Enhancing Medical Performance Assessment using Competency Frameworks

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ABSTRACT

Military medical training uses a wide range of training technologies and pedagogies to impart the knowledge, skills, and abilities necessary to render care in treatment facilities and on the battlefield. Teaching methods utilize patient actors, medical manikins, and task trainer for psychomotor skills and virtual simulations and classroom instruction for procedural knowledge. During these activities, student performance is assessed via training aids, written exams, or observer checklists. Despite the potential for a comprehensive assessment of a learner, at present, these data sources are not aggregated or mapped to a set of medical competencies. Within this manuscript, we present an approach utilizing a competency framework (CaSS) that will aggregate disparate training modalities and inform a medical competency model. The exemplar use case focused on airway competencies at the level of a combat medic, specifically rapid sequence intubation. Two training modalities were used to inform the airway competencies and their underlying knowledge and skills: a virtual simulation (TC3Sim) and the advanced joint airway management system (AJAMS). The results using simulated data are presented, demonstrating the ability to inform hierarchal competencies using a variety of training technologies. The approach enables an ensemble approach to student assessment, combining multi-modality training aids, knowledge assessments, and digitized observations. In the future, the capability will enable competency-based medical education, personalized instruction, and improved analytics at the student, instructor, and enterprise levels.

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INTRODUCTION

Combat casualty care is an incredibly complex and challenging endeavor, combining the rigors of patient care with the myriad of dangers on the battlefield. In this environment, successful healthcare providers must demonstrate a comprehensive understanding of the knowledge, skills, and abilities (KSAs) required to render effective patient care. These KSAs cover foundational knowledge of the human body in the form of anatomy and physiology, as well as procedural knowledge associated with medical treatment. Psychomotor skills are also critical, focused on the physical skill related to performing a procedure, such as inserting a needle or physical examination of a patient. Finally, a successful provider also embodies the necessary abilities to function in such a challenging environment, including advanced situational awareness, team communication, and stress management.

In the military healthcare system, combat casualty care is split into three discrete portions: tactical combat casualty care (TCCC), en-route combat casualty care (ERCCC), and surgical combat casualty care (SCCC). This manuscript focuses on TCCC, the military standard for treating and stabilizing a battlefield casualty, beginning at the point of injury (Butler et al., 1996). TCCC instruction is stratified into four tiers: (1) All Service Member, (2) Combat Lifesaver, (3) Combat Medic / Corpsman, and (4) Combat Paramedic / Advanced Provider (Hackett et al., 2020). An array of educational pedagogies is utilized to educate and train these providers, supported by a suite of simulation and training technology. To begin, classroom instruction delivers foundational knowledge, ranging from 4 hours (Tier 1) to multiple weeks or months (Tier 3 and 4). Within these programs of instruction, classroom instruction leads to hands-on individual skills training using part-task trainers or medical mannequins. Trainees also participate in team exercises to integrate multiple, discrete learning objectives; courses commonly utilize multiple casualty scenarios involving casualty extraction, assessment, treatment, and evacuation. After training, culmination events such as lane training occur with medical squads treating simulated casualties in a field exercise environment. In addition, after completing a medical training course, units often take part in large-scale force-on-force engagements at combat training centers, integrating their medical expertise with the rest of their warrior skills.

Throughout the education and training process, trainees are assessed to determine their mastery of knowledge or skills. The objective is for the trainee to demonstrate proficiency in the KSAs necessary to provide care commensurate with their role; in other words, the result of training ensures that medical providers are ready to perform patient care. However, comprehensive trainee assessment is a significant challenge in the current education and training construct. To begin, classroom instruction, simulation-based instruction, lane training, and large-scale exercises often occur in different places with different instructors. Because of this, assessments are usually not standardized, resulting in a significant degree of subjectivity.

Additionally, many of these training experiences are not recorded with meaningful performance measures. Simulation-based training with task trainers often pass/fail with an instructor overseeing assessment, as many simulators are not instrumented. Simulator metrics are available for manikin platforms but are frequently proprietary and reside within vendor-specific learning management systems. Many of these training experiences are not stored in any manner, meaning a classroom assessment may not combined or compared with psychomotor assessments. At the end of these courses, a trainee is given a pass or fail, the sole record of their performance. As they progress in their career, specific deficiencies may never be remediated, as they were never recorded. The result is that a series of disparate training experiences are never truly aggregated, yielding a largely incomplete understanding of the current proficiency of a trainee.

Within this effort, we seek to develop a prototype medical competency framework that will integrate multiple training modalities across training experiences. We will integrate virtual and physical simulations, each of which will inform specific competency components. This prototype will focus on the airway task of intubation, including the knowledge and psychomotor skills needed for proficiency. We will demonstrate the system using simulated data from multiple simulations, highlight how this can be generalized and extended to other medical competencies, and discuss the impacts of such a capability on the medical training enterprise.

Background

Competency Frameworks

Competency frameworks arose from a question inherent to educators, employers, and regulators: is this trainee ready to perform the tasks critical for their intended job? To address this question, competency frameworks seek to define a core set of qualities indicative of proficiency for a given role; these qualities are mapped to education interventions, training events, or job tasks, which can build towards proficiency in these qualities. The idea of competency frameworks arose from both the educational and employment sectors. Within education, the idea emerged that a set of knowledge, motives, traits, and skills could be a superior indicator of performance than single-focus tests such as IQ ((McClelland, 1973). Over the years, this evolved to include knowledge, skills, behaviors, values, and attitudes within the overarching scope of a competency. This behavioral approach emphasized that competency was not a static concept but rather a continuous and evolving competency; this also indicates an iterative approach wherein competency must be maintained and grown through education and training rather than serving as a definitive endpoint (Mills et al., 2020). In addition to the educational field, competency frameworks within the labor market focused on employers and industry needs, often referred to as functional competency. The functional approach highlights the need to define measurable performance standards, which a prospective employee would meet to be qualified and suitable for a given position (Boritz & Carnaghan, 2003). This approach also tends to view competency as a criterion which, once met, makes a trainee qualified and competent, rather than an evolving state of competency suggested in the behavioral approach. The distinctions are relatively nuanced, and within this manuscript, the competency terminology focuses on the education and training setting, wherein competency changes over time based on educational interventions and job activities.

Competency-Based Medical Education

In medical education, focusing on specific competencies became increasingly popular for preparing civilian medical providers, particularly nurses (Burns & Poster, 2008) and physicians (Epstein, 2007). The shift towards competency-based medical education became so popular that researchers sought to provide a unified definition – "Competency-based education (CBE) is an approach to preparing physicians for practice that is fundamentally oriented to graduate outcome abilities and organized around competencies derived from an analysis of societal and patient needs. It de-emphasizes time-based training and promises greater accountability, flexibility, and learner-centredness" (Frank et al., 2010). However, researchers have noted significant challenges in implementing CBE, particularly related to the lack of flexible curricula models and inconsistent competency frameworks (Hawkins et al., 2015). However, the benefits include a greater focus on outcomes and learner achievement and increased flexibility in a learner's educational trajectory.

Competency-Based Education in the Military

The military training enterprise is vast, ranging from training highly technical skills associated with nuclear engineering, communications, or medicine to softer skills like problem-solving, communication, and emotional intelligence, often emphasized in developing leaders. Within the military, the education and training associated with nearly all roles are highly structured, rigid, and generally 'one-size fits all.' Yet, the benefits of CBE are apparent, and researchers and policymakers have suggested employing CBE for improved human capital management and lifelong career development (Zook, 2006). Recent efforts continue to further this, with technological and pedagogical changes as the military evolves its training and education platforms (Schatz et al., 2015; Schatz et al., 2019).

METHODS

System Architecture and Prototype Development

A prototype was designed to address the challenge described above: TCCC training delivered throughout a soldier's career or other uniformed personnel through disparately delivered training events not aligned to a comprehensive TCCC competency framework. The prototype consisted of elements proposed by the Advanced Distributed Learning (ADL) Initiative in the Total Learning Architecture (TLA) concept (Smith et al., 2018) and demonstrated in part in the STTC effort, STEEL-R.

The resulting prototype, Tools for Enhancing Medical Preparedness by Extending Synthetic Training (TEMPEST), was to provide a picture of the real-world performance of KSAs in the form of competencies in a variety of settings and not just the learning environment. TEMPEST is a competency-based system of systems that would allow for seven critical research and development objectives derived from the core challenge statement:

- Evaluate learning performance data from disparate, non-linear sources of learning experiences.
- Evaluate learning performance data from multimodal learning environments.
- Determine competency from non-linear, multimodal learning experiences.
- Determine an individual's competence progression through a hierarchical competency structure.
- Display a hierarchical representation and calculation of competencies for individuals' learning progress.
- Provide a dashboard view of an individual's progression through a competency hierarchy.

The system should provide the capability to collect and assess KSAs in both technical (techniques, tactics, and procedures) as well as non-technical (communication and leadership) forms across training events and throughout the training lifecycle of a soldier.

TEMPEST accomplishes these core objectives by applying and integrating several technologies, systems, and open data standards. Figure 1 diagrams the various systems and technologies utilized by TEMPEST. Actual data flows (xAPI and competency assertions) between systems are represented by solid lines, while simulated data (student performance data) is defined by dashed lines.

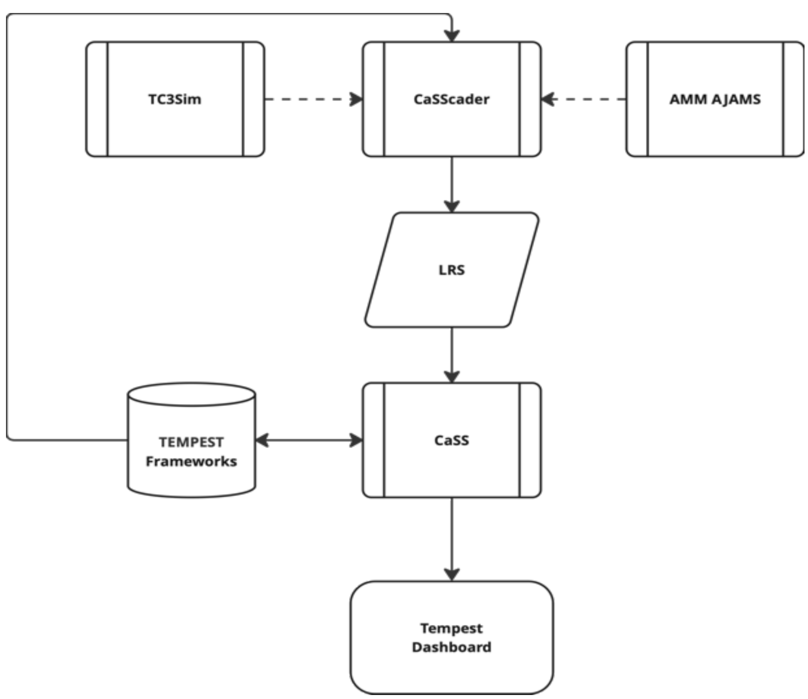

Figure 1: System Architecture and Data Flow

These systems include:

- **Training Experiences** are interactive media in which instructional content is presented and interactive experiences are presented to a learner. These include classroom instruction, online learning management systems (LMS) content, and simulations. TEMPEST included two disparate learning experiences, TC3Sim and the Advanced Modular Manikin (AMM) Advanced Joint Airway Management System (AJAMS)
- **CaSScader** - CaSScader creates simulated xAPI data for the experiences of multiple learners and transmits it to the LRS. The training experiences listed above cannot transmit learner performance data. CaSScader served as a simulated agent in the role of the learner to publish notional learner performance data. CaSScader allowed for a more significant iteration of the learner profiles and models, the xAPI profile, and the hierarchical competency model aggregating the training experiences.
- **Learning Record Store and xAPI** – The Learning Record Store stores xAPI statements. xAPI is a JavaScript Object Notation (JSON) data model format and a Representational State Transfer (RESTful) Web Service Application Programming Interface (API) for transferring experiential data of individuals, groups, or other entities. Both are part of the xAPI standard developed by the ADL (ADL, 2024). xAPI has become an IEEE standard and is maintained and further developed by the IEEE Learning Technology Standards Committee (IEEE, 2024). The use of "noisy" and "transactional" LRS is part of the strategy recommended by the ADL.
- **CaSS** - Competency and Skills System was first developed in partnership with the ADL initiative and is part of the ADL's TLA (ADL, 2024). CaSS maintains competency and skills frameworks, collects and stores assertions about the competencies and skills demonstrated or possessed by individuals or teams, and estimates the level at which competencies and skills are held by individuals and teams using a math model. For TEMPEST CaSS contained the frameworks for the learning experiences and the hierarchical framework.
- **TEMPEST Competency Dashboard—**The TEMPEST Competency Dashboard allows users to navigate through their students' profiles. The prototype user interface has both the CaSScader triggers through a profile selection and the TEMPEST hierarchical competency completion chart on the same screen.

Competency Model

TEMPEST is designed to support disparate training systems based on the Advanced Distributed Learning Initiative's (ADL) published recommendations (Robson & Poltrack, 2017) of using competency across multiple events. This approach allows TEMPEST not to be limited to a single pedagogical learning model. The competency concept supported in this effort is a hierarchical competency model based on doctrinal requirements expressed at several levels. Mirroring the approach from the Synthetic Training Environment Experiential Learning for Readiness project (STEEL-R) (Goldberg et al., 2021), the initial competency structure relied on the affective, behavioral, and cognitive (ABC) Model (Figure 2). For this effort, the focus was individual competencies that can be tied into teamwork competency concepts in the future. Based on the levels of the ABC model below, TEMPEST collects learner performance data in Level 5 and calculates competencies contained in Level 4.

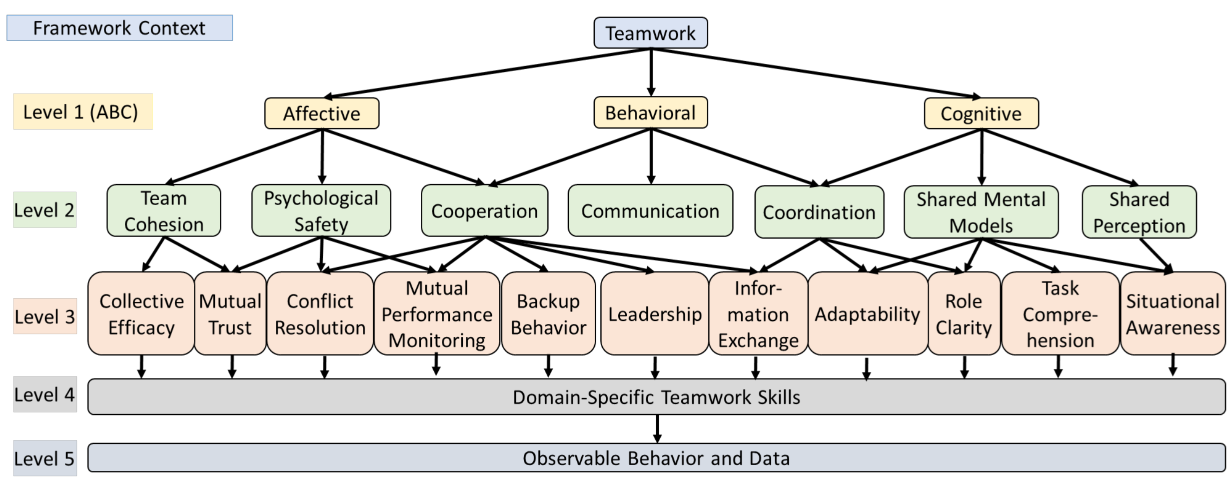

Figure 2: ABC Model

Observable Behavior and Performance Data

For this effort, TEMPEST collects and calculates competency from learner data from two disparate training systems that provided content and experiences in the Tactical Combat Casualty Care (TCCC) domain. These tasks and related competencies can have overlapping descriptions. TCCC training is scattered across the training progression for US Army soldiers and units, making it nearly impossible to attest to training and readiness at the competency level accurately. TEMPEST was designed to collect data from these disparate training sources and provide a means to calculate competency from training designed for differing levels of the TCCC competency hierarchy. Specifically for this effort, two available learning experiences were chosen: TC3sim and the Advanced Modular Manikin.

TC3Sim

TC3Sim is a virtual simulation for training procedural knowledge associated with TCCC. TC3Sim is a 'first-person thinker,' requiring a trainee to take the role of a combat medic or combat lifesaver performing care under fire and tactical field care (Sotomayor, 2010); TC3Sim scenarios end when a patient is evacuated to the next role of care. TC3Sim provides data on trainee performance in the form of a go/no-go checklist, requiring that trainees address all critical steps associated with treating and stabilizing the battlefield casualty. TC3Sim is playable on a tablet or PC and can be used to reinforce initial instruction or to provide refresher training. Data on scenario performance, including go / no-go checklists is taken from the application for use in TEMPEST.

Advanced Modular Manikin Advanced Joint Airway Management System

The Advanced Modular Manikin (AMM), funded by the US Department of Defense and developed by the Center for Research in Education and Simulation Technologies (CREST) at the University of Washington (UW Medicine, 2024), is a universal platform for manikin modularization. Designed as a standardized blueprint that links segmented body parts, shares data, power, and fluids, and provides software and hardware connections to external peripherals and virtual patients. Scenarios utilizing AMM are simulated experiences focused primarily on skill assessment through cognitive and psychomotor domains. Psychomotor data is captured through interactions with the modular components in the form of simulated physiological data and assessed in the AMM assessment module. Cognitive skills are assessed through instructor observation. (UW Medicine, 2024)

The advanced joint airway management system (AJAMS) is a task trainer utilizing the AMM blueprint. AJAMS is a high-fidelity partial manikin focusing on upper airway management, including nasal-pharyngeal airway, intubation, cricothyrotomy, bag-valve-mask (BVM), and repositioning training. Unlike many airway simulators, AJAMS is highly instrumented, with sensors that can detect proper intubation, improper bronchial intubation into the bronchus, respirations via BVM, and incision via cricothyrotomy. A scenario for Failed Intubation Leading to a Surgical Airway closely aligned to content in TC3Sim was selected for the prototype.

TEMPEST Competency Hierarchy

For the TEMPEST system to calculate competencies and then make individual learner competency profiles, the training objectives from TC3sim and the AMM scenario were developed into competency frameworks stored in CaSS. A CaSS framework is machine-readable and linked to open data containing performance statements describing competency. A framework can have internal and external relationships that denote hierarchical, equivalence, and exclusionary structures.

TEMPEST provides a capability to crosswalk competency frameworks for equivalency calculations. Additional frameworks outside TCCC were included to provide additional fidelity to the TEMPEST competency hierarchical framework. Table 1 lists the sources that were included in competency research and framework development:

Table 1 TEMPEST Competency Framework Sources

Title	Source	Purpose
STEEL-R	US Army, STTC	Initial competency hierarchy and model
TCCC	US Army Doctrine	Scope of
11B MOS	US Army Doctrine	Identified phases of TCCC

68W MOS	US Army Doctrine	Identify phases of TCCC
TC3Sim	US Army, STTC	Primary Knowledge performance measures
AMM	UW CREST	Technical documentation
AJAMS scenarios	UW CREST	Primary skill performance measures
OCCSTDS	US Navy	Inclusion as a framework for potential expansion
ONET frameworks	ONET	Inclusion as a framework for potential expansion

STEEL-R

The STEEL-R competency model served as the originating structure that could link TCCC competencies across MOSs and serve as the model for structuring competencies relationships and representations in the TEMPEST system.

TCCC

TCCC requirements are well documented in various US Army doctrine based on CoTCCC guidance. The team amended the ABC model developed for STEEl-R to account for the TCCC requirement. STEEL-R began with applying the ABC model to the 11B Advanced Leaders Course. The resulting competency hierarchy map, the General 11B competency framework, was an example of a competency structure that could be applied to all 11B foot soldiers. The addition of a TCCC competency was in concert with this use case.

TCCC was further derived according to guidance and doctrine to lower phases of activities and tasks, with TCCC connected to the 11B and 68W competencies at differing levels. Only the relevant portions of the TCCC phases were completed in the TCCC competency map for the initial phase, which focused on airway intubation.

MOS Frameworks: 11B and 68W

11B Infantryman and 68W Combat Medic were utilized to demonstrate how TEMPEST can interweave related components of separate competency structures through disparate training events. 11B was cited in the original STEEL-R frameworks. Since TC3 is presented to every service member regardless of rank or MOS, those training objectives were tied to the 11B and 68W. 68W competencies were linked in the later phases of care in TCCC and were tied to the AJAMS scenario objectives.

AMM and AJAMS

Due to time constraints, the full suite of AMM technical data was not used in this prototype, as it includes significant physiological, pharmacological, and medical equipment based data. However, the capabilities of the type of data that could be captured and utilized to inform the competency structure and selection of training objectives from the AJAMS scenarios. The AJAMS scenarios were developed for three-person teams, but for the TEMPEST prototype, the objectives were structured in a linear, progressive competency framework for a single trainee.

The linear narrative structure of the AJAMS scenario was used to derive and map the TEMPEST competency framework, demonstrating the integration of two separate competency frameworks (11B, soldier, with 68W, medic) and two disparate training events (TC3Sim and AMM AJAMS scenario). This process usually would unfold in the opposite direction, in which an existing competency framework would then be mapped to individual learning objectives contained in a learning event.

Experience API

For the TEMPEST prototype, learner activity data was simulated to verify data flows and establish initial capability, prior to collecting human performance data in later phases of the effort. As discussed earlier, defined sets of potential xAPI activity statements could be transmitted from xAPI-instrumented versions of AMM and TC3Sim. For each of the simulated assessment events, we defined an xAPI activity ID to use as a reference, and then in CaSS, we manually modified the specific competencies that are impacted by "is assessed by" relationships to each of the relevant xAPI activity IDs. We also defined three demo student sets of xAPI activity to exemplify beginner, average, and advanced learner outcomes in these simulated training events. This simulated xAPI data traffic is conducted for the TEMPEST demonstration using the CaSSCader interface, discussed next. The xAPI statement profile and mapping to specific

Learning events are illustrated in Figure 3 TEMPEST Prototype Dashboard. The Syllabus events referenced are TC3Sim and AJAMS scenarios 1, 2, and 3.

	A	B	C	D
1	xAPI ID	LO#	Learning Objective	Syllabus Event
2	https://tempest.army.mil/demo/med/LO/1/assessment	1	Perform the appropriate steps to achieve a secure airway in a sick patient	
3	https://tempest.army.mil/demo/med/LO/2/assessment	2	Perform rapid sequence intubation procedures	1+2+3
4	https://tempest.army.mil/demo/med/LO/2.1/assessment	2.1	Perform patient assessment	1
5	https://tempest.army.mil/demo/med/LO/2.1.1/TC3Sim/assessment	2.1.1	Identify sick patient condition	TC3Sim
6	https://tempest.army.mil/demo/med/LO/2.1.2/TC3Sim/assessment	2.1.2	Recognize inadequate airway	TC3Sim
7	https://tempest.army.mil/demo/med/LO/2.1.3/AMM/assessment	2.1.3	Check vital Signs: capnography, BP, HR, RR, O2 saturation, EKG	1
8	https://tempest.army.mil/demo/med/LO/2.1.3.1/AMM/assessment	2.1.3.1	Monitor vital signs: capnography, BP, HR, RR, O2 saturation, EKG	1
9	https://tempest.army.mil/demo/med/LO/2.2/AMM/assessment	2.2	Perform endotracheal tube intubation IAW basic life support and advanced life support procedures	2+3
10	https://tempest.army.mil/demo/med/LO/2.2.1/AMM/assessment	2.2.1	Perform non-invasive respiratory interventions	1
11	https://tempest.army.mil/demo/med/LO/2.2.1.1/AMM/assessment	2.2.1.1	Bag valve mask assisted respirations	1
12	https://tempest.army.mil/demo/med/LO/2.2.1.2/AMM/assessment	2.2.1.2	Determine the need for CPAP if time allows. Consider CPAP/ Nebulizer if available	1
13	https://tempest.army.mil/demo/med/LO/2.2.1.3/AMM/assessment	2.2.1.3	Position patient to recruit lung space	1
14	https://tempest.army.mil/demo/med/LO/2.2.2/AMM/assessment	2.2.2	Place ETT according to best practice and procedures	2
15	https://tempest.army.mil/demo/med/LO/2.2.2.1/AMM/assessment	2.2.2.1	Utilize checklist for placement of ETT including failed airway plan	2
16	https://tempest.army.mil/demo/med/LO/2.2.2.2/AMM/assessment	2.2.2.2	Perform laryngoscopy	2
17	https://tempest.army.mil/demo/med/LO/2.2.2.3/AMM/assessment	2.2.2.3	Apply apneic oxygenation w/ nasal cannula	2
18	https://tempest.army.mil/demo/med/LO/2.2.3/AMM/assessment	2.2.3	Confirm proper placement of ETT	2
19	https://tempest.army.mil/demo/med/LO/2.2.3.1/AMM/assessment	2.2.3.1	Visualize ETT pass through cords	2
20	https://tempest.army.mil/demo/med/LO/2.2.3.2/AMM/assessment	2.2.3.2	Confirms positive capnography	2
21	https://tempest.army.mil/demo/med/LO/2.2.3.3/AMM/assessment	2.2.3.3	Identify lung function: hears lung sounds, sees chest rise	2
22	https://tempest.army.mil/demo/med/LO/2.2.4/AMM/assessment	2.2.4	Perform medication administration for Bronchospasm	3
23	https://tempest.army.mil/demo/med/LO/2.2.4.1/AMM/assessment	2.2.4.1	Determine need for intramuscular epinephrine	3
24	https://tempest.army.mil/demo/med/LO/2.2.4.2/AMM/assessment	2.2.4.2	Start IV	3
25	https://tempest.army.mil/demo/med/LO/2.2.4.3/AMM/assessment	2.2.4.3	Administer RSI drugs aligned to presenting vital signs and symptoms	3
26	https://tempest.army.mil/demo/med/LO/2.2.4.4/AMM/assessment	2.2.4.4	Administer inline nebulizer or MDI post intubation	3
27	https://tempest.army.mil/demo/med/LO/2.2.4.5/AMM/assessment	2.2.4.5	Administer post intubation drugs	3
28				

Figure 3: TEMPEST xAPI Profile and LO Mapping

Data Simulation - CaSSCader

To provide a realistic demonstration of the use of centralized framework definitions and computed profiles for TEMPEST, targeted training systems would need to be instrumented to share performance data using xAPI. Instead, the team provided for the simulation of xAPI activity to represent the learner interactions in the identified learning experiences. CaSScader creates simulated xAPI data for the experiences of multiple learners and transmits it to the LRS. The team relied on CaSS's xAPI adaptor to generate assertions for each learner as it monitors the LRS activity feed. When assertions are added, the CaSS Assertion Processor automatically recomputes a learner's profile. This approach allows us to test and demonstrate a standardized, scalable TEMPEST architecture without the delay of waiting for training technologies to be modernized with xAPI. Additionally, the generation of simulated data over time supports the design and development required to improve dashboard visualizations and reports and to begin work on data-driven AI services that can seek to compare job performance for assessment and perform fault analysis for after-action reviews, among numerous other possibilities.

In the CaSSCader interface, a user can select a student performer and then navigate through the curriculum outline as that student. For each syllabus event, users can transmit the selected student's xAPI data into the LRS by clicking the "Send Statements" button. As such, the student's training event performance data becomes a part of the LRS activity feed. CaSS automatically proceeds with assertion processing and profile computation behind the scenes. These data updates are retained in CaSS and available via the CaSS API.

Results

The TEMPEST prototype supported a learner pathway between disparate learning events mapped to an integrated competency framework for TCC that accommodated and could scale to support additional career fields, learning events, and learning environments. Figure 4 illustrates the utilization of the simulated learner data flow between TC3sim as a prerequisite activity and the three levels of AJAMS scenarios.

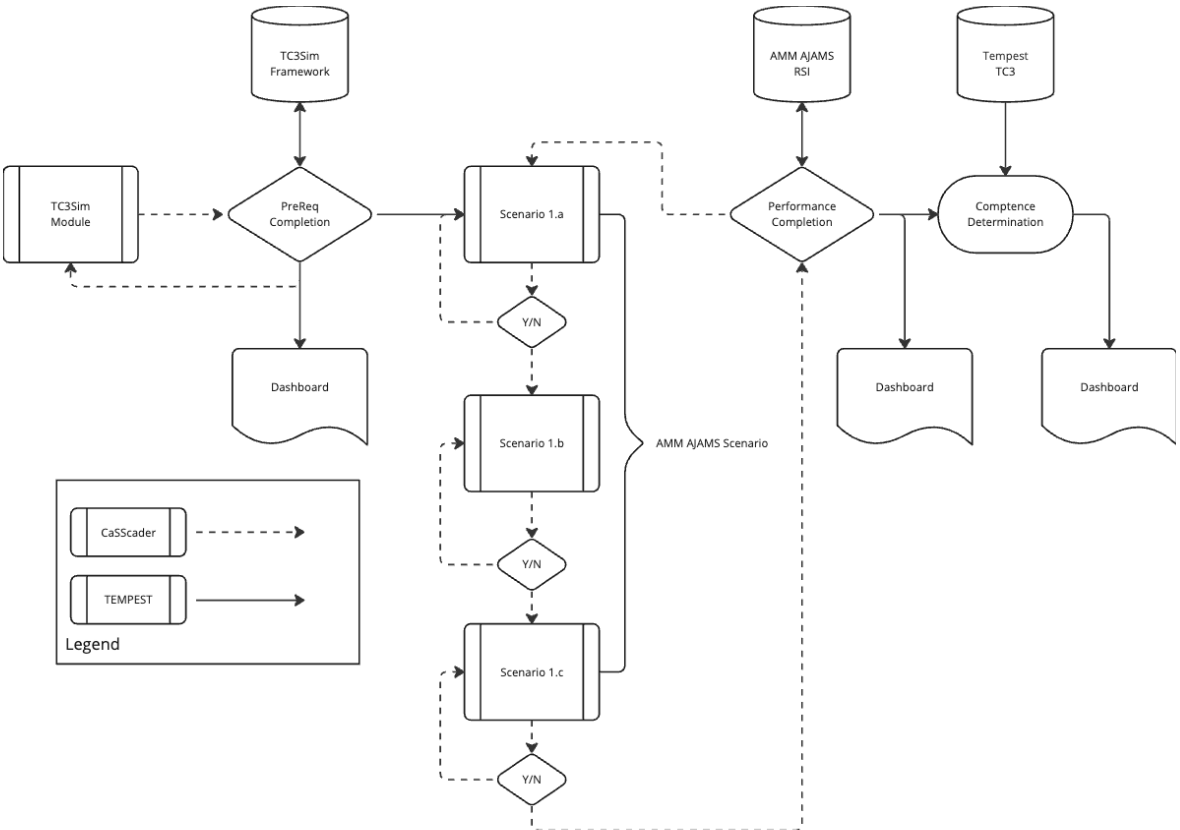

Figure 4: TEMPEST Prototype Learner Pathway

Figure 5 shows the final integration and display of the learner pathway results. This example demonstrates an underperforming student who still needs to complete all of the competencies. On the left are simulated learning events; on the right is the updated competency framework based on assertions processed using the aforementioned pathways.

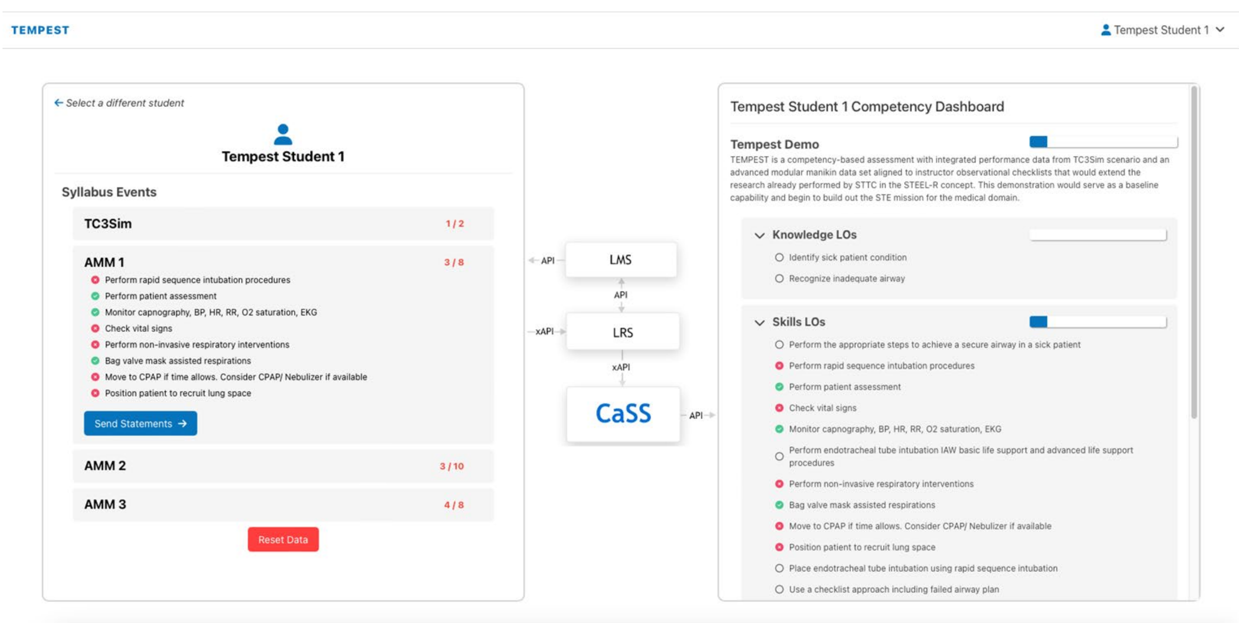

Figure 5: TEMPEST Prototype Dashboard

Future Work and Conclusion

TEMPEST demonstrated a capability to aggregate multiple, disparate training experiences and align them to a medical competency framework. Further, this research showed the ability to crosswalk competencies for multiple job categories and across disparate training events accurately providing a concise learner pathway along with discrete assessment and evaluator analytics. This effort achieved the six essential objectives with an architecture that utilizes high technology readiness level (TRL) systems and open-data standards. Despite significant limitations, unconnected simulations, and simulated learner performance, the competency framework development process and competency-based learning architecture should scale to include additional competency inclusions and training modalities.

The challenges to standardizing and optimizing force-wide TCCC training will require competency-based training assessment, which this effort begins to address. Additional work will require the systematic expansion of the TCCC competency framework to best accommodate and enable the crosswalk of multiple training modalities in the same specific domain. The team would like to expand beyond the automated data expression of xAPI from digital systems to include direct instructor observation and assessment. Additional competency modeling of specific training events and simulations would allow for more accurate and efficient cross walking for the construction of dynamic learner pathways. The competency-based medical education holds the promise of improving learning, reducing costs, and ultimately improving patient outcomes. To achieve that, the ability to assess a learner in a comprehensive manner across the entirety of their career is necessary, and this effort has demonstrated an initial steps integrating multiple learning events into a single, cohesive snapshot of a learner’s competency.

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