Leveraging Legacy Training in Modern Systems: Framework and Implementation

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ABSTRACT

Just as existing infrastructure is maintained and enhanced, training programs can be revitalized by incorporating advanced capabilities for the future while preserving and leveraging past successes and investments. These legacy training programs have demonstrated intrinsic value over time and should not be discarded and replaced haphazardly in pursuit of developing new systems with advanced technologies and training methodologies. Instead by thoroughly understanding legacy systems and their implementation, developers can successfully adapt these systems and incorporate them using modern developmental frameworks. In general, these systems can be viewed from two perspectives: (1) educational and (2) implementation. The former includes the content (and its delivery), assessments, feedback, and other learning artifacts. The latter includes the software systems and their implementations which store and allow users to access and interact with the aforementioned educational elements. This paper presents a novel training system framework designed to leverage legacy components as critical elements in support of accomplishing the following objectives: (1) enhance learning and assessment of demonstrable proficiencies through incorporation of a competency model and associated rubrics and protocols and (2) introduce a feedback loop that uses increasingly intelligent, actionable analytics to continuously support evolving program goals. Both goals are supported by balancing the educational and implementation perspectives while integrating a feedback loop with an adaptive inference engine which provides increasingly intelligent and relevant feedback and output. An example of the framework implementation will be presented by showing the evolution from an existing Navy training program to the initial iteration of the Operationally Directed Instructional Network - Engineering Library (ODIN-EL). The paper will conclude with conclusions drawn from the framework development and implementation and directions for future work.

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INTRODUCTION

Learning and training programs are constantly revitalized to incorporate new pedagogical and methodological techniques powered by technological advances. These perpetual changes emphasize the need to adhere to fundamental principles of learning while embracing adaptation (Takanishi, 2015). The military is one example of a societal structure where embodiment of common set of values is a defining tradition (Crosbie & Kleykamp, 2018). The United States Navy has embraced these changes in the three tenets of its Sailor 2025 initiative which include modernization of personnel management systems; emphasis on ready, relevant learning; and programs that support career readiness (Spina & Spina, 2020). While dealing with the complexities induced in the current age of digitalization and automation, it is increasingly important to focus on management of human resources through a competency management approach (Simic & Nedelko, 2019).

There are three main contributions of this work. The first a characterization of legacy training programs with consideration for both educational and implementation qualities and goals. This characterization supports the second contribution which is a modern systems framework that can be employed to leverage the assets of legacy training programs in current educational systems. Finally, a thorough implementation of the framework in an active United States Navy maintenance training program is provided.

It should be noted that since this framework was developed with the intention of implementation to a military training program, some of the language in the framework will be consistent with military roles in order to ease the transition from the framework definition and development to application. However, all terms for users can be translated to terms that are more common in educational paradigms. For example, leadership can include training program managers and stakeholders. Sailors or trainees can be translated as learners.

The remainder of this paper is organized as follows: The next section will provide an overview of characteristics of legacy training programs including strengths and weaknesses. The following section will provide an overview and details of the framework that has been developed including identification of modern training system goals, mapping existing, legacy capabilities to these goals, and, finally, the framework overview including educational and implementation perspectives. Then, an example implementation will be provided as the modern Operationally Directed Instructional Network (ODIN) framework has been applied and implemented for an existing Navy training program. The paper is concluded with a review of the contributions of the current work and a brief discussion on directions for future work.

CHARACTERISTICS OF LEGACY TRAINING PROGRAMS

Legacy training programs have demonstrated intrinsic value over time, but also tend to be less flexible and more costly than modern alternatives such as e-Learning and simulation-based training. This section discusses the strengths and weaknesses of legacy training. While various strengths and weaknesses are discussed, this is by no means intended to be an exhaustive enumeration of all legacy training program characteristics.

Strengths

A key characteristic of the legacy training programs targeted in this work is that they have demonstrated success throughout their program histories. While it is often thought that this success can be improved upon by implementing modern practices, just implementing modern approaches does not guarantee improvement or success as demonstrated by many failed attempts (DeRouin, Fritzsche, & Salas, 2004).

Traditional training content can be readily produced by trainers, educators, and subject matter experts whereas some forms of modern training require software development. As educational content producers and instructional designers are not usually software developers, traditionally produced content often adheres more closely to educational and pedagogical principles (Govindasamy, 2001; Williams, Boone, & Kingsley, 2004).

A final strength of legacy training programs is that their content can often be printed and does not require devices to interact with the content. While this may be a limitation in some cases, there are situation where there is no guaranteed internet connectivity or access to mobile devices. One example where connectivity could become a concern is in remote locations or on-board certain types of transportation. Additionally, mobile devices, most of which have cameras, are not usually allowed in secure locations which can be a hinderance for military or security training.

Weaknesses

For hands-on-training, the ability to allow trainees to perform a task repeatedly to practice and learn from errors can hinder legacy training programs where access to hands-on-training is limited. Exposure to errors has been shown to have positive correlations to learning retention and transfer (Burke & Hutchins, 2007; Gardner, Abdelfattah, Wiersch, Ahmed, & Willis, 2015).

There are also trends in educational practices that have led to the promotion of more modern techniques. One example is that traditional methods for teaching tend to be more teacher-centered than learner-centered. More innovative methods place the learner in a more central role (Karagiozov, 2003). The emergence of Industry 4.0's emphasis on adaptive instructional systems, artificial intelligence, and machine learning disturbs the sustainability of legacy systems and equipment.

Lastly, legacy training methods can be much more difficult to assess and monitor as recording trainee progress and calculating metrics has historically been a highly manual progress. By leveraging e-learning systems, data can be collected about learner behavior and understanding as learning takes place. Then, metrics calculation and delivery can be automated to streamline feedback and progress monitoring.

NOVEL FRAMEWORK

This section will introduce a modern framework for training systems. First, three goals for the modern systems developed using this framework will be elucidated. This will be followed by a discussion of how existing capabilities in legacy training systems can be leveraged to support the aforementioned modern goals. Finally, the overall framework will be introduced and described.

Identifying modern system goals

There are three overall goals for the instructional system defined in this work. The first is the creation of an environment where leaders and learners can monitor progress towards defined programmatic and individual goals. In order to provide meaningful measures of progress, the modern system will be required to produce and provide metrics and reports that are tailored to the specific needs of the program and learners.

The second goal is development and implementation of a competency model which objectively defines proficiency levels. In particular, competencies for individual trades need to be mapped across a hierarchy of competencies using a competency model. It is common to map these competencies into groups, for example personal, social, action-related, and domain-related competencies (Erol, Jäger, Hold, Ott, & Sihn, 2016), in order to facilitate the organization

of individual content objectives under program objectives and provide a rubric for competency organization with respect to level of proficiency.

The final goal it to integrate feedback and information from the overall learning and training system to continually improve and customize program interventions across all levels from individual to programmatic. To support this goal, it is important to be able to provide stakeholders and decision makers with data in a manner that is timely enough to support programmatic decisions. In addition, customization of training programs with the goal of optimizing outcomes for individual learners requires analysis of not only the program and the learner, but how the learner interacts with content in real-time. To meet individual and programmatic goals, it becomes necessary to utilize modern machine learning and analytics techniques to support constant flexibility and improvement (Smith, Shull, Shen, Dean, & Heaney, 2017).

Due to the initial implementation of this framework to a Navy program, it is prudent to note that though this approach is consistent with the Navy's Ready, Relevant Learning approach it goes beyond that framework by providing a model for implementation that incorporates educational and development implementation considerations. In particular, Ready, Relevant Learning focuses on modernizing when, how, and where Sailors receive and interact with training material (Naval Education and Training Command, 2021). This framework embraces those goals for content but is developed and implemented to provide an environment to monitor individual learner and overall organization progress toward individual and program goals. Specifically, this framework can be used as a tool to modernize existing legacy programs to include Ready, Relevant Learning components, but is also adaptable to allow mapping to objectives from other organizations.

Mapping existing capabilities to modern goals

In legacy training programs, there may be existing components that partially or fully meet some or all of the modern system goals defined above. Therefore, it is critical to understand these programs, their components, and functionalities in order to transition from the current to future systems. With respect to the goal of creating an environment where leaders and learners can monitor progress towards defined programmatic and individual goals, many training programs will already be providing feedback to leaders and learners. Examples of feedback to program leadership may involve the manual or semi-automated production and distribution of various metrics and reports. As program leadership has become used to conducting program assessment and monitoring using these reports, one way to ease into a more modern system is to continue calculation of the most used and informative metrics in more modern systems, but fully automate these calculations in order to perform them in real-time. Examples of feedback to learners likely includes scores on assessments and progress tracking to determine if learners are completing programs within recommended timelines. In all likelihood, feedback on assessments will not be removed, but instead will be supplemented by additional feedback at smaller time increments. Additionally, learning deployed on digital platforms has the opportunity to provide learners with a better picture of their actual versus expected progress by incorporating more up-to-date information and providing automated reminders when they fall behind.

While legacy training programs may lack a true competency model that is linked to demonstrable proficiencies, most have content that has been used, reviewed, and improved for many years. By creating a competency model that maps competencies by type to a set of proficiencies, learners will be able to translate the knowledge acquired in the program to transferrable skills that have meaning in other organizations or domains. Additionally, trainees who have demonstrated superior skills or expertise may have previously been informally recognized to have attained a higher level of proficiency. By formally defining these additional levels of proficiency, the array of levels at which learners can demonstrate their proficiency can be extended past a single level.

Finally, though the goal of the modern system framework is to continually improve and customize interventions by consistently defining and assessing success, nearly all training systems that have stood the test of time have demonstrated ability to be responsive to feedback. The simplest and most common way to gather feedback is through participant surveys. Additionally, piloting interventions at selected sites can allow program leadership to assess their effectiveness prior to rolling out program-wide changed. However, neither of these approaches allows for agility in monitoring and assessing effectiveness which is required to customize interventions for individual participants, locations, and subprograms.

Framework combining educational and implementation perspectives

An overall diagram of the modern systems framework for leveraging legacy training programs is provided in Figure 1. The main components, or modules, of the framework include: the learning and practice module, knowledge and skill assessment module, learning artifact and information storage module, decision making and competency assessment engine, and the tangible outputs module. Each module considers implementation issues, such as using a consistent application programming interface, as well as educational issues, such as accounting for trends toward more learner-centered training environments. This subsection will provide an overview of each of the modules shown in Figure 1.
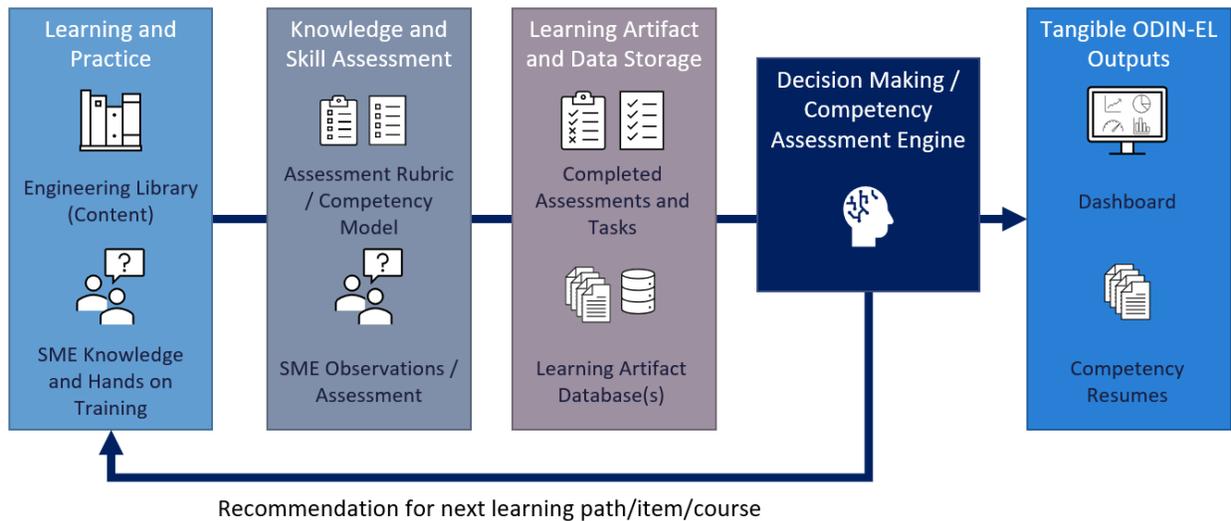

Figure 1. Modern systems framework.

Learning and Practice

The learning and practice module consists of content and training delivered in a variety of modalities. Legacy content often exists as written documents or slides distributed in portable document format (PDF). Additionally, in hands-on or peer-to-peer training scenarios, content may be undocumented subject matter expertise or defined in instructional guidelines. Throughout the history of mobile learning, content and pedagogy are becoming increasingly centered on the learner (Crompton, 2013). This framework pushes modern learning management systems and training delivery platforms one step further to allow for content to be presented in an array of modern modalities that are linked together across e-learning platforms through learner centered data. By establishing standard protocols for recording and transmitting learning artifacts, an array of diverse learning systems can communicate learner behavior and results. One example of such a standard that could be used for implementation is the Experience API (xAPI) standard (Advanced Distributed Learning Initiative, 2021). Focusing on preserving the carefully crafted legacy content, there are a variety of authoring tools and approaches that can be used to migrate document-based content into e-learning systems (Haghshenas, Khademi, & Kabir, 2012; Orsborn, 2017). Additionally, quick response (QR) codes have been explored as a way to augment instruction in the locations where learning and training are occurring (Thorne, 2016; Walsh, 2010).

Knowledge and Skill Assessment

The knowledge and skill assessment module includes assessment rubrics and subject matter expert guidelines that are linked to the conceptual competency model and associated rubrics. The competency model is designed to identify competencies across seven hierarchical levels of competency (Figure 2). This competency model informs a subsequent competency rubric that allows individual objectives within skill paths to be linked to demonstrable levels of proficiency. The result of mapping the objectives for all skill paths to the competency rubric is a competency query set that can be used to support transferable, competency-based qualifications.

Figure 2. Conceptual Competency model.

Learning Artifact and Information Storage

Now that objectively defined competencies have been linked to skill path objectives, completed assessments and tasks can be stored as learning artifacts. These learning artifacts are the data points that can be used to inform customization of content, feedback, and assessment to optimize outcomes for each learner (Figure 3). These artifacts can be used to provide guidance for learners and learning coordinators that will support on time, successful program completion. Additionally, the combined repository of learning artifacts for all trainees serves as the data set from which program metrics and analytics can be calculated.
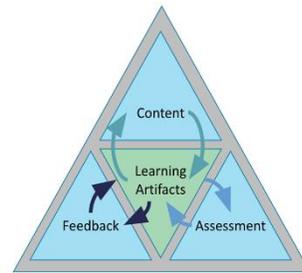
Figure 3. Interaction with learning artifacts.

Decision-making and Competency Assessment Engine

The decision-making and competency assessment engine will take the learning artifacts as inputs and output tailored program metrics and reports, individualized learning paths, and transferable competency resumes. The overall flexible, data-centric implementation of the training system will allow the decision-making and competency assessment engine to become smarter over time. In its initial implementation, it is likely to be a simple rule-based system that makes decisions based on coded guidance extracted from interviews with subject matter or program experts. As more data is collected, machine learning and artificial intelligence algorithms can be implemented to make decisions and assign competencies with decreasing user-intervention and increasing accuracy.

Tangible Outputs

Tangible system outputs include a dashboard and individualized competency resumes. The dashboard provides and interactive overview that allows stakeholders to investigate questions and identify and explore trends. In its final iteration, the dashboard displayed informative analytics that are responsive to the current user and their needs. At the highest levels, this can inform and drive program-wide decisions. At lower levels, this can help training coordinators understand how their trainees are learning along with the best ways to support them. The second tangible output is a transferable competency resume. Because the entire framework is data-centric and competency driven, each trainee can be provided by a set of competencies tied to demonstrated levels of proficiency. As a result, these competencies are then mappable and transferable to other similarly defined programs.

FRAMEWORK IMPLEMENTATION

In order to provide an example of how the framework from the previous section can be applied, this section will provide an overview of the Navy training program used to demonstrate initial implementation followed by details on how the current work was implemented as the Operationally Directed Instructional Network (ODIN).

Overview of a legacy program

The legacy Navy training program that was started nearly two-and-a-half decades ago in order to increase the self-sufficiency of the United States Naval fleet by training sailors to maintain the ships they are serving on. There are currently twenty-five different maintenance skill paths implemented for sailors to complete at shore-side regional maintenance facilities and at sea on selected Navy vessels. Examples of these skill paths include maintenance courses in areas such as pipefitting, welding and brazing, inside and outside electrical and others. In 2021, a set of core competencies was extracted as a standalone pre-requisite skill called Core Fundamentals. Other than Core Fundamentals, each skill path requires trainees to complete objectives associated with fundamental knowledge, equipment knowledge, and process knowledge. After completing all objectives, trainees must pass a written exam and an oral board to earn the corresponding Navy Enlisted Classification Codes (NEC). This achievement corresponds to a journeyman level proficiency in the given skill path.

The organization and coordination of the program including storage of program data is quite complex. A learning management system is implemented only for trainees to attempt written exams. Regional coordinators enter trainee data in both Navy and contractor managed systems. Program implementations vary greatly with respect to number of skill path implemented, number of sailors enrolled, and site logistics. All these complexities must be managed while ensuring that program integrity and standards are maintained.

Modern framework implementation: Operationally Directed Instructional Network

The application of the modern educational system presented in this work to the program is referred to as the Operationally Directed Instructional Network (ODIN). The initial requirement for ODIN is to preserve current functionality of the existing system while providing enhanced visualizations in the form of an interactive dashboard and more robust database design and implementation. To accomplish this while maintaining required security, the entire software suite received an overhaul and transition to an enhanced operational environment. Figure 4 shows a schematic of the current system after the initial implementation.
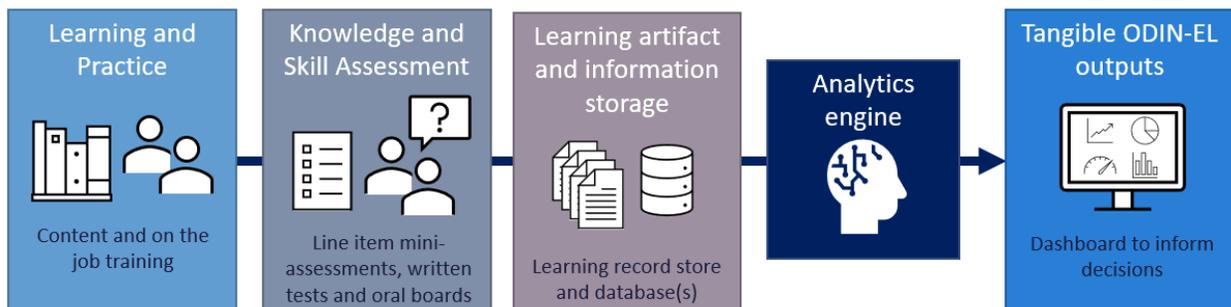

Figure 4. ODIN initial implementation.

The focus for the initial implementation of ODIN across the program has been on development of a competency model and associated rubric, learner and learning artifact centered data storage, and an interactive dashboard to support overall program decisions and management. The organization of the training program into objectives divided into fundamental, equipment, and skill knowledge has supported the development of a competency rubric that will be used to map individual skill path objectives to competencies. From the default, single proficiency for the skill paths, the rubric extends the program to allow demonstration at five distinct proficiencies values organized into three proficiency levels (Figure 5). Using this rubric can also aid curriculum developers in selecting instructional methods that are conducive to the identified goals. For example, at the novice level, recognizing nomenclature lends itself to assessment using technology-based training while expert level proficiency requires a more in-depth demonstration of tasks requiring assessment by an instructor or subject-matter expert.

Development of the program competency model and rubric has also supported a revamp of the overall program databases to make them learner and learning artifact centered. Additionally, data structures have been carefully redesigned to allow preservation of historical data, a higher level of data granularity overall, and future considerations to allow customized learning paths and feedback.

The interactive dashboard brings automated calculation, interactivity, and real-time updates to metrics that are historically calculated and distributed with monthly program reports. In addition, novel types of visualizations, such as heat maps, have been incorporated with the goal of optimizing the efficiency with which users can explore the data. The dashboard will support metrics to allow program stakeholders to monitor intervention effectiveness over time. The dashboard currently monitors learner participation, graduation, and enrollment. Analysis is planned using times series techniques and historical data to investigate program efficacy and return on investment before and after each intervention is implemented including the implementation of this overall model.

		Performance Levels & Evaluative Criteria				
		Apprentice		**Journeyman**		**Expert**
	Proficiency Value	*Novice*	*Advanced Beginner*	*Competent*	*Proficient*	*Expert*
Level 100	Fundamental Knowledge Levels	Recognizes nomenclature. Is capable of recalling the name of parts, tools, procedures, and simple facts about the task.	Differentiates, distinguishes, and generalizes procedures. Is capable of identifying and characterizing the procedures of the task.	Demonstrates emergence of operating principles. Is capable of identifying the processes and principles of the task.	Analyzes, diagnoses, and evaluates operating principles. Is capable of engaging in advanced task theory principles predicting, isolating, and resolving problems within the task.	Categorizes, develops, and enhances operating principles. Formulates new solutions to problems within the provided task.
Level 200	Subject Knowledge Levels	Remembers, identifies, and names basic facts and/or terms about the subject with little to no detail.	Compares, contrasts, and describes basic facts and/or terms about the subject in minimal detail.	Recalls, demonstrates, and understands relationships between facts and general principles about the subject with detail.	Analyzes, explains, justifies, and draws conclusions of facts and principles between facts and general principles about the subject with enhanced detail.	Formulates, generalizes, models, and evaluates conditions to make proper decisions about the subject with maximum detail.
Level 300	Performance Task Levels	Cites, defines, and identifies simple portions of a task. Capable of recognizing important components of a task. Task knowledge is extremely limited. Requires extensive supervision.	Compares, describes, demonstrates, and explains most parts and components of a task. Task knowledge is partially proficient. Requires moderate supervision.	Applies, classifies, examines, and distinguishes most parts and components of a task. Task knowledge is knowledgeable. Requires minimal supervision.	Analyzes, adapts, constructs, and prioritizes components of a task with effectiveness. Task knowledge is highly proficient. Requires only inspections of completed work.	Evaluates, cultivates, produces, and understands the importance in principles of tasks and components. Capable of facilitating task knowledge in others. Requires no supervision.
	Information Exchange & Decision Making	Shares surface-level information without considering context or priorities; Fails to verify information was received; Additional probing required to obtain full scope of information.	Exchanges full scope of obtained information with few to no errors; Rarely integrates potentially related information; Communication may be delivered out of sync, labor-intensive, or reduced at times.	Relays complete information fluently any by priority; Considers factors relevant to the reception of the message; Verifies messages and communication has been received accurately. Requires minimal supervision.	Actively engages in discussion about situational factors and integrates related information troubleshooting decisions and priorities; Relays information and communicates systems and subsystems. Requires minimal supervision.	Utilizes all available information to support decision making; Actively seeks out available information to ensure alignment; Communicates entire scope of knowledge and processes with continuity; Adapts effortlessly and is reflective in considerations. No supervision required.

Figure 5. ODIN competency rubric.

CONCLUSIONS AND FUTURE WORK

Based on the recognition that there is demonstrated, intrinsic value in legacy training programs, this work endeavors to develop a framework incorporating the successful components of these programs into modern systems. This modern training systems framework entails specific consideration of both educational and implementation characteristics. In addition, an overview of an initial implementation of this framework to a Navy maintenance training program is provided.

Future work includes assessing the applicability of the framework to legacy general education systems rather than specifically training systems. Additionally, the implementation of the framework to the Navy training program will be completed. This implementation will guide development of generalized recommendations and best practices for implementation of the framework.

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