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Dede, C., Richards, J., & Saxberg, B. (2019). Learning Engineering for online education: Theoretical contexts and design-based examples. New York, NY: Routledge.

Anna Mihaylov

Academic Director, Business and Finance, Kaplan Business School, Australia

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In 2016, Massive Open Online Courses (MOOCs) had 50 million students enrolled from around the world. At the same time, Google Analytics that was running free Analytics Academy courses with 5.9 million users, found that 90% of student traffic fell off after just two sessions due to the lack of interactivity and personalisation. Student participation in online education offerings is creating valuable data that can be used to help drive their motivations and learning outcomes. Against this backdrop, industry-leading academics and practitioners in the fields of learning engineering, AI, learning technologies and instructional design have written *Learning engineering for online education: Theoretical contexts and design-based examples*. This book posits that learning engineering, or "evidence-based approaches, measurable and measured outcomes, and iterative processes" (7), can utilise student data from online platforms to create better and more engaging learning experiences.

The book poses some tantalising questions:

- What if teaching practices were documented, measured and constructed as learning experiences based on reliable feedback data?
- What if these experiences were systematically recalibrated based on timely student engagement data?
- More specifically, in a time when online learning is becoming the most scalable form of education dissemination, what if student learning data from interactions with online media and systems could be used to determine and influence their motivations and outcomes?

If you are an instructor, course designer or academic leader in an online or blended environment who has wondered about this, this book will help you explore how learning engineering can integrate data analytics, learning science and evidence-based learning improvement approaches to recalibrate online delivery for the new digital age.

But what exactly is learning engineering? To explain I will ask you to imagine, as Bror Saxberg does in Chapter 9, that you are a learning engineer for an organisation preparing online students for complex reasoning tests. Drawing on research into working and long-term memory, you surmise that working memory could be overloaded by these logical reasoning problems. You then run a randomised control trial comparing your current training approach, which uses online videos and workbooks, to a worked example approach pioneered through decades of research and find that worked examples produce statistically significantly better results. Your organisation is then forced to do some soul-searching and redesign its whole educational model.

As demonstrated by this example, learning engineering has two main dimensions. First, the improvement science itself and second, the institutional-level changes that are needed to create a culture that encourages learning improvement based on concrete evidence and data. Part 1 of the book addresses the former and sets out in the first four chapters the remit of a learning engineer as well as delving into the minutia of integrating learning engineers into the culture and operational fabric of an institution. Part 2 is made up of chapters presenting case study examples of how learning research and engineering can transform the student experience. The book is organised with each chapter being written by a different academic, researcher or innovator from the online learning sphere.

In Part 1, Phillip D. Long, an academic leader and activist in technology enhanced learning, defines a learning engineer as someone able to instigate evidence-based interventions by using the "interactions students engage in through digitally mediated coursework and in-class activities" (22). These learning "sensors" (27) available to data scientists are currently increasing, as granular data sets enable the personalisation of a student's learning experience. The other chapters in Part 1 explore how educational institutions could go about embedding learning engineering teams into their teaching and content creation function, to create new and engaging digital assets (animations, videos, assessments), identify learner pain points and design evidence-based interventions. Importantly, the authors in these chapters acknowledge the complexity of this process but also set out a formula that institutions can follow to encourage a data-driven culture promoting trust, respect and collaboration between all stakeholders, especially learning engineers and

faculty. As a manager in an academic institution, the advice in the chapters in Part 1 was very practical and revealing about potential stumbling blocks to changing to a culture of learning improvement. These chapters are therefore geared towards influencers, or managers in the academic space, as well as facilitators who want to encourage the change from the ground up.

Part 2 goes on to provide cutting-edge, actionable and detailed case studies which can be immediately useful to institutions trying to implement a learning engineering approach to learning improvement. Also, the chapters in this section provide many current online tools and websites being used by Harvard, MIT, Google and other online education providers.

For example in Chapter 6, Chris Jennings, the senior instructional designer at the Google Analytics Academy, explores different types of personalisation (explicit, implicit and adaptive) and creating custom learning paths, like machine learning diagnostics, to maximise engagement and make learning personally relevant and meaningful to students. Ashok Hoel, a leader in future of pedagogy and learning systems initiatives, addressed in Chapter 7 the problem of limited online teaching staff by introducing Jill Watson, a virtual teaching assistant. She can monitor discussion forums and respond to routine frequently asked questions with high accuracy and readers are provided with actual conversation logs between her and students.

Chapter 8 contains one of the best examples of learning engineering in the book with two educators and online entrepreneurs exploring how deep machine-learning technology can "help recapture that learning magic moment that so often occurs within the traditional physical classroom" (162). They describe how they created "idealised learner groups" (153) to increase online education persistence in the student forums of a live-streaming online platform. They first considered literature on external factors influencing student engagement, on the positive peer effects of grouping high and low achievers, as well as theory from traditional classrooms around how social learning affects academic performance. This research then informed an algorithm which dynamically grouped students based on demographics, educational performance as well as personal data such as hobbies and maintained an ideal composition of high, mid and low achievers in each group. They found that as a result of these groupings, 84% of learners answered online questions posed by fellow students, with 79% of the responses being correct.

The final two chapters in Part 2 by Saxberg and Sarma set out the pedagogical and cognitive basis for learning engineering. Saxberg starts by stating that "technology in itself does nothing for learning... What it does is make good or bad learning more affordable, more accessible, more data-rich and more personalised. However you need to start with good learning solutions..."(171). He suggests that these solutions will come from cognitive insights drawn from educational literature. First, from the cognitive science behind short- and long-term memory and how both are involved in learning. Second, from research on how value, self-efficacy, attribution and emotional states drive student motivation. He advocates evidence-based technological approaches to refining the learning experience but reminds us to always go back to the student, the learner and the cognitive processes behind them.

In Sarma's final chapter, "Rethinking Learning in the 21st Century", we are reminded that the lecture is a blunt and old educational old, a remnant from an industrial age of creating followers, not critical thinkers. Despite being enticing due to its convenience, it goes against what we know from research into cognitive psychology and learning science, especially when applied to the online environment. He echoes Saxberg's proposition that we need to use technology to take advantage of what we already know about the learning process to develop a "richer orchestra" (198) of instruction through online and technological capabilities. He reminds us about the shortness of our attention spans, the demands placed on it by learning, the need for mind wandering and curiosity which triggers the release of dopamine and better learning. He speculates on how the Ebbinghaus (forgetting) curve should inform when to ask students to retrieve information, so it is encoded in long-term memory, and how IoT applications like Alexa or Echo can play a part in this retrieval. Reading this chapter was inspirational, informative and clarifying in equal measure.

In summary, this book is a brilliant challenge, a gauntlet thrown down, to any teacher, content designer, academic manager or researcher. It challenges the reader to do better as an educator by integrating learning analytics and learning science into their online instruction and by systematically measuring the effectiveness of their teaching innovations. It is also carefully curated by its editors, with a guiding introduction and a conclusion summarising the main themes. Thus, it convincingly outlines the argument for why learning engineers are a crucial component of academic units producing, iterating and improving online educational content.

I did feel however that the case studies in Part 2, as well as Sarma's and Saxberg's chapters, would have had more impact being placed at the beginning of the book. This is because they set out clearly the value add of integrating good learning science into educational design in a systematic way through learning engineering. Nonetheless, I found Part 1 hugely useful from an institutional and academic management perspective, as it outlined the cultural and organisational change necessary to put learning science and engineering into practice.

A conclusion I walk away with, is that if learning engineering is to become a bedrock of educational design at academic institutions, there is a need for true collaboration, open-mindedness and discussion across institutional and physical borders. The Kaplan Learning Architect Community mentioned in Chapter 9 and communities such as this could generate the required enthusiasm to elicit serious commitment from management and key stakeholders. I felt part of such a community when reading this book.