Lifelong Learning Is an Ethical Responsibility of Professional Engineers: Is School Preparing Young Engineers for Lifelong Learning?

Kamryn Froehle, S.M.ASCE

Design Engineer, Coffman Engineers Inc., 11080 Circle Point Rd. #440, Westminster, CO 80020.

Adam R. Phillips, Ph.D., M.ASCE

Assistant Professor, Dept. of Civil and Environmental Engineering, Washington State Univ., Pullman, WA 99163 (corresponding author). ORCID: https://orcid.org/0000-0003-2486-6039. Email: a.phillips@wsu.edu

Homero Murzi, Ph.D.

Assistant Professor, Dept. of Engineering Education, Virginia Tech, Blacksburg, VA 24060. ORCID: https://orcid.org/0000-0003-3849-2947

https://doi.org/10.1061/(ASCE)EI.2643-9115.0000045

Introduction

The Professional Engineering (PE) license is a symbol of technical competency and dedication to ethical practice of engineering. Continuing education requirements for PE licensure are regulated by the individual states and are not consistent across all states. While different rules for license renewal exist between states, the majority (42 of 50) have a requirement for continuing education credits, or professional development hours (PDHs). The most common explanation for having a continuing education requirement is to ensure engineers are keeping current with advancements in the field, as exemplified by Louisiana's administrative code:

> The requirement for continuing professional development is also intended to help protect the public by reinforcing the need for lifelong learning in order to stay more current with changing technology, equipment, procedures, processes, tools, and established standards. (Louisiana Register 2019)

This recognition that engineers must have the ability to be lifelong learners in professional practice is also present in the ABET Criteria for Engineering programs (2018) and the ASCE Body of Knowledge (BOK; ASCE 2018), which is a document that defines that knowledge, skills, and attitudes necessary for entry into practice. However, are we, engineering educators, adequately preparing students to be able to engage in lifelong learning in practice? Are we presenting lifelong learning in context with the values held by licensed professional engineers?

The authors would like to present observations from interviews conducted with 15 licensed civil engineers which show that the continuing education strategies used to fulfill licensure requirements and the continuing education strategies used day-to-day in the workforce do not overlap as much as it first appears. Our work was based on lifelong learning research in engineering education (Jiusto and DiBiasio 2006; Litzinger et al. 2005; Oliver 1999), which shaped the development of the interview protocol. The results of our study show that real-world lifelong learning does not mostly consist of passive learning (i.e., workshops, seminars, lectures, etc.) and therefore it does not reflect the predominant learning structure of formal engineering education. Our interviews with practitioners suggest that educators need to take a proactive role in ensuring that students are provided opportunities to develop skills related to self-directed learning. Second, practitioner perceptions about the importance of lifelong learning were deeper than knowing if they needed to collect PDH credits for their license. Lifelong learning is perceived as an ethical responsibility that is part of the ethos of what it means to be a responsible professional engineer. Furthermore, self-directed learning is perceived as a key skill for success in the engineering workforce. Educators will benefit their students if they present the motivation for lifelong learning early and in context with the ethical values that underlie the civil engineering profession. Similarly, learning theories propose that understanding how to learn (i.e., metacognition) and becoming self-directed learners are the two most important aspects to develop deep, long-term learning (Ambrose et al. 2010; Shackleton-Jones 2019), the type of learning we aspire to develop in engineering.

Summary of Study Findings

Semistructured interviews with 15 licensed practitioners, all located in the Pacific Northwest, were conducted to determine their perceptions about lifelong learning (Froehle 2020). Participants were chosen based on their years of experience and status of their professional license. Eight of the 15 participants hold a PE license in a state that has a continuing education requirement, and the remaining participants hold licenses in states that do not (mostly Washington and California). The participants were from five different engineering firms, which ranged in size from approximately 200 employees to more than 10,000 employees. The interviews were conducted by the first author, but analysis and synthesis of the results was completed by all three authors. Data were analyzed using thematic analysis (Braun and Clarke 2012; Miles and Huberman 1994; Saldaña 2013) by first grouping emerging themes around participant responses and then grouping emerging themes based on overall intent. Following the interview, participants were sent a short online survey asking them to rank their most preferred learning strategies for acquiring new skills in professional practice from 1 to 6, with 1 being the most preferred and 6 being the least preferred. Additional information and details about the interviews and follow-up survey can be found in Froehle (2020).

The interviews suggest that all practitioners viewed continuing learning as essential for professional practice. However, the discussions and a subsequent online survey also showed that practicing engineers do not prefer to rely on learning methods associated with

J. Civ. Eng. Educ., 2021, 147(3): 02521002

formal education or accruing PDH credits. The follow-up survey was responded to by 10 of the 15 practitioners. The results were that eight out of ten respondents listed on-the-job experience (i.e., "working through real problems") as either their first or second choice for preferred lifelong learning method, and seven out of ten listed mentorship as either their first or second choice (Froehle 2020). Conferences and presentations weren't in the top two for any participants and formal courses were chosen as either the first or second preferred choice by three out of ten respondents. The observation by the researchers was that the preferred methods of learning require a high degree of self-directed learning and interpersonal communication skills.

The BOK (ASCE 2018) states that students should be able to acquire new knowledge and skills using self-directed learning by the end of their undergraduate degree. While undoubtably there are brilliant professors across the country fostering self-directed learning in students and the engineering education field has been working on the implementation of active learning (for an overview of all the different approaches, see Prince 2004) most engineering education still follows a lecture-based format, which is passive learning and requires little self-directed learning. Moreover, most of the work on implementation of pedagogical strategies that emphasize the importance of lifelong learning, e.g., problem-based learning (e.g., Andersen et al. 2019; De Graaf and Kolmos 2003; Murzi et al. 2020), flipped classroom (e.g., Baytiyeh and Naja 2017; Lo and Hew 2019; Herreid and Schiller 2013), and experiential learning (e.g., Abdulwahed and Nagy 2009; Chan 2012; Patil and Meena 2018), has been conducted later in the students' programs (i.e., junior and sophomore years). Therefore, it begs the question as to whether the current lecture-dominant format does an adequate job at preparing students for self-directed learning in practice. A quote from a senior engineer in the study describing the process of entry-level engineers developing self-directed learning skills as a "learning curve," would suggest that students are ill-prepared for engaging in self-directed learning upon graduation:

> I think it's tough because when you're in school you always have everything at your fingertips. You have all the information that you need, you have all of the example problems so when you get out to work, you don't necessarily have that. You have to do that learning curve of figuring out how to find out what those steps are on your own. (Senior Engineer, Technical Expert, 17 years' experience)

When study participants were asked how university faculty should prepare students for on-the-job learning, the majority said to focus on the fundamentals of engineering and prepare students to learn for themselves. In essence, practitioners are asking faculty to place greater emphasis on metacognitive activities that encourage students to analyze and reflect on learning techniques that work for them. This metacognitive awareness of your own learning attributes is an important component of self-directed learning (Zimmerman 1990). One participant who is a Vice President of a large engineering corporation, but is also a former professor, shared:

> My premise was we're teaching you how to learn so when you get done with your degree here it's not over. (Vice President, 35 years' experience)

During the interviews, another theme emerged: all the practitioners conveyed the idea that engineers have to continue learning regardless of requirements. Approximately half of the participants hold their PE license in either Washington state or California, which do not have a continuing education requirement. However, they all still stated that they prioritize lifelong learning and view it as necessary for practice. The authors' observation was that the practitioners hold continuing education as an ethical value that runs deeper than a mandated requirement. One participant linked continuing education to the legal responsibilities of professional engineers:

> I mean I honestly don't know how you could be an engineer and not do some sort of training. Codes change all the time and requirements and products change all the time ... I don't see how you can do this job and be successful at it and be legal without at least a little bit of training. (Senior Engineer, 12 years' experience)

As faculty we also need to think about lifelong learning beyond requirements from ABET or guidelines in the BOK. Engineers require the ability to adapt their knowledge to different contexts as industry changes and evolves continuously. We should do our best to instill deep ethical understanding about the importance of lifelong learning in engineering practice. Further, from a big picture perspective, we should be instilling the value system inherent to professional engineering in students early. For example, when a young person says they want to be a doctor, do people commonly respond with "I hope you are really good at biology and anatomy?" No, their focus is instead on the values of doctors and how they are devoted to helping people. However, when a young student is asked about pursing engineering, the conversation almost always involves something along the lines of "I hope you're really good at math and science" and rarely includes discussion about how engineers improve and facilitate our modern society. This lack of understanding about the ethical, moral, and public responsibilities that are at the core of civil engineering is an opportunity to engage students in the bigger picture ideals of engineering as a service-oriented profession that stewards public safety and improves society. It is through this lens where the authors think lifelong learning can be presented as an ethical responsibility of engineers and opportunities promoting self-directed learning can be incorporated into engineering instruction.

Discussion and Recommendations

The discussions with practicing engineers confirmed that lifelong learning is a critical skill for professional development and requires self-directed learning skills. Further, the dominant methods of learning on the job were experience and mentorship with colleagues or senior-level engineers. With this in mind, faculty should seek to develop the skills needed to learn through self-directed study, asking of pertinent questions, and working with teammates, which also aligns with learning theories on how people learn (Ambrose et al. 2010; Shackleton-Jones 2019). However, the authors also understand that large pedagogical shifts in the classroom are outside the reach of many faculty, so a few recommendations are provided here that can be incorporated into existing course structures that encourage student development of self-directed learning abilities while also exposing students to the broader value of civil engineers.

First, understand that some students may not know how to engage in self-directed learning upon entry into your class. Much of K–12 and higher education does not require self-directed learning to achieve satisfactory grades. To rectify this, try using a portion of the first week lecture time of each undergraduate course to expose students to the self-directed learning cycle. There is a plethora of literature on self-directed learning, however the second author likes to utilize the University of Waterloo Centre for Teaching Excellence webpage on self-directed learning (University of Waterloo, n.d.) and a two-page summary document developed by the author (see Appendix I), which are both provided to students on the course learning management system (LMS) site. The overarching goal of this early presentation in the semester is to get students to understand the necessity of self-directed learning and to highlight the four steps in the process so they can start to think about their own learning processes. An additional recommendation is that guest speakers from industry emphasize the importance of self-directed learning, as sometimes that has greater impact on students than their Professor delivering the same message.

Second, add at least one low-consequence assignment that emphasizes development of self-directed learning skills to your existing course (extra credit works great in the authors' experience). It is important that the assignment clearly emphasizes the motivation of developing self-directed learning skills, not specific technical skills. The authors suggest leaving the topic of the assignment as open as possible. This provides the students the maximum amount of autonomy in figuring out what they would like to learn about and present in a professional way. It allows them to dig into subjects on their own and typically lowers their anxiety about what is going to be deemed "correct." Additionally, as the instructor, you may be pleasantly surprised by the topics the students choose and their unique perspectives. An example from the second author's senior-level introductory steel design course is to prepare a group paper on any topic related to structural steel and how it has had implications on practice today (assignment provided in Appendix II).

Third, taking a note from problem-based learning strategies (Andersen et al. 2019; De Graaf and Kolmos 2003; Murzi et al. 2020), provide at least one to two rounds of constructive feedback that attempts to mimic the design office, where entry-level engineers are expected to do most of their learning on their own but have mentors to lean on to keep them on track, provide feedback, and correct errors. One suggestion, when possible, is to include a round of peer-to-peer feedback. Much of on-the-job learning is struggling through new tasks and materials prior to talking with a mentor and discussing where answers are incorrect and then revising the solution. Most course assignments miss that critical last step of learning through mistakes, because once homework is graded many students never go back through it to correct their errors. This extra assignment provides at least one avenue in an existing class structure for students to work on their revision skills.

Fourth, incorporate time for reflection into courses. Reflection is a major aspect of self-directed learning and metacognition. Including a couple of reflection assignments where students can think on their own assignments, the decisions they made, or the outcome of a test can be really helpful. For example, Murzi asks students to reflect on how they prepared and how they performed following every test. Then, they can write out what they would do differently next time they are studying new material to be better prepared. This reflective assignment is an opportunity for students to gain a little extra credit on a test, but also reflect on their learning process.

Lastly, emphasize lifelong learning's role in the ethical responsibility of engineers in as many courses as possible. Lifelong learning and ethics are philosophical concepts and, like many deep ideas, they may require more than one exposure to sink in. Lifelong learning, at a minimum, is the responsibility of professional engineers to ensure the safety of the public. However, it also supports the continued innovation of professional practice. Similarly, teaching the importance of lifelong learning and empowering students to develop self-directed learning skills is the responsibility of faculty. It doesn't have to take a lot of course time or require large restructuring of curriculum. However, it does require effort from faculty to impress on students the idea that professional engineers have a common value system and that lifelong learning is critical to that system. Much of the interactions between entry engineers, senior engineers, and project managers focus on the transfer of knowledge and new skills between collaborators to complete project tasks. While it is undoubtedly difficult to replicate this in an engineering classroom, steps should be taken to make certain that engineers don't leave the academy with the feeling that they are "happy school is over," because their learning journey is just beginning.

Appendix I. Help-Sheet: Self-Regulated Learning Strategies

Definition

Self-regulated learning is the ability to manage your *own* learning motivation, metacognitive processes (i.e., planning, goal setting, organization, monitoring, evaluating), and behavioral processes (i.e., structuring and creating optimal learning environmental, discipline, time management) to accomplish academic tasks (Zimmerman 1990).

Self-regulated learning has four phases:

1. *Planning and Design*: Establish attainable problem goals, break down large tasks into smaller steps, recall various learning strategies that may work for problems, select suitable strategies, and formulate plans.
2. *Priorities and Resources*: Identify priorities among problem goals, plan for an efficient allocation of time, and think of available resources that can be used for given parts of a problem.
3. *Execution and Monitoring*: Execute learning and problem-solving plans, overcome distraction and frustration, monitor progress toward goals, modify plan if necessary, and review performance.
4. *Reflect and Control*: Review finalized work (i.e., graded assignment) and compare with original goals, reflect on effectiveness of learning strategies and plan, initiate proper adjustments, and revise learning strategies.

Why: Self-regulated learning is essential to being a proficient practicing engineer. Practicing engineers are frequently faced with large, complex problems that they must solve relatively unassisted. This means they must be able to break the problem down into smaller goals, analyze the goals, and seek out additional information when needed. Knowing how best *you* learn and solve problems will assist you in being an independent engineer.

How this class will help you practice:

1. For homework problems and exams you should take time to think about the four steps of self-regulated learning (SRL) listed above and how you accomplish each phase.
2. After completing the assignment/exam predict your performance and the efficacy of your plan.
3. Following the return of the assignment/exam, reevaluate how your plan worked/didn't work and determine what changes are needed. Work through your mistakes!

By the end of the semester, every student should know strategies that work *for them*. I can't stress enough how important these skills are to your professional development.

Problem-solving strategies:

1. Solve from memory using known subject knowledge (i.e., a determinate statics problem). *Not many real-world problems fit into this strategy.*
2. Solve using recalled solution procedure of a similar problem (i.e., use previous R/C design problem as guide for current problem). *Be careful that previous problem is a suitable reference! A rectangular R/C beam will have a different design procedure than a T-shaped R/C beam.*

3. Solve using a procedure from a design guide or published example problem (i.e., use ASCE 7 Wind Design Guide to help calculate wind loads on building).
4. Research and learn underlying concept of problem subject, then solve the current problem (i.e., read the pertinent section of the R/C textbook before trying the problem). *This is always a good strategy, though sometimes it can be time consuming. So, budget accordingly!*
5. Google current problem (i.e., Google "How to design rectangular reinforced concrete beam"). *Seriously, Google it. The top search results are a YouTube instruction video and examples from Texas A&M University. As always, vet your sources and apply good engineering judgment before following guidelines from the internet*.
6. Ask colleague or supervisor for advice and guidance (i.e., go to teaching assistant for help). Don't make it a habit to go to your boss saying "I don't know how to do this." Instead, formulate the best plan you can, work through it to find the sticking points and ask directed questions. Seeing the effort and having specific questions can make a world of difference between being perceived as unprepared versus highly motivated and curious.

Learning strategies:

1. Reading print references (textbooks and articles). *Many times, this can be a difficult way to learn for mastery. Engineering is a practical field; therefore, my experience is that DOING is more effective than READING*.
2. Watch tutorial videos (see Problem-Solving Strategy #5).
3. Do practice problems. *Make sure you have the solution available to make sure you did the practice problem correct. Bad practice is worse than no practice*.
4. Study group (i.e., do homework with classmates). *Be careful to not overly rely on your group members. Are you able to solve the problems unassisted or are you dependent on your group members?*

Appendix II. Extra Credit Group Paper

Adam R. Phillips—CE 431—Intro to Steel Design

Washington State University

The intention of this assignment is twofold. First, it is an opportunity for you to explore past, present, and future developments in structural steel technology. Looking into past technological developments can provide perspective on how creativity and ingenuity, backed by a solid understanding of fundamentals, can revolutionize design and construction practices. Additionally, keeping current on modern research can delineate where the frontier of steel technology lies.

Second, it is an exercise in professionalism. Many skills that are required of a practicing engineer are not typically exercised in the classroom. Some of those skills are the ability to learn new subjects on your own, the ability to write a clear and persuasive technical document (that is, comprehensible by the layperson!), the ability to comprehend technical documents, and the ability to communicate and work with a team. This assignment is aimed at providing you at least some opportunity to grow those skills.

The challenge of this assignment is to take the combined efforts of three to four students and distill it into an eight-page narrative paper. Details on the requirements of the submittal are provided in subsequent pages. Hopefully, this assignment will spark your curiosity about a subject in structural steel, and I encourage you to follow that curiosity down the rabbit hole of discovery.

Each group should e-mail me your group member's names and paper/project topic as soon as you settle on something. For entirely selfish reasons, I do not want multiple groups to work on the same topic.

Group Paper Assignment Details

The specifics for the group paper assignment are listed below. Papers should be written in groups of between three to four people on a topic of your choosing

- Paper should be no more than eight pages in length and of high quality.
- High quality means the paper should have gone through *multiple* revisions to improve it. In the book *On Writing Well*, by Yale English instructor Zinseller, he states that most first draft manuscripts can be cut by 50% through editing. That means your final eight-page paper should be approximately 15+ pages of research and discussion in its original form.
- High quality also means any figures/tables are clear, readable, and informative. A general rule is that a figure is only worth the space if its contents can't be explained in writing, with equal clarity, using less space.
- Paper should conform to typical professional guidelines. You can use this document as a template or ask me for more examples.
- You must cite ALL your references. I am not giving a minimum or maximum number of references, but I will say that having more references decreases the likelihood of inadvertently plagiarizing and increases the likelihood of adding nuance and richness to your discussion.
- Abstracts are due no later than January 27th.
- First drafts are due to me no later than March 24th. First draft means it is a complete document, has been proofread, and you are looking for critical feedback.
- Final Paper due April 14th.

A note on group editing: Good editing is brutally honest and thorough (though not personal, mean, or vicious). As a reference, I have never gotten a conference or journal paper out the door without at least three to ten full-draft revisions between my coauthors and me. Then, I have never gotten a journal paper accepted through peer review without having to respond to at least one round of reviewer comments. Writing quality work and making it interesting is hard! But it can be enjoyable too.

Possible Topics

First, let me say that this assignment will be much more enjoyable if you select a topic that is interesting to your group. The list of topics below are topics that I have found interesting over the years. Many of these topics were originally thought of by previous students. However, the list is by no means complete. So do a bit of Googling, watch some TED talks, and spend some time researching possible topics before settling on one

- Environmental impact of steel. Is it "green"?
- Evolution of computational simulation methods. How do practitioners use FEM programs (i.e., ABAQUS, LS-DYNA) versus structural analysis programs (i.e., ETabs, RISA).
- Fatigue of steel structures. Specific questions such as how does temperature effect fatigue? What about loading frequency? Any famous failures caused by fatigue?
- Self-centering lateral load resisting systems.
- Issues affecting seismic moment-resisting connections and the effect of Northridge Earthquake on ductile moment frame design.
- What is a Buckling Restrained Brace (BRB)? How do they work?

- Historical structures, such as first steel tall building, longest steel bridge, etc.
- History of steel industry or the evolution of steel making. What is the Bessemer process and who is Andrew Carnegie?
- What is performance-based design and how does it change the design of a steel building?
- Interview with a practitioner about some topic interesting to you both.
- Future predictions of the role of technology in engineering design; i.e., machine-learning, automation, vertically-integrated business models, etc.

Data Availability Statement

All data, models, and code generated or used during the study appear in the published article.

Acknowledgments

This material is based upon work supported by the National Science Foundation under Grant No. (RFE:1925968). Any opinions, findings, and conclusions or recommendations expressed in the material are those of the author and do not necessarily reflect those of the National Science Foundation. Thank you to the participants that took time out of their schedules to meet with us.

References

Abdulwahed, M., and Z. K. Nagy. 2009. "Applying Kolb's experiential learning cycle for laboratory education." *J. Eng. Educ.* 98 (3): 283–294. https://doi.org/10.1002/j.2168-9830.2009.tb01025.x.

ABET. 2018. "Criteria for accrediting engineering programs." In *Engineering accreditation commission*. Baltimore: ABET.

Ambrose, S. A., M. W. Bridges, M. DiPietro, M. C. Lovett, and M. K. Norman. 2010. *How learning works: Seven research-based principles for smart teaching.* New York: Wiley.

Andersen, A. L., T. D. Brunoe, and K. Nielsen. 2019. "Engineering education in changeable and reconfigurable manufacturing: Using problem-based learning in a learning factory environment." In Vol. 81 of *Proc., 52nd CIRP Conf. on Manufacturing Systems Engineering*, 7–12. Ljubljana, Slovenia: International Academy for Production Engineering.

ASCE. 2018. *Civil engineering body of knowledge (BOK)*. 3rd ed. Reston, VA: ASCE.

Baytiyeh, H., and M. K. Naja. 2017. "Students' perceptions of the flipped classroom model in an engineering course: A case study." *Eur. J. Eng. Educ.* 42 (6): 1048–1061. https://doi.org/10.1080/03043797.2016.1252905.

Braun, V., and V. Clarke. 2012. "Thematic analysis." In *APA handbook of research methods in psychology, Vol 2. Research designs*, edited by H. Cooper, 58–71. Washington, DC: American Psychological Association.

Chan, C. K. Y. 2012. "Exploring an experiential learning project through Kolb's Learning Theory using a qualitative research method." *Eur. J. Eng. Educ.* 37 (4): 405–415. https://doi.org/10.1080/03043797.2012.706596.

De Graaf, E., and A. Kolmos. 2003. "Characteristics of problem-based learning." *Int. J. Eng. Educ.* 19 (5): 657–662.

Froehle, K. 2020. "Assessing practicing civil engineers perceptions of lifeline learning using semi-structured interviews." M.S. thesis, Dept. of Civil and Environmental Engineering, Washington State Univ.

Herreid, C. F., and N. A. Schiller. 2013. "Case studies and the flipped classroom." *J. Coll. Sci. Teach.* 42 (5): 62–66.

Jiusto, S., and D. DiBiasio. 2006. "Experiential learning environments: Do they prepare our students to be self-directed, life-long learners?" *J. Eng. Educ.* 95 (3): 195–204. https://doi.org/10.1002/j.2168-9830.2006.tb00892.x.

Litzinger, T. A., J. C. Wise, and S. A. Lee. 2005. "Self-directed learning readiness among engineering undergraduate students." *J. Eng. Educ.* 94 (2): 215–221. https://doi.org/10.1002/j.2168-9830.2005.tb00842.x.

Lo, C. K., and K. F. Hew. 2019. "The impact of flipped classrooms on student achievement in engineering education: A meta-analysis of 10 years of research." *J. Eng. Educ.* 108 (4): 523–546. https://doi.org/10.1002/jee.20293.

Louisiana Register. 2019. "Title 46: LXI, professional and occupational standards: Professional engineers and land surveyors." Accessed July 24, 2020. https://www.doa.la.gov/osr/lac/46v61/46v61.doc.

Miles, M. B., and A. M. Huberman. 1994. *Qualitative data analysis: An expanded sourcebook*. 2nd ed. Thousand Oaks, CA: SAGE.

Murzi, H. G., T. M. Chowdhury, J. Karlovsek, and B. C. Ruiz Ulloa. 2020. "Working in large teams: Measuring the impact of a teamwork model to facilitate teamwork development in engineering students working in a real project." *Int. J. Eng. Educ.* 36 (1): 274–295.

Oliver, P. 1999. "The concept of lifelong learning." In *Universities and continuing education: What is a learning society?*, edited by P. Oliver. Aldershot, UK: Ashgate.

Patil, M., and M. Meena. 2018. "Effect of practicing experiential learning (Like online learning-ICT) in engineering education." *J. Eng. Educ. Transform.* 31 (3): 95–101.

Prince, M. 2004. "Does active learning work? A review of the research." *J. Eng. Educ.* 93 (3): 223–231. https://doi.org/10.1002/j.2168-9830.2004.tb00809.x.

Saldaña, J. 2013. *The coding manual for qualitative researchers*. 2nd ed. Los Angeles: SAGE.

Shackleton-Jones, N. 2019. *How people learn: Designing education and training that works to improve performance*. New York: Kogan Page.

University of Waterloo. n.d. "Self-directed learning: A four-step process." Accessed September 29, 2020. https://uwaterloo.ca/centre-for-teaching-excellence/teaching-resources/teaching-tips/tips-students/self-directed-learning/self-directed-learning-four-step-process.

Zimmerman, B. J. 1990. "Self-regulated learning and academic achievement: An overview." *Educ. Psychol.* 25 (1): 3–17. https://doi.org/10.1207/s15326985ep2501_2.