Upskilling: A Necessary and Misunderstood Part of Digital Transformation

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ABSTRACT

Digital transformation (DT) efforts allow technical improvements that introduce new capabilities into the work or battlespace. These capabilities, in turn, afford organizations the opportunity to create new processes to increase automation and efficiency. However, this creates a dilemma: how will organizations ensure their workforce has the skills necessary to implement processes that have not been invented yet? Forward-leaning organizations respond by stating their intent to upskill their current workforce. This buzzword/catch-all term describes the actions associated with developing new abilities within an existing workforce to minimize skills gaps across an agency. Unfortunately, many approaches to upskilling rely on industrial-age models of education and training; which do not match learner needs.

Consider the introduction of model development tools into the engineering discipline. The ability to digitally visualize and model change within and across systems has created a need for a new workforce- specifically model based systems engineers (MBSEs) who can work with new tools and can incorporate a new type of thinking into their practice. This suggests the current engineering workforce must face a paradigm shift in their thinking as they develop mastery with a new toolset.

One upskilling approach is to expand the skillsets of experienced and competent systems (and other) engineers; thereby "creating" MBSEs from an existing workforce. In the authors' organization, experts had begun to develop training using this approach. Their training products were technically accurate, but did not follow educational best practices such as reducing cognitive load. In addition, time experts spent developing training products was time away from performing MBSE work – magnifying the problem of the MBSE shortage.

The authors conducted a qualitative case study from the lens of heutagogy theory, which focuses on student-centered instructional practices designed to develop learner autonomy in tandem with capability. They provide findings related to the effect on the workforce members' skillsets, and suggest strategies for applying heutagogy to workforce upskilling efforts.

ABOUT THE AUTHORS

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DIGITAL TRANSFORMATION AND WORKFORCE DEVELOPMENT AT SPEED

The digital transformation of everyday life has changed the way people access and share knowledge--people have ready access to just about any information they need or want. As a result, the demands of the current workplace are too complex for mere competence. Not only must people constantly acquire new knowledge and skills, they also need to be prepared to address highly complex problems and must make decisions about what to do "long before [they] have been able to fully understand what is happening" (Blaschke & Hase, 2016, p. 29). Unfortunately, one unintended consequence of top-down imposed training is that it creates dependence among learners. These hierarchical approaches not only undermine the learner's self-sufficiency, they also may undermine digital transformation efforts.

The training community has tried to "get the workforce trained fast,", and engaged in "new upskilling" efforts, but many of their approaches were rooted in ideas about learning that are bound up in old paradigms, and were thus doomed to fail. This paper will describe an approach that relies upon new ways of considering how people learn, especially in light of the fact that people have very different access to learning and information than they did in the past. The authors use the term upskilling to refer to two concepts: 1) learning opportunities that enable a worker to expand their skills and capabilities by building on foundations they already have from previous education or experience on the job; and 2) continuously integrating additional skills as new external capabilities are provided so that the workforce is prepared for the work of the future, including the future work that is not completely known.

Digital Engineering Challenge

The authors' organization faced a problem with a shortage of workers that could meet the demands of the Department of Defense (DoD) Digital Engineering Strategy, established in June of 2018. DoD defines digital engineering (DE) as "an integrated digital approach that uses authoritative sources of system data and models as a continuum across disciplines to support life cycle activities from concept through disposal" (Directorate of Defense Research and Engineering for Advanced Capabilities, n.d.). The digital transformation is skill-based, not process-based; and success largely hinges on the competence and experience of the practitioners. The enterprises' DE organization needed engineers skilled in critical DE tools and techniques who could effectively deploy DE at the speed of relevance with a minimal level of risk. There were not enough skilled workers in the market so "hiring away the problem" was not an option; the organization needed a way to train its own people and build the workforce from within.

The company recognized that old paradigms would not work: they could not send everyone to school and simply wait for them to complete their education. (Even if they could do that, there would not be enough slots in the universities for all of the students required). And, if they sent everyone to 2-3 week certification trainings and "boot camps," this too, would not be enough to ensure that the workforce had the requisite competence and experience. They needed to think differently about ways to build the proficiency of the workforce. Not only did they need to train the workforce in skills to do the work today, but they also needed to train the workforce to be able to answer questions and solve problems on their own as the technology and discipline continues to evolve.

The organization took a many-pronged approach that included providing access to traditional courseware and instructor-led training, but also included developing training videos and hosting them on an internal platform where learners could access the videos on-demand as well as share videos with each other. The authors were involved in the development of the videos and the training platform, and undertook this research effort to examine learners' experiences with the videos and the platform as well as with other learning activities, in order to better understand how to provide training to the workforce in the digital age. The example of the DE workforce shortage can serve as a

case study in approaches to meeting upskilling challenges for a highly skilled workforce. Therefore, the overall research question is:

> *What paradigm shifts have occurred (if any), or need to occur, in order for learners to direct their own learning to maximize their development of DE skills?*

THEORETICAL FRAMEWORK

Old training paradigms are built around hierarchical structures, and assume that all people learn in exactly the same way. Yet, the digital age workforce wants and needs to direct their own learning and travel on uniquely chartered paths. Fortunately, heutagogy is a learning theory that can help us understand how people learn in the digital age because heutagogy recognizes that people learn on their own and are self-directed in their learning – in complete conflict with most training development paradigms and methodologies. Heutagogy is "an evidence-based approach to learning, grounded in neuroscience" (Agonács & Matos, 2019, p. 224).

Heutagogy

In 2000, Hase and Kenyon coined and introduced the term *heutagogy*, which means "self-directed learning" (Glassner & Back, 2020). There are many tenets to heutagogy, but at its core, it is a learning theory, which says that **learners decide** how, what, and when they will learn; and they even decide how to assess their learning (Agonács & Matos, 2019). Clearly, this self-directed piece is different from Industrial Age ideas where an instructor, employer, or Colonel decides what the learner needs and when they need it. But there is a more critical difference between heutagogy and those other paradigms – heutagogy views each learner as unique, so much so that "there is no such thing as a standard learning outcome" (Hase, 2016). This idea of unique learning experiences is revolutionary when compared to Industrial Age training that assumes that all people respond to the same stimuli in the same way. But, as Hase describes, scientists have learned a great deal about what happens to the brain when it is exposed to stimuli; and the science supports the view of unique brains.

It might be tempting to think of heutagogy as synonymous with andragogy, sometimes referred to as "adult learning theory." But, unlike andragogy, heutagogy describes how *all people* learn--not just adults (Agonács & Matos, 2019). In addition, heutagogy emphasizes the need for learners to develop skills that enable self-directed learning while also addressing the idea of non-linear learning (Blaschke & Hase, 2016). Table 1. Principles of Heutagogy describes four of the many principles of heutagogy that set it apart from other learning paradigms.

Table 1. Principles of Heutagogy

Principle	Description
Learner-Centered and Learner-Determined	Learners are able to direct their own learning, and they do so. All learning activities support the learner.
Capability	Sometimes described as transfer (both near and far transfer) - The ability to transfer or apply knowledge, skills, or abilities to situations different from the one in which the skill was initially learned.
Self-reflection and Metacognition	Learners think about what they learned and how they learned it to gain insights to help them better understand their own learning processes.
Nonlinear Learning	The learning journey is not a simple direct path from point A to point B; rather learners collect knowledge and build skills in unique ways over time, layering knowledge and skills on top of one another.

It should be noted that heutagogy does allow for curriculum to be formally designed by an outside source or instructor. In fact, Blaschke and Hase (2016) provide guidance on how to use heutagogical principals in the design of such curricula. What is important and distinguishing about a heutagogically-influenced curriculum design is the notion that the learner must play an integral role in making decisions throughout the course design. While students are the ones who drive or determine what they will learn, instructors are still critical to the process. The instructor's role must shift to one that guides students as they develop autonomy and self-efficacy. It is also true that some training does need to be developed by leadership and pushed to the workforce. Even so, the standard should be to involve learners as much as possible in decisions about training (content, delivery, evaluations, etc.), veering from that only when deemed absolutely necessary.

The issue of non-linear learning is perhaps the characteristic of heutagogy that makes it most suited to the challenges of the digital age where learners have access to more information than ever before. Interactions with the internet and our many devices serve as an analogy to learning itself. Learning is like entering a "mesh network [that] has no entry point. It is possible to join the net of connections at any point and go anywhere in it. ... It does not force the traveler to follow a certain predetermined path but offers him multiple opportunities to explore" (Glassner & Back, 2020, p. 81). Whether an organization is comfortable with heutagogy or not, workers and warfighters need to be able to address their own gaps in knowledge or skill, using different means such as reaching out to peers, searching the internet, or even looking to formal training. Because learners are going to search for themselves, it is important to encourage, and even teach skills related to exploration (Blaschke & Hase, 2016). In the workplace, this could involve teaching employees how to explore company-provided assets, when to use the public square (e.g., the internet), and how to vet and examine information for accuracy. Ultimately, organizations need to transform their training approaches so that instructors become learning leaders who see their mission as one of guiding learners rather than controlling the information flow, and the training and learning path. The cost of holding onto the control over knowledge is too great.

Training Delivery and Learning Sharing in One

As noted above, part of the organization's approach to upskilling the workforce was to develop and host videos on an internally developed platform called in-SITE. in-SITE is a cloud-native video delivery platform that was designed to support and encourage learners to share knowledge with one another, and provide a way for learners to learn while they were working. Learners can also upload their own material so that they can view it later, and/or share it with other learners in the organization.

The authors designed this platform to provide a way for learners to learn the way that they learn outside of work. But learners need more than just what is available in the public square (e.g., on the internet). Conducting a search online for an answer about how to recall an email works just fine, but there are many other questions that people have that are unique to the organization. Interestingly, Giannokos et al. (2016) found that learners are more likely to trust the contents of training when it is hosted on an organization's site as opposed to the internet. Which illustrated the need for the internal platform. There is also the need to protect intellectual property, even while building a culture where learners share with one another, so the platform included multi-level security features to address this need.

METHODOLOGY

The purpose of this study was to determine what (if any) paradigm shifts have occurred and are necessary to ensure DE learners can direct their own learning. In order to answer this question, the authors needed to hear directly from engineers about their perspectives, and therefore chose a qualitative research design. According to Hatch (2002), "Part of the power of qualitative work is that it provides a careful description and analysis of social phenomena *in particular contexts"* (p. 43). This study is situated at the researcher's organization, and is specific to the DE training provided within the organization with the goal of using the study results to develop practices that better support workers (and warfighters) in the digital age.

The researchers used a form of purposeful sampling known as criterion-based selection, or the selection of participants based on criteria that would provide information that is closely related to the topic of the research (Merriam & Tisdell, 2016). The criterion for selection were: 1) users of the hypermedia platform, in-SITE, and 2) junior to mid-level systems engineers. In order to find participants who met this criterion, the researchers selected participants who had accessed the hypermedia platform and held a job title that indicated they were junior to mid-level Systems Engineers.

Because each person possessed this similar trait- notably membership in this particular discipline/work group, the study used *homogeneous* purposeful sampling (Creswell, 2005).

Participants

The researchers identified six potential participants (3 men and 3 women), and 5 agreed to participate in the study. Prior to engaging with the participants to conduct the qualitative inquiry, the researchers applied for permission to study the individuals via SAIC's Human Subjects Institutional Review Board. Once the approval was granted, the researchers invited the participants to an individual interview via a personal email. The email explained that the purpose of the study, and that their participation would involve an open-ended interview where they would share about their experiences engaging in DE upskilling efforts. Five accepted: three men and two women.

Data Collection

After collecting signed agreements from each of the participants, the researchers conducted separate, individual interviews with each of the subjects. The interviews were conducted via Zoom in June 2021; each lasted between 30-45 minutes. The researchers began each interview explaining the purpose, and asked permission to record the conversation. The researchers used a semi-structured interview to gain some understanding of the conditions under which the subjects would seek information via in-SITE versus other available training, how the videos helped them to do their job better, and any limitations of using the hyper-media structure in general. Figure 1 provides some of the initial questions. During the interview, they used member checking to ensure they understood the participants' ideas and intents. Member checking can be done in many different ways, but for this study, the researchers used the practice of restating ideas or otherwise clarifying their understanding of participant's responses during the interview to ensure the participant agreed with that understanding.

Current and older/traditional learning methods for digital engineers

- What are some of the sources you use for information on how to improve on-the-job?
- What is your preferred method to learn digital engineering skills?

Paradigm Shifts

- How would you compare the benefits and weaknesses of different digital engineering training approaches?
- How do you vet the quality of the material you are viewing?
- What kinds of changes would you like to see in the way people share knowledge or information?

Usage Patterns with Videos

- When, or under what conditions, do you use in-SITE videos?
- What circumstances have led to you share videos (or links to videos) with co-workers?

General Strategy and Governance for Video Development

- What do you think makes one of the DE instructional videos "good"?

Overall Training Thoughts

- Think about your training experience. Was there something that you either tried on your own or that was prescribed to you, that didn't provide value?

Figure 1. Sample of Questions from Interview

After each interview, the researchers debriefed and shared initial thoughts and observations. They reflected upon their thoughts, positionality, and biases, as suggested by Merriam & Tisdell (2016). As for their positionality, the researchers work for the same company as the participants and are instructional systems designers. They have more than 15 years of experience and expertise in developing, delivering, and measuring effectiveness of training, which inform their own ideas about approaches to training and upskilling a workforce. They also view workplace training from the lens of workplace outcomes (i.e., what you do on the job vs. whether you passed a test). In fact, they have a

bias against the idea of certification as a way of demonstrating knowledge or qualification. In their experience, holding a certification does not necessarily equate to having the skills to do the work itself.

Another identified bias has to do with whether the individual or the employer is responsible for training and education. The researchers lean towards the view that individuals ought to be responsible for themselves, and should not exclusively rely upon their employer to pay them for time spent improving their own skills. When the researchers analyzed the transcripts and considered the emerging themes, they paid special attention to the influence of their own biases and positionality.

The researchers transcribed the interviews, adding descriptive information to clarify things when the words would not be enough by themselves. The researchers anonymized references the participants made to companies or individuals they worked with, and password protected all transcripts.

Analysis

In qualitative studies, the analysis and data collection are continuous (Merriam & Tisdell, 2016). The researchers wrote notes and memos within each transcript, and did some open coding. For the final coding, the authors worked individually to code two of the transcripts with open codes. They shared their codebooks, discussed the different codes, and agreed upon the final codes (what Merriam and Tisdell refer to as axial codes). They used the axial codes to create a final code sheet, and used this code sheet as a guide for coding all of the interviews, including re-coding the first two. They re-read the transcripts for distinguishing comments related to the codes, participant by participant. They then looked for relationships between the themes, stated by multiple participants that generated new conclusions.

FINDINGS

Throughout this paper, all participants are referred to by pseudonyms. The participants' undergraduate education spanned different engineering disciplines and their level of on-the-job experience ranged from less than five years to more than 15. Three participants had previously participated in structured learning engagements offered by the company: one worked as a summer intern while in college and another is currently working on a Systems Engineering degree as part of an SAIC corporate/university partnership. The third was part of a Tech Leadership company-sponsored cohort designed for junior employees to advance their technical skill base, and gain leadership experience in order to prepare for future career opportunities within the company.

As the researchers analyzed the coded transcripts, the following findings emerged:

- The inherent complexity of DE as a discipline is further compounded by the complexity of the tools themselves. This makes it challenging to provide training that is at the right level for learners.
- Participants who had attended certification boot camps described training differently than the participants who did not attend a boot camp.
- Opportunities to communicate about DE models in practice were associated with learners' intent to transfer their new knowledge and skills to meet the customer mission.
- Participants described a variety of preferences and expectations about training in alignment with a variety of motivational attributes

Inherent Complexity of DE Training

The participants offered different perspectives on DE as a field of study, and provided the researchers with a better understanding of how its inherent complexity impacts those who are entering the field. By definition, DE is "an umbrella term for the synergistic application of electronic and software technologies to facilitate the architecture, analysis, design, simulation, building, and testing of complex software-intensive systems-of-systems." (Pivotpoint Technology Corp., n.d.). The first element of the complexity challenge is that the systems of interest that benefit from DE methods are complicated and can be overwhelming for a novice to understand. Training engagements that include "DE-appropriate" complex examples can put excessive cognitive load on the learner (trying to understand the example *and* the DE concepts). In contrast, using "manageable" examples for learning, such as an automobile, run the risk of not being complex enough for the learner to understand the benefits and relevance of DE. One participant described

the challenge of convincing co-workers and customers of the *need for DE.* He explained that there was a tendency for people to want to just "do what we have always done" (using paper-based data management methods) rather than make the transition to DE approaches, even though the old methods introduced technical risk.

Additionally, new tools to model complex systems are continuously being introduced which are also (as a tool) inherently more complex. The paradigm of "learning on the job" appears to be getting increasingly more difficult: not only are more tools being introduced at a rapid pace, but also their capabilities are more complex because they are designed to keep pace with the increasing complexity of the systems they are designed to model. In analyzing the interviews, the researchers discovered that participants are facing a multi-faceted challenge that involves engaging with complex systems, complex tools to model them, and managing ambiguity associated with multiple ways to establish correct models. The participants who showed the least amount of discomfort with this challenge were those who regularly met with subject matter experts to discuss multiple "what if" scenarios for a single concept, considering the advantages and disadvantages of each in real time. Chris, who regularly participated in the "Community Engagements" (described under Community Engagement), expressed the challenge of learning to deal with "*decision fatigue,*" indicating his understanding that there are frequently many correct approaches to model development. In contrast, Cameron described her challenges as "*needing [someone] to tell me how to do it,"* which suggests a desire for a single, authoritative source to direct the development of the model, which may not be reasonable.

Certification Boot Camp

Three of the participants had participated in company-provided OCSMP (Object Management Group Certified Systems Modeling Professional) certification "boot camps." Two participants did not mention this boot camp. These two conditions are noted as boot camp (BC) and non-boot camp (NBC). One BC participant had passed "a couple of the exams," and one had failed a particular exam twice. All BC participants associated "getting certified" as a desired goal and a good introductory or early learning activity. One common finding from all of the BC participants was the desire for a learning structure provided from an external source--*even* when engaging in non-structured learning engagements. As an example, when asked about how they used the in-SITE platform to access the videos, Cameron stated:

> *I think kind of integrating a follow-along type of thing might be really helpful with some of those videos.... in case you want to pause or go back and read back something." and "there's 23 parts [videos containing a particular subject] and none of them are labeled in order.* - Cameron, BC participant

In contrast, an NBC participant with a similar level of experience viewed in-SITE as a tool for non-linear learning:

> *As soon as I run into a roadblock. If I'm trying to do something, I don't know how to do it, I'll probably mess with it a little bit. If I can't figure it out immediately, I immediately would search it on [the platform] and try and see if I can find a solution.* - Chris, NBC participant

The BC participants also viewed the certification as a "gate." Cameron thought it would be valuable for new-hires to be "*given a week to complete*" the certification before they "*started their work.*" Another participant who was given time to study for the certification exam (while waiting for her security clearance) noted the difficulty associated with being given one week to watch 40 hours' worth of 3-hour videos, and then sit for the exam. She described the experience as tedious and difficult. (Note that the 3-hour videos were originally designed to be watched one per week over several weeks).

Another difference between BC and NBC participants was in their idea about the source of knowledge itself. Even though all the study participants acknowledge the complexity of model-based systems engineering and the vast amount of available, useful information, one BC participant stated it would be nice if there was "*one giant repository where you can find things.*" Another stated, "*It would have been really helpful if someone just packaged everything and was like 'here'."* (These participants did caveat their statements by expressing frustration over training approaches that left them to their own devices where they were handed a lot of material and told to figure it out on their own without any guidance at all). In contrast, Chris (an NBC participant) stated the available resources are kind of like a "*cover letter model"* in that no single template will be applicable to every situation and that (like the cover letter template situation), *"you still have to WRITE it."*

A third difference between BC and NBC participants was related to who is responsible for training costs. The BC participants expressed concerns about "having a charge number to complete trainings." They felt the company should

provide dedicated time (at company expense) for training. In contrast, NBC participants viewed these activities as help seeking, and part of "*solving the customer's problem.*" NBC participants communicated their learning experiences as a means to support transfer with greater frequency than their BC counterparts did. As an example, Chris stated "*figuring out your time*" was part of his job responsibility and that included finding time for training or expanding his skills. Interestingly, while the BC participants expressed the desire for a charge number or organization's support to complete their training to increase their skill base, two of them did not participate in the company-provided community forum (described in the next section).

The Role of Community Engagement in Training

Each of the participants had the opportunity to meet weekly with Digital Engineering subject matter experts (SMEs) in an open forum. The purpose of the meetings was to bring questions to the experts who would discuss possible solutions. The engagements included screen sharing, if necessary, and allowed the display of actual models so that they could examine and discuss possible ways to address challenges or fix problems in real-time. The weekly forum was scheduled on Mondays for an hour each week, although it would occasionally run a bit longer as needed, and if scheduling allowed. Three of the participants specifically discussed their engagement in the forum and talked about how the engagement helped to support transfer (i.e., the ability to use what they learn in unique situations). The degree to which a participant engaged with the community appeared to have a direct effect on their view of how they would become successful MBSEs.

At one end of the spectrum was Brook who was given time (and a charge number) to complete a variety of formal training opportunities. (Interestingly, this was exactly the training opportunity that Cameron thought would be beneficial). Unfortunately, even with the time and resources, Brook failed the certification exam twice. She now has no interest in MBSE, despite the fact that she had successfully completed her degree in Systems Engineering at a university with a highly ranked engineering program, and presumably had the necessary foundation to become an MBSE. In order to better understand Brook's experience, the researchers asked additional questions about the kind of social learning engagements in which she participated. Brook expressed the desire to have "*an in-person study group"* as a method to support passing the certification exam; she said the "*people who took certifications the year before me, they said they would be able to come into the office and study together."* The COVID-19 pandemic prevented the in-person option, and limited her to engagements with a single co-worker that consisted of messaging "*oh, do you understand this? Do you understand that?"* Brook felt this was not comparable to being able to study in person but did not mention any engagement within the weekly community forum. The researchers describe her overall experience as one that is defined by traditional educational models which separate learning from on-the-job activities where study time is separated from time spent "working."

Similarly, Terry viewed his learning engagements as "*learning nuggets here and there,*" and "*went ahead and gotten the first two certificates*", he, too, viewed training from a traditional lens, stating that the best training sources have "*checkpoints [and] quizzes.*" His preferred method of training to expand his digital engineering skills was to participate in asynchronous self-paced courseware. He was the only participant who stated that he did not work with other team members--he was a "*team of one"* -- and had been so for quite some time. Like Brook, he seemed to view the training as an activity to complete separate from work.

In contrast, both Chris and Dale talked about the weekly forums as a way to establish relationships, to make "*sure that new people feel comfortable asking the questions they're going to need to ask."* And, the opportunity to engage with the SMEs was "*phenomenal to bounce ideas and questions off of.*" Instead of favoring the traditional process (1. train, 2. answer a quiz question, 3. get a certification), Chris described his learning method as:

> *Going through the sample models and understanding exactly … this is the reason that they're doing this and trying to recreate the exact same complex behaviors or queries they were; a lot of it was just practice trying to look at what other people have done, learn from that and then recreate it on my own.*

Similarly, Dale described the weekly engagements as "*health sessions,"* as something to continuously attend to as opposed to "finish the training and be done." He specifically appreciated the forum as:

> *an open line of communication where, I've had times where I'm ... building a model and I'm trying to capture a certain aspect and I'm struggling with it. I'll usually try to write it down. Okay, here's the stuff I'm getting kind of caught on ... that's when you can come to these experts on some of these digital engineering approaches, they kind of not only provide context to your question, but you can get a little more detail.*

The participants who did not participate in the forum did not describe any examples of transfer. They also did not mention their customers at any point during the interviews. In contrast, the members who participated in the forum frequently spoke of their work with their customers.

Ideas About Training and Upskilling

Participants expressed different ideas about training, which included their expectations and perception of its value. Some participants spoke about the integration of communication in the overall learning process, specifically engaging with SMEs, and practicing their DE communication skills within the forum. Chris specifically stated that having the opportunity to communicate regularly with the SMEs was "*absolutely integral"* to developing his own "*niche knowledge."* Dale stated that the "*collaboration element was where he made the most strides... where you have to convert from your brain and send it through a filter to say actual words."*

In contrast, Brook, Cameron, and Terry described the opportunities they had to communicate about DE in terms of traditional "school-like" activities, such as: asking co-worker about questions in preparation for the certification exam (Brook) and "*pick their [the SME's] brain"* but within the context of collection knowledge only (Terry). The different ways in which the participants expressed their goals provided the researchers with some insight into their overall motivational attributes. Some of the participants discussed training solely *for the purpose of training*, whereas others talked about training as the vehicle to be able to solve DE challenges on the job.

Participants also described training as a discrete event (with a beginning and end) versus an ongoing journey. Those who held the first belief seemed to have a hesitation to engage in DE work until they had finished their training. Terry acknowledged, *"much of digital engineering…is knowing how to use the tools because there are a lot of tools besides MagicDraw. There's also the Simulation ToolKit ... [and] ModelCenter."* His desired approach to build his skills and competencies was through training "*on the whole suite or the whole ecosystem…to expand my knowledge*" because he currently was "*pretty much focused on SysML.*" This association of training as a *linear* event with a beginning, an end, and upon completion, the learner would be "done" is in direct conflict with upskilling, which is a continuous activity necessary to understand complex concepts that continue to increase in complexity.

DISCUSSION

The research question asked about paradigm shifts needed to support learners in directing their own learning to develop DE skills. This section considers the four identified themes and explores how the principles of heutagogy can help organizations meet the needs of the workforce.

Inherent Complexity of DE Training

The challenges related to upskilling for DE are related to the complexity of the work itself, the complexity of the software tools, and the dynamic nature of the field. Perhaps it is not surprising that participants who engaged with other experts on a regular basis were more comfortable learning in this fluid environment than those who needed some top-down guidance on how to solve each particular problem (e.g., Cameron's "*needing [someone] to tell me how to do it*"). But it is not enough to simply ask "how we can hire or train more 'Terrys'?." Organizations also need to consider whether they have any cultural or organizational structures that encourage or create dependent employees.

According to the principles of heutagogy, training should be learner-centered and learner-determined (Blaschke & Hase, 2016). That means organizations need to provide environments where learners can direct their own journey. This does not mean the organization simply tells learners to go it on their own. In fact, participants described how difficult it was to learn when they were simply handed volumes of material, or told to go search the internet on their own. Instead, training providers need to find a balance between structure and chaos to allow learners to learn in their

own non-linear way. Some learners are going to master a particular software (or at least some component of it, in the case of DE), while others are going to master a particular capability in several areas. Still others will pick up pieces in an entirely different fashion. Basically, training experts have to be comfortable with the fact that they are now just one of many experts who are helping learners rather than being *the* expert who directs the entire learning path. (The authors admit they, too, are adapting their own understanding of what it means to be a training expert in these evolving times).

Certification Boot Camp

While the idea of boot camp as a training approach for certifications is not new and is not unique to DE, it warrants some discussion. The concept of boot camp comes from the military, where boot camps are (usually) purposefully designed as short and intense engagements that are delivered with strict discipline such that the group of individuals each reach a common (better) state that will allow them to be successful later on.

One problem with the idea of certification boot camp is that it creates or reinforces a focus on certifications over mastery. The authors acknowledge that certifications are critical, in particular to the field of DE. However, the end goal should not be certification. This focus on certification may lead the workforce to believe that once they gain their certification, they are truly qualified to do the work and simply need to maintain their certification. Even if they understand that they need to keep learning, the over-emphasis on the certification (and boot camp approach) can create a skewed view of what it means to build and develop skills. Heutagogy's ideas about capability and competency can help us address the challenge of certification vs. mastery. From heutagogy theory, capability is defined as the ability to use what is learned in different and even unusual contexts, and competency is defined as the ability to apply the skills in typical situations (Agonács & Matos, 2019). This is why heutagogy stresses the importance of training for capability, not competency. One way to support capability is to provide opportunities for learners to practice and use the skills in different environments. One of the best ways to provide these opportunities is to use real-world (i.e., actual workplace) problems along with a way for learners to ask questions or work with experts who can provide guidance as needed. The weekly meetings (DE SME forum) the participants described are one example of how this might work in practice.

Another problem with the over-emphasis on certifications is that it could create an environment in which management goals are prioritized over mastery goals. As differentiated by Ford (1992), management goals are associated with "maintaining organization…especially with respect to the relatively mundane, everyday tasks", such as passing a certification exam (p. 95). Whereas mastery goals represent a desire to "improve one's performance or reach or maintain a challenging standard" (p. 95). While the researchers do not mean to suggest omitting management goals within an organization, learners should engage in training which provide activities that focus on mastery goals-especially in early stages. This idea is supported by Zimmerman & Kitsantas (1997), whose research suggested that students faced with learning a complex task, and who set initial mastery-oriented goals and then shifted to outcome (attaining a score) goals (i.e, management goals), would surpass learners who simply set only outcome-oriented goals. Consider that one BC participant actually *wanted* the company to provide her with one week to cram in all of the material designed to be learned over several weeks' time so that she could get her certification. And, another BC participant was given time to cram everything in, and failed the test twice. We can contrast this with Terry, who began with mastery goals in engineering, and then set management goals for himself and has already gotten two certifications.

The Role of Community Engagement in Training

Learners clearly had different ideas about the value of community and the weekly DE SME forum. It is not surprising that participants who engaged in these weekly meetings provided examples of how these meetings supported their DE skills on the job—they were developing capability (instead of competency). But, what does an organization do with workers who are unwilling, unable, or otherwise uninterested in taking advantage of these training engagements? Heutagogy clearly would say that forcing them to attend is contrary to learner-centered, learner-driven approaches. However, the principles of learner-centered, learner-driven training also require learner agency where learners possess the attitudes and skills needed to direct their own learning (Glassner & Back, 2020). While one approach is to provide training to develop those attitudes and skills, research suggests this is not enough. In the specific case where learners are not taking advantage of the training engagements, organizations should explore the reasons people are not participating, and may find ways to address those issues. For example, the timing of the engagement might conflict

with other work responsibilities and the meeting could be held at alternate times to accommodate a larger audience. It is also possible that the format of that particular training does not meet the needs of some workers. If that is the case, we recommend that organizations make sure that they support learners in directing their own learning path. This does not mean simply leaving the learner to figure out what to do instead or even making assumptions that the learner knows what s/he needs. Rather, the training approach should be one that seeks to partner with learners to find out what they need and then support them in creating their learning path. Training specialists may have to morph their role into one of a "learning coach" to engage with learners about the kind of training events they are relying on, and support them in creating and owning their own learning path. Additionally, training specialists must support learners in articulating how *they* will measure their success in learning, as opposed to doing it for them.

Not only did participants have different ideas about participating in the community forum, they also had different ideas about what constitutes "training." Consider Terry, who viewed training as a set of exercise and quizzes to be mastered. This is an example of a top-down view of training (framed by management goals) where the instructor determines when practice is needed and how it will be done. It also demonstrates an unintended consequence of developing training with knowledge checks—it creates a dependent learner, as suggested by the management goal paradigm. As with the earlier recommendations, the authors are not suggesting that training cannot have quizzes or other ways to help learners gauge their understanding. Rather, it is important to balance cognitive skill questions with the ultimate goal of helping learners to develop their independent learning skills.

Ideas About Training and Upskilling

Some of the participants viewed training as a distinct event, or something that they would complete, that is an end in and of itself. However, the current workplace climate requires workers to learn new things all the time, and to be ready to solve problems they did not anticipate and that they may not even be able to tightly grasp. Organizations need to find a way to help the workforce *members* think differently about their own training. One way for organizations to help the workforce make this shift is to provide training that helps people to develop their expertise in learning how to learn. According to heutagogy, a critical component of all learning events involves asking learners to reflect upon their learning (Blaschke & Hase, 2016). Learners think about what they learned and how they learned it to gain insights to help them better understand their own learning processes (Agonács & Matos, 2019). The principle of self-reflection and metacognition are important in heutagogy because self-directed learners need to be able to understand how they learn and improve their learning skills, not just their worker skills. In other words, help digital engineers think about how they solved the problem, not just from a technical perspective (in terms of the tools they used or how they used the tools), but also in terms of how they identified the problem and different approaches they could take in solving it or in seeking help from others.

Limitations and Areas for Further Study

As this was an exploratory study, the scope was deliberately small. This study could be expanded to include exploration of the specific components and approaches taken in the different training engagements, including the boot camp and the weekly SME meetings. In addition, further study is needed to investigate organizational factors that are critical to developing workers and warfighters who are self-directed learners. Because many of the research questions related to these subjects will require investigations into attitudes, belief structures, and social constructs, the researchers expect an increase in qualitative studies to examine this challenge fully.

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