1 Abstract

Several research and development efforts have attempted to address the communication between activities such as games and simulations, however the focus of these efforts has been on a single-learner data model: one learner playing a game and data being reported from the game back to an LMS. That is a much needed solution for many use cases, but as greater emphasis is placed on collaborative learning experiences and high performing teams, SCORM 2.0 must support a collaborative learning activity data model (CLAM) that allows for the tracking and reporting of data from multiple simultaneous learners participating in the same activity. This paper defines the problem space and outlines two use cases where there is a need for a CLAM to enable individualized learning based on team performance.

2 Problem Definition

Applied, team-based learning activities are an important aspect of many learning experiences. In these activities, multiple individuals simultaneously work together in virtual experiences that strive to replicate real-life systems and situations in real time. Since the focus of many of these activities is on the interaction between the team members, an instructor often subjectively assesses the interaction. In the past, team-based learning was limited to the classroom. Today, simulation, game, and social networking technologies enable team-based learning in an on-line environment. As we move towards implementing Web 2.0 technologies that facilitate collaboration, it becomes imperative that SCORM 2.0 also incorporate some type of collaborative learning activity model (CLAM) for data tracking.

Current SCORM specifications make it relatively easy to assess and track individual knowledge, skills, and abilities (KSAs). Data for an individual can be tracked at the Shareable Content Object (SCO) level with individual interactions within a SCO also being track. Some data may also be tracked at the content package level. A SCORM collaborative learning activity data model would allow SCORM 2.0 to track and assess the activities of a team of learners and allow the activities of one team member to impact not only his or her future individual activities, but also the activities of the team as a whole. A CLAM enabled data model might track and report such information as the:

- Names and other identifying information of each team member.
- Names and other identifying information of other teams and their team members who are currently in a given team activity.
- Progress and status of individual learners as well as the team.
- Time spent on individual and collective problem solving.
- Preferences and roles of individual team members.
- Competencies assessed for individuals and the team.

Using this model, content developers could create courses that would:

- Track and remediate activities on both a team and individual basis.
- Simulate team interactions in activities.
- Allow collaboration among team-members.

Table 1: Team Example describes a four-member team in multi-learner activity where one team member is the designated leader. All team members must perform effectively as a team in addition to showing they are individually competent in their specified KSAs to "pass" the activity. For simplicity sake, the individual KSAs are represented as "subject matter expertise".

Table 1: Team Example

Learner 0, the designated team leader, must:	**Learner 1 must:**	**Learner 2 must:**	**Learner 3 must:**
Demonstrate subject matter expertise	Demonstrate subject matter expertise	Demonstrate subject matter expertise	Demonstrate subject matter expertise
Communicate with other teams members	Communicate with other teams members	Communicate with other teams members	Communicate with other teams members
Make time critical decisions effectively		Respond to time-sensitive decisions made by Learner 0	

How could CLAM incorporate team interactions into the learning process, provide tracking and individualized remediation for the individual and the team, and facilitate collaboration to enhance team performance? Consider the team described in
Table 1 and how its members interact with each other to refine their teamwork.

2.1 Team Tracking and Remediation

SCORM 2004 tracks an individual's progress through a learning activity. In addition to providing individual data about learner performance, CLAM would also provide a means to track scores and progress information for the team as a whole. This would enable scenarios where the team leader, Learner 0, could not pass the activity until all of his or her team members passed the activity. It would also enable tracking for "soft-skill" type objectives that are best measured at the team level rather than the individual level. For example, the team above must communicate successfully to pass the activity. CLAM would permit the entire team to fail if one of its members failed a critical team skill.

Team structure might have an impact on how tracking and remediation is implemented. In some organizations, such as first responders, teams are often predefined or "fixed" and always work together. In other situations, such as with military and commercial aircrews, fluid team structures or "formed teams" are used. In a formed team structure, individuals work with a uniquely formed team each time they perform. As a result, an individual learner's team performance score could allow one team member to pass the activity while other team members fail. Depending on the team composition and organizational dynamics, the entire team may be forced to remediate the activity as a group or individuals may be reassigned (either automatically or manually by the registrar or instructor) onto a newly formed team to repeat the activity until they can "pass". This may require the ability to designate multiple teams per learning activity and individuals would need to be able to move between teams.

2.2 Team Interactions and Sequencing

SCORM 2004 provides a mechanism for sequencing an individual's learning activities. CLAM would still require some sequencing mechanism. However, CLAM would allow not only an individual's performance in a learning activity to impact the sequencing of future activities for that team member, but it would also allow the team's performance in the learning activity to impact the delivery of future learning activities for other members of the and the team as a whole. For the team described in Table 1, Learner 2 must be able to respond to decisions made by Learners 1 and 3. Or, Learner 0 may see a unique set of activities based on his or her performance as the team leader.

2.3 Collaboration

SCORM 2004 does not provide individual learners with any information about other learners who are engaged in the same learning activity. CLAM would allow the individual members of a team to know what other teams are involved in the same or similar activities, or know which teams had successfully completed the activity. Imagine a situation where Learner 1 fails the activity the first time, but the rest of his or her team passes and moves to another activity. CLAM could check to see if other learners were available to form a new team and then alert Learner 1 that a new attempt for the activity was available. CLAM might even allow Learner 1 to see the names of all individuals who are available to attempt the activity.

The table below shows each learner's performance in the competency areas assessed by the example activity. It also shows their individual score and their score for team collaboration. A team member could conceivably pass most of the individual competencies, but still fail in the team performance area based on an algorithm computed by the activity that bases scoring on the combination of competencies passed or failed. For simplicity purposes in this paper, the table below uses a "+" to indicate mastery of a competency and a "-" to indicate that remediation is required. Based on the individual performance of these learners, some of them would require individual formalized remediation in certain areas while the entire team would have to re-attempt the activity as a team since the team score indicates the team failed the activity.

Scoring Constraint	0	1	2	3
Subject Matter Expertise	+	+	+	-
Individual Performance Score *(determined by assessment engine)*	**+**	**+**	**+**	**-**
Communication with Other Team Members	-	+	+	+
Decision Making Ability	-	+	-	+
Time Management Ability	-	+	-	+
Individual Score for Team Work *(determined by assessment engine)*	**-**	**+**	**-**	**+**
Team Score *(determined by assessment engine)*	**Fail**			

In the example above, Learner 3 would be assigned individual, customized remediation based for the subject matter expertise he or she failed. While Learner 3 did achieve a passing score for individual performance in teamwork, since the whole team failed, Learner 3 would also remain in the activity until the team is able to demonstrate proficiency in the activity. Learner 1 has demonstrated competency in all of the assessed areas but since this team is a fixed team and works together regularly in the real world, Learner 1 must also complete remediation for the activity with the team.

Current instances of these types of activities are possible in web-based training, but current instances use custom tracking, reporting, and competency models, so there is currently no interoperable way to track the results of both individual and team performance for multiple learners in the same activity, particularly when they are completing the activity synchronously. CLAM would provide an interoperable way to measure team performance. It might also provide an interoperable way for complex gaming engines, proprietary third party software, or simulators and part-task trainers (such as an aircraft or tank simulators) to communicate with learning management systems.

3 Use Case 1: Game-based Activities

Hazmat: Hotzone is an instructor-based simulation that uses video game technology to train first responders about how to respond to hazardous materials emergencies in a variety of scenarios. Hazmat: Hotzone was developed at the Entertainment Technology Center at Carnegie Mellon University in collaboration with the Fire Department of New York (FDNY). *Hazmat: Hotzone* was transitioned to SimOpsSystems, a Carnegie Mellon spin-off, for final development and has been freely distributed to fire departments across the country.

Although *Hazmat: Hotzone* was a prototype for future first responder games produced by SimOpsSystems, it represents the type of learning experience that would benefit from a multi-learner data model because of the need to ensure mastery of technical knowledge and soft-skills on both an individual and team basis. The passage below[i] describes *Hazmat: Hotzone*.

> Hazmat: Hotzone is a networked, multiplayer simulation that uses videogame technology to train first responders for chemical and hazardous materials emergencies.
>
> It is designed to give the instructor maximum control and flexibility over the scenario. For the first responder trainees, the primary objective of the simulation is communication, observation, and critical decision making.
>
> The program begins with an instructor creating the hazardous scenario. They are able to determine such factors as the location of the hazard, its effects, the weather conditions, and the placement and symptoms of the victims involved.
>
> Once the scenario has been set by the instructor, the students who are situated at their own computer stations will log into the scenario. One student assumes the role of the incident commander and establishes a decontamination zone. The others students communicate over radios and respond to the situation accordingly.
>
> The instructor has the ability to pause the game or trigger unexpected actions and secondary events at any time. They may even incapacitate a first responder who has taken an unsafe action. When the scenario has been completed, the instructor can then lead a discussion using specific examples of what actions were and were not effective. The scenario can then be repeated to test for lessons learned, or a new scenario can be loaded to train for different situations.

Currently, the *Hazmat: Hotzone* instructor would have to personally assess both individual and team performance in the activity, and then, if deemed appropriate, assign remediation activities to each individual in the appropriate system (either the *Hazmat: Hotzone* game or an LMS if formal learning were required for remediation of the individual competencies). Providing a data model that could allow a learner's performance in *Hazmat: Hotzone* to influence their individual instructional program as well as their team learning experience would enable completely customized remediation, resulting in individualized learning experiences that provide better and more focused learning outcomes.

4 Use Case 2: Full- or Part-Task Trainer Activities

In industries as varied as the aviation, defense, healthcare, and nuclear power industry, simulators and part-task trainers are used to reinforce, refresh, apply, challenge, and assess learners' performance. A full-scale simulator is a "training device that simulates the salient features of the equipment and environment for all major tasks for a particular mission on a given system"[ii]. A part-task training device (PTT) "permits selected aspects of a task to be practiced independently of other elements of the task … to provide economical training on specified task elements requiring special practice, but that are not dependent upon the total equipment."[iii] Simulators, especially integrated systems where learners performing various tasks may be physically separated, but make inputs that impact other learners, are especially beneficial in developing effective teamwork.

Simulators and PTTs typically require an instructor to input a scenario and the learners then perform their specified tasks, roles, or activities as they would on the real equipment. In most situations, the instructor rarely intervenes so that the scenario can unfold naturally. The instructor typically facilitates a discussion with the learners once the scenario has reached its natural conclusion (which could be defined in numerous ways). Like the game-based activity described in Use Case 1, the instructor would have to personally assess both individual and team performance in the activity, and then, if deemed appropriate, assign remediation activities to each learner in the appropriate system.

Providing a data model that could allow a learner's performance in *Hazmat: Hotzone* to influence their individual instructional program as well as their team learning experience would enable completely customized remediation, resulting in individualized learning experiences that provide better and more focused learning outcomes. For individual competencies, the appropriate system may be formal, individual instruction. For team collaboration skills, the appropriate system may be another session in the PTT or simulator. Providing a data model that could allow a learner's performance in a simulator or PTT to influence their individual instructional program as well as their team learning experience would enable completely customized remediation, resulting in individualized learning experiences that provide better and more focused learning outcomes.

5 Potential Stakeholders

The United States Departments of Defense (DoD), Justice, Energy (Nuclear Regulatory Commission), and Homeland Security (DHS), as well as the aviation and healthcare industries, and others have a strong need for team-based collaboration activities that simulate real-world situations and can ensure mastery of learning material through individualized remediation.

6 Proposed Solution and Recommendations

Creating a multi-learner data model to enable communication between a collaborative learning activity model (CLAM) and an LMS would allow designers to create comprehensive curriculums with embedded remedial strategies that ensure mastery of content at all points in the learning experience.

To enable individualized remediation to formal learning content from a CLAM, the SCORM data model would need to be extended to allow multiple types of data from multiple users. For example: A single learner's individual performance could be tracked using an element such as *cmi.teammember.n.individual* where n is a positive integer and represents each of the potential users in a single CLAM instance. For individual learners potential data model elements might include:

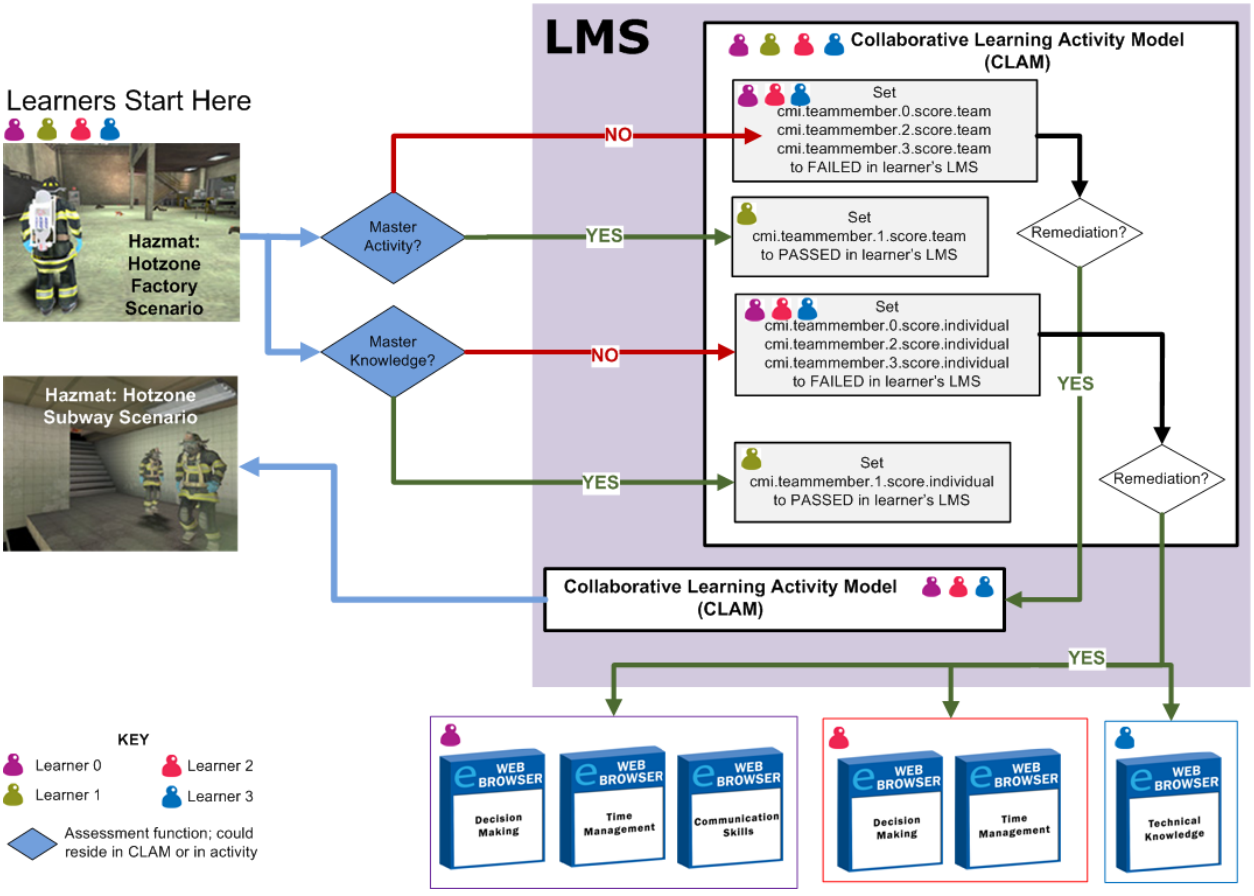
- *cmi.teamember.n.online*
- *cmi.teammember.n.individual.learner_id*
- *cmi.teammember.n.individual.learner_name*
- *cmi.teammember.n.individual.learner_preference*
- *cmi.teammember.n.individual.learner_role*
- *cmi.teammember.n.individual.interactions* to include the number and quality of interactions from each learner.
- *cmi.teammember.n.individual.progress_measure*
- *cmi.teammember.n.individual.scaled_passing_score*
- *cmi.teammember.n.individual.score*
- *cmi.teammember.n.individual.success _status*
- *cmi.teammember.n.individual.total_time*
- *cmi.teammember.n.individual.session_time*
- *cmi.teammember.n.individual.competency.001*

That same learner's performance as part of the team could be tracked using an element such as *cmi.teammember.n.team.score* n is a positive integer and represents each of the possible users in a given delivery instance of the activity. Likewise, the *cmi.interactions* data model element may need to be extended to track the two different types of interactions, individual and team, resulting in *cmi.interactions.team* and *cmi.interactions.individual.* This would enable unique tracking and data collection for both types of interactions, and would facilitate remediation based on interactions data. The types of data model elements for the team might include:

- *cmi.teamember.n.team.online*
- *cmi.teammember.n.team.team_id*
- *cmi.teammember.n.team.team_name*
- *cmi.teammember.n.team.team _preference*
- *cmi.teammember.n.team.interactions to include the number and quality of interactions for each team activity.*
- *cmi.teammember.n.team.progress_measure*
- *cmi.teammember.n.team.scaled_passing_score*
- *cmi.teammember.n.team.score*
- *cmi.teammember.n.team.success _status*

- *cmi.teammember.n.team.total_time*
- *cmi.teammember.n.team.session_time*
- *cmi.teammember.n.team.competency.001*

The following diagram shows conceptually how multiple learners might experience a CLAM for the *Hazmat: Hotzone* activity—receiving two scores, one for team performance and one for individual performance. An individual and team competency tracking data model element would be used for precise remediation to specific SCORM content (shown by the web browser icon). The blue diamonds for mastery represent an assessment engine that could live within each activity or within the CLAM. The model should support both receiving raw result data from the activity for the CLAM to assess or allow the CLAM to received data that has already been assessed data in a standard way.



7 References

[i] Downloaded from http://www.etc.cmu.edu/projects/hazmat_2005/about.php on August 8, 2008
[ii] DoDI 1322.20: Development and Management of Interactive Courseware (ICW) for Military Training
[iii] Ibid