Experience API and Team Evaluation: Evolving Interoperable Performance Assessment

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ABSTRACT

Simulation and training technologies continue to advance the ways we assess individual and team performance on a range of skills. Given that training is costly, military organizations are developing solutions for tailored learning since they represent a path to larger efficiencies. While many training systems can assess and report a trainee's performance, most have no way to share collected learner data with other training systems. Collecting data in a complete profile of performance could lead to the ability to leverage performance data to save time and money training personnel or increase training effectiveness. Limited interoperability of performance assessment and tracking across training systems continues to constrain the ability of these solutions to adapt, or personalize, across a lifeline continuum of the learning experiences. The Advanced Distributed Learning Initiative is supporting community developed specifications and tools, such as the Experience Application Programming Interface (xAPI). The Army Research Laboratory (ARL) is exploring the use of the xAPI for Interoperable Performance Assessment (IPA) to support the assessment of individuals and teams across multiple training systems. These efforts are beginning to establish best practices to create a "universal language" for Live, Virtual, Constructive, and Gaming systems to share performance data and provide adaptive learning regardless of the technologies or platforms used. Previous work established example methods, an architecture, and tools to capture interoperable data to support individual adaptations. In this paper, we will describe and provide best practices for this evolving approach of tracking and using team performance data. Tracking this data in an interoperable way can provide the basis to support both macro and micro adaptations at the individual level. Practical examples using a single gunner simulator along with team-based data from a crew trainer will be provided. Lessons learned will also be outlined to inform considerations for approach and usage.

ABOUT THE AUTHORS

Michael Hruska is a technologist with experiences spanning across standards, emerging technologies, learning, and science. He is a former researcher at the National Institute of Standards and Technology in Gaithersburg, Maryland. He is currently the President / Chief Executive Officer of Problem Solutions, and provides learning technology solutions to government, commercial, and nonprofit organizations. His team has been supporting efforts for the last 4 years at the Advanced Distributed Learning (ADL) Initiative on the future of a Training and Learning Architecture (TLA) and the Experience Application Programming Interface. He holds a Bachelor of Science from the University of Pittsburgh and is a member of the e-Learning Guild, American Society of Training and Development (ASTD) and the National Defense Industrial Association (NDIA).

Tara Kilcullen is the Director of Training Product Development at Raydon Corporation. Ms. Kilcullen has over 12 years of experience leading and managing cross-functional teams in the design and development of training simulation systems with a focus on training technologies and development as well as data collection and analyses for both military and commercial systems. She has helped to implement and drive process improvements both within her organization and other organizations at Raydon. With these improvements came better metrics through enhanced data collection and analysis methods which specifically allowed Training Product Development to gain numerous development efficiencies revolving around project planning, organization, execution, and quality. She holds several Bachelor of Science and Associate of Science degrees from University of Pittsburgh and Full Sail University.

Charles Amburn is the Senior Instructional Systems Specialist for the United States Army Research Laboratory, Human Research and Engineering Directorate, Simulation Training and Technology Center (STTC) in Orlando, Florida. After obtaining both a Film degree and a Master's degree in Instructional Systems Design from the University of Central Florida, he began his Department of Defense civilian career in the Advanced Instructional Systems Branch at the Naval Air Warfare Center Training Systems Division (NAWCTSD). There he worked on special projects for the Navy and Marine Corps for 10 years before becoming the Lead Instructional Designer for the Army's Engagement Skills Trainer (EST) program at the Program Executive Office for Simulation, Training and Instrumentation (PEOSTRI), Orlando, Florida. Since 2011, Mr. Amburn has worked on various projects within the Soldier-Centered Army Learning Environment (SCALE) and Joint and Coalition Training Rehearsal and Exercise Research (JCTRER) research programs at STTC.

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Tiffany Poeppelman is a contractor at Google serving as an Evaluation Project Manager within the PeopleDev team. She has experience in both the commercial and government sector, specifically regarding cutting-edge adaptive training technologies, training development and applied research. Ms. Poeppelman is a seasoned training specialist who designs, develops and evaluates trainings within different environments such as Live-Virtual-Constructive (LVC), computer-based training events, instructor-led training, simulations and game-based solutions. She also conducts functional research to create innovative adaptive training solutions that adjust training experiences via human performance algorithms, scenario engineering, scaffolding, and other methods of intelligent adaptation. Ms. Poeppelman received a Master of Science in Industrial and Organizational Psychology from Northern Kentucky University and a Bachelor of Science in Psychology from Bowling Green State University.

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INTRODUCTION

Today's military, considering adaptive or personalized training a higher priority, is developing associated assessment methods (Spain, et al 2013) and technology (Landsberg, Van Buskirk, Astwood, Mercado, Aakre, 2010) to support these goals (Spain, Priest, & Murphy, 2012). While training used to be a "one size fits all" approach, methods to customize, adapt, or tailor the learning experience of the end user (Mödritscher, Garcia-Barros, & Gütl, 2004; Park & Lee, 1996; Shute & Towle, 2003; Shute & Zapata-Rivera, 2008) are desired by the Army (Department of the Army, 2010). However, today's military faces a challenge of modernizing training methods using adaptive methods because the design efforts, tools, and technologies required are cost prohibitive.

Across the Department of Defense (DoD), there are a number of research efforts underway to automate or simplify tracking and assessment of performance to enable adaptive learner-centric environments. Specifically, the Army Research Laboratory's (ARL) Simulation and Technology Training Center (STTC) has been researching and defining best practices and tools, like the Soldier Performance Planner (SP^2), for encoding performance measurement data using Experience Application Programming Interface (xAPI) statements (Poeppelman, Hruska, Ayers, Long, Amburn, & Bink, 2013) which define a way to track data about learning experiences. Additionally, the initial efforts supported the development of a technical architecture for interoperable activity tracking across current Army training systems called Interoperable Performance Assessment (IPA). The IPA work allowed various systems to connect and share individual data, but recent efforts have expanded the collection to include group or team performance data. By understanding the current state and granular historical data of a learner, these systems may ultimately be able to adapt learner pathways at the macro and micro level. This paper extends the IPA approach defined for individuals to the broader scope of encoding team performance. Insight into the use of xAPI beyond individuals allows an expanded consideration for its use in IPA across the military. This paper will highlight the methods and considerations for individual and team performance encoding as well as future research goals in order to continue to support adaptive and tailored learning that incorporates simulations, Intelligent Tutoring Systems (ITS), and other systems.

EXPERIENCE API

As we are currently immersed in a technology age, a realization is emerging that learning is continuously happening beyond formal training environments and that experiential and informal methods should be considered in solutions with greater weight (Rosenheck, 2013). Technology continues to drive the training community toward new training approaches and the development of systems that create, view, and present content to learners in new ways. A need for common specifications to support data sharing across these environments is emerging.

In 1999, the Advanced Distributed Learning (ADL) Initiative, currently of the Office of the Under Secretary of Defense for Personnel and Readiness (OUSD P&R), set out to modernize learning and training in the DoD through large-scale development, implementation, and assessment of interoperable and reusable learning systems (Training Industry, 2013)." As a result of the creation of ADL, the Sharable Content Object Reference Model (SCORM) emerged (Advanced Distributed Learning, 2014b).

While the SCORM provided capabilities a number of limitations exist related to using SCORM in environments like simulations, mobile, virtual worlds, or games. The ADL's Training and Learning Architecture (TLA) capability which "encompasses a set of standardized Web service specifications and Open Source Software (OSS) is designed to create a rich environment for connected training and learning" and is intended to move beyond SCORM (Advanced Distributed Learning, 2014c). Under the TLA capability, work is focused on extending the future support of interoperability of learning systems. The first effort of the TLA, the Experience API, or xAPI, reached 1.0 specification in April of 2013 (Advanced Distributed Learning, 2014d) and enables tracking across platforms which SCORM could not serve easily to capture data about learners and learning experiences.

The xAPI defines a means to describe data and allows statements of experience to be created and stored in a Learning Record Store (LRS) (Advanced Distributed Learning, 2014a). The LRS is simply a storage mechanism for xAPI statements. The format of these statements is based on Activity Streams (Activity Streams, 2013) in the following format: (<Actor, Verb, Object> or "I did this"). In this format, the Actor is the agent the statement is about, like a learner, mentor, teacher, or group. The verb describes the action of the statement, such as read, passed or taught. Finally, the object is what the Actor interacted with such as a test, a video, a class, a mentor or training event. These are some of the simplest examples, but xAPI also allows complex statements corresponding to anything conceivable in the natural human language. Figure 1 shows first three elements of a larger example xAPI statement outlined in this paper in both Figures 1 and 3.


```
{
           "actor": {
               "mbox": "mailto:name@domain.com",
               "name": "Jane GI",
               "objectType": "Agent"
           },
           "verb": {
               "display": {
                   "en-US": "completed"
               },
               "id": "URI://for/verbs/completed"
           },

           "object": {
               "definition": {
                   "type": "URI://for/activities/simulation",
                   "name": {
                       "en-us": "Driving training during gunnery training"
                   },
                   "description": {
                       "en-us": "A soldier learns how to drive during gunnery training."
                   }
               },
               "id": "URI://for/xapi/simulations/gunnery1/driver",
               "objectType": "Activity"
           },
```


Figure 1. xAPI statement example

These statements can be used by themselves to capture and track data about learning experiences. The collection of learning experiences over time may provide the ability to allow learning environments to leverage the data to improve the experience of the user through adaptation. The xAPI specification was also developed to be flexible enough to meet the varying use cases of the learning technology community. While the xAPI provides flexibility for encoding, various ways to encode data may exist and communities of practice should agree to certain conventions. These conventions and rules on how to encode specific data types for specific domains using the xAPI can be collected into companion specifications and applied to the base xAPI specification as profiles. ADL is currently developing a profile for the SCORM community that addresses topics such as launch of traditional web content, statement verbs and results for reporting success and completion. The effort described within this paper is intended to serve as a baseline for additional profiles.

PREVIOUS IPA RESEARCH

Multiple efforts are currently underway to support the above adaptive training goals, including specifications like the xAPI as well as current Army Research Laboratory (ARL) efforts supporting IPA and the Soldier Performance Planner (SP²) (Hruska, M., Poeppelman, T. R., Dewey, M., Paonessa, G., Paonessa, M., Nucci, C., Ayers, J. 2013). These efforts are focused on defining best practices, developing a technical architecture, and planning for interoperable performance data activity across current Army architectures to provide a basis to inform adaptation of individual-based training events (Poeppelman, Hruska, Ayers, Long, Amburn, & Bink, 2013).

As a starting point, previous efforts were focused on the encoding of data from an unstabilized gunnery simulator and a helicopter flight simulator for individuals. Data encoding principles were applied to datasets from simulators and data was encoded in xAPI statements.

CURRENT RESEARCH

The current focus of research is to extend encoding methods for individuals to track group experiences. Capturing data about a group is important for analysis of team chemistry, contributions, and reasons for success or failure. Groups can be identified in multiple ways, either as permanent entities consisting of specific members or as ad-hoc groups that are not expected to persist beyond a single activity. Ad-hoc groups are especially useful if every team member is not known or where only some of the larger team is present for an activity.

The concept of absence is an important distinction between individuals and groups. Groups have a notion of membership which introduces a dynamic that single-learner tracking systems do not have to account for. First, a group may run with different members at different times. There may be cases where a team of 10 only uses 5 members at a time or the team is missing 5 members but can still perform the activity. A team may have a substitution of someone who isn't normally on the team. Teams may also permanently change members. Re-assignments, career changes, promotions, tactics, etc. can all cause the "normal" team to take on different members. Tracking performance in these varying conditions is challenging and is a necessity of group training, whether it is as a measure of individual performance or to identify points which are outliers of the ideal.

Encoding Team Performance Data

Within the current ARL effort, individual data from a single gunner simulator has been leveraged along with team-based data from a crew trainer. A library was developed to support the encoding of both individual and team performance data into xAPI statements. The development of an "xAPI for IPA" library came in two parts: the development of the library itself and the integration of the library into both an individual and crew training curriculum.

For the library integration a virtual convoy trainer was chosen as the platform as it supports both individual and team training. The curriculum and training exercises in the crew gunnery training were used for the team proof-of-concept. The team consists of three individual crew positions: commander, driver, and gunner. The group encoding strategy developed is based on intelligent, query-based systems rather than brute force data dumps. xAPI offered a few different options for the use-case of identifying individuals and placing them in a hierarchy while maintaining their identity at each hierarchical level. xAPI allows for individuals and groups, but not groups of groups. In this way, a representation of a group of 100,000 individuals would consist of a Statement of over 100,000 lines. Groups of groups was a concept considered for this effort but the xAPI does not support that and it wouldn't work due to the logic needed by a LRS to support the base case changes. In addition, the Agent profile should not become bloated with a series of memberships of groups the individual is in. The entire processing of managing groups across time becomes a task that quickly needs many more resources than any organization is likely to spend. A group membership change either means a loss of data (losing the previous group membership) or causes further bloating of agent profiles.

To address this challenge, a context-driven approach was used which aligns with the spirit of xAPI - keeping statements granular - and can easily utilize intelligent searches and data aggregation services. By defining hierarchical elements such as "unit," "company," and "platoon" and using identifiers, meaningful connections can be made from minimal data. To aid querying, activities of individuals also link to their parent, so if only the parent activity is queried, all of the children will be found. The biggest benefit to this solution is that the temporal nature of groups is managed. All statements are time stamped so that name, rank, and group identifier are captured. Furthermore, one could query across the group and time to see the exact membership at that time without the necessity of updating group objects or the agent profile.

The system is able to encode and receive individual Experience Records through the xAPI for IPA library, adapt the individual's training curriculum based on their Experience Record, and report on both individual and team Experience Records through the xAPI for IPA training library. The interaction and adaptive training is depicted in Figure 2, below.

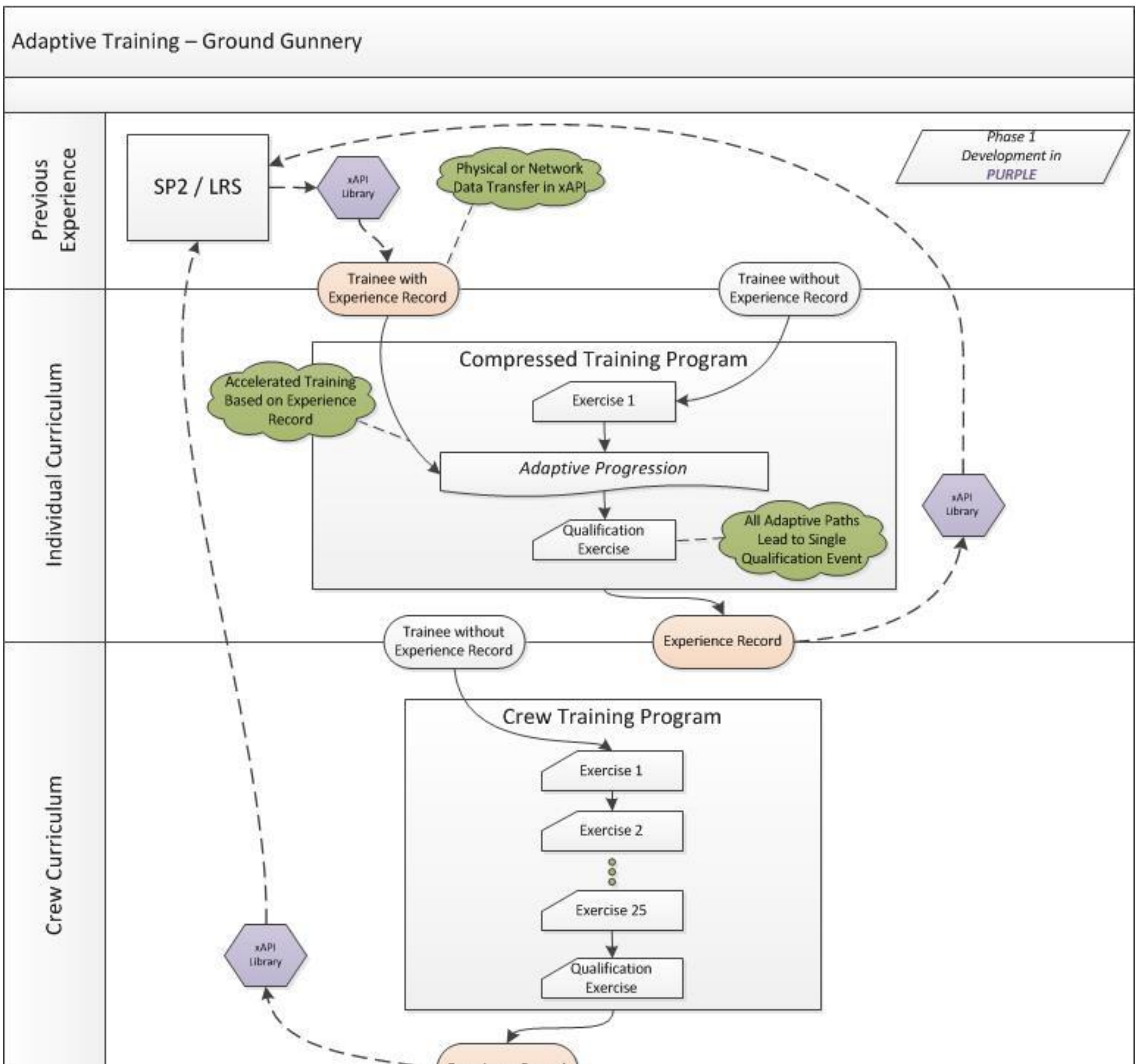

Figure 2: IPA Gunnery Example

The following (Figure 3) is a continuation of the statement example from Figure 1 and shows group activities within the context of unstabilized gunnery training. In the training, a team of three individuals makes up a unit. Each unit has three roles as well; a gunner, a driver, and a commander. This statement (Figure 1 and Figure 3) defines a method to encode not only the performance of an individual, but also to define the individuals or roles performing in the context with the individual. A further look into encoding a single statement about a group is also defined in Figure 4.

The xAPI has the flexibility of allowing these individuals to not be tied to a single permanent role, rather only for the duration of the actual training. This implementation defines both a unit and training unit, with the training unit being the three individuals training and the unit being the "normal" team of three that would typically train together. Tracking both individual and team data is important, and this implementation is able to distinguish both without sacrificing granularity.

An example statement below shows the entire statement at the time of completion for the driver role of "training unit 127-7," which is also unit 127-7, meaning the "normal" team was together for this training. The other important pieces of the statement are the Identifications (IDs) of the activity (object) and the context activities. The IDs can be generic as seen below, with IDs that allow many different drivers, gunners, and commanders to roll-up into the same activity. They also roll-up into a larger activity of unstabilized gunnery training (seen as the parent context activity below).


```
"result": {
    "score": {
        "scaled": 1
    },
    "response": "assessment",
    "extensions": {
        "URI://for/xapi/resultExtensions/roundsFired": "101",
        "URI://for/xapi/resultExtensions/targetsKilled": "5",
        "URI://for/xapi/resultExtensions/targetsPresented": "20",
        "URI://for/xAPI/activityStartTime": "2013-05-18T05:32:34.80Z",
        "URI://for/xAPI/activityEndTime": "2013-05-18T05:52:56.12Z",
        "URI://for/xAPI/measure": "measure",
    }
},
"context": {
    "platform": "VehicleType",
    "contextActivities": {
        "parent": [
            {
                "id": "URI://for/xapi/simulations/gunnery1",
                "objectType": "Activity"
            }
        ],
        "grouping": [
            {
                "id": "URI://for/xapi/simulations/gunnery1/driver",
                "objectType": "Activity"
            },
            {
                "id": "URI://for/xapi/simulations/gunnery1/gunner",
                "objectType": "Activity"
            },
            {
                "id": "URI://for/xapi/simulations/gunnery1/commander",
                "objectType": "Activity"
            },
        ],
        "other": [
            {
                "id": "URI://for/xapi/contextextensions/METL",
                "objectType": "Activity"
            },
        ]
```

```
        },
        "extensions": {
            "URI://for/xapi/contextextensions/trainingObjective": "training objective",
            "URI://for/xapi/contextextensions/knowledge": "Knowledge",
            "URI://for/xapi/contextextensions/experience": "Experience",
             "URI://for/xapi/contextextensions/trainingUnit": "127-7",
            "URI://for/xapi/contextextensions/role": "Driver",
            "URI://for/xapi/contextextensions/unit": "127-7",
            "URI://for/xapi/contextextensions/company": "A",
            "URI://for/xapi/contextextensions/platoon": "1",
            "URI://for/xapi/contextextensions/targetCount": "4",
            "URI://for/xapi/contextextensions/vehicleNumber": "1",
            "URI://for/xapi/contextextensions/ovPosture": "Offensive",
            "URI://for/xapi/contextextensions/targetRange": "100m",
            "URI://for/xapi/contextextensions/targetMovement": "North",
            "URI://for/xapi/contextextensions/rank": "1LT",
            "URI://for/xapi/contextextensions/weapon": "1"
        }
    },
    "timestamp": "2014-04-17T14:39:38Z"
}
```


Figure 3. xAPI statement example (continued from Figure 1)

The example below (Figure 4) shows the first 3 elements of a statement about a team's performance. While the previous example (Figure 3) defines roles associated in the context of one individual's performance, this example outlines a method to defining the performance of the entire group. Leveraging this method will also ultimately enable reporting and visualization to be done in a hierarchical model that parallels the military hierarchy.


```
{
   "verb": {
       "display": {"en-US": "unqualified"},
       "id": "http://www.example.domain.com/verbs/unqualified"
   },
   "object": {
       "definition": {
           "type": "http://www.example.domain.com/simulations/Collective_Gunnery",
           "name": {"en-us": "Platoon Table X"}
       },
       "id": "http://www.example.domain.com/simulations/Platoon_Unstabilized",
       "objectType": "Activity"
   },
   "actor": {
       "account": {
           "homePage": "URN:UUID:844dfbd3-97ce-488a-ba7c-757419729b99",
           "name": "25CAVAB1"
       },
       "objectType": "Group"
   },
```


Figure 4. xAPI Statement Example for a Group

LESSONS LEARNED

While defining and developing an implementation for tracking performance data for individuals and teams, the following considerations were discovered:

- ***Upfront research of the xAPI specification***. As with any specification, team members that are unfamiliar with xAPI should review the specification and read ancillary materials. Engineers assigned to the project should be allocated time for this activity.

- ***Identity.*** Identity of the learners can be handled many ways by many systems. Considerations for identity should be made early in a project. Items like Personally Identifiable Information (PII) as well as Information Assurance (IA) should be within the scope of consideration.

- ***Development of standardized tool assets.*** Often, once developers understand the xAPI standard, they realize that there are limited tool assets of varying utility currently available to assist in the encoding and decoding of data into this standard. Community development or additional tools would continue to enhance the capabilities of data capture.

- ***Determination of shared data scope***. One of the strengths of xAPI is its ability to encode such a wide array of user experiences. Generally, this is a very positive attribute, but in this specific case, and given the data sets that need to be encoded and exposed to other systems, teams will need to determine what data is restricted to their system (e.g. proprietary data) and which data is encoded in xAPI statements to be sent to an LRS for sharing with other systems.

- ***Integrating exchanged data into the training systems***. For training adaptation, identifying and understanding the aforementioned factors may be time-consuming. For both xAPI developers and consumers, the development of a document that discusses actions each party should perform at the start of a project in order to build data alignment is critical. This document will not only help expedite the successful reporting and consumption of xAPI data sets between two or more applications, but it will, and should, continue to grow based on continued interoperable development using xAPI.

- ***The need for tools and libraries***. While providing a predictable structure to the data set, one way to reduce the upfront development effort is to develop and share libraries which can help provide flexibility in encoding specialty data in a variety of domains.

- ***Alteration of source code.*** Many early adopters will have concerns about significantly altering the source code of training systems in order to extract the needed performance data, but that is not the case. Through the current effort, a plug-in was created to extract or insert the data necessary to encode and store performance data in an LRS. This can allow the team to bypass the intrusive and risky alteration of a stable working baseline but still gain the desired results.

- ***Granularity.*** While many different types of data are created at different levels throughout systems, it is important to consider grain size of capture. Granularity for data capture at both the individual and team levels should be defined and the value of the data to external systems should be considered. Focus on competencies, knowledge, skills, or abilities should be used as a baseline for approach.

- ***Group context encoding for individuals.*** While capturing data for individuals is important, considering contextual elements of other individuals or roles they were performing with may provide additional value to an individual's performance data. Considerations and examples for capturing the group of individuals and roles surrounding an individual's performance are possible and are described in Figure 3.

- ***Group performance statements.*** Defining experiences that a group shares is also important. Creating assessments of group performance is possible and should be approached. Group composition and definition should be defined and encoded in numerous ways where possible to allow for the greatest flexibility in reporting and visualization. Approaches to such encoding are described in Figure 4.

FUTURE RESEARCH

This effort provided a baseline for encoding individual and group performance in context. The tools and methods produced provide a capability to encode data from simulation and other systems. The development of a library and example approaches and output in this effort should serve as a guide for future development. Future research efforts should focus on the following:

- ***Context rich individual or group performance in multiple domains.*** Baseline encoding practices, examples, and tools have been developed. Extension of work to other domains of performance context will be important to validate and extend practices. Capturing expanded definitions of team performance should be focused on.

- ***Team performance at multiple levels of hierarchy.*** Current efforts provide a baseline for multiple levels or groups to be define. Efforts should focus on encoding performance of sections, platoons, and other larger groupings in the military hierarchy.

- ***Adaptation of individual experience based upon team data.*** With additional encoding of team data, the possibility for defining datasets that could drive adaptation of individual experiences will exist. Determining data of interest in multiple domains should be explored. Practical examples of adapting individual data using team data should be defined.

- ***Adaptation of team experience based upon individual data.*** As more data is collected on individual performance systems managing team experiences may be able to leverage the data to provide adaptations to groups. This data could also be made available to personnel responsible for planning and monitoring simulations to allow instructors to make micro adaptations during the current training event.

- ***Team composition based upon either individual or team data.*** Individual and team data sets could reveal proficiencies or deficiencies that prove valuable in group definition, formation, or selection. Teams may be composed of homogeneous or heterogeneous mixes of strengths or weaknesses or other criteria. Investigating team composition and live team alterations based upon either individual or team data should be explored.

- ***Capture of physiological data in context.*** Physiological data is or can be collected in a number of training environments. Capturing and encoding physiological data in a relevant manner to existing practices for individual and group encoding will be an important consideration to leverage this potentially valuable data. Exploring datasets that have both granular simulation data and physiological data for encoding will add further insight in this area.

CONCLUSION

While current research is demonstrating interoperable data sharing across systems, there is still work to be done. Encoding the data for individuals and teams is a first step towards the sharing and use of performance data across the Live, Virtual, and Constructive (LVC) training continuum. Much of the future is focused on systems that provide an interoperable assessment capability, not only for individuals but for teams as well. While a method for capturing individual and group data is defined, visualizing and understanding individual and team performance data from multiple systems connected in real time still poses a unique set of challenges that need to be explored further. Additional understanding from longitudinal datasets may be defined. The focus remains on having a highly agile system and approach that is capable of tracking experiences to improve the use of LVC training for mission rehearsal for both individuals and teams. Such approaches are critical for future combat capabilities and threats in emerging environments.

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