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Chapter 1

Introduction:

Improving Efficiency and Effectiveness Through Learning Engineering

Chris Dede

In the last two decades, digital media have greatly expanded the scope and impact of distance education, as well as widened the range of models used for teaching and learning. The rise of online learning as a major form of education for adults, coupled with the advent of MOOCs (massively open online courses), highlights the importance of enhancing digital education's outcomes through improved instructional design. As a powerful method for accomplishing this goal, *learning engineering* applies a principled set of evidence-based strategies to the continual re-design of educational experiences to optimize their effectiveness and efficiency. This book centers on the use of learning engineering to improve online courses in higher education.

Both online teaching and blended instruction (online plus face-to-face) are good venues for learning engineering because the digital media used automatically generate rich, time-stamped logfiles documenting each student's interactions with curricular materials, peers, and instructor. The evidence that guides constant, rapid cycles of improvement in learning engineering comes from this form of big data coupled with high quality outcome evidence (both near- and long-term). Doug Laney, an analyst with the META Group (now part of Gartner), described big data with a collection of "v" words (Laney, 2001), referring to (a) the increasing size of data (*volume*), (b) the increasing rate at which it is produced and analyzed (*velocity*), and

(c) its increasing range of sources, formats, and representations (*variety*). To this, other authors have added *veracity*, to encompass the widely differing qualities of data sources, with significant differences in the coverage, accuracy, and timeliness of data (Dong & Srivasta, 2013).

Technological and methodological advances have enabled an unprecedented capability for decision making based on big data, and its use has become well established in business, entertainment, science, technology, and engineering (Dede, 2015). For example, online purchases are now guided by recommendation engines that analyze an individual's shopping patterns and suggest products bought by others who have similar patterns of purchases. Big data is beginning to be utilized for decision making in higher education as well; one example is early identification of at-risk students based on analysis of their behavioral patterns. Thus far, these analytics focus on students' macro-behaviors (e.g., adding or dropping courses) rather than their micro-behaviors (second-by-second activities in learning experiences coupled with evidence about learning outcomes).

Practical applications to analyzing students' learning behaviors and outcomes in college and university *instruction* remain rare because of challenges unique to higher education (Dede, Ho, & Mitros, 2016). First, the sector lacks much of the computational infrastructure, tools, and human capacity required for effective collection, cleaning, analysis, and distribution of large datasets. Second, in collecting and analyzing student data, colleges and universities face privacy, safety, and security challenges not found in many scientific disciplines. Third, higher education should also be concerned with long-term goals—such as employability, critical thinking, and a healthy civic life—even though at many institutions these objectives are not apparent in their tactical decision making. Since it is difficult to measure these outcomes, particularly in short-term studies, researchers studying effectiveness in higher education often rely on theoretical and substantive arguments to justify imperfect, immediate proxies for these longitudinal objectives. This is made more difficult by a lack of training for or awareness among most faculty of the challenge of gathering valid and reliable evidence about learning outcomes, either near- or long-term.

Learning engineering cannot resolve these difficulties in measuring long- or short-term goals, but it can use big data to iteratively improve the design of learning experiences. *Learning analytics* and *educational data mining* are concerned with exploring the unique types of data that come from educational settings. Learning engineering combines methods from these fields with design-based research to better understand how students learn, what instructional strategies enable optimal learning (Baker & Yacef, 2009), and how to gather valid, reliable evidence about learners' mastery of intended outcomes.

Learning engineering can improve online learning outcomes in higher education in a variety of ways. Through educational optimization, students' engagement with courses can deepen, teachers can improve the efficiency of their instruction, and a broader range of learners can succeed because courses are tailored to their individual needs. The chapters in this book describe these and other types of improvements from learning engineering. *Personalized learning* is a conceptual framework that articulates the mechanisms that create many of these improvements.

Personalized Learning

The U.S. Department of Education's *2010 National Education Technology Plan* provided an early, influential definition of personalization, stating:

> Personalization refers to instruction that is paced to learning needs, tailored to learning preferences, and tailored to the specific interests of different learners. In an environment

that is fully personalized, the learning objectives and content as well as the method and pace may all vary. (p. 12)

In the same time frame, the 2010 SIIA Symposium on [Re]Design for Personalized Learning articulated five essential elements of personalized learning: *flexible*, *anytime/everywhere learning*; *redefine teacher role* and *expand* "*teacher*"; *project-based*, *authentic learning*; *student driven learning path;* and *mastery/competency-based progression/pace*.

Since then, personalized learning has been clouded by many definitions, most of which weaken the concept to the point that everyone can claim they are already "personalizing" learning. (This bastardization of a rigorous educational innovation is unfortunately quite common.) For the purposes of contextualizing learning engineering, we define personalized learning as having four fundamental attributes:

1. Developing multimodal experiences and a differentiated curriculum based on universal design for learning principles;
2. Enabling each student's agency in orchestrating the emphasis and process of his or her learning, in concert with the evidence about how learning works best and with mentoring about working toward long-term goals;
3. Providing community and collaboration to aid students in learning by fostering engagement, a growth mindset, self-efficacy, and academic tenacity; and
4. Guiding each student's path through the curriculum based on diagnostic assessments embedded in each educational experience that are formative for further learning and instruction.

Substantial evidence exists that combining these four attributes leads to learning experiences that provide strong motivation and good educational outcomes for a broad spectrum of students (Dede & Richards, 2012).

As targets of opportunity for learning engineering in higher education, the strategies below for instructional interventions based on big data potentially provide several ways to improve learning through personalization (Dede, Ho, & Mitros, 2016):

- Individualizing a student's path to content mastery, through adaptive, competency-based education. One example is using game-based environments for learning and assessment, where learning is situated in complex information and decision-making situations that adapt to each learner's progress.
- Improving learning as a result of faster and more in-depth diagnosis of learning needs or course trouble spots, including assessment of skills such as systems thinking, collaboration, and problem solving in the context of deep, authentic subject-area knowledge assessments.
- Increasing the efficiency of learning to reduce overall costs to students and institutions.

The chapters in this book provide examples of applying learning engineering to these and other targets of opportunity.

The Value of Personalization in Online Learning

Throughout its history, distance education has struggled with efficiency and effectiveness due to a lack of personalization. A brief history of distance education illustrates this problem (Dede, Brown-L'Bahy, Ketelhut, & Whitehouse, 2004). In the 19th century, distance education in the United States was shaped by new technologies that allowed educators to overcome barriers of distance and time—shifting understandings of the purpose of education—and social, political and geographic forces. The development and implementation of the first correspondence courses were credited to Sir Isaac Pitman of England, the inventor of shorthand. In 1840, he used the postal service in England to reach learners at a distance. A more formal version of the early American correspondence course was created by Anna Ticknor of Boston in 1873. In order to increase educational opportunities for women, she originated the Society to Encourage Studies at Home. The society provided courses of study for women of all social classes and served over 10,000 women over its 24 year lifespan (Nasseh, 1997; Stevens-Long & Crowell, 2002).

In 1878, John H. Vincent, co-founder of the Chautauqua Movement, created the Chautauqua Literary and Scientific Circle. This Circle offered a four-year correspondence course of readings; students who successfully completed the course were awarded a diploma. This course was open to all adults, including women and senior citizens (Scott, 1999). By 1892, the 19th century version of the "Information Superhighway" (otherwise known as rural free delivery) paved the way for Penn State University to provide higher education to rural families (Banas & Emory, 1998). Other institutions of higher education, notably the University of Chicago and the University of Wisconsin, modeled their extension schools after the Chautauqua program (Scott, 1999).

At the start of the 20th century, distance education still relied on correspondence courses delivered primarily through the postal service. Many of these courses were delivered to their students by mail, as discussed earlier, but did not allow much interaction or individualization (Moran, 1993). Although rules for home study were established in 1926 to allow some form of governmental control, correspondence methods were not conducive to supporting learners nor were they standardized (PBS, 2002). One of the main goals of early distance education was to help inculcate immigrants into the "American way of life" (Sumner, 2000), but these learners needed substantial guidance and aid. As a result, poor curricular design and lack of support were particularly problematic, and the dropout rate was high (Shea & Boser, 2001).

While distance education is rooted in the 19th century, the field blossomed in the 20th century. Distance educators looked to technological innovations to provide new opportunities for their field, and the 20th century was rife with technological advances (Mood, 1995). During the 20th century, distance education embraced radio, television, computers, and ultimately the Internet. As the methods of delivery for distance education expanded, so did the diversity of learners seeking distance education and their reasons for enrolling in such courses. Individuals interested in learning cultural norms, becoming more capable in the workforce, or hoping to re-situate themselves in their social context after wartime service, became major consumers of distance education (Dymock, 1995).

In the 1920s, distance education started to utilize radio for delivery of lessons (Bourke Distance Education Centre, 2002; Nasseh, 1997). In a push to widen access, speed the interaction between student and professor, and personalize the delivery of distance education, the use of radio was seen as an exciting opportunity. In the mid-1930s, an American art history course was offered by radio broadcasts (Funk, 1998), and other courses supported forming listening groups to enhance learning (Mood, 1995).

However, despite the rapid rise of radio technology, distance education courses were rarely if ever offered for credit in higher education (Nasseh, 1997). The education community, along with society as a whole, regarded legitimate education as only possible in conventional locales, such as classrooms (Funk, 1998). To address concerns about a lack of teacher interaction in distance education, a modification of the correspondence course was designed in Soviet Russia in the 1930s, called the Consultation Model (Tait, 1994). As its name implies, this type of correspondence course included periodic face-to-face meetings with instructors; however, unlike its name, the consultations were mostly lecture-based meetings intended to spread Communist dogma.

Television was the next big advance in distance education technology. As early as 1934, the State University of Iowa used television to deliver course content. Early research into learning via television indicated mixed results, with several studies showing that it was similar to conventional instruction. Gayle Childs referred to televised distance education as an "'instrument' of delivery, not a pedagogical method" (Jeffries, 2002, p. 6).

Prior to the introduction of computer technologies in the 1960s, correspondence-course and independent-study models of distance education posed challenges to the learning and teaching processes. This contributed to a persistent problem of credibility for the field. Tele-courses (Verduin & Clark, 1991), which developed in the 1970s, showed promise for minimizing some of these problems. Previously, television had primarily been used as an electronic blackboard and for the delivery of standardized content through lectures intended to reach wide audiences. The development of videotape allowed educators to customize the same content for different learning environments. This medium also allowed increased flexibility; course content could be stored, delivered, and repeated at will. This minimized time-dependency, a drawback of previous televised courses. However, despite their advantages, the cost and complexity of producing tele-courses made them impractical for teaching large numbers of students.

Around the same time, the open university concept was launched. The creation of universities open to all was driven by the need to provide alternative education for adults whose needs could not be met in the traditional classroom. The British Open University began in 1969 through video broadcasting of its weekly courses on the BBC. Over time and with the advent of new technologies, the British Open University's model of distance learning evolved into a student-centered delivery system and administrative structure separate from a campus setting. More economically practical than tele-courses, this system envisioned each student as "a node in the network" (Granger, 1990, p. 189) that provided individualized instruction in a virtual classroom. The students had access to a virtual library—customizable based on their particular learning style—and to collaborative tools that encourage discourse and critical thinking (Prewitt, 1998). By encouraging a community of learners, this model overcame some of the problem of isolation.

During the 1970s, the capability of computers to automate tasks and deliver information made them invaluable tools for many companies, thereby increasing the need for technologically competent workers. This prompted the inception of corporate training programs focused on technology literacy. In schools, word processors, spreadsheets, and database applications enhanced the productivity of educators and students. In turn, the development of educational software offered interactive ways to deliver academic content. In the 1980s, due to the rapid evolution of information technology and our increasing dependence upon computers as a society, the use of educational technologies expanded considerably. However, during these first few decades, information technologies were used more to automate traditional models of educational delivery than to develop new forms of pedagogy or to enhance learning across distance. This issue of "old wine in new bottles" is a perennial problem in the history of all educational technologies (Cuban, 2013).

In contrast, during the 1990s, widespread usage of the Internet transformed the nature of distance education. The present-day Internet traces its origins to the ARPANET, a system developed in the late 1960s (Leiner et al., 1997). The ARPANET was initially used by instructors and researchers to share files of information. In 1972, however, email capability was added, transforming computers into a medium that facilitated direct, people-to-people interaction (WSU, 1997). In subsequent years, the advancement of networking technologies led to the eventual development of the Internet. Increasing use of personal computers in schools, businesses, and homes helped to establish this budding network of computers. In particular, with the development of the World Wide Web (WWW) as a means of representing and accessing information, Internet use expanded exponentially.

In 1992, it is estimated that the WWW contained a mere fifty webpages (Maddux, 2001). During the 1990s, decreasing prices for computer technologies led to increases in personal ownership, and self-publishing resulted in an explosion of web-based information. By 2000, the number of webpages rose to at least one billion (Maddux, 2001). With its capability to facilitate communication between people in various geographic locations and to disseminate information quickly and relatively inexpensively, the Internet appeared well-matched for distance education; Long's chapter in this book describes details of this evolution. However, change has been very slow in both face-to-face and distance-based educational practice (Cuban, 2013), with a perennial emphasis on presentational instruction and content coverage despite research-based findings emphasizing active learning and skill development (National Research Council, 2005; National Research Council, 2012; Clark & Mayer, 2016).

In online learning, while MOOCs were hailed as a breakthrough, their instructional practices have remained entrenched in outdated models of teaching (Dede, 2013). In particular, methods for personalization such as individualizing a student's path to content mastery—through adaptive learning or competency-based education—have typically not been utilized (Dede, Ho, & Mitros, 2016). Similarly, more efficient and effective learning as a result of faster and more in-depth diagnosis of student needs or course trouble spots has languished, including assessment of skills such as systems thinking, collaboration, and problem solving in the context of deep, authentic subject-area knowledge assessments.

Learning Engineering as a Means of Enhancing Educational Efficiency and Effectiveness

As discussed earlier, learning engineers are professionals who understand theoretical and evidence-based research about learning and learning measurement, apply these findings to test their value in the crucible of specific situations of practice, and refine initial approaches to develop heuristics and models to make students' learning more efficient and effective. Thus, learning engineering is characterized by evidence-based approaches, measurable and measured outcomes, and iterative processes (Hess & Saxberg, 2013; Saxberg, 2015). This chapter has framed the value of learning engineering for the goal of personalizing online and blended learning. However, learning engineering can take many forms in improving a spectrum of instructional approaches, ranging from data analysis of existing data gathered through students' interaction with learning management systems to targeted A/B testing of the effects of a particular intervention implemented across online courses (Rosen, 2016).

Contributing disciplines include cognitive science, computer science (human-computer interaction, machine learning, artificial intelligence), cognitive psychology, education (psychometrics, educational psychology, learning sciences), and statistics. In 2016, the MIT Online Education Policy Initiative called for greater integration of insights about learning across these disciplines, using a coordinated research agenda (Willcox, Sarma, & Lippel, 2016). The concluding chapter of this book draws on insights from its chapter authors to offer suggestions about next steps in learning engineering research.

The 2016 MIT report also emphasized the importance of online learning in providing a dynamic digital scaffold for instrumented learning that can aid customization, remote collaboration, just-in-time scenarios, continuous assessment, and blended learning. In particular, among many other evidence-based ideas, the report highlighted *spaced learning* to improve retention, which allows students and teachers to focus on applying that learning to challenging problems, as well as *game-based learning*, which can contextualize abstract concepts and provide data on student challenges back to the teacher. Also, some types of online gaming can induce psychological immersion by students, which enables situated learning and transfer to real world applications (Dede, 2014).

Another recommendation of the 2016 MIT report calls for building capacity for educational effectiveness and efficiency through developing many more learning engineers. In addition to the characteristics described above, the importance of learning engineers being able to work with educators is stressed, both in creating new learning experiences and in integrating new technologies and approaches into existing courses. Finally, the 2016 MIT report emphasizes the importance of institutional and organizational changes to take full advantage of the opportunities learning engineers provide. This theme of change in organizational policies and culture is stressed in many of this book's chapters, particularly Saxberg.

Overview of Chapters

The book begins with this introductory chapter introducing terms and conceptual frameworks, as well as providing a quick summary for the contents of each chapter, grouped into three types of discussions. *Dimensions of Learning Engineering* are delineated in chapters by Long, Means, and Roberts and Miller. *Cases of Practice* that illustrate learning engineering knowledge, processes, and pragmatics in action are provided by Leitner, Nesson, and Walker; Jennings; Martin; Goel and Polepeddi; and Saxberg. The book concludes with a chapter by Richards, Saxberg, and Dede summarizing cross-cutting themes from the chapters, describing Digital Teaching Platforms as an infrastructure learning engineers are creating, and delineating important next steps in research and practice for the learning engineering field.

Dimensions of Learning Engineering

Long's chapter, "The Role of the Learning Engineer," explores the background for and implications of what *learning engineer* means in the context of course design, development, and support. The growth of technology development, an exponential increase in our scientific understanding of the world, and the resulting specialization of faculty, particularly at research intensive institutions, challenge the model of the renaissance person commanding all they need to design and build courses in today's university environment. Most faculty in disciplines other than cognitive or educational psychology find themselves in the classroom with no background in learning sciences. Designing engaging learning experiences demands a motivational context grounded in the identity of the learner and a grasp of technical, psychological, disciplinary, and practical group management knowledge that exceeds what can reasonably be expected of the academic training of today's instructor or tenure track faculty. Four themes shape this analysis of learning engineering as a response to this challenge: the history of learning technologies; recognition of what an engineering skill set brings to course development; the role of learning sciences in the design of learning activities; and how the art of design deals with the complexity of real-world situations and their resistance to experimental control.

Means's chapter, "Tinkering Toward a Learning Utopia: Implementing Learning Engineering," articulates how the capability of digital learning systems to collect data as people use them, coupled with advances in data science, offers exciting opportunities to improve learning. The learning data available for research has expanded dramatically in terms of the amount of detail around individuals' learning processes, the number of people learning with systems that generate such data, and the ability to run a series of rapid experiments online. Learning system data can be used in feedback loops that inform the design of learning technology products, students' future learning approaches, instructor practices, and the knowledge base around human learning.

Bringing together teams of collaborators with different kinds of expertise—teaching, subject matter knowledge, instructional design, and data analysis—is a prerequisite for realizing the full potential of learning system data. They characterize such work as collaborative data-intensive improvement research (CDIR) to signal their twin commitments to doing research with, rather than on, educators and to using data to help education systems improve. This chapter will describe several of our CDIR collaborations, including the successes and the challenges encountered in their execution. These include the rush to premature impact evaluation, difficulty synchronizing research activities with product development cycles, and a lack of evaluation capacity within educational institutions. These challenges and possibilities for ameliorating them will be discussed from an organizational change perspective. Finally, the chapter makes a case for the importance of obtaining consensus around key learner outcomes and of having valid and reliable methods for assessing those outcomes.

Roberts and Miller's chapter, "Learning Engineering Teams: Capabilities and Process," discusses how effective improvement of learning outcomes through the implementation of evidence-based interventions requires the coordination of many stakeholders from across an organization. This chapter addresses the capabilities a learning engineering team should contain and the processes for engaging stakeholders in an iterative process to improve learning outcomes. They recommend a learning engineering team should have the ability to: (a) assess learner and faculty needs and advocate for programs, resources, and services to meet those needs by working with appropriate individuals and groups across the university and collaborating with other universities and technology vendors; (b) apply instructional design theory and utilize established, curriculum-development methodology to help instructors and programs achieve their learning goals; (c) lead production, management, deployment, and quality assurance of digital assets; (d) conduct research that generates opportunities for intervention, assesses usability, optimizes outcomes, measures outcomes longitudinally, and synthesizes contemporary approaches; (e) understand the behavior of faculty, students, and other stakeholders as a key variable in the sustainable uptake, adoption, and implementation of evidence-based interventions. In terms of process, they propose a learning engineering team engage contemporary models (e.g., ADDIE, design-thinking) and approaches to developing innovations but remain flexible with regards to the particular innovation's stakeholders as well as the particular phase of development. For example, early collaboration with faculty stakeholders might rely on principles of learner-centered design thinking, while prototyping and production phases involving broader technical teams and stakeholders might adopt agile or agile-like frameworks for rapid iteration.

Cases of Practice

Leitner, Nesson, and Walker's chapter, "From Artisanship to Learning Engineering: Harvard DCE's Framework for Improving Teaching and Learning," discusses how Harvard's Division of Continuing Education (DCE) maintains a commitment to learner-centric design and delivery of courses while applying insights that link evidence and structure to improved course quality, student success, and administrative efficiency. An approach to learning engineering is described that enables asking big-picture questions about the design and delivery of courses and applying answers that amplify the impact of faculty leadership, knowledge, and effort. DCE's classrooms and instructional technologies are instrumented to provide a rich cascade of clickstream and other data, which provides the basis for continuous improvement of course design and enables flexible, timely adaptation during course delivery. A partnership model between faculty and learning engineers enables integrating complex, higher-level relationships between course structure and instructional methodology with practice based on evidence from the dynamic interaction that occurs during teaching and learning.

Jennings's chapter, "Personalization to Engage Differentiated Learners at Scale," discusses how personalization can make learning more relevant and meaningful but has yet to be embraced by mainstream online instruction. With the arrival of MOOCs, a one-size-fits-all curriculum serves to disengage all but the most highly-motivated learners. Google's Analytics Academy includes users from different business types, job roles, and experience levels from multiple countries speaking different languages. Data shows that some segments of users are less engaged and that most students "prospect" the course for relevant information. To increase engagement, completion, and satisfaction metrics, the Academy utilizes a personalization model that suggests specific learning paths through courses and customizes lesson content for users.

Martin and Trang's chapter, "Creating Personalized Learning Using Aggregated Data from Students' Online Conversational Interactions in Customized Groups," describes several platforms that move beyond the limitations of conventional, online teaching by using live and archived streaming instruction coupled with interactive communication chat channels. In addition to providing knowledge from instructors and peers, these platforms are configured to generate teaching and learning assessment datasets. Deep machine-learning using unique datasets derived from each learner's communication tendencies and social interactivity may help optimize the learning environment for that individual, provide guidance and support, as well as enable the use of cognitive memory maps to store and retrieve a student's academic journey.

Goel and Polepeddi's chapter, "Jill Watson: A Virtual Teaching Assistant for Online

Education," presents a case study from the Georgia Tech Online Master of Science in Computer Science (OMSCS), a low cost, easily accessible, accredited degree program. One recommendation for improving learning and retention in MOOCs is to enhance the interaction between the teacher and the students. However, the number of teachers required to provide learning assistance to all students enrolled in all MOOCs is prohibitively high. One strategy for improving interactivity in MOOCs is to use virtual teaching assistants to augment and amplify interaction with human teachers. This chapter describes the use of a virtual teaching assistant called Jill Watson (JW) for the Georgia Tech OMSCS 7637 class, Knowledge-Based Artificial Intelligence (KBAI). JW has been operating in the online discussion forums of different offerings of the KBAI class since Spring 2016. By now some 750 students have interacted with different versions of JW. In the Spring 2017 offering of the KBAI class, JW autonomously responded to student introductions, posted weekly announcements, and answered routine, frequently asked questions. This chapter describes the motivations, background, and evolution of the virtual question-answering teaching assistant.

Saxberg's chapter, "Executing the Change to Learning Engineering at Scale," discusses how recognizing the potential value of applying learning science, and even having examples of the value of applying evidence-based approaches (learning engineering), still does not address how to make such practices stick at scale. What is known about the increasing value (and rate of change) of better skills for almost all people over time is that this definitely has to happen at scale to not leave people behind (economically, socially, emotionally) for decades. A way to move a large organization from varied, traditional approaches to learning to a more evidence-based learning engineering approach involves a series of phases. First, provide exposure to key learning development people to the possibilities and promise of evidence-based approaches—

things they did not know mattered—and get a few examples done with early adopters. Second, as interest begins to build, manage and deliver education to these same learning development folks across the whole organization in a consistent way to share language ideas and even evidence-based processes. Third, with these key professionals ready to help, get the whole organization to mobilize effort behind the changes-over-time required, especially including the general managers who allocate effort and resources across all the activities of the organization. Finally, establish strong evaluation practices and cycles to make this new way of focusing on evidence-based learning measurement and success "the way we do things around here."

Sarma's chapter, "Rethinking Learning in the 21st Century," discusses the evolution of learning over time. In the last century, the modern lecture-based classroom and teaching have become more pervasive, displacing earlier educational approaches of apprenticeships, mutual instruction, and hands-on work. Yet we know that those historic models are closer to our theories and evidence about how people gain deep understandings than are instructional strategies involving teaching by telling and learning by listening. Sarma describes online learning as a new "instrument in the orchestra," an emerging, novel model that enables entirely new combinations of educational experiences.

Following these two sections on *Dimensions of Learning Engineering* and *Cases of Practice*, a concluding chapter by Richards, Saxberg, and Dede summarizes cross-cutting themes, describes Digital Teaching Platforms as an infrastructure learning engineers are creating, and delineates important next steps in research and practice for the learning engineering field. The book ends with the biographies of the authors.

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