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INDUSTRY CONNECTIONS REPORT

IEEE IC INDUSTRY CONSORTIUM ON LEARNING ENGINEERING

Proceedings of the 2019 Conference on Learning Engineering

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Towards a Definition

Learning Engineering is a process and practice that applies the learning sciences using human-centered engineering design methodologies and data-informed decision making to support learners and their development.

Why ICICLE?

Shelly Blake-Plock

So . . .

ICICLE was formally established as an IEEE SA Industry Connections activity sponsored by the IEEE Learning Technology Standards Committee in December 2017. For the next two years, the question that I was asked most often as ICICLE's chair was: "What is Learning Engineering?"

And my usual response was: "We don't know."

In fact, this lack of definition around Learning Engineering is the reason that ICICLE was formed. Tasked with helping to convene an international conference for the purpose of bringing definition to the term and its application within industry, government, and academia, the consortium has benefited from the work of practitioners and scholars across fields, many of whom are represented in this volume.

You will find in these pages a variety of views, reflecting the ongoing evolution of a term with distinct connotations to professionals across domains serving the scalability of best practices in learning and in engineering.

Why ICICLE?

As for that elusive definition? Well, over the course of two years, ICICLE sponsored special interest groups that engaged in conversation and debate around the meaning and meaningfulness of Learning Engineerings across applications to industry, government, and academia. The SIGs included the following:

- AI and Adaptive Technologies
- Data Governance and Privacy
- Design for Learning
- Learning Engineering among the Professions
- Learning Technology Data Standards
- xAPI and Learning Analytics
- XR for Learning and Performance Augmentation
- Competencies, Curriculum, and Credentials

With regard to a work-ready definition, the last group on the list made significant headway. It was the definition developed through hours of debate within that SIG that led to the Conference's answer to the question: "What is Learning Engineering?"

The answer:

Learning Engineering is a process and practice that applies the learning sciences using human-centered engineering design methodologies and data-informed decision making to support learners and their development.

Why ICICLE?

While it should be noted that there was at the conference and continues to be ongoing debate especially between the variety of practitioners across the instructional design field and the engineering field, the definition itself holds up relatively well and is equally applicable across the variety of formats that a learning engineerings program or position may fill.

Regarding the ongoing debate, it looks like a matter where certain arguments fall on the side of engineering the design of learning that scales; whereas, others represent the side of technical engineering necessary for sustaining the scaling of learning. Both sides are equally invested in solving issues created by learning at scale—meaning both globally distributed learning and its impact on the design of learning experiences as well as the technical feasibility and requirements to support those experiences, as well as the impact of data and AI techniques on both the experience of learning and the outcomes of learning—not to mention the ways that we may come to redefine “learning” itself in the future.

The following pages represent the variety of views presented at the 2019 Conference on Learning Engineering. A note on format: the conference itself was designed as a series of conversations as opposed to a series of lectures and papers. This conference proceedings reflects this format. The goal within these pages is to represent the full range of conversations and to provide documentation of the gathering. The result is a curation of papers, reflections, presentations, demos, videos, and brainstorming. May this compendium not serve as the last word on Learning Engineering but rather as a starting point for further development in the field and in its practice across industry, government, and academia.

What We Discovered at the Roots of Learning Engineering

Jim Goodell, with Mark Lee and Jodi Lis

Introduction

In mid-November 2018 Mark Lee, Jodi Lis, and I went back to where it all began. The place where more than 50 years ago the Carnegie Mellon University (CMU) professor Herbert A. Simon coined the term “learning engineering.” Simon, a Nobel Laureate, was instrumental in launching departments at the Pittsburgh-based university that continues to be a world leader in cognitive and learning sciences, learning technologies, and the application of the sciences to optimize human learning.

The IEEE IC Industry Consortium on Learning Engineering (ICICLE) had been meeting for almost a year. There had been amazing interest and great discussions in the various special interest groups that met almost weekly, but these groups had not yet reached consensus on a clear and concise definition of learning engineering. We thought that a visit to Pittsburgh to explore Herb Simon’s heritage might help add clarity to our own understanding of learning engineering and what we could offer various ICICLE special interest groups (SIGs) in which we participate.

Read the entire article

I Want to Be a Learning Engineer

Avron Barr

Re-Engineering

Recent conversations about the competencies of a Learning Engineer have brought to mind my pre-ICICLE ideas about "re-engineering" concepts applied to the several ed tech markets. I started with imaginations about what kinds of problems LEs will be asked to solve, what kinds of solutions they will build, and what tools and materials they will use? We can't base our ideas about LE competencies only on what data scientists and instructional designers are asked to do today.

So, riffing off of Michael Jay's "I am a Learning Engineer because . . ." idea, I present for your consideration the following ambitions of some hypothetical youngsters. What knowledge, skills, and abilities will they need?

In my village, the teacher visited once a week and brought books and an Internet connection from her bus. When I graduate from college, I want to design, build, and operate a national e-learning wifi grid for our country using 5G technology. We will never have enough schools and teachers in remote areas. We can design a national school systems based on the grid and thus allow all students, teachers, and schools access to the best online learning materials.

I Want to Be a Learning Engineer

When I was in high school, I used a remote telescope through an online lab to collect real data for my senior project. There's nothing like that available at my college. I want to start a company to make virtual labs available to every student.

My school's online Algebra II course is beautiful. I love the 3D graphics and online games. My team built the Great Pyramid in a Virtual Reality lab. But its AI algorithms are stupid. For instance, I took trigonometry online in the summer. My school gave me credit, but none of the courses here know that already know what a cosine is. I know that data scientists at Amazon have better algorithms, which seem to know about everything I do anywhere online. I wanna build a better AI for learning.

Math is my thing. But in high school I learned everything from Mr. Khan's Academy. My Ed School masters program is working with local school districts evaluating a new online math curriculum. I visit several schools once a week to work with teachers and observe the students. Truth is, current practices and policies make our system much less effective than it could be. When I graduate I want to work with school districts to completely re-engineer middle school math education.

I'm going to go to law school after I graduate. I always thought I'd be a programmer, but my Spring Break trip got cancelled because a hacker stole my deposit and I didn't even know. I want to make sure the law keeps up with technology, and I think there will be a lot of jobs for lawyers that sue companies about data breaches. I wonder if my college's records are secure!

I Want to Be a Learning Engineer

I've been a fan of online learning since grade school. I'm getting a masters degree in LE this spring. A prospective employer recently asked for clarification about my issues with a big national publisher that my high school was using. Turns out the company could see all my online learning records, which I didn't even know existed. That's not right. I cleared up the issue, and when I finish my masters program, I got hired by the publisher to work with their head of data governance policy and operations.

My college uses the worst LMS in the world. I asked my professor, who was on the committee, about why they didn't use an cloud-based solution. His answer made me decide to start a consulting business, working with college and school district acquisitions committee to help them understand what they're buying and what assurances they need to put in their contracts about data governance about performance expectations about integration with existing systems, etc.

I'm a student teacher in middle school. I feel like I fighting my environment every day. Someday, I want to design a building that separates learning from daycare and maximizes the use of teachers' time by creating spaces that help teachers teach and help students learn.

I hate high school. This is stupid, watching a teacher stand up in front of the class giving the same lecture I saw online last night. I think the classroom is the problem. I want to design a new kind of classroom that takes into account the affordances of learning technology.

I Want to Be a Learning Engineer

I've been working as an intern at a big, international tech company. My job is to put together a competency framework for our company that will be used for recruiting, company talent management, rapid team formation, internal training, and our certificate programs for our customers. Basically, I'm using spreadsheets — there are no adequate tools. When I finish my LE degree, I've been invited to come back and lead a product team to make this job make sense.

I love the way Netflix recommends stuff for me. At school, every day, every week, every year goes in every subject seems to go lock step along predetermined "right way to learn". There's plenty of online stuff in almost any subject nowadays. I want to build Netflix for learning where you build a profile and as you use it, it learns more and more about what works and what doesn't.

I took the "Data and the Law" course this year. First time my law school offered it. Did you know you can sue a school or a publisher if someone hacks them and steals your learning records? The number of cases is growing exponentially. Some of us second-year students are thinking about forming our own law firm that specializes in cases like this. But I'm thinking if I could publish a book and position myself as an expert, I could start a consultancy to help companies, schools and government agencies conform to the law. Way better than a year as an associate at a law firm.

I really don't know what I want to do, but I hear anybody can work on standards.

Language Matters: Exploring the Use of Figurative Language at ICICLE 2019

Chelsea Chandler, Ph.D., University of Michigan

Aaron Kessler, Ph.D., Massachusetts Institute of Technology

Jacob Fortman, University of Michigan

Abstract

This paper began as an exploration of metaphor and figurative language between colleagues and culminated in exploring the use of figurative language during the 2019 ICICLE Conference on Learning Engineering. We provide an anecdotal collection of metaphors and figurative language used during conference presentations and discussions and suggest ways in which we can converse more effectively around the notion of Learning Engineering to facilitate fluid, shared understandings that cross the boundaries of organizational backgrounds.

Language Matters: Exploring the Use of Figurative Language at ICICLE 2019

A Little Background

To begin, it is important to understand that this paper began as a collegial debate about the merits of one metaphorical understanding of teaching over another. The debate began nearly three years ago in a colleague's office. Aaron mentioned the metaphor Instructional Engineer (Kessler, 2015) in the conversation and my (Chelsea) immediate reaction was to cringe—noticeably. My mind quickly connected the word engineer to the social efficiency and scientific management traditions of the early 20th century (Null, 2010).

My understanding of social efficiency relates to the work of three prominent figures during the early 20th century: David Snedden, Franklin Bobbit, and Frederick Taylor. The common thread connecting Snedden and Bobbit's work, according to Null (2010), is the idea that schools should "look to the needs of industry" in the creation of curricula geared toward occupations and vocational training (p. 791). While Taylor was not directly associated with the tradition of social efficiency, his beliefs in the application of business principles in schooling were very much in line with Snedden and Bobbit's interest in vocational training.

According to Barone (2010), Frederick Taylor's work included removing the design of curricula from teachers and handing it over to efficiency experts who would then engineer efficient designs that would maximize the amount of material taught to the "greatest number of students in the least amount of time" (p. 321). Having read and critiqued the works of

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these men, my own biased filter made the connection between social efficiency, scientific management, and Aaron's conception of Instructional Engineering. Without further discourse, I would not have been introduced to a new frame from which to view the idea of engineering in education.

Through conversations, Aaron helped me understand that his notion of the term Instructional Engineer was different from my conception. Instead of teachers being taken out of the equation, Aaron's metaphor conceived teachers as engineers who design, build, and implement solutions to complex problems that are situated in environments with dynamic variables.

For Aaron, the realization that the metaphor of Instructional Engineer could be misconstrued by other education colleagues was a harsh realization. The purpose of using the metaphor was to help distill down pages of detailed description of the work required to be done by educators to enact reform instruction in complex settings into something that could easily be understood by both researchers and practitioners alike. Despite the goal of better communicating the complex work required of classroom educators the metaphor, only further complicated some of the arguments Aaron was attempting to build, as it required understanding and negotiating colleagues' own perceptions of the work associated with engineering.

Fast forward three years—both Aaron and I have since moved out of faculty roles and are currently assisting in the design of learning environments at MIT and The University of Michigan (U-M) respectively.

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We had a lull in the debate regarding Instructional Engineering, but as ICICLE 2019 approached, Aaron mentioned that the topic of discussion at the conference might interest me: Learning Engineering. I was enticed by the conference for two reasons. First, for the practical purpose of exploring university programs offering degrees in Learning Engineering. Second, from the standpoint of continuing to explore what Learning Engineering actually means in a variety of contexts.

In May, Aaron and I attended the IEEE ICICLE conference along with Jacob, a Learning Experience Design fellow from the Office of Academic Innovation at U-M. Each of us came away from the event with a variety of figurative phrases we encountered and a realization that many people at the conference were using metaphors and figurative language in conversations with people of diverse backgrounds. Much like our conversation around Instructional Engineers three years ago, we began to notice challenges, potential complications, and possible opportunities in discussing the idea of Learning Engineering using such language.

Collecting Figurative Language Use at ICICLE 2019

The ICICLE 2019 conference attracted numerous individuals from academia, private industry, and government agencies. It seems as if the ideas and discussions around Learning Engineering appeared to capture the attention of these diverse stakeholders. While a diversity of organizations and professions allows for exciting collaborative potential, it also entails some challenges, particularly when stakeholders have diverging understandings, interests, and contexts, which can manifest in vastly

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different uses of language seemingly all describing the same idea.

During the conference, we collectively recorded, in a shared document, anecdotal instances of figurative language used (Table 1). We found that the language used went beyond metaphor and included other types of figurative language. It is not our intention to suggest this is an exhaustive list. Simply, we aim to capture examples that the three of us experienced, individually and collectively, during the conference. As such, we will leave the instances unelaborated to serve as a heuristic for considering the language we use in a diverse community.

Descriptions of Learning Engineering as a Field

- Jazz Improvisation
- Flower
- Many Cogged Machine
- Process
- Mirrors, Doors, and Windows for Inclusion
- Art of the Possible
- Tree
- Horizons of the Field
- Bridge Being Built Over a River

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Descriptions of Learning Engineers

- Jazz improvisation
- Sherpa
- Change Agent
- Systems Engineer
- Conductor
- Test Engineer
- Build Bridges

Descriptions of Feelings Evoked During Dialogue

- Drink Our Own Champagne
- Eat Our Own Dog Food
- Either Get on the Bus or Get Under It
- Infection
- Pipeline of Learning Engineers

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Each of the anecdotal examples listed previously was intentionally left unelaborated. As one might notice, these uses of metaphor and figurative language have the potential to present both challenges and opportunities for extended dialogue. Unfortunately, many of the examples were said and left for conference-goers to take at face value with little elaboration or analysis.

Discussion

Anna Sfard's article in the Educational Researcher entitled On Two Metaphors for Learning and the Dangers of Choosing Just One offered inspiration and guidance for us as we considered the figurative language used. In the article, Sfard (1998) described her analysis of two metaphors specifically related to the way in which K-12 students learn: acquisition and participation. The first metaphor, Acquisition, was based on the idea that knowledge is something that can be possessed and accumulated over time. The second, participation, situated learning as something that is active—beyond the accumulation of knowledge.

What does this have to do with our discussion of metaphors and figurative language? Well, Sfard's (1998) difficult conclusion was that we must learn to live with both metaphors—finding value in each when the context is right and the evidence thoroughly convincing. She suggests that it is important to remember that metaphors utilized in efforts to theorize may suffice to fit certain portions of a field, but they will not create a "unified, homogenous" phrase to conveniently explain all of the complexity and nuance of our work

(p. 12). It is no new thing to conceive of metaphors and other types of figurative language to re-describe abstract ideas. This type of language helps us to understand the world in which we live. What may be new in this context—in this moment in time—is to consider how we, as a diverse community of stakeholders, might develop ways of communicating more productively that move beyond the assumption of universal understanding.

In her article, Sfard (1998) alluded to the importance of dialogue and continuous conversation within a community. In the case of our community of educators and professionals in industry and government, this means that we should take care to thoughtfully communicate the meaning of our words and continue to speak openly to each other about our unique contexts.

To address these challenges, discourse around Learning Engineering needs to take account of the diverse stakeholders by understanding specifically how learning engineers function between contexts. While there may be many points of divergence, one point of convergence between academia, industry, and government is in the need for establishing competencies for Learning Engineering. Establishing competencies is crucial for developing graduate curricula, hiring learning engineers, communicating across institutions, and organizing project responsibilities. While there may be broad agreement on the need for competencies, establishing what these competencies are is a more challenging task.

For instance, one potential competency discussed throughout the duration of the conference was that of the application of learning sciences research. The dialogue around this competency included questions about whether the application of the learning sciences is relevant for learning engineers in an industry context. In this instance, it would have been helpful to elaborate on how the learning sciences are being applied and then compare this understanding to another context. By elaborating and comparing across contexts in this way, diverse stakeholders will be able to shed light on diverging understandings and interests within learning engineering.

One critical point in developing these competencies is assuring that the language used to describe the work of learning engineers(ing) is also clearly understood and jointly negotiated by the diverse stakeholders throughout the development and instantiation process. In the remainder of this paper, we propose a set of recommendations for engaging in conversations and negotiations with other stakeholders across the Learning Engineering community.

Recommendations

Since the catalyst for this endeavor was the misunderstanding of a metaphor, we certainly acknowledge the benefits of having multiple metaphors as potential heuristics. The potential learning and shared understanding (if not agreement), however, lies in the hands of those having conversations about Learning Engineering. To do this work, we have included several recommendations for communication and discourse when interacting with a passionate and diverse group of stakeholders. The first set of recommendations is for those listening to others speaking. We suggest

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listeners try to be open-minded, to attempt to suspend judgment while listening to others speak, to assume that the speaker is coming from a place of positive intent, and to respectfully highlight points of clarification. Attempting to achieve a state of open-mindedness may help listeners notice important distinctions and points of convergence for further conversation while reducing miscommunication.

The second set of recommendations is for those who are actively speaking. Most importantly, be aware of the metaphors and figurative language used to describe Learning Engineering. By articulating these specific ideas, we limit opportunities for others to misinterpret our intended ideas in favor of their own conceptions of what the metaphor could imply. Second, be open to elaborating on context-specific ideas, metaphors, or other figurative language you are using.

Third, if listeners do not ask for explanations or clarification, consider furthering the conversation by asking others what they think about when they hear the metaphor or figurative language being used.

Our final recommendation is specific to those presenting on topics related to Learning Engineering or Learning Engineers at conferences or in professional settings. When participating in group presentations or large group discussions, presenters should attempt to limit the number of metaphors and instances of figurative language used unless such language is deemed integral. Metaphors and figurative language used should be contextualized and concretized by elucidating explicit examples of the related Learning Engineering work.

Language Matters: Exploring the Use of Figurative Language at ICICLE 2019

As our diverse community moves forward and prepares for ICICLE 2020, these communication considerations may help coalesce instances of convergence and more importantly open points of divergence up for continued discussion. Explanation of the language we use combined with explicit examples of the work of and around Learning Engineering may make it more likely that we can facilitate fluid, shared understandings that cross the boundaries of organizational backgrounds.

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ICICLE: Historical Articles and Presentations 2017–2019

ICICLE-related Articles & Events

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IEEE ICICLE Official Public Kickoff Meeting, January 2018

Avron Barr, Jodi Lis, Shelly Blake-Plock, Robby Robson, Megan Bowe, Frank Polster

Overview

ICICLE was approved as an Industry Connections activity by the IEEE Standards Association in December of 2017. On January 3, 2018, we held our first public community call.

View Slideshow

What is a Learning Engineer?
Presented at Emerge Africa, July 2018

Jodi Lis

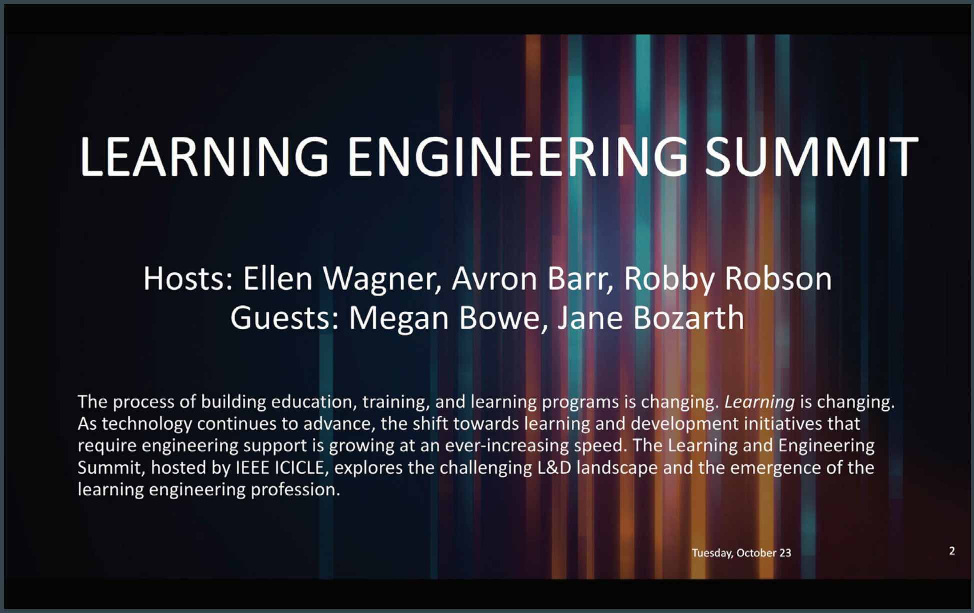
Overview

This presentation covers background on Herb Simon and discusses the presenter's journey into Learning Engineering. It provides background on what and who makes up Learning Engineering. Finally, it wraps up with Getting Involved: IEEE IC Industry Consortium on Learning Engineering (ICICLE).

View Slideshow

Presentation from the Learning Engineering Summit at DevLearn, October 2018

Ellen Wagner, Avron Barr, Robby Robson



Overview

The process of building education, training, and learning programs is changing. Learning is changing. As technology continues to advance, the shift towards learning and development initiatives that require engineering support is growing at an ever-increasing speed. The Learning and Engineering Summit, hosted by IEEE ICICLE, explores the challenging L&D landscape and the emergence of the learning engineering profession.

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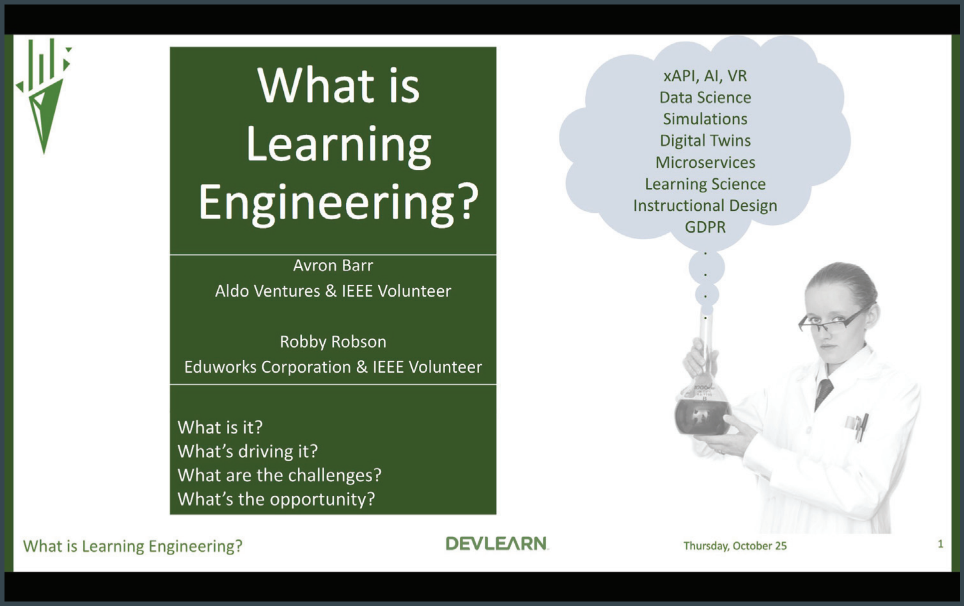
What is Learning Engineering? Presented at DevLearn, October 2018

Avron Barr, Robby Robson



Overview

"As innovative teachers, schools, and training departments deploy an ever-expanding array of new products and explore new ways of teaching and learning, the body of knowledge about how to use these technologies and how to design the increasingly complex information systems that result is the basis for a new engineering discipline." — Avron Barr

View Slideshow

Learning Engineering: Areas of Development

The ICICLE 2019 Conference on Learning Engineering was organized around the following three questions:

- What are the competencies of learning engineering?
- What do we know about learning, and what does our knowledge suggest about design of learning experiences, conditions for learning, and use of supporting technologies?
- How will the emerging learning engineering profession address privacy versus personalization?

Competencies of Learning Engineering Teams and Team Members

Jim Goodell, Aaron Kessler, Dina Kurzweil, Janet Kolodner

Introduction

The types of educational problems that previous generations were tasked with solving could be addressed in particular silos (for example, software design, instructional design, teaching, educational technologists, etc.). We've never designed educational opportunities that meet the needs of all learners, and we're at a time in history when that needs to be the goal. Technology offers new opportunities for addressing these goals, but we still need to discover the best ways of using it. Thus, we are at a crossroad where problem solving for learning requires the integration of expertise from across a variety of team members who can work together to solve the problems of today and in the future. Multiple types of expertise are required from across numerous professions that requires new sets of team competencies and porcessies. Like many other fields tasked with solving complex, everchanging problems, the work of learning engineering requires a multidisciplinary approach.

Competencies of Learning Engineering Teams and Team Members

The kinds of engineering problems associated with supporting, enhancing, and creating equitable, effective life-long learning opportunities and conditions possible in the future have not yet been fully identified. The types of problems that previous generations were tasked with solving could be addressed in particular silos (software design, instructional design, teaching, educational technologists, etc.). We've never designed educational opportunities that meet the needs of all learners, and we're at a time in history when that needs to be the goal. Technology offers new opportunities for addressing these goals, but we still need to discover the best ways of using it. Thus we are at a crossroad where problem solving for learning requires the integration of expertise from across a variety of team members who can work together to solve the problems of today and in the future. Multiple types of expertise are required from across numerous professions that requires new sets of team competencies and porcessies.

While the current professions tackling these types of problems can be situated in silos, an integrated approach is far more likely to develop the necessary solutions. In fact, many people, including most who have contributed to these very proceedings, have advocated for the integration of professional practices and expertise from across the learning sciences, instructional design, software engineering, user experience design (UX), and others aimed towards imagining and designing the kinds of learning experiences afforded by new technologies and new ways of using technology and the as learning engineering.

Like many other fields tasked with solving complex, everchanging problems,

Competencies of Learning Engineering Teams and Team Members

the work of learning engineering requires a multidisciplinary approach. The image below attempts to capture the beginnings of this idea and provide some insights into the shared and distributed understanding necessary to engage in the work of designing for learning.

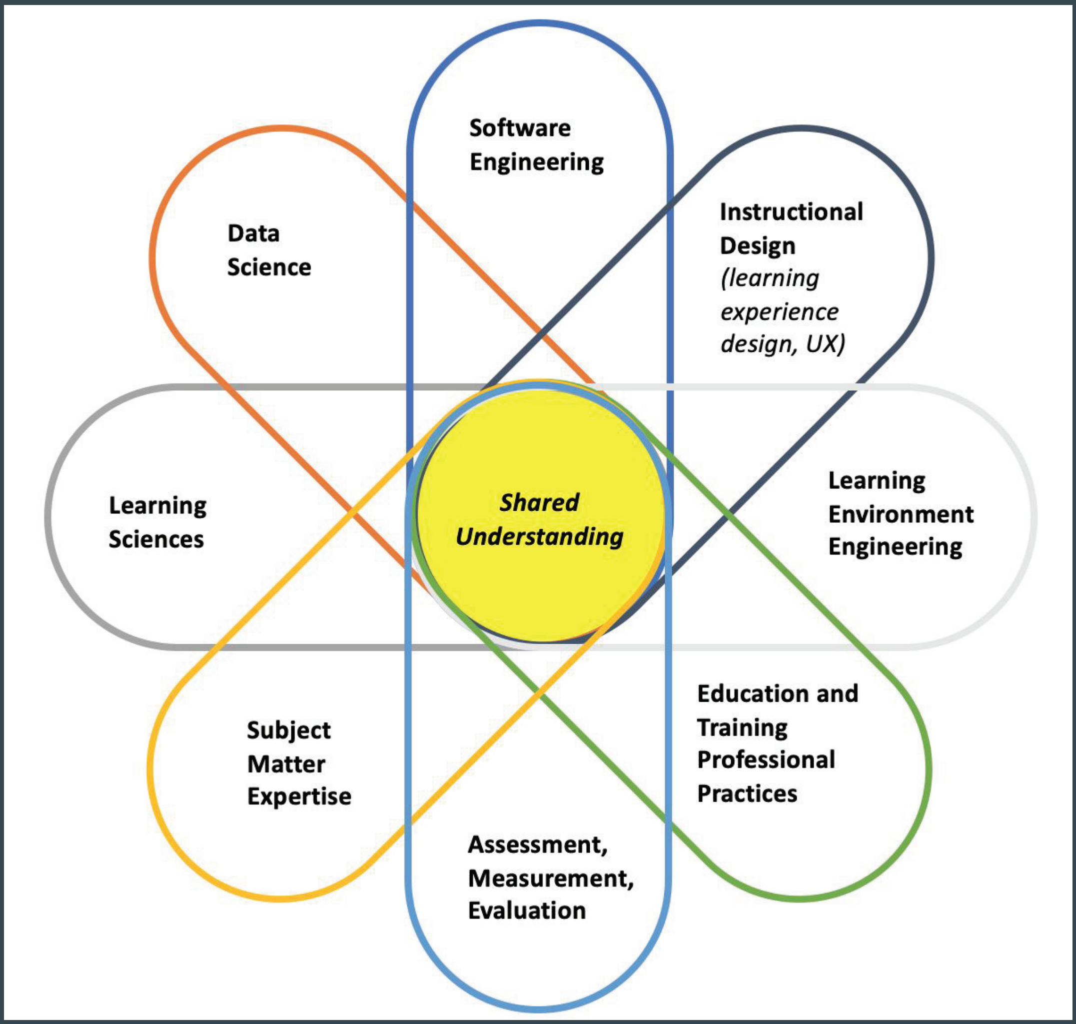


Figure 1: Learning Engineering Teams (CC BY 4.0 Jim Goodell)

Competencies of Learning Engineering Teams and Team Members

In Figure 1, each petal of the flower in the image represents a field that has previously been associated with design for learning. (Note: Other fields and areas of expertise might need to be added to a learning engineering team depending on the specific project or problem.)

The goal of the image is to demonstrate how learning engineering teams are made up of many types of expertise (each petal) while also having shared understandings (the central circle) that are critical for solving complex challenges.

Determining the correct distribution of members that are part of a team doing learning engineering will depend on the product being designed (technological system, instructional intervention, data visualizations, etc) and the context or problem the product is intended to address. The team will, together, have an understanding of how people learn, design processes, and using data to make informed decisions.

Further, they need to share a specific mindset or set of dispositions, possess collaboration skills and knowhow, and imagination about ways technology can support learning. That means that while everyone doesn't have to be an expert in all of the petals (silos), they need to be able to collaborate and work with those who have the necessary expertise to achieve the necessary requirements for the project. Successful collaboration in such ways are likely the result of all team members having dispositions and habits of practice that fit into the following categories:

Competencies of Learning Engineering Teams and Team Members

- Focus on Learning and Learners
- Reflective Practitioner and Iterative Refiner
- Responsive to Data, Evidence, Research, and Requirements
- Leverage Systems Thinking
- Mindful of Context

Beyond this, the individual member of the team will need to be grounded in the processes and practices that make up Learning Engineering, such as the following:

- applying the learning sciences,
- using human-centered engineering design methodologies, and
- data-informed decision-making to support learners and their development.

Applying the Learning Sciences

The team needs to at least appreciate the complexities of processes involved in learning, variations across learners in their capabilities, preferences, and what they are willing to put time into, and choice and adaptations of pedagogies that will support those variations.

Using Human-centered Engineering Design Methodologies

When appropriate the team will need to agree on models of change and may need to determine models, frequent trial, and iterative approaches to design informed by data.

Competencies of Learning Engineering Teams and Team Members

The team will need to be comfortable with balancing imagination and the art of the possible, buy into design that is informed by a combination of what the research and what the data tell us about good practices and processes of learning, and keep learners' needs and dispositions in the forefront of their thinking. Every person needs to understand what each member of the team brings to the group. The entire group must buy into the idea that a team working together can accomplish far more than any of the individuals themselves. Human-centered design starts with the learners being served and ends with a solution that has been informed by a deep understanding of the learners' needs.

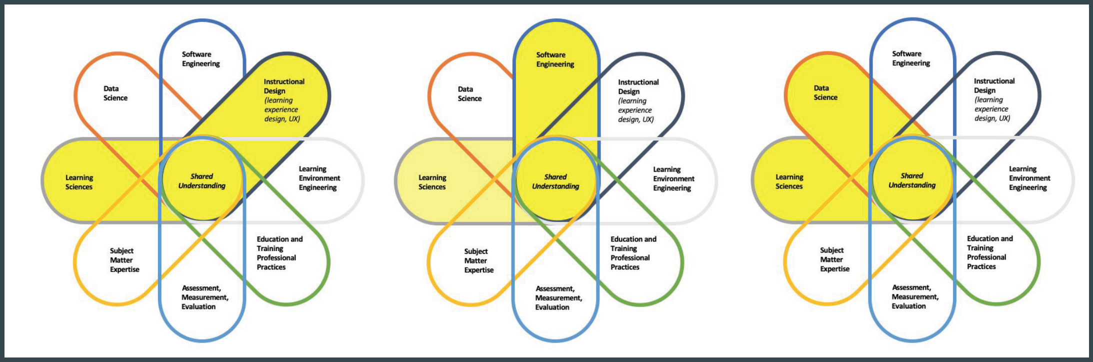


Figure 2: Learning engineering team members need to understand what each member of the team brings to the group that contributes to the solution.

Making Data-informed Decisions

All members of the team should have an understanding that learning

Competencies of Learning Engineering Teams and Team Members

engineering requires data to inform iterative improvements in the solution design. The data-driven mindset of learning engineering asks questions that help inform future improvements to the design or solution. They also look at how to "instrument" the learning experience to collect data needed to answer those questions.

An important piece of this puzzle uncovers from the available data what is working and what is not working for individual learners or under various conditions. Lastly, when the data shows something is not working optimally the team explores how data combined with pedagogical context knowledge can be combined to identify the root cause(s). Finally, the team may look at data-driven experiments that can test possible solutions to the problem.

Conclusion

Designing learning experiences requires a multidisciplinary effort. In the best of all worlds, teams should be formed deliberately and carefully to support outcomes that no individual can meet alone. To support learners and their develoment, Learning Engineering teams will need to be grounded in the following:

- Applying the learning sciences
- Using human-centered engineering design methodologies
- Making data-informed decisions

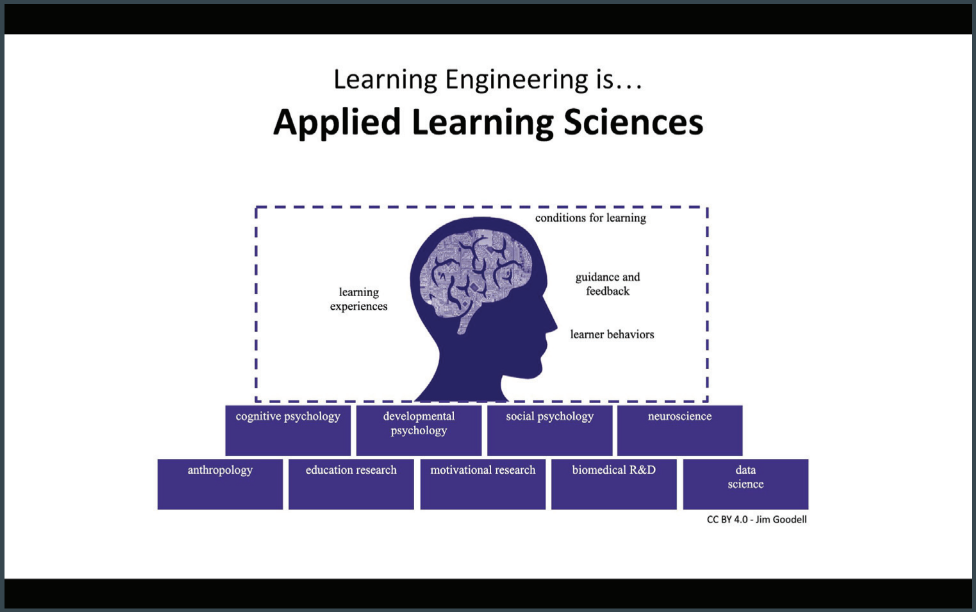
Competencies of Learning Engineering Teams and Team Members

Teams will also need expertise around the populations they are designing for, the kinds of venues they are designing for and norms of those venues, the disciplinary knowledge and skills they want learners to learn and more. Only some of the people on these teams will come grounded in the three areas listed previously.

Next steps are to operationalize these organizing principles into sets of specific competency definitions necessary so that educational programming (both formal and informal) can be developed and aimed toward producing people with the grounding necessary to participate effectively in such teams and become better members of those teams over time.

Why Do You Need Learning Engineering?

Scott Erb, Kumar Garg, Ellen Wagner, Jim Goodell



Overview

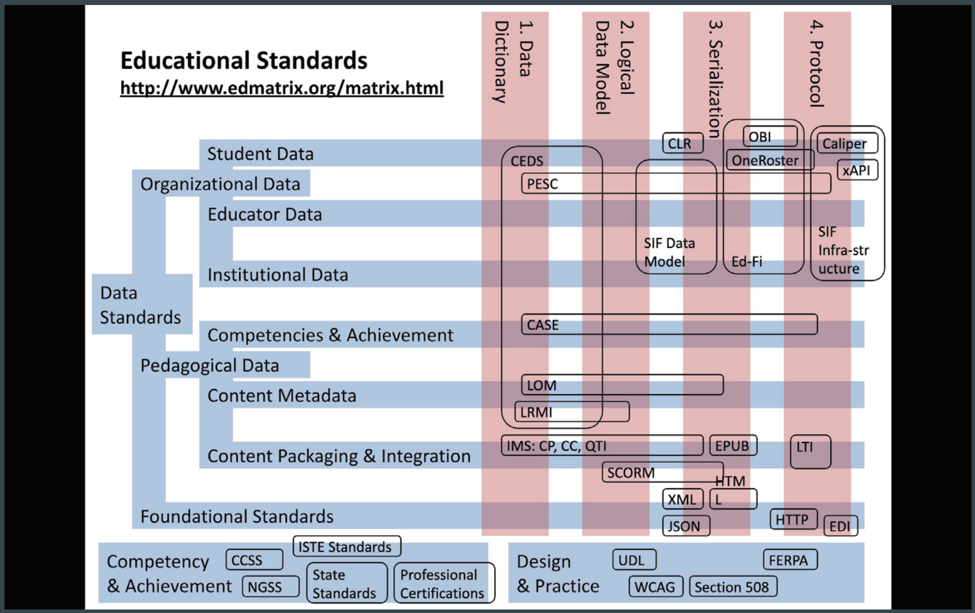
Why are institutions implementing learning engineering policies and practices? And what can leaders do to foster organizational culture and behavior to take advantage of learning engineering practices?

These slides introduced a working definition of learning engineering to frame a panel discussion on why learning engineering is needed.

View Slideshow

Interoperable Standards in Support of Intelligent Learning Environments

Brandt Redd



Overview

Monolithic Solutions fail to achieve broad adoption because they do not interface with existing school systems. Most schools, districts, and colleges lack the capacity to implement systems integration – they need complete solutions. Standards-based solutions greatly reduce the systems integration burden. Nevertheless, this is not sufficient to enable schools to perform integration themselves.

View Slideshow

xAPI: An Intro for Instructional Designers

Peter Guenther

Overview

What is xAPI? How do I send data? What data do I send? Where do I send it? How do I keep it organized? In this introduction to xAPI for Learning Engineers, these and related key questions and concepts are explored.

[View Slideshow]

xAPI and Blockchain for Open Learning Ecosystem in 4th Industry Revolution

Jessie Chuang

Overview

Talent development is crucial support for business outcomes, but it's always hard to measure ROI of L&D in terms of business results, which is the true purpose of L&D. What if we can let employees be CEO of their jobs as micro-enterprises and share the business impact of their works directly?

View Slideshow

Standardization Opportunities for AI in Education

Richard Tong

Overview

Standards lower the cost of development, which leads to lower costs for consumers and increased innovation by producers. Standards provide quality assurance that is badly needed because "AI" is a marketing term. And standards provide frameworks and baselines for research and analysis.

AISs are computer-based systems that guide learning experiences by tailoring instruction and recommendations based on the goals, needs, and preferences of each individual learner or team in the context of domain learning objectives . . . and include the following: intelligent tutoring systems (ITSs), intelligent mentors (recommender systems), and intelligent media.

In this presentation, we look at standards activity in the AIS domain.

View Slideshow

Frameworks and Standards to Accelerate the Development of Adaptive Instruction

Robert Sottilare

Abstract

Adaptive instruction is any learning experience guided by artificially-intelligent, computer-based systems that tailor instruction and recommendations based on the goals, needs, interests, and preferences of individuals or team of learner. Adaptive instructional methods have become more desirable options for education and training with a greater understanding of the benefits that tailored training and educational experiences provide to learners. This paper examines the use of existing and emerging frameworks and standards with the goal of accelerating the adaptive instruction authoring process, providing more consistent and interoperable adaptive instructional products, and lowering the burden of authoring to enable subject matter experts to author adaptive instruction without the need for computer programming.

Keywords: Adaptive Instruction, Authoring, Frameworks, Learning Engineering, Standards

Frameworks and Standards to Accelerate the Development of Adaptive Instruction

Introduction

As part of exploring the efficacy of learning engineering as both an academic and career field, it is essential that we examine what skills and learning technology are integral to success as a learning engineer. A large part of learning engineering is an understanding of how people learn (the process of knowledge and skill acquisition), what tools and methods they use to learn, and how learning differs under varying domains of instruction. How people learn is a complex topic and will not be covered in any detail in this paper. Instead, we have chosen to focus on a specific class of learning technologies that has garnered significant interest due to their potential to influence both the effectiveness and efficiency of learning experiences. This class of learning technologies is adaptive instructional systems (AISs).

Defining Adaptive Instructional Systems (AISs)

AISs are artificially-intelligent, computer-based systems that guide learning experiences by tailoring instruction and recommendations based on the goals, needs, and preferences of each individual learner or team in the context of domain learning objectives. The goal of adaptive instruction is to provide computer-guided, self-regulated experiences for individuals and groups that are equivalent to or better than instruction provided by an expert human tutor. For individuals, it has been shown that one-to-one tutoring experiences are significantly more effective than traditional classroom instructional experiences. For groups, collaborative learning enhances the social skills of learners who engage in situations where "two or more people learn or attempt to learn something together." AISs are tools that support technology-enhanced learning (TEL), which "aims to design, develop, and test sociotechnical innovations that will support and enhance learning practices" for both one-to-one tutoring and collaborative learning.

Types of AISs

AIS learning technologies include intelligent tutoring systems (ITSs), recommender systems, and other intelligent media (Figure 1) that model the learner and tailor instruction based on each individual learner model.

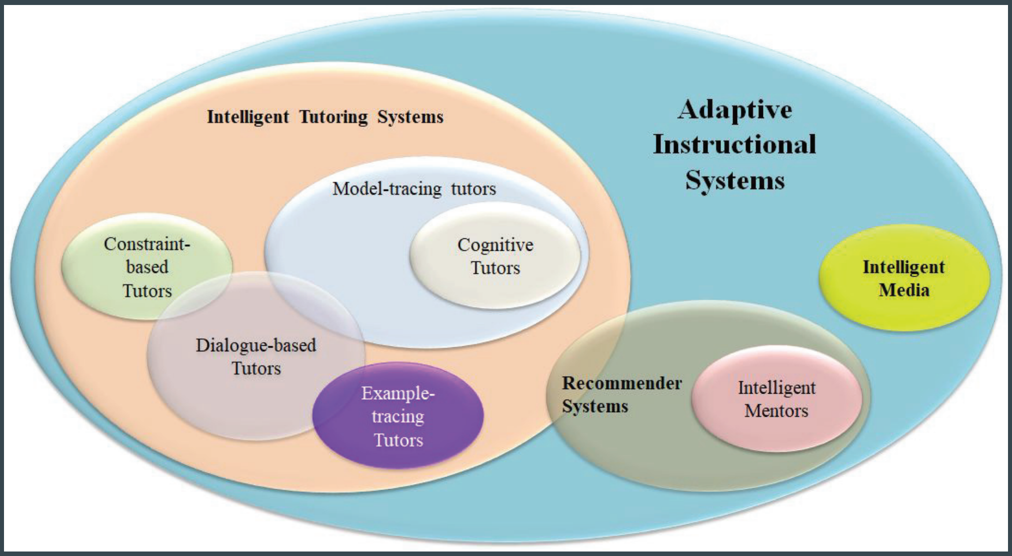


Figure 1. Categories of Adaptive Instructional Systems

Frameworks and Standards to Accelerate the Development of Adaptive Instruction

ITSs are computer-based learning environments that help learners master knowledge and skills using intelligent algorithms that tailor instruction to each learner's idiosyncrasies. This tailoring is at a fine-grained level and instantiates complex principles of learning. ITSs normally work with one learner at a time, but emerging concepts are beginning to support automated instruction for groups of collaborative learners or teams of learners.

Recommender systems provide strategies or plans for the AIS's next action based upon the learner's state(s) or suggestions about what the learner should do next. Recommendations can include suggestions about where to find novel domain resources, identification of other learners with similar interests or optimal learning paths through the learning resources. Finally, we have created the category of "intelligent media" as a catch-all for AISs that are not specifically ITSs or recommender systems. This was done primarily to simplify the model shown in Figure 1 and provide a category to anticipate future categories of AISs.

AIS Standards, Recommended Practices, and Guides

One of the tenets upon which this paper is based is the potential to reduce development time and accelerate concepts to the marketplace through standardization. Under the auspices of the IEEE Learning Technology Standards Committee, participants in Project 2247 are examining the potential of AIS standards, recommended practices, and guides for AIS developers and users. According to IEEE, standards are documents that

Frameworks and Standards to Accelerate the Development of Adaptive Instruction

establish mandatory requirements. Recommended practices are documents in which procedures and positions preferred by the IEEE are presented, and guides are documents that suggest alternative approaches to good practices without any clear-cut recommendations. To date, three subgroups have emerged to support 1) conceptual modeling of AISs, 2) interoperability of AISs, and 3) evaluation practices and guidance for AISs.

AIS Conceptual Modeling

A conceptual model is a set of concepts (ideas) used to a represent the features, events, and processes of a system and is developed to aid developers and users understand how the system works. The purpose of the conceptual modeling subgroup (IEEE Project 2247.1) is to establish standards, recommended practices, and guides to:

- enable producers of AIS to describe the overall operation of an AIS;
- specify its approach, method, and level of adaptation;
- identify the methods used to implement specific components and interfaces;
- enable consumers of AIS to make comparisons to inform purchasing and deployment decisions;
- serve a reference for technical standards that support the exchange of data among AISs and between AISs and other education and training systems;
- incorporate and promote the principles of ethically aligned design for the use of artificial intelligence (AI) in AISs.

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AIS Interoperability Standards, Recommended Practices, and Guides

Interoperability is "the ability of two or more software components to cooperate despite differences in language, interface, and execution platform. It is a scalable form of reusability . . ." (Wegner, 1996). Santos and Jorge argued that "because of interoperability issues, intelligent tutoring systems (a subset of AISs) are difficult to deploy in current educational platforms without additional work. Interoperability is the primary reason that the reuse of AIS features, structure, and components is currently low.

The purpose of the interoperability subgroup (IEEE Project 2247.2) is to establish standards, recommended practices, and guides to:

- describe the overall operation of an AIS in terms of interactions and exchanges between AIS components (e.g., learner models, instructional models, domain models, and user interface models) and other AISs;
- specify its approach and method of interoperation;
- identify the methods used to implement specific components, models, and interfaces;
- enable consumers of AISs to make comparisons to inform purchasing and deployment decisions;
- serve a reference for technical standards that support the exchange of components and data among AISs and between AISs and other education and training systems;

Frameworks and Standards to Accelerate the Development of Adaptive Instruction

- incorporate and promote the principles of ethically aligned design for the use of artificial intelligence (AI) in AISs.

Evaluation Methods and Recommended Practices for AISs

Evaluation involves making judgments or valuations about AIS features, events, and processes. The purpose of the evaluation subgroup (IEEE Project 2247.3) is to establish standards, recommended practices, and guides to:

- enable AISs to be characterized in terms of instructional effectiveness and other characteristics of concern to consumers when making purchase decisions (e.g., data handling and privacy protection methods);
- establish criteria and best practices for evaluation of AISs so that consumers can determine the likelihood of desired learning outcomes and program impacts based on the features included in the AIS and the intended usage frequency of those AIS features.

In the next section, we examine the characteristics of prevalent AIS software architectures or frameworks to identify potential AIS standards, recommended practices, and guides for development, use, and evaluation.

AIS Frameworks

There are lessons learned and de facto standards to be found within the

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conceptual models of existing and emerging AIS frameworks. In this section, we discuss characteristics of four prevalent AIS frameworks with the goal of identifying potential standards, recommended practices, and guides to:

- improve interoperability and reuse;
- reduce development time and lower skills needed to author AISs;
- protect intellectual property;
- ease the transition of AIS concepts to the learning technology marketplace;
- support the consumer in the evaluation of AIS features.

Generalized Intelligent Framework for Tutoring (GIFT)

GIFT, developed by the U. S. Army, is an open source AIS software architecture to enable the authoring, delivery, management, and evaluation of adaptive instruction. AIS architectures like GIFT are not specifically ITSs, but they do provide the building blocks (components, tools, and processes) needed to generate ITSs and instantiate the design principles that govern the delivery and management of automated instruction by their ITSs. GIFT is composed of models of the learner(s), the instruction, the domain, and the user interface (Figure 2).

Frameworks and Standards to Accelerate the Development of Adaptive Instruction

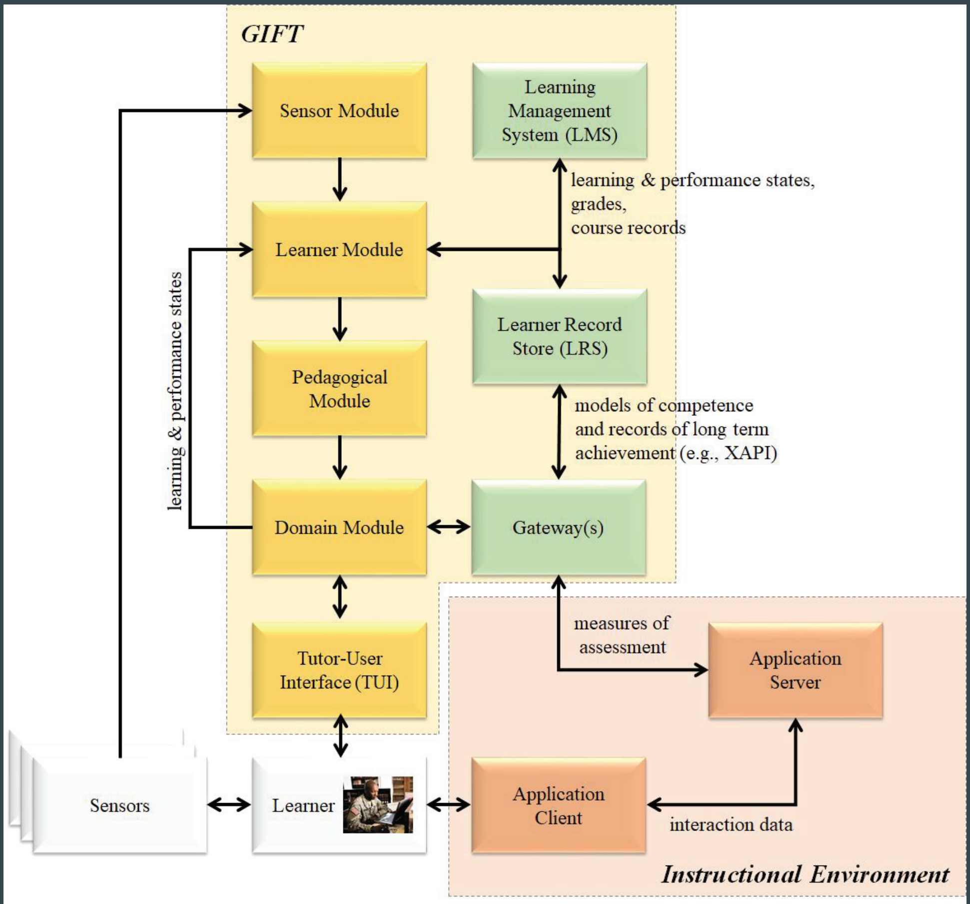

Figure 2. Features, Events, and Real-time Processes in GIFT

The GIFT authoring tools enable users to develop courses in a variety of cognitive, affective, psychomotor, and collective (team) instructional domains. For most applications, GIFT authoring tools require no knowledge of computer programming or instructional design to develop effective ITSs. The authoring tools permit the instructional designer or subject matter expert to define learning objectives (LOs), link learner states, questions, and content to LOs, assign meta-data attributes to content, and configure defined instructional environments and sensors to acquire measures to determine progress toward LOs.

A gateway specification enables GIFT to interact with external (non-GIFT) training and educational environments to tailor learner feedback or modify the difficulty of scenarios to match learner competency in the domain of instruction. Similar specifications known as condition classes allow GIFT to acquire learner data from sensors to support learner state classification. GIFT uses learner states to determine appropriate instructional strategies and formulate individual learner recommendations. Instructional strategies and context are used to select appropriate instructional actions from an available list of tactics. GIFT delivers instruction via the cloud (Amazon Web Services), a local version for your desktop or you can request virtual machine implementation. Additional information about GIFT is available at www.GIFTtutoring.org.

AutoTutor

AutoTutor, developed at the University of Memphis, is a dialogue-based ITS that engages the human learner in Socratic conversations with the human learner in natural language. AutoTutor has produced learning gains across multiple domains (e.g., computer literacy, physics, critical thinking). Like GIFT, AutoTutor maintains models of the learner, the instruction, the domain, and the user interface.

AutoTutor research has focused on three primary main areas: human-inspired tutoring strategies, pedagogical agents, and natural language tutoring. AutoTutor has been applied to several task domains in support of one-to-one tutoring, and like GIFT it has a comprehensive set of authoring tools and services. Additional information about AutoTutor is available at: www.autotutor.org/.

Cognitive Tutor

The Cognitive Tutor, developed at Carnegie Mellon University in the U. S., is an ITS tool suite that enables you to learn by doing (i.e., active learning). The Cognitive Tutor Authoring Tools (CTAT) is a suite of ITS authoring tools for developing and delivering ITS and been around for many years and continues to evolve. CTAT can create ITSs to support both simple and complex problem-solving. Tutors built with CTAT provide step-level guidance for complex problem solving activities as well as individualized task selection based on a Bayesian learner model. CTAT tutors track learners as they work through problem sets (primarily in mathematics or physics) and then provide context-sensitive, just-in-time help.

In order to develop a domain model in CTAT, a cognitive task analysis is required to model the process of learning the required concepts. CTAT requires familiarity with the Java Expert System Shell (JESS) production rule language to develop a cognitive tutor and includes authoring tools for both cognitive and example-tracing tutors. Cognitive tutors use a cognitive model to provide feedback to students as they are progress through the task of solving problems. An author can build a rule-based cognitive ITS either through Artificial-Intelligence (AI) programming or by using a non-programming module called SimStudent. Example tracing tutors evaluate learner behavior and compare it to generalized examples of problem-solving behavior. An author can create an example-tracing tutor using non-programming methods in CTAT.

Authoring Software Platform for Intelligent Resources in Education (ASPIRE)

ASPIRE, developed by the University of Canterbury in New Zealand, is a system for developing and delivering adaptive instruction on the web. The system consists of ASPIRE-Author, a tutor development server, and ASPIRE-Tutor, a tutoring server that delivers the resulting ITSs to students for guided instruction. The authoring system provides a unique process for composing an ontology of the domain by outlining basic domain concepts, their properties, and the relationships between concepts forming the basis of an expert model. Additional information about ASPIRE is available at http://aspire.cosc.canterbury.ac.nz/.

Discussion and Recommendations

The existing AIS architectures share some common components: learner models, instructional models, domain models, and interface models. Learner models contain data about the learner that is sourced from sensors, record stores, self-reporting, assessments, learner interactions with the AIS, learner interactions with others (e.g., fellow learners during collaborative learning). This data is used by the learner model to represent various states of the learner which can then be used by the instructional model to decide on instructional strategies and tactics.

The instructional models of AIS also vary in terms of the instructional and learning strategies that they employ. For instance, the instructional model in GIFT uses a mastery approach to guide learner through four phases of instruction governed by Merrill's component display theory. Domain model contain all the content, remediation, and assessments needed to demonstrate proficiency in a domain of instruction (e.g., mathematics, physics, marksmanship, and processes).

While these components have similar names, their features and processes differ, and the information that they exchange with each other also differ. This adversely affects interoperability.

Implications for Learning Engineering

One of limiting factors for introducing new technology (tools or methods) into the learning engineering workspace is the usability of tools and their return on investment. Both of these aspects are tied together. If a technology is not relatively easy to use, it will remain in the hands of specialists. If the cost of applying the technology is too high with respect to its value (e.g., improved performance, quality, speed) then managers will find

Frameworks and Standards to Accelerate the Development of Adaptive Instruction

it difficult to justify technology purchases.

In order to move the AIS marketplace forward, we will need to promote competition in the marketplace and for competition to be optimal, it must be easy to bring technologies into the market. Reducing the tangled web of AIS technologies to practical use by the masses may be a bridge too far, but bringing suitable tools to qualified professionals (learning engineers) is much more likely. Standards will help in this endeavor and we recommend the following community actions.

First, develop a standard AIS conceptual model as a basis for identifying AIS components, processes, and data exchange needs. This will allow learning engineers to communicate with standard terms. Second is to develop standards for AIS interoperability to support data exchanges between common AIS components as described in the AIS conceptual model.

Our third action should be to incentivize the AIS marketplace to produce much needed AIS prototype architectures to support both stimulator and embedded modes. Stimulating existing instructional systems will demonstrate the value of AISs by leveraging the current investment in instructional technology. Owners of that technology want better effectiveness, but don't really want to toss out their expensive and effective systems. Developing design principles to support native or embedded solutions will help learning engineers innovate on current AIS designs by considering adaptivity as an essential design element from the start.

Frameworks and Standards to Accelerate the Development of Adaptive Instruction

Our next action should be to develop recommended practices for evaluating the capabilities of new AIS technologies (tools and methods). This will help bring consumers into the marketplace by demonstrating the ability to discern differences in AIS features so consumers can buy what they need.

Previously in this paper, we discussed examples of AIS architectures. The AIS and learning engineering community should engage in the mission of building standards and recommended practices for new AIS architectures that are based on need, but also based upon already proven design principles in AIS architectures such as GIFT, AutoTutor, and the Cognitive Tutor.

Finally, we should incentivize the AIS marketplace to enhance authoring, deployment, instructional management, and evaluation processes to further improve the cost/benefit (and ROI) associated with AISs. This will build consumer trust and enhance competition and quality in the AIS marketplace.

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Learning Sciences Cards

Jim Goodell and Janet Kolodner

Overview

Professionals engaged in learning engineering must draw on key findings from the learning sciences. It is valuable for everyone developing learning experiences and conditions for great learning to be familiar with some key truths about how people learn.

A prototype of game-based learning cards centered on key learning sciences findings was "play tested" at the first IEEE ICICLE Conference on Learning Engineering in the session "Key learning sciences findings and their application through learning engineering." (Early testing of prototypes and subsequent iterative improvement is a practice of iterative human-centered design identified by ICICLE as a key component of learning engineering.) The idea for the cards was inspired in part by Digital Promise's 10 key insights about how people learn and by examples of game-based learning from an MITx course and various other sources.

See the directions to the game here.

Learning Sciences Cards

The ICICLE Conference Cards and Activities

The prototype card deck and two activities (a card game and a social-collaborative experience) were developed by Janet Kolodner and Jim Goodell. Steve Ritter and Aaron Kessler helped refine the session and activities.

At the conference the play-test session was a surprise. It began as a panel discussion on learning sciences with Aaron Kessler, Janet Kolodner, Steve Ritter, and moderated by Jim Goodell. After the first question, Steve Ritter walked off the stage in protest that the panel format was not the best modality to achieve the session objective. The other panelists followed. Then Goodell suggested that a different approach would be needed and invited conference attendees to move to the next room where tables were set up with the cards and instructions for the game/activity. (Thanks to Jodi Lis.)

Both activities involved creating posters that provided feedback to inform iterative improvement of the cards and activities.

Learning Engineering Toolkit

This card deck is one example of a resource that might be further refined and become part of a “toolkit” to make learning engineering principles and practices more accessible to professionals who design and develop learning solutions—both engineers and non-engineers.

Learning Sciences Cards

Members of the ICICLE community have begun work on other “tools” such as a handbook, online resources, and process tools.

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Check out the cards themselves.

What a Learning Engineer Needs to Know about DoD Learning

Mitch Bonnett

Overview

This paper explores what a Learning Engineer needs to know to analyze, design, develop, implement, and evaluate learning in a large-scale learning factory like the DOD. It answers the following questions:

- What will the future seamless learning system look like across military, federal and state government, industry, and academic boundaries that the learning engineer may traverse?
- What are the system components that the learning engineer may need to implement (policy, people, doctrinal content, learning technology systems) within each boundary?
- What are the strategic and tactical boundary specific steps a learning engineer may need to take to fund, design, develop, implement, and support learning systems?
- What are the barriers that a learning engineer may need to overcome?

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The DOD Learning Factory

Nations educate and train their military forces to ensure the survival of their states. Successful nations know that educating and training their armed forces in their occupational roles and missions and then rehearsing (simulating) their individually and collectively performed tasks for those roles and missions during times of peace is necessary to win battles during times of war (Bonnett, 2015). The methodical Romans (AD 284–476) individually trained soldiers and collectively trained teams and organizations in maneuvers of entire legionary battle groups. These live rehearsals were so successful that Josephus well stated "Roman exercises were bloodless battles and their battles were bloody exercises" (De Souza, 2008, p. 201).

Learning the ancient Romans lessons, and understanding the consequences of failure to defend the nation state, the leaders of the U. S. Department of Defense (DOD), considered the "greatest training organization of all time" (Aldrich, 2004, p. 7), invest more funds in planning and innovating military education, training, and mission rehearsal for its workforce than any organization in history—employing large formations of instructional systems designers and computer scientists and engineers that depend on each other so significantly that an argument has been made that they need to be part of the same occupation—the Learning Engineer. To understand this gap and proposed solution it is important to understand the two business model processes, each with deliberate structured approaches that support DOD military education, training, and mission rehearsal, hereafter called learning for these now separate occupations.

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The first business process at Figure A is the international ADDIE business model process used to analyze, design, develop, implement, and evaluate learning materials and resources. Often confused with learning models and their methods of learning, ADDIE is a business model process critical to the DOD "learning factory" that materially develops the means of learning by the use of tooling that are learning technology systems, labor that is many different kinds of very skilled workers, and measurement that is analytics (metrics) that work together to design, develop, implement (delivery) and evaluate the learning materials used by the learner. The ADDIE business process is the model wherein the instructional system developer, sometimes called an instructional systems specialist, is the critical occupational specialty.

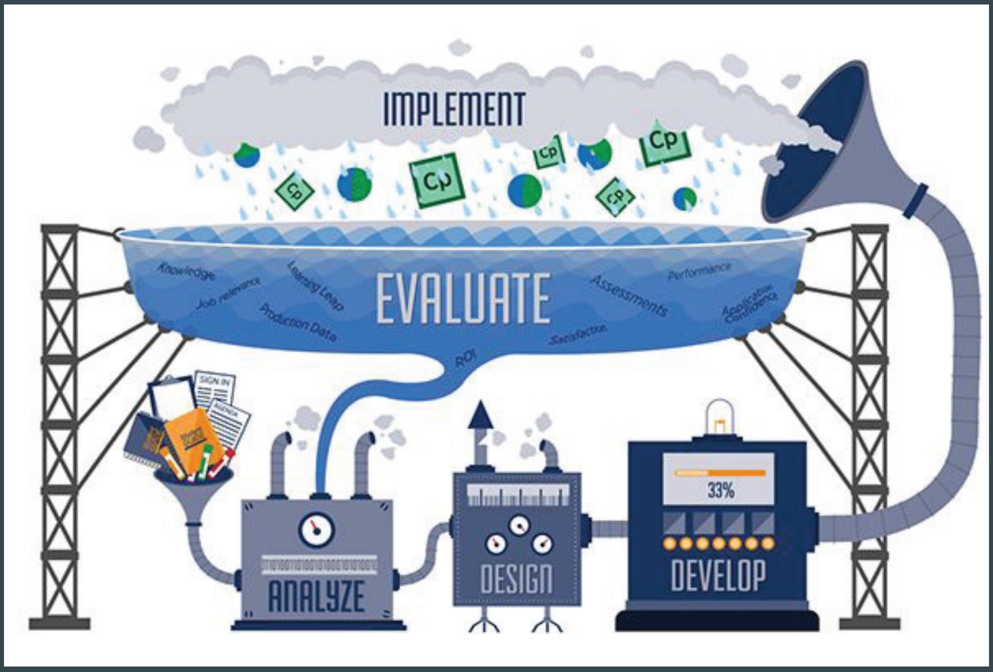

Figure A. Analyze, Design, Develop, Implement, and Evaluate (ADDIE) Model. (Fisher, 2013).

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The second business process acquires the tooling (learning technology) systems that support the learning factory workers throughout the ADDIE process in producing the learning materials as well as the tools that support the learner in the ADDIE Implementation stage where learning is delivered. If this second process does not provide the factory with the required tooling, and those tools do not support measurement, the learning enterprise will eventually fail.

That second business model process generates capability requirements and acquires systems to mitigate the requirements gaps between what an existing system can do for ADDIE and what it is that the DOD needs the system to do for ADDIE. Two similar requirement generation and acquisition DOD variants are used for this second process.

The Joint Capabilities Integration and Development System (JCIDS) process is used when the learning provided is expected to be “accomplished through the use of the trainee’s operational system within a live virtual constructive (LVC) training environment” (Office of the Secretary of Defense, 2017, p. 2), called Embedded Training (ET).

The Business Capability Acquisition Cycle (BCAC) process at Figure B is used when the learning system component is expected to “be acquired as a business system that will be aligned to commercial best practices and that will minimize the need for customization of commercial products to the maximum extent possible” (Office of the Under Secretary of Defense for Personnel and Readiness, 2017, p. 4).

In either case groups of professionals called capability developers that are usually subject matter experts in the doctrinal area the learning will be for that have had special training, material developers that are often computer scientists and engineers, and training developers that are often instructional system developers/specialists, work together in the ADDIE and JCIDS or BCAC processes to keep the learning factory working on schedule and on budget to provide DOD learners learning materials.

Although both ADDIE and BCAC require support from the legislative and executive branches of the U. S. government for funding, both can be adapted for use by any organization. In other words, these two models can be applied at smaller scale by any organization.

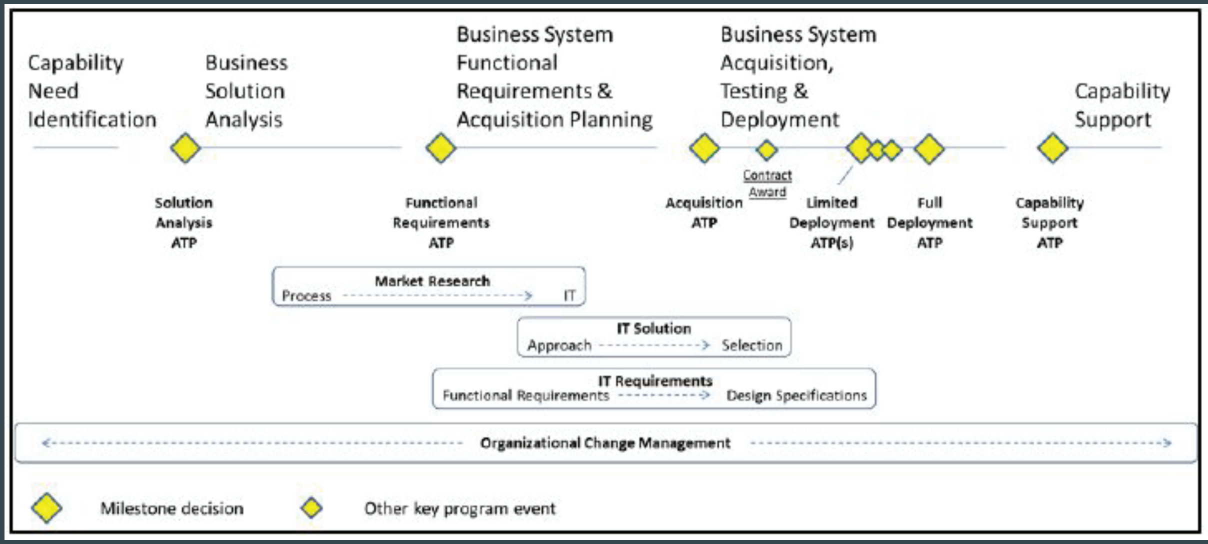

Figure B. DOD Business Capability Acquisition Cycle (BCAC). (Office of the Under Secretary of Defense for Acquisition, 2017, p. 5)

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This paper's focus is the learning engineering gap in implementing learning via the ADDIE process and BCAC business model processes—BCAC used as the example instead of JCIDS because learning embedded within a combat system is beyond this paper's scope. Also, although both ADDIE and BCAC are discussed as to their purposes, because BCAC is a more complex DOD unique process, and ADDIE is the process most transferable to non-DOD use cases of this conference, and for purposes of brevity, ADDIE will be discussed in more depth.

This paper will first discuss ADDIE, why it's necessary and how it supports the future seamless learning system across the DOD, leading to the discussion of the components the DOD or any large learning factory might need (policy, people, doctrinal content, learning technology) to implement a future learning ecosystem, and what steps the learning factory might need to take to fund, design, develop, implement, and support such a future learning system requiring these learning engineers. Finally, barriers to implementing learning engineers in a future learning ecosystem are discussed.

But first, understanding what learning a large learning factory conducts—in this case the DOD, and how the learning factory (DOD) structures that learning must be understood.

DOD Learning

With some exceptions, DOD learning establishes and conducts "individual military training programs to qualify personnel for assignment to authorized billets within the force structure" or establishes and conducts "individual, collective, and staff training programs . . . to support joint and integrated operations training" (Office of the Secretary of Defense, 2017, p. 7).

Within the DOD, as if often the case outside of the DOD, learning is usually defined as either education or training.

Education is defined by the DOD as "Developing an employee's general knowledge, capabilities, and character through exposure to and learning of theories, concepts, and information. Education is traditionally delivered by an accredited institution and may relate to a current or future mission-related assignment" (Office of the Secretary of Defense, 2013, p. 46).

Training is defined by the DOD as the "Process of providing for and making available to an employee, and placing or enrolling the employee in, a planned, prepared, and coordinated program, course, curriculum, subject, system, or routine of instruction or education, in scientific, professional, technical, mechanical, trade, clerical, fiscal, administrative, or other fields that will improve individual and organizational performance and assist in achieving the agency's mission and performance goals" (Office of the Secretary of Defense, 2013, p. 48).

Although the terms education and training are defined slightly differently from service to service they are substantially the same, so the differences are not enumerated here. It is how the services separate their training and

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education learning into structured domains to efficiently establish and conduct their learning within the ADDIE and BPAC models that the differences are more apparent. For brevity and because the services differences are more in implementation naming than in implementation method, the three learning domains for the service with the largest education and training population—the Army—are used as (modified) examples.

The institutional domain includes organizations most resembling schools and colleges in the civilian sector. This domain provides initial military training and subsequent functional and professional military education and training for each service's uniformed personnel, their military leaders, and the service's civilian employees. This domain ensures that the service's personnel can perform critical tasks to prescribed standards throughout their careers, and support units in the operational domain on a continuous basis. The domain instills the service's professional creed and ethics and assists in character development of its professionals (U. S. Army, 2018).

A course, that may be delivered by resident (live), computer-aided, or computer-managed instruction, or a blend of these, is a group of instructional units that deliver critical learning requirements to qualify someone for a specific job or function—called primary instruction. To accomplish this, the institutional domain typically uses three scoring methods, shown in Figure C, for primary instruction that can be used to qualify service personnel in their Military Occupational Specialty (MOS), an Additional Skill Identifier (ASI) or a Special Qualification Identifier (SQI).

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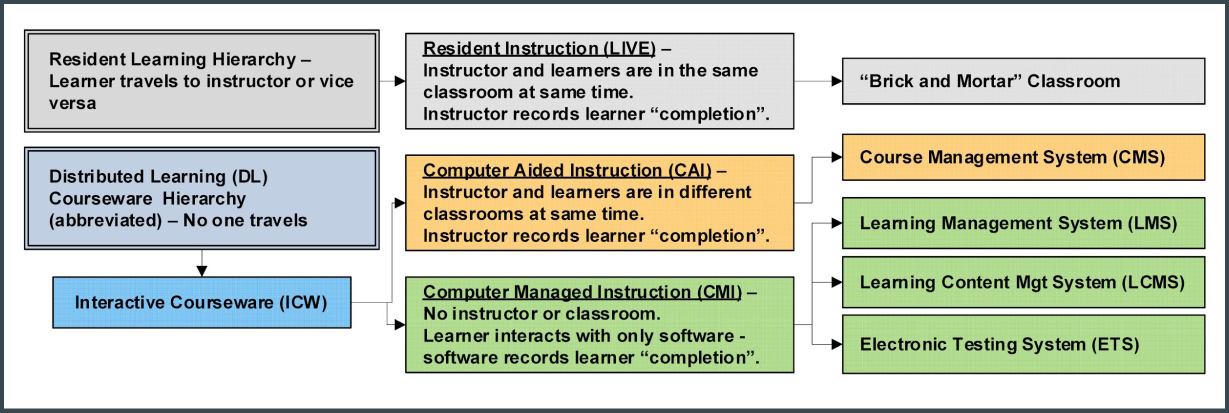

Figure C. DOD Instructional Hierarchy for Resident and Distributed Learning. Adapted from "Army Training and Leader Development," by U. S. Army, 2017, p. 236. Copyright 2017 by the Government Printing Office and "Department of Defense Handbook, Development of Interactive Multimedia Instruction (IMI) (Part 3 of 5 Parts)," by Department of Defense, 2001, p. 3. Copyright 2001 by the Government Printing Office.

Resident Instruction (Live) is learning, whether it is called education or training, that is "presented, managed, and controlled by an onsite instructor or facilitator, small group leader, or otherwise designated trainer" (U. S. Army, 2018, p. 236). There is an instructor, a classroom, and one or more learners, and they are all in the same classroom at the same time.

This is often referred to as "brick and mortar" instruction. The instructor scores the course and determines if the learner has mastered the Terminal Learning Objectives (TLOs). The instructor records the learner's completion status in a student registration system. Live instruction can be more expensive than other methods of instruction because either the learner or the instructor must travel to the classroom, incurring temporary duty (TDY) costs for travel, billeting, food, etc. "Seat" limits of the available classrooms and "load" limits on how many learners an instructor should instruct at once may mean that the target audience for Live must be divided up into different class iterations, requiring more classrooms and more instructors.

The concepts and learning technology used for resident instruction are well-known and not that much different between the civilian sector and the military so they are not discussed in detail here, except where there is variance. In the Army for example Live training is considered "resident" if conducted within an approved Total Army School Systems (TASS) schoolhouse and "non-resident" if not.

Computer Aided Instruction (CAI) is learning presented, managed, and controlled by an instructor that is in a different classroom than the learner(s). The instructor is assisted by a Course Management System (CMS) that provides a means of communicating and passing documents back and forth between the instructor and the learner.

The instructor still scores the course and determines if the learner has mastered the TLOs. The instructor records the learner's completion status in the CMS, and the CMS updates the student registration system. Because there are no TDY expenses CAI is often less expensive than Live instruction. Like Live however, "seat" limits of the available classrooms and "load" limits of instructors may mean that the target audience in CAI must be divided up into different class iterations. CAI may be supported by a help desk but is not always.

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The concepts and learning technology used for CAI are also well-known and not much different between the civilian sector and the military so they too are not discussed in detail here, except where there is variance. For example, Army CAI training is considered “synchronous” if the instructor and learner are communicating at the same time and “asynchronous” if not.

Computer Managed Instruction (CMI) is learning presented, managed, and controlled by course software, called courseware (CW). There is no travel. There is no instructor. There is no classroom. The CMI provides all course and lesson content interaction with the learner.

CMI is discussed in more depth because it is with CMI that the DOD varies most with the civilian sector learning factories, it is with CMI where most of the more recent innovation has and is occurring, and it is with CMI that the learning engineering gap between instructional system developers/specialists and computer scientists/engineers is most acute. Although this paper discusses DOD Sharable Content Object Reuse Model (SCORM) 2004 examples the same issue will and have already started to arise with xAPI and its profiles.

CMI measures mastery by automated evaluation that requires that the CMI code calculate and report learner scores to a Learning Management System (LMS), Learning Content Management System (LCMS), or Electronic Testing System (ETS) and they then report the score to either an internal or external student registration system. Well-developed CMI that is coded to capture learner CMI interaction data supports automated collection and reporting of item analysis data necessary to conduct Training Effectiveness Analysis (TEA). For these reasons, CMI is the only type of Interactive Multimedia Instruction (IMI) capable of being used for primary instruction. CMI and its supporting systems will be discussed in more detail later.

CMI uses the data model defined in IEEE Std 1484.11.1-2004 to interchange agreed upon data elements and their values between a learning-related content object and a runtime service (RTS) used to support learning management. The content object is a collection of digital content intended for presentation to a learner by a learning technology system that may include learning material and processing code. The RTS controls the execution and delivery of learning content and may provide resource allocation, scheduling, input-output control, and data management services (IEEE Learning Technology Standards Committee, 2007).

The recognized and RTS recordable input or group of inputs from a learner to a content object is called CMI interaction data. The two most important interaction datum, that the DOD Sharable Content Object Reuse Model (SCORM) 2004 Data Model requires that CMI report to the RTS—as they are the basis for scoring CMI—are accurate capture and reporting of the cmi.interaction datum and accurate reporting of the content object's "cmi.completion_status" as "completed," "incomplete," "not attempted," or "unknown" as appropriate (U. S. Army, 2018).

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While the DOD currently requires reporting only CMI completion data, the Army requires collection and reporting of learner CMI interaction data to support item analysis and to catch learners that cheat on CMI. The DOD may adapt the Army policy, and you should consider doing that also for at least your high-stakes examinations delivered via CMI.

Item analysis, that is a required component of Training Effectiveness Analysis (TEA), cannot be conducted without interaction data and learners should not get credit for completing CMI without this datum because of the ease with which a learner may cheat in a CMI system that has not been designed specifically to prevent some of the more advanced cheating methods. The bottom line is that it is much more difficult to prove a CMI learner cheated without the retention of the CMI interaction data; the absence of the interaction data being proof that the learner never interacted with the CMI but used a code cheat instead to get a completion code.

Remember CMI is the most complex method of instruction. No instructor to assist the learner means CMI is most dependent upon analytics driven issue detection and a help desk.

Learning Enablers

In addition to operating schools and colleges that support the education role, the institutional domain creates and operates training support enablers that realistically portray the environment that the operational domain may have to operate within—and they need learning engineers also. These learning simulation enablers, most used for the training role instead of the education role, are called the Live, Virtual, Constructive, and Gaming (LVC-G) training support enablers.

The live training enablers train real people in the real world using real or fake equipment. Most large-scale exercises, like those of the ancient Romans, are live collective training simulations. The virtual simulation training enablers train real people in a simulated world using simulated equipment, and can support both individual and collective training, usually in large buildings constructed to house many large simulated vehicles or aircraft that totally enclose and immerse the learner. The constructive simulation training enablers train real people by using simulated people in a simulated world using simulated equipment. Constructive training computer programs can provide accelerated results of decisions that can be integrated into the other enablers in blended training exercises (Joy, Rykard, & Green, 2014). Due to their size and complexity these LVC enablers usually involve the training target audience traveling to and working in the same location on military provided equipment—precluding participation issues.

A fourth learning enabler is emerging with different adoption rates and methods between the services called serious gaming. It a learning enabler because it can support education and training, and can use less expensive computing platforms or even learner owned computers. Zyda (2005) stated that a serious game is “a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives" (p. 26). Adcock, Watson, Morrison, and Belfore (2010) stated, "Serious games are, at their core, exploratory learning environments designed around the pedagogy and constraints associated with specific knowledge domains. This focus on instructional content is what separates games designed for entertainment from games designed to educate" (2010, p. 152). Like other DL IMI types, and for the same reasons, distributed serious games need to be monitored to preclude issues with learner propensity to not complete the learning or to cheat.

The institutional domain, using the ADDIE and BCAC business processes, directly as training developers that are usually instructional system developers/specialists or in cooperation with capability and material developers that are usually computer scientist/engineers, need to be able to materially develop and provide learning support products, information, and materials needed by individuals not only in the institutional domain, but also for individuals in the self-development domain and to individuals and unit leaders in the operational domain necessary to accomplish their learning—whether that learning is education, training, mission rehearsal, or assessment (evaluation). In short, the need for learning engineers is great and growing.

The operational domain "encompasses training activities that unit leaders schedule, and individuals, units and organizations undertake" (U. S. Army, 2018, p. 4). Unit leaders are responsible for the proficiency of their subordinates, subordinate leaders, teams/crews, and the unit as a whole. For service members, the operational domain is where leaders undergo the bulk of their development. It includes deployable units and organizations designed and maintained to accomplish strategic, operational, and tactical missions.

In the operational domain, experience is essential for learner and leader development. Experience enables leaders to execute command at all levels of responsibility. It is where learners and junior leaders achieve technical competence, mid-grade leaders further develop their ability to lead units and organizations, and senior leaders are developed to contribute to national and geo-political strategy. Learning activities include: progressive training conducted at home station, at regional collective training centers, and at mobilization centers; and during Joint exercises and Combat Training Center (CTC) rotations. These exercises may occur while units are operationally deployed. For the reserve component forces, the operational domain includes reserve centers, armories, and state training areas and facilities (U. S. Army, 2018).

The operational domain, with minor exceptions not discussed here, depends on the institutional domain to materially develop and provide learning support products, information, and materials needed by the operational domain, to include staffing and operating collective and regional training and mobilization centers, so that the operational domain can concentrate on their warfighting, and training for warfighting, roles.

The self-development domain “includes planned and goal-oriented learning that reinforces and expands the depth and breadth of an individual’s knowledge base and self-awareness. Self-development bridges learning gaps between the operational and institutional domains and sets conditions for continuous learning and growth. Required conditions in the self-development domain follow life-long learning model" (U. S. Army, 2017, p. 4). The three types of self-development as defined by the Army but applicable to all services are as follows:

- Structured self-development. Learning that continues throughout a career and that is closely linked to and synchronized with classroom and on-the-job learning.
- Guided self-development. Recommended but optional learning that will help keep personnel prepared for changing technical, functional, and leadership responsibilities throughout their career.
- Personal self-development. Self-initiated learning where the individual defines the objective, pace and process, such as: pursuing college education, advanced degree programs, seeking mentoring or coaching opportunities, completing leadership or other assessments, self-initiated credentialing opportunities, etc. (U. S. Army, 2017, p. 4).

The self-development domain builds on the institutional domains structured learning and the operational domains on the job learning to augment the learner's professional competence, and to help meet the learner's personal objectives. Self-development domain learning requires learners to "develop a personal commitment to gain knowledge and to learn," with "few or no boundaries regarding topics of personal and professional interest;" that the institutional domain make appropriate learning resources available that are "meaningful, engaging to use, and accessible when needed and as needed;"

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and that operational domain leaders “limit their desire to direct subordinates to pursue specific fields of study for self-development, and then encourage and expect that subordinates seek knowledge on a topic or field of study that interests them” (U. S. Army, 2017, p. 4).

BCAC Business Process Model in the DOD

As explained earlier, the BCAC process is used when the learning system component is expected to “be acquired as a business system that will be aligned to commercial best practices and that will minimize the need for customization of commercial products to the maximum extent possible” (Office of the Under Secretary of Defense for Personnel and Readiness, 2017, p. 4). BCAC is a process that “seeks to develop and implement business/acquisition processes to acquire systems more efficiently” by facilitating “changes in the process through doctrine, organization, training, materiel, leadership and education, personnel, facilities, and policy to drive performance improvements, efficiencies and effectiveness” (Defense Acquisition University, 2017). Five phases accomplish the purpose:

- Capability Need Identification: The objective is to establish a clear understanding of needed business capabilities so that the functional sponsor and MDA can decide to invest time and resources into investigating business solutions.
- Business Solution Analysis: The objective of this phase is to determine the high-level business processes supporting the future

- capabilities so that the functional sponsor and CAE or designee can maximize use of existing business solutions and minimize creation of requirements that can only be satisfied by a business system.
- Business System Functional Requirements & Acquisition Planning: An objective of this phase is to establish the acquisition strategy that will support functional requirements.
- Business System Acquisition Testing & Deployment: The objective of this phase is to achieve organizational change through business process changes and delivery of the supporting business system, with minimal customization.

Capability Support: The objective of this phase is to provide enduring support for the capability established by the business system. This includes active engagement in both functional and technical opportunities for continuous process improvement to maintain the relevance of the capability, the supporting technology, and the hosting solution. (Defense Acquisition University, 2017.)

The Milestone Decision Authority (MDA) is the overall executive sponsor responsible of any Major Defense Acquisition Program (MDAP). The Component Acquisition Executive (CAE) is a single official responsible for all acquisition functions within a DOD component.

The important thing to remember about BCAC or any acquisition process is that for it to be able to provide the tooling (learning technology) systems that support the learning factory workers throughout the ADDIE business

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process it must have approved functional requirements that "describe how the business system will achieve the future business processes" (Office of the Under Secretary of Defense for Acquisition, 2017, p. 17) and it must have learning engineers so that the learning technology systems are built to approved requirements documents or else they have little or no chance of success.

ADDIE Business Process Model in the DOD

Purpose—In 1974, a year after the United States ended its direct involvement in the Vietnam War and in anticipation of joint warfare in defense of the North Atlantic Treaty Organization (NATO) nations against the Warsaw Pact, the heads of the training commands for the U. S. Army, Air Force, Navy and Marine Corps began an initiative to "develop a common doctrine and procedures for systematic development of training and education curricula" (Anderson, 1986, p. 1). The U. S. Army Training and Doctrine Command (TRADOC) funded the effort; the U. S. Navy provided the first chair for the enduring Inter-service Training Review Organization (ITRO), and Florida State University conducted the research (Anderson, 1986).

Out of that effort came the still-in-effect agreement that the uniformed services would systematically develop training methods, training media, and instructional materials using the Instructional Systems Development (ISD) approach, that utilized the Analysis, Design, Development, and Implementation (ADDI) model, in a process to be called the Systems Approach to Training (SAT) (Anderson, 1986). At some point before 1989,

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Evaluation was added to ADDIE—possibly by the American Society for Training and Development (ASTD) (Molenda, 2015, p. 2). In 2001, the ITRO first published the five inter-service ISD procedures handbooks for implementing the science of ISD, described as "the most basic and authoritative document on that subject in the world" (Anderson, 1986, p. 1).

FUTURE LEARNING SYSTEM COMPONENTS (AKA THE LEARNING FACTORY)

Policy for the learning factory

The DOD establishes policy, assigns responsibilities, prescribes procedures, and establishes information requirements via the use of DOD Instructions (DODI). The DODI that provides guidance for developing, managing, providing, and evaluating DL for DOD military and civilian personnel is DODI 1322.26 Distributed Learning (DL), dated 5 Oct 2017.

DODI 1322.26 directs "that DOD personnel will have access to state-of-the-art, affordable, effective, and convenient education and training opportunities . . . related to education and training;" "that DL is an affordable, effective, and convenient medium for education and training activities;" that "during the instructional design process, DL should always be considered as a potential instructional delivery option;" that "DL capabilities will be based on interoperable standards;" and that "DL systems, content, assets, and exchange data will be shared throughout DOD" to the "maximum extent possible using a net-centric DOD architecture and common standards" (Office of the Under Secretary of Defense for Acquisition, 2017, p. 3). The DOD Component heads are required to implement the DoDI to include developing their own implementation guidance that will be specific to them.

DoDI 1322.26 directs "the DOD components shall when developing or acquiring DL search for existing DL content that may be reused or repurposed;" design and develop DL "that leverages learning science, technology, specifications, and standards to produce state-of-the-art, affordable, effective, and convenient education and training;" consider "security of networks, data, and personal information in DL content and systems development, and comply with all applicable policies and requirements for the protection thereof" (Office of the Under Secretary of Defense for Acquisition, 2017, p. 6). It also directs the DOD components to "make existing DL assets, content, and other reusable resources visible and accessible to other DOD components" and "record, analyze, measure, manage, and, as appropriate, exchange learning experience data among themselves" (Office of the Under Secretary of Defense for Acquisition, 2017, p. 6).

Plans for the learning factory

During the acquisition process different kinds of plans are needed to build components of the learning factory and to provide the workforce that will operate the factory. The BCAC process uses approved capability requirements documents to acquire factory tools, that may be systems, by either

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purchasing them or building them. DOD learning technology tools (systems) that are acquired are required to conform to the applicable interoperable standards, which are almost always international standards developed by IEEE or ISO.

For widest applicability and longest usability, when designing learning technology tools (systems), standards are often used "as-is," meaning the tool (system) strictly complies with the standard. For example, the IEEE Learning Technology Standards Committee (LTSC) developed Computer Managed Instruction (CMI) group of standards are often applied this way. The CMI standard is a multi-part standard that allows "different lessons to work with different CMI systems . . . courses to move from one CMI system to another with minimal effort (course interchange/interoperability) . . . modification/expansion of a course by any instructor with his/her preferred CMI tools," and "enable easier analysis of student data from different lessons" (IEEE Learning Technology Standards Committee, 2007). Two CMI standards from this group that the learning factory must comply with are the CMI Data Model (1484.11.1) standard that describes "a data model to support the interchange of agreed upon data elements and their values between a learning-related content object and a runtime service (RTS) used to support learning management" and the ECMAScript API (1484.11.2) standard that describes "an ECMAScript application-programming interface (API) for content-to-runtime-services communication" (IEEE Learning Technology Standards Committee, 2007).

If no international standard exists for the factory component yet, the DOD may permit acquisition of a tool based on a specification adapted from a standard or another specification instead. For example, the DOD Sharable Content Object Reference Model (SCORM) specifications that specify the construction of DL systems and content are based upon not only the IEEE CMI Data Model (1484.11.1) and ECMAScript API (1484.11.2) standards but also the IEEE Learning Object Metadata (LOM) group of standards and the IMS Content Packaging and Simple Sequencing specifications. The LOM standard is a multi-part standard that allows the reusability of learning objects, to aid discoverability, and to facilitate their interoperability, usually in the context of online learning management systems (LMS). Two LOM standards from this group that the learning factory must comply with are the LOM (base) Standard (1484.12.1) standard that describes "specifies which aspects of a learning object should be described and what vocabularies may be used for these descriptions; it also defines how this data model can be amended by additions or constraints" and the XML Schema Definition Language Binding for LOM (1484.12.3) standard that describes "define how LOM records should be represented in XML" (IEEE Learning Technology Standards Committee, 2007).

Learning technology systems and labor for the learning factory by ADDIE stage

This section describes the labor force and technology systems necessary for a notional DOD learning factory. It's notional because the DOD is undergoing a government mandated reform initiative to consolidate systems that may be

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the subject of a follow-on paper when that data becomes releasable to the public. Enough is known publicly to acquaint the prospective DOD learning engineer with the broad strokes that follow—that are based on the author's work and research with the DOD learning systems. The integration definition (IDEF) chart for human-system interaction design, typically referred to as an IDEF-08 chart, is shown at Figure D.

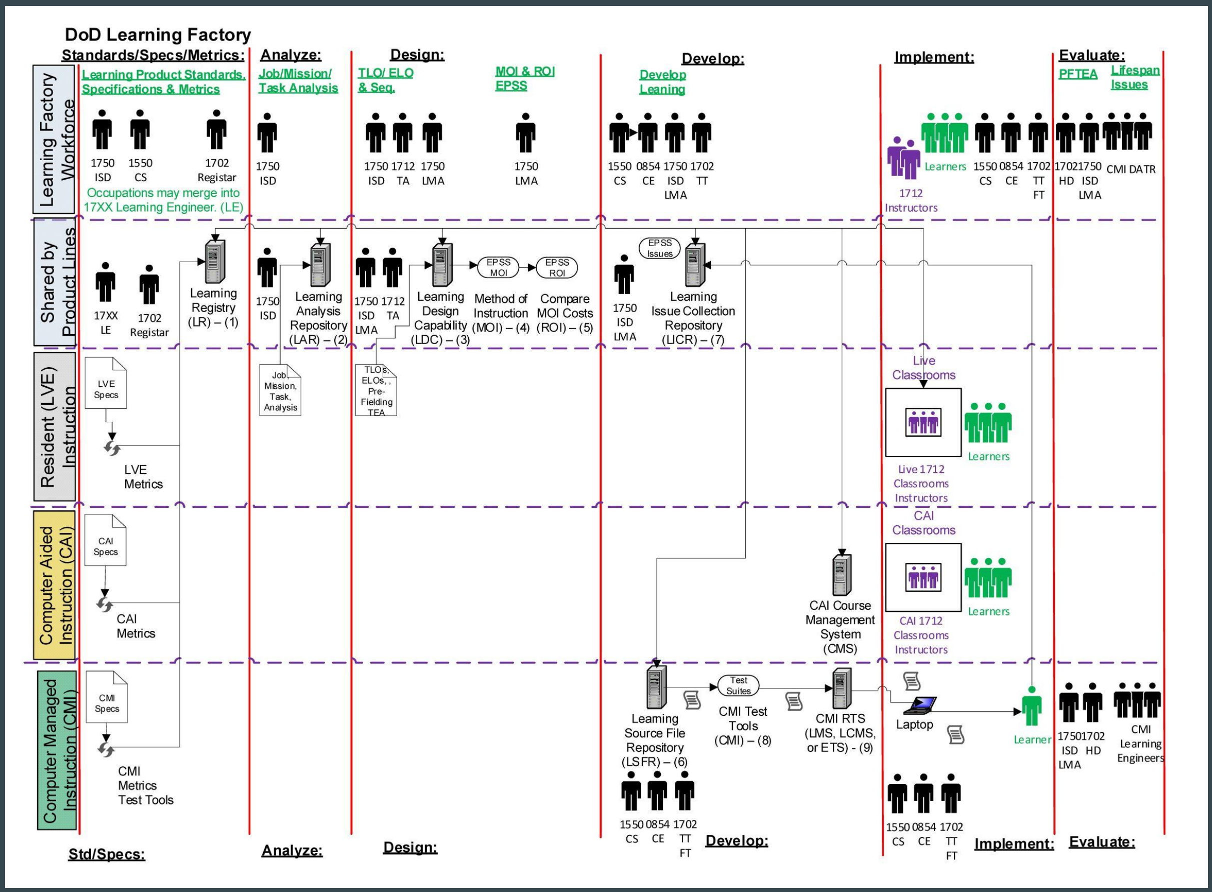

Figure D. Sample DOD Learning Factory Human-System Interaction Design

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Beginning in the ADDIE Analysis stage

Learning Registry (LR). The LR will provide a single capability to register, track and manage all learning products throughout their life cycle life span as they progress through the entire ADDIE process at a high level and the labor required by occupation and skill level for that progress. It will provide the capability for the factory registrar (GS 1702) to create and assign rights in the factory's other components. The LR will collect and report analytics (metrics) for use by learning metrics analysts (GS 1750).

Learning Analysis Repository (LAR). The LAR will provide the capability in the ADDIE Analyze stage for instructional designers (GS 1750) to conduct or update needs analysis, target audience analysis, mission analysis, collective task analysis, job analysis, and individual task analysis, and to store them there. The LAR will support learning product content validation and automatically exchange datum with the item analysis component of the Electronic Testing System (ETS) for Pre-Fielding Training Effectiveness Analysis (PFTEA). The LAR will collect and report analytics (metrics) for use by learning metrics analysts (GS 1750).

Beginning in the ADDIE Design stage

Learning Design Capability (LDC). The LDC will provide the capability in the ADDIE Design and develop stages for instructional designers (GS 1750) and training analysts (GS 1712) to design or update individual and collective learning that can be developed or updated for differing methods of instruction. In the Design stage, the LDC will develop and update individual training plans, course administrative data, and program of instruction resourcing documents; produce or update learning product research reports and learning design documents; and develop or update design documents. For course design documents in the Design stage, the LDC must create or update instructor requirements, terminal learning objectives, enabling learning objectives, structure and sequence design information, outline and specify learning step activities, and support development of course assessment and evaluation plans. In the develop stage, the LDC will develop and update formative evaluation reports, course management plans, assessment instruments, and final evaluation plans. In the develop stage, the LDC will support learning product development. The LDC will collect and report analytics (metrics) for use by learning metrics analysts (GS 1750).

Between the ADDIE Design and Develop stages

Method of Instruction Selection (MOI) EPSS. Selection of the best method of learning (instruction—sometimes abbreviated MOI) to develop, implement, and evaluate doctrinal content for is a complex decision involving many complicated variables. Making the wrong choice can have, and for some has had, disastrous consequences that may not be apparent until after potentially hundreds of thousands or even millions of dollars have been spent and the anticipated date for the learning to begin has come and gone with no usable learning materials or with a MOI that cannot scale to large numbers of learners as might have been intended.

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In many cases the MOI selection is based on the wrong criterion. It might be that the selecting official prefers the technology that the official is familiar with or that a subordinate is familiar with. Or the selecting official has a bias against a MOI based upon what they had heard about the MOI rather than what was the case with the MOI. Using an EPSS to make that initial determination ensures that all of the applicable criterion is considered. It ensures that, as stated by the Rolling Stones, “You can't always get what you want, But if you try sometimes you just might find, You get what you need” (Beviglia, 2016).

Because of the large number of variables that must be considered, and the fact that the variable decisions cross several occupational expertise specialties—especially for CAI and CMI, the logical way to determine the best method of implementing learning is by using a logic chart of decision criterion to guide the determination instantiated in an Expert Performance Support System (EPSS). Composed of yes and no questions in a logical order a MOI EPSS can determine the best-fit MOI, down to the sub-types of more complex CMI. Figure E shows a sample logic chart that might soon update the Army’s current Delivery System Selection EPSS.

What a Learning Engineer Needs to Know about DoD Learning

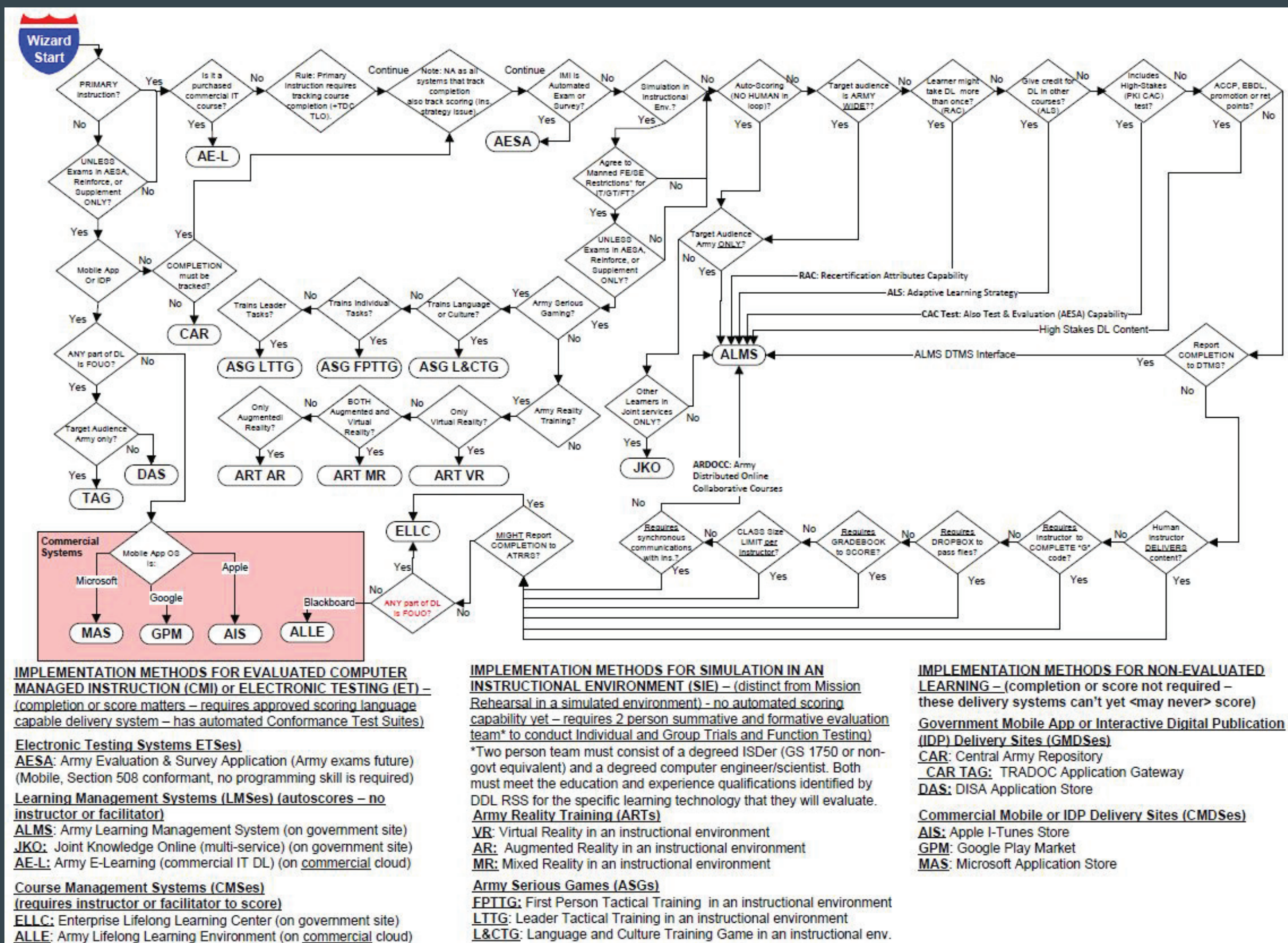

Figure E. Sample Logic Chart for Method of Instruction Expert Performance Support System.

Cost Comparison (AKA Return on Investment <ROI> EPSS). Although cost comparison and return on investment are different calculations, within the DOD the ROI term is so frequently confused with cost comparison that they are considered synonymous for this discussion here.

Because the DOD uses government funds to implement the learning in the MOI recommended by the MOI EPSS or in the MOI the selecting authority decided to use if other than that recommended by a MOI EPSS, an additional step may be required before entering the ADDIE Develop stage. That step is to compare the anticipated costs of implementing the learning by the selected MOI with the anticipated costs of implementing it via other MOIs. This is required because in the DOD cost is a required independent variable for any acquisition decision and that should include MOI determinations for learning. Analysis has shown that certain variables can significantly affect the cost of developing, implementing, and evaluating learning so much that the cost of a preferred MOI may lead to a decision to implement the learning in a different MOI than had been recommended had cost not been a required independent variable.

Figure F shows a sample total cost per learner cost by MOI chart. It is important to understand that unless all the required variables are populated, and populated accurately, that the results can easily become misleading and subject to being taken out of context. The most important variables for cost are student (learner) load, whether travel is required, and for who (learner or instructor). This is because the largest cost driver for live (resident) learning is travel costs. For example, the sample data below suggests using CMI over CAI and Live because of the numerous numbers of learners in the course (600,000 in row 5 column 6) that drive the per learner cost to $3.84 for the first three-year build for the course and $7.67 if it is rebuilt in three years vice $207.11 for CAI and $1172.22 for live (resident). Calculated just on total costs the total ADDIE costs in the Develop and Implement stages for the three primary MOI methods in the sample is ~ $2M for CMI, ~$40M for CAI, and ~$730M for live – CAI costs driven by the costs of the instructors and the live costs driven by instructor costs and student travel (TDY).

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	A	B	D	E	G	H
1	**Shared data entry fields (only data that crosses IMI types)**					
2	Classroom cost per day per learner (constant)($418/260 days)	$1.61				
3	Loaded annual cost for each instructor (avg grade that class)	$100,000.00				
4	TDY cost per day for each learner (for avg grade that class)	$100.00				
5	Total Learner Target Audience Throughput (not annual)	600,000				
6	**CMI <Distant> (auto-scoring, learner only, no instructor or classroom) - All learners can take learning at same time**	**CMI Costs**	**CAI <Distributed> (human-scoring, learner and instructor in different classrooms) *May have CMI part**	**CAI Costs**	**Live <resident> (human-scoring, learner and instructor in same classroom) - Instructor to learner ratio in effect**	**Live Costs**
7	**Single IMI type data entry field (only enter CMI data here)**		**Single IMI type data entry field (only enter CAI data here)**		**Single IMI type data entry field (only enter Live data here)**	
8	Finished IMI Hours	76	Length of course in hours (often different than IMI hours)	76	Length of course in hours (often different than IMI hours)	76
9	Contract IMI Hours (anticipated labor cost is x IMI hours)	182	TDY Days (TDY period in days + 1 day travel each end)	11.5	TDY Days (TDY period in days + 1 day travel each end)	11.5
10	Content Packages per course (Combined Topics & Exams)	46	# of Classrooms Required (CAI = 1 + ea location)	10	# of Classrooms Required (Live = 1 location)	1
11	**ADDIE Stage**		**ADDIE Stage**		**ADDIE Stage**	
13	**Analysis (fixed - Job analysis, etc. - by ISD - no tools)**		**Analysis (fixed - Job analysis, etc. - by ISD - no tools)**		**Analysis (fixed - Job analysis, etc. - by ISD - no tools)**	
14	**Design (fixed - TLOs, ELOs, Sequencing - done in TDC)**		**Design (fixed - TLOs, ELOs, Sequencing - done in TDC)**		**Design (fixed - TLOs, ELOs, Sequencing - done in TDC)**	
15	**Development (does not include ISD work in ADDIE Design)**		**Development**		**Development**	
16	TADLP Contract Cost	$2,295,802.68	Instructor Content Hour (ICH) not computed		Instructor Content Hour (ICH) not computed	
17	Finished IMI Hours	76	Non-Instruction Content Hour (NICH) not computed		Non-Instruction Content Hour (NICH) not computed	
18	Cost Per IMI Hour (constant)	$ 30,207.93				
19	Learner Target Audience Throughput	600,000				
20	*Development Cost Per Learner for This Course*	$ 3.83	*Development Cost Per Learner for This Course*		*Development Cost Per Learner for This Course*	
21	**Implementation (Includes Delivery)**		**Implementation (Includes Delivery)**		**Implementation (Includes Delivery)**	
22	TADLP Government Review (SCORM Log Review)		Total Learner TDY cost for Target Audience	$0	Total Learner TDY cost for Target Audience	$690,000,000
23	Impl,. Br. GAR Labor Rate (GS6 Step 6)(constant)	$ 18.03	# Instructors Required for Every 25 students	24,000	# Instructors Required for Every 25 students	24,000
24	IMI Hours (anticipated labor cost is x IMI hours)	182	# Ins Teaching 40 Weeks a Year (20 2 week classes)	1,200	# Ins Teaching 40 Weeks a Year (20 2 week classes)	1,200
25	Hours to complete GAR (IMI x 1.6 constant)	291.2	# Ins Teaching 40 Weeks a Year (40 1 week classes)	$0	# Ins Teaching 40 Weeks a Year (40 1 week classes)	
26	GAR Cost for this course	$ 5,250.34	# Ins Needed for Course if Spead Across 3 Yrs	400	# Ins Needed for TDY Course if Spead Across 3 Yrs	400
27	*GAR Cost Per Learner for This Course*	$ 0.01	Ins Cost Annually (loaded $100K assumption)	$40,000,000	Ins Cost Annually (loaded $100K assumption)	$40,000,000
28	DLS ACAT Program Function Testing and Fielding		Learner TDY cost per TDY	$0	Learner TDY cost per TDY	$1,150.00
29	FY14 ALMS Cost Per Training Unit Offering (constant)	$ 1.86	Cost Per Annual Student for Ins (Ins/3 years)	$22.22	Cost Per Annual Student for Ins (Ins/3 years)	$22.22
30	Content Packages per course (Combined Topics & Exams)	46	Cost of One Classroom For One Course Length Per Learner	$184.88	Cost of One Classroom For One Course Length Per Learner	$0.00
31	FT and Fielding Cost for This Course	$ 85.56				
32	*Implementation Cost Per Learner for This Course*	$ 0.0001	*Implementation Cost Per Learner for Course (TDY + Ins + CR)*	$207.11	*Implementation Cost Per Learner for Course (TDY + Ins + CR)*	$1,172.22
33	**Evaluation (Computations Not Computed)**		**Evaluation (Computations Not Computed)**		**Evaluation (Computations Not Computed)**	
34	Army Training Help Desk (ATHD)		Army Training Help Desk (ATHD)		Army Training Help Desk (ATHD)	
35	ATHD RightNow Liscense Cost (for all ATHD Agents)		ATHD RightNow Liscense Cost (for all ATHD Agents)		ATHD RightNow Liscense Cost (for all ATHD Agents)	
36	TKT Hours (anticipated labor cost is x tickets)		TKT Hours (anticipated labor cost is x tickets)		TKT Hours (anticipated labor cost is x tickets)	
37	DL DART Costs					
38	*Evaluation Cost Per Learner for This Course*		*Evaluation Cost Per Learner for This Course*		*Evaluation Cost Per Learner for This Course*	
39	**Totals**		**Totals**		**Totals**	
40	*Total Cost for selected Method of instruction*	$2,301,053.02	*Total Cost for selected Method of instruction*	$40,000,000	*Total Cost for selected Method of instruction*	$730,000,000
41	*Total Cost Per Learner for This Autoscoring DL Course*	$ 3.84	*Total Cost Per Learner for This Course*	$207.11	*Total Cost Per Learner for This Course*	$1,172.22
42	*Total Cost Per Learner if course is rebuilt after 3 years*	$ 7.67				

Costs Per Learner by IMI type | Charts

Ready | Average: 257433684.3 | Count: 6 | Sum: 772301053 | 100%

Figure F. Sample Total Cost per Learner Cost Comparison Chart for Method of Instruction.

Changing just one of the critical variables however changes the calculations to be considered tremendously. For example, changing the student (learner) load from 600,000 to 600 changes leaves the cost per learner and CMI costs the same but changes the total ADDIE costs in the Develop and Implement stages from ~$40M to ~40K for CAI, and ~$730M to ~730K for live, highlighting while great care must be taken to examine every use case on its variables.

In the sample there are no costs calculated for the ADDIE Analysis, Design, and Evaluate stages. Analysis and Design stage costs are not included because these costs are incurred before any learning MOI decision is recommended or made so they have no effect upon the MOI selection. Evaluate stage costs are not included because they have not yet been calculated. When they are they will likely raise the CMI costs to an as-yet undetermined degree because CMI is more dependent on metrics (analytics) to identify issues quickly and on an emergency diagnosis and repair team to ensure that critical CMI remains available to learners.

Beginning in the ADDIE Develop stage

Learning Source File Repository (LSFR). The LSFR will provide the capability, starting in the ADDIE Develop, Implement, and Evaluate stages, for computer scientists (GS 1550), computer engineers (GS 0854), and training technicians (GS 1702) to transfer, store, check-in/check-out, search, and manage learning product source files by versions through creation, testing, fielding, and retirement. The LSFR will store, package and test learning objects and content packages and perform other scoring language tests performed manually now. The LSFR will collect and report analytics (metrics) for use by learning metrics analysts (GS 1750).

Learning Issue Collection Repository (LICR). The LICR will provide the capability, starting in the ADDIE Design, Implement, and Evaluate stages, for computer scientists (GS 1550), computer engineers (GS 0854), instructional designers (GS 1750), and training technicians, function testers, and help desk agents (all GS 1702s) to collect, track, diagnose, manage complaints (issues) about, and report metrics upon all learning product types using approved learning incident codes during development, individual and group trials, function testing, acceptance review, and during its life-cycle life-span after fielding. The LICR will use automated detection capabilities to identify the learning the learner is taking and an Expert Performance Support System (EPSS) to guide personnel that use the LICR to identify the cause of issues, recommend or implement fixes, or refer for advanced diagnosis and repair by advanced diagnosticians. A sub-component will automatically capture the learner's computing environment details and store them for diagnosis. The LICR will collect and report analytics (metrics) for use by learning metrics analysts (GS 1750).

CMI Learning Management Systems. As you may recall, CMI measures mastery by automated evaluation that requires that the CMI code calculate and report learner scores to a run-time service (RTS) that is usually either a Learning Management System (LMS), a Learning Content Management System (LCMS), or an Electronic Testing System (ETS).

Learning Management System (LMS). The typical RTS used to deliver auto-scoring CMI is an LMS, that the IEEE defines, and the DOD uses, as a computer system that provides the capability starting in the ADDIE Implement stage, to register learners, schedule learning resources, control and guide the learning process, analyze and report learner performance, and schedule and track learners. But before then. in the ADDIE Develop stage and continuing through the ADDIE Evaluate stage, it provides the capability for learning factory computer scientists (GS 1550), computer engineers (GS 0854), instructional designers (GS 1750), and training technicians, function testers, and help desk agents (all GS 1702s) to collect, track, diagnose,

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manage complaints (issues) about, and report metrics upon all learning product types using approved learning incident codes during development, individual and group trials, function testing, acceptance review, and during its life-cycle life-span after fielding. While an LMS must have the delivery files, it may or may not have the source files that made them.

Learning Content Management System (LCMS). An LMS that uses a proprietary authoring system and that stores the source files used to create executable files is an LCMS.

Electronic Testing System (ETS). An ETS is a specialized RTS that can develop, store, manage, and administer learner tests, evaluations, and surveys from a central web-based system integrated with other training systems (Live, CAI, and CMI). It also provides automated item analysis to support Pre and Post Fielding Training Effectiveness Analysis (PFTEA).

The key distinction between systems that Manage CMI based learning and systems that Report on some aspect of CMI based learning, such as a Learning Record Store (LRS), is that the LMS, LCMS, or ETS is responsible for managing the learners through the learning process. Thus, the DOD LMS, LCMS, or ETS must be of sufficient scale and transactional capacity to manage literally millions of learners in tens or hundreds of millions of some-times lengthy (SCORM 2004 3rd Edition) tracking and scoring transactions—while computing, recording, and reporting the learners CMI interactions for TEA item analysis and to prevent cheating. It’s hard.

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Testing Tools. CMI must be supported in the learning factory by tools and documents, some used by computer scientists (GS 1550) and others by training technicians (GS 1702), that determine if the CMI conforms to CMI standards and specifications for CMI and the scoring language used. Without these tools the factory could not operate cost-efficiently. For example, for CMI that is SCORM 2004 3rd Edition conformant, the tool set must include a Conformance Test Suite (CTS) for both the RTS and the learning content, a Resource Validator that Identifies files found or not found in the content package but listed in the manifest and vice versa, a Metadata Editor that does as it is titled, and a Log Parser that analyzes logs from other tools and outputs a comprehensive validation log for SCORM 2004 3rd Edition CMI.

Beginning in the ADDIE Evaluate stage

Currently, immediately after a course is fielded in the Delivery sub-part of the ADDIE Implement stage, issues with the course should be reported into an analytics (metrics) system monitored by learning metrics analysts (GS 1750). They may be entered directly by the learners or via learner communications with a help desk manned by help desk agents (may be GS 1702). Whether learners or agents, they should be assisted by a logic chart inculcated within an EPSS that uses yes and no responses to a series of questions to rapidly identify the correct incident code path to assign to the ticket to speed diagnosis for management triage efforts. Figure G shows a sample process used to conduct the necessary analysis for the logic chart to determine incident code paths, sequence the chart, assign incident codes to the path, and to create the EPSS. This work is performed by computer scientists (GS 1550),

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computer engineers (GS 0854), instructional designers (GS 1750), and training technicians, function testers, and help desk agents (all GS 1702s) working together, and it must be updated periodically.

Sometime after a learning course is fielded, typically not earlier than 180 days afterward, post-fielding TEA should be performed by the instructional designers (GS 1750) with the TEA including item analysis as part of the TEA.

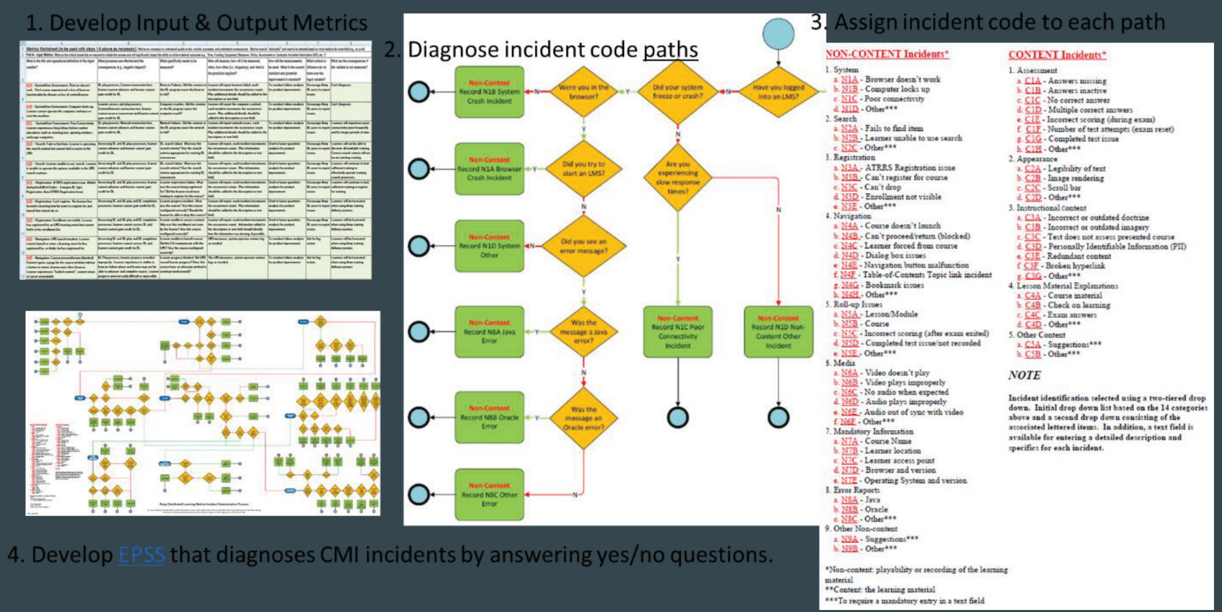

Figure G. Sample Process for CMI Incident Code Path Determination for Analytics.
Adapted from "Learning Analytics for the DL Courseware Factory; Analysis, Solutions, Approved Capability Requirements to Support Them, and Way-ahead, by M. Bonnett, 2018, in iFest 2018—The Future Learning Ecosystem."

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During the course's lifecycle lifespan, the computer scientists (GS 1550) and learning metrics analysts (GS 1750) will frequently (weekly) analyze collected Evaluation stage data to produce the reports at Figure H (issues with courses) and Figure I (issues with technology).

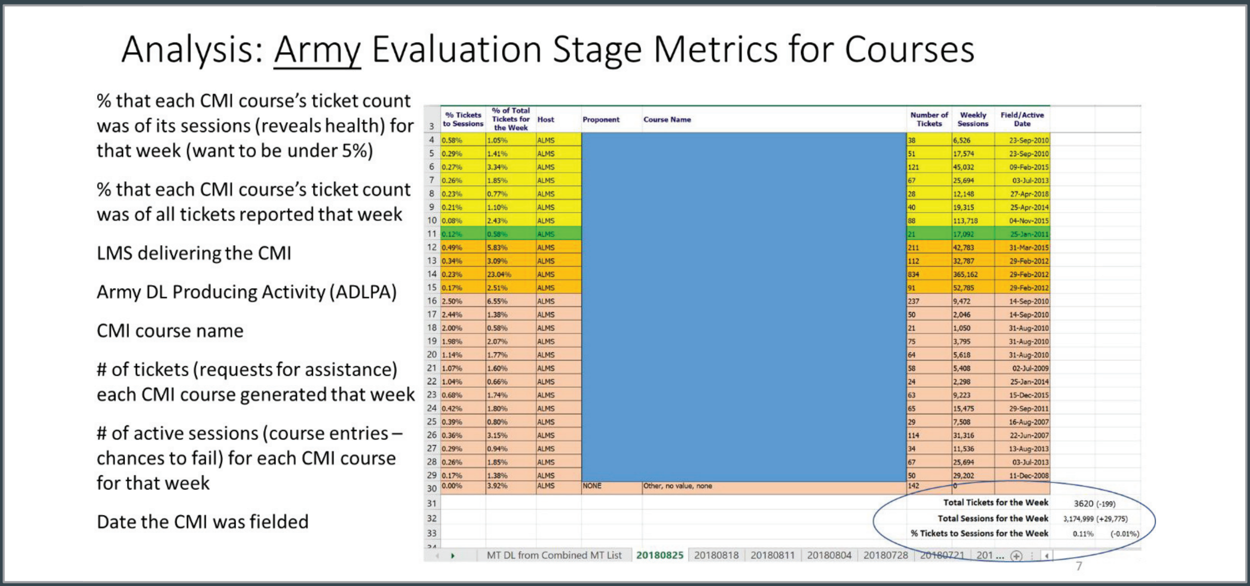

Figure H. Sample Evaluation Stage Course Metrics for Analytics. Adapted from "Learning Analytics for the DL Courseware Factory; Analysis, Solutions, Approved Capability Requirements to Support Them, and Way-ahead, by M. Bonnett, 2018, in iFest 2018—The Future Learning Ecosystem."

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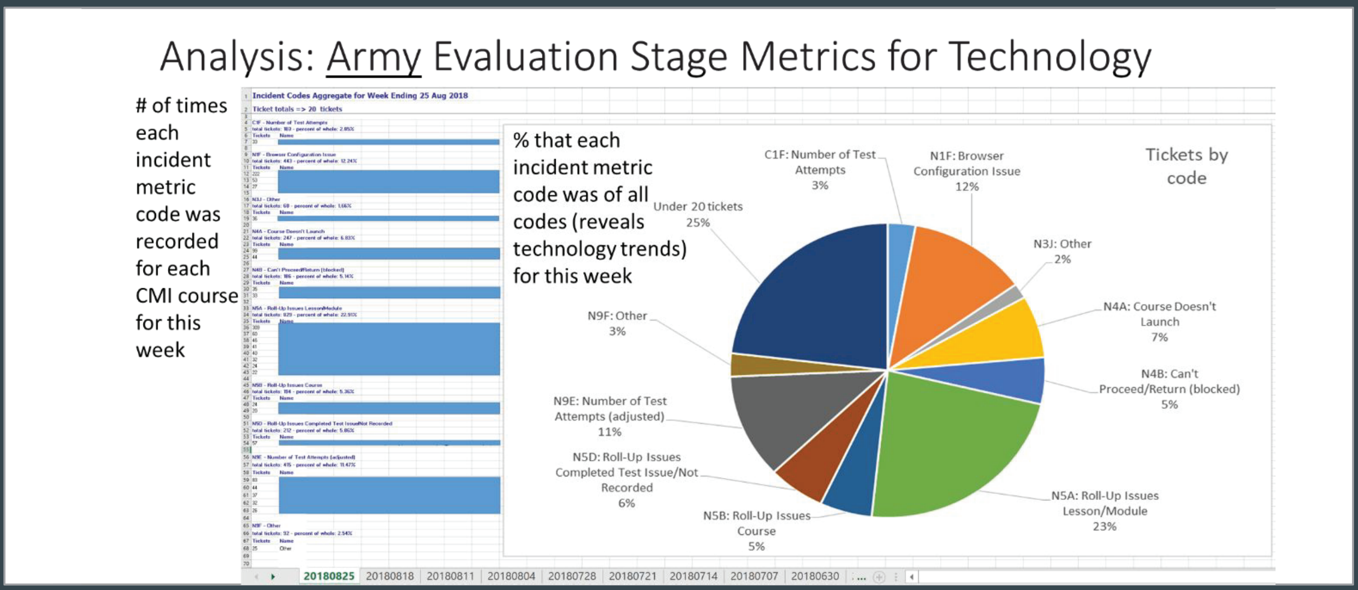

Figure I. Sample Process for CMI Incident Code Path Determination for Analytics.
Adapted from "Learning Analytics for the DL Courseware Factory; Analysis, Solutions, Approved Capability Requirements to Support Them, and Way-ahead, by M. Bonnett, 2018, in iFest 2018 —The Future Learning Ecosystem."

Learning analytics for the learning factory

Measurement Analytics. Within the ADDIE process in the DOD CMI is too often produced and sustained over its life-cycle life-span with issues that afflict it as the learner's computing environment changes over time—aging it out of usefulness. Too often the malfunctioning CMI is not reported to the authorities responsible for the CMI because there were no metrics in place to catch the issues or the metrics were too late in ADDIE—in the Evaluate stage if at all.

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The failure to adapt metrics earlier in the ADDIE process and use them throughout the CMI's life-span can cause project failure in the Develop stage, failure to identify and repair issues in salvageable CMI in the Implement stage, and an expensive over-reliance on manned Help Desks and failure to capture data for Post-Fielding TEA (PFTEA) in the Evaluate stage. Unfortunately, within the DOD, too little analytics occur in too few ADDIE stages for the learning factories to be as proactive as they should be—too often limited to the Evaluate stage.

In 2017 the Advanced Distributed Learning (ADL) Initiative, in its DL Gap Report, recommended increased use of standards and specifications and incorporation of learning metrics (Advanced Distributed Learning Initiative, 2017). A year later, the chairman of the Defense Science Board (DSB) stated in their 2018 Final Report of the DSB Task Force on the Design and Acquisition of Software for Defense Systems, "Software is a crucial and growing part of weapons systems and the Department needs to be able to sustain immortal software indefinitely. The Task Force concluded that the DOD would benefit from the implementation of continuous iterative development best practices as software becomes an increasingly important part of defense systems" (Defense Science Board, 2018). That report recommended that the DOD transition to software factories, utilize agile software practices, and utilize metrics.

CMI needs to be analyzed throughout the ADDIE process to ensure the success of the learning factory, especially if Agile techniques will be used. Per Bonnett (2018) and Davis (2015), within the designated ADDIE stages, the Agile questions to answer are in Figure J.

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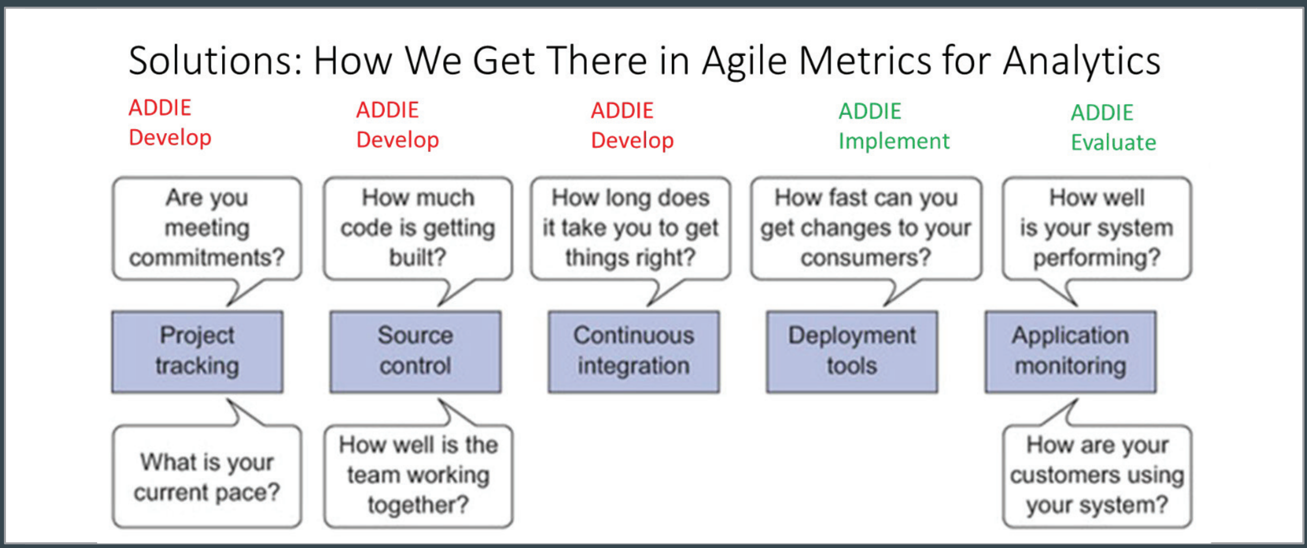

Figure J. Solutions: How We Get There in Agile Metrics for Analytics.

Adapted from "Learning Analytics for the DL Courseware Factory; Analysis, Solutions, Approved Capability Requirements to Support Them, and Way-ahead," by M. Bonnett, 2018, in iFest 2018 — The Future Learning Ecosystem" and from "Agile Metrics in Action: How to Measure and Improve Team Performance," by C.W.H. Davis, 2016.

BARRIERS TO FUTURE LEARNING SYSTEM

For one learning factory to support all the DOD, the DOD would need to standardize on learning product standards and specifications—and enforce strict conformance to them. As it is, each service tends to make its own decisions about whether a new learning technology such as serious games, or virtual or augmented reality have achieved a high enough Technology Readiness Level (TRL) to adapt as instructional media. Decisions to adapt seem too rarely to be based upon data proving they are ready to be used at scale, or that learners will use them, but too often on whatever the last shiny object was displayed at the trade fairs DOD people attend.

One example already discussed is the requirement that the Army has that CMI must capture, record, and report the learner's interaction data to the RTS—which the DOD does not. Learner interaction data is critical for Item analysis and factor analysis that should follow it to ensure validity, and discriminant analysis between adaptor and non-adaptor responses for test instruments (Moore & Benbasat, 1991). Factor analysis is "used for theory and instrument development and assessing construct validity of an established instrument when administered to a specific population. Once the internal structure of a construct has been established, factor analysis can also be used to identify external variables . . . that appear to relate to the various dimensions of the construct of interest . . ." (Pett, Lackey, & Sullivan, p. 3).

In short, unless DOD CMI captures and reports the CMI learner's interaction data to the RTS no factor analysis can be conducted and there will be no way to tell what test items should to be developed during Pre-Fielding TEA or how the items should be changed during Post-Fielding TEA. If the CMI cannot reliably discriminate (tell) between learners that mastered the knowledge and those that did not—via the evaluation—they why spend limited DOD resources on it? And as discussed earlier, without reporting the CMI interaction data to the RTS, it will be impossible to prove a learner cheated on an exam to get credit (promotion, retention, etc.).

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Tendency to focus only on learner vice factory needed to support learner

Within the DOD there has historically been an unfortunate tendency to provide only capabilities needed to support the labor, tooling, and measurement analytics for learning where the capabilities directly support the learner in the delivery sub-part of the ADDIE Implementation stage, too often ignoring the requirements of the learning factory in the other ADDIE stages. While the learner should be the focus of learning, learning factories cannot succeed in producing and maintaining learning unless they too are supported by labor, tooling, and measurement analytics capabilities in all ADDIE stages.

For example, within the Army the ability for The Army Distributed Learning Program (TADLP) to produce and maintain Distributed Learning (DL) suffered from such an absence of necessary capabilities when another TRADOC Capability Manager (TCM) was responsible for supporting TADLP that the RAND Corporation in its 2012 report, “Making Improvements to The Army Distributed Learning Program,” recommended TADLP be designated its own capability developer rather than continue to depend upon other capability developers (Shanley et al., 2012). Stating “Because the execution of DL is heavily dependent on technological capabilities, achieving an expanded DL program is strongly related to TCM combat developer success” and that “improvement of the TCM’s performance in the combat developer role is needed,” TADLP should be the combat developer for technology that supports TADLP execution.

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TADLP became a TCM in 2012 and for five years much progress was made in developing and approving the capability requirement sets needed to produce the tools and measurement (analytics) necessary to support DL across all ADDIE processes—not just the Implementation stage. These requirements that were also passed to the DOD to mitigate would have provided the Army and DOD with the tooling needed to efficiently and cost-effectively modernize DOD learning factories. However, in 2017 the Army directed that the same TCM that had insufficiently supported TADLP before 2012 would again perform capability development roles for TADLP. As of this writing, the actions the gaining TCM agreed to do to mitigate the requirements for the factory in these ADDIE stages have not occurred. The gaps remain.

People (Learning Factory Labor)

Within the DOD each component service constantly identifies and assesses gaps in its capabilities and then conducts analysis to identify functional solutions, called mitigation, to those gaps. The solutions may include better training of existing personnel of the hiring of new personnel to mitigate the capability gap or gaps.

A recurring capability gap for the past decade is that across the DOD the services lack sufficient personnel, qualified in both the instructional system design (GS 1750) and software computing (GS 1550) sciences, necessary to design and build their new learning in their new learning technologies in their learning factories.

What a Learning Engineer Needs to Know about DoD Learning

Statements in these gap analysis documents are similar to these from one of them; that the service lacks “sufficient on-demand distributed training capability,” “the ability to provide full access to training products that . . . units require to conduct . . . training without significant external support,” “sufficient DL policy and personnel . . . to quickly develop adaptive, effective T&E products . . . ,” “sufficient and synchronized . . . procedures to . . . quickly insert new technologies . . . to update, change, or redesign . . . T&E programs,” “adequate technology to capture/document training events and <learner> performance . . . ,” “sufficient . . . procedures, and strategy to leverage best practices from industry/academia . . . to quickly insert new technologies . . . that . . . certify . . . relevant . . . learning” and “the ability to . . . quickly integrate new technologies . . . necessary to update, change, or redesign T&E products” (U. S. Army, 2011).

One example is the lack of enough instructional system designers (GS 1750) that have been trained, as part of earning their ISD degree, in how to conduct item and factor analysis and the lack of Computer Scientists (GS 1550) that can program CMI in the difficult aging scoring language used by the DOD that is SCORM 2004 3rd Edition. The shortage of these skills in the DOD is why ETS’s need to be adapted that automatically code the scoring language without error and automatically perform the item and factor analysis until the creation of the “learning engineer” occupation, discussed in this conference, begins to fill the 1750 and 1550 gaps.

What a Learning Engineer Needs to Know about DoD Learning

Propensity of learners to not adapt to new learning technology

Paraphrasing Bonnett (2015, p. 1), although PC technology is physically capable of transitioning new learning technologies such as into mainstream military learning, the DOD has little research available to prove that learners will readily adapt to using them. The DOD is most cases has no research indicating the influence of specific learner factors upon DOD learners' attitude toward using them as a behavior. This potential attitude towards use knowledge gap may become more severe because learners may expect to learn using the new technologies from locations that are distant from other learners in the same learning experience—perhaps even from their own homes using their own computing devices. This learning at the point of need model, already in use in TADLP that includes "simulation, interactive training technologies, mobile learning, . . . , and serious gaming when appropriately utilized within the instructional environment" (U. S. Army, 2017, p. 140), may produce learning products all learners may not want to use, especially if they are asked to use their own computing devices on their time.

An example is the differing service attitudes toward the use of serious games. As stated by Bonnett (2015, p. 7), "Zyda (2005) stated that a serious game is 'a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy and strategic communication objectives' (p. 26). Adcock, Watson, Morrison, and Belfore (2010) stated, 'Serious games are, at their core, exploratory learning environments designed around the pedagogy and constraints associated with specific knowledge domains. This focus on instructional content is what separates games designed for entertainment from games designed to educate' (2010, p. 152)." The Army was initially most serious about serious games but that has waned recently while the Marine Corp seems to have found the Army's former zeal for them. Neither set of interest or investment seems to be based on any serious analysis indicating that learners would choose to use them.

As stated by Bonnett (2015, p. 23) in discussing whether DOD learners will use perform the behavior of participating in a new technology (serious gaming), "As Ajzen and Fishbein stated, 'Individuals will intend to perform a behaviour when they evaluate it positively and when they believe that important others think they should perform it' (1980, p. 6) and that 'to predict a single behaviour we have to assess the person's attitude toward the behaviour and not his attitude toward the target at which the behaviour is directed' (1980, p. 27)."

Unless DOD mandates randomly selected forced samples of the target audience's population to take a validated adaptation survey instrument to determine if the target audience will use a new learning technology before it is adapted, the DOD may need to consider barring services from adapting the new technology, until research shows learners will use it.

Propensity of learners to not complete

Because there is no instructor checking on the learner's progress in CMI as there is in live (resident) and CAI, CMI tends to be susceptible to learner's not completing the learning. While this phenomenon is well known to MOOCs it must be guarded against in CMI that may be used for primary instruction. It is not uncommon for as many as half of the personnel assigned to take mandatory compliance training to not complete it when it is CMI—because no-one is checking and (usually) the only person getting automated notices from the RTS is the learner.

This is because most DOD learning technology systems do not have access to reliable leader-to-led datum that would permit the RTS to send non-completion notices to the learner's leader. Although the leader-to-led data is routinely updated automatically in DOD HR systems the DOD has been unable to populate that data to learning systems—hindering learning.

Propensity of learners to cheat

As with their civilian counterparts that grew up with the same values they did, cheating on examinations for many DOD uniformed personnel and civilian employees "has become second nature" (Wolverton, 2016, p. 4). Worse, the technology and pay-to-cheat industry that has sprung up to assist those that are willing to cheat, and even pay for the assistance, makes it extremely difficult to identify, much less punish, a learner that cheats via a distance exam.

The rewards for cheating that may include retention in the service, promotion over peers that did not cheat, an unearned college degree or certification, or even retirement credit is considered by many to be worth the remote risk of getting caught. Many correspondence courses, for which there are many web-based cheating sites, seem not to be taken not to learn but rather to game the services promotion and retirement systems. That except for the Army, the DOD does not even require that "high-stakes" CMI capture, record, and report to the RTS the learner's CMI interaction data—necessary to prove the learner cheated as well as to support item analysis—sends the message to DOD personnel that choose to cheat that the DOD does not consider cheating to be a problem when it's done via distance technologies. The same message is sent when learners that cheat at live courses are punished but those that cheat via DL are not.

For the prospective DoD learning engineer, the author's hope is that this paper did not dissuade you but rather encouraged you to take up the challenge of embarking upon a career in the federal service as one of the pioneer Learning Engineers. We need you.

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Learning Engineering: Resources and Frameworks

OpenSimon: A Learning Engineering Community

The Simon Initiative at Carnegie Mellon University

Introduction

The OpenSimon project is part of the Simon Initiative at Carnegie Mellon University. It includes the OpenSimon Toolkit, a shared, reliable set of learning engineering tools that serve as a foundation for a broader learning engineering community.

These tools benefit from and contribute to the community's shared socio-technical infrastructure to support improved outcomes for learners. The tools in the OpenSimon toolkit allow you to perform the cycle of learning engineering: designing, developing, delivering, and discovering new insights about your instructional strategies and content. Many of these tools take the form of instructional activities and content that anyone can add to their online course development efforts. All of the tools in the toolkit are open-source and therefore offer their codebases from Github repositories.

Read more about the OpenSimon Initiative

Learning Design Reference Models

Peter Berking

xAPI Reference Model

The Experience API (xAPI) provides a way to create flexible, semantically-defined “statements” about user activities. These are sent to and stored in a learning record store (LRS).

View the complete model.

XR Reference Model

XR is short for “Mixed Reality,” blending face-to-face experiences with Augmented Reality and Virtual Reality.

View the complete model.

IEEE IC Industry Consortium on Learning Engineering

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