complicated, requiring negotiation and thoughtful design with multiple stakeholders. That is what makes technology infusion difficult. And yet, it is only through this deep engagement with systems of teacher education that technology infusion can truly take hold and allow for the development of the next generation of educators. This is not an easy task, but it is an important one. We praise the editors of this book and the authors of each of the chapters for taking on this challenge. The theories of change, the data and practical evidence they provide, and, as importantly, the stories they tell, will be invaluable to others who take on this challenge. We believe this broader perspective, that of technology infusion, requires expanding our focus to include experiences, systems, and culture to help *all* teachers effectively integrate technology into teaching and learning.

References

Adler, P. S. (1993). The learning bureaucracy: New United Motor manufacturing, Inc. In B. M. Staw & L. L. Cummings (Eds.), *Research in Organizational Behavior* (Vol. 15, pp. 111–194). Greenwich, CT: JAI Press.

Ellsworth, J. (2000). *Surviving change: A survey of educational change models.* Syracuse, NY: ERIC Clearinghouse on Information and Technology.

Ertmer, P. A., & Ottenbreit-Leftwich, A. (2013). Removing obstacles to the pedagogical changes required by Jonassen's vision of authentic technology-enabled learning. *Computers and Education, 64*(May), 175–182. doi.org/10.1016/j.compedu.2012.10.008

Fullan, M. (2007). *The new meaning of educational change* (4th ed.). New York, NY: Teachers College Press.

Glass, I., & Langfitt, F. (2010, March 26). 403: NUMMI. In *This American Life*. www.thisamericanlife.org/403/transcript

Jonassen, D. H., Carr, C., & Yueh, H.P. (1998). Computers as mindtools for engaging learners in critical thinking. *TechTrends, 43*(2), 24–32. doi.org/10.1007/BF02818172

Knezek, G., Christensen, R., Miyashita, K., & Ropp, M. M. (2000). *Instruments for assessing educator progress in technology integration*. Denton, TX: Institute for the Integration of Technology into Teaching and Learning.

Koehler, M. J., Mishra, P., Hershey, K., & Peruski, L. (2004). With a little help from your students: A new model for faculty development and online course design. *Journal of Technology and Teacher Education, 12*(1), 25–55. www.learntechlib.org/p/14636

Mills, S. C., & Tincher, R. C. (2003). Be the technology: A developmental model for evaluating technology integration. *Journal of Research on Technology in Education, 35*(3), 382–402.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054.

Norum, K. E., Grabinger, R. S., & Duffield, J. A. (1999). Healing the universe is an inside job: Teachers' views on integrating technology. *Journal of Technology and Teacher Education, 7*, 187–203.

Reid, P. (2014). Categories for barriers to adoption of instructional technologies. *Education and Information Technologies, 19*(2), 383–407. doi.org/10.1007/s10639-012-9222-z

Rogers, P. L. (2000). Barriers to adopting emerging technologies in education. *Journal of Educational Computing Research, 22*(4), 455–472. doi.org/10.2190/4UJE-B6VW-A30N-MCE5

Teo, T. (2015). Comparing pre-service and in-service teachers' acceptance of technology: Assessment of measurement invariance and latent mean differences. *Computers & Education, 83*, 22–31. doi.org/10.1016/j.compedu.2014.11.015

Warr, M., Mishra, P., & Scragg, B. (2019). Beyond TPACK: Expanding technology and teacher education to systems and culture. *Society for Information Technology & Teacher Education International Conference*, 2233–2237. www.learntechlib.org/primary/p/208009