Adaptive Training through Standards for Reconfiguring Serious Game Narratives

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ABSTRACT

Games should encourage repeated play by users, consistent with the adult learning theory of deliberate practice. Game design experience indicates that a consistent, relevant, and fresh narrative is critical to player engagement. A challenge for serious game design is inexpensively adapting the narrative to be both relevant and fresh for multiple player sessions while the learning objectives remain the same.

This paper shows how two standards (ISO/IEC 19778 and ISO/IEC 24763) can describe variable narratives for team training that are internally consistent and relevant to the learning objectives. We have enhanced the semantics of ISO/IEC 19778, a standard for collaborative workgroups, to capture the three "R's" of collaboration: Roles, Rights, and Responsibilities. ISO/IEC Technical Report 24763 describes a conceptual reference model for competencies that can formalize learning objectives for serious games in terms of required actions, actors, and outcomes. When used in combination, these standards can help to (1) maximize the reuse of narrative elements, (2) link the learning objectives to aspects of the narrative, and (3) specify elements of the game design that are accessible to the different game design disciplines.

We show how these standards could specify a game and discuss how different elements of the standard would change to (1) vary the scenario for repeated deliberate practice with constant learning objectives, (2) adapt skills for different situations, and (3) make the training more relevant to a particular learner.

Game development is an interdisciplinary effort that requires tradeoffs across disciplines to get the most "bang for the buck." The use of standards to describe the narrative aspects of game designs can assist tradeoffs and allow broader sharing of games for training, providing designers a way of comparing games to see what would have to be modified so that the game could serve a different purpose.

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[1] RTI International is a trade name of Research Triangle Institute.

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INTRODUCTION

The U.S. military is looking for reconfigurable games as a method for reducing the cost of virtual training, allowing training to be adapted to a learner's needs and situations. Training using games that operate on personal computers can be delivered to the learner at the right time and place at very low cost. Roger Smith (2007) describes this approach as exploiting the digital long tail of military simulations, emulating the success of online businesses such as Amazon.com.

The existing international standards will encourage more reuse of games for team training by enabling more efficient modification of scenarios and will provide a basis for estimating the cost and risk of creating new scenarios. The standards provide a basis for a set of tools that can check the consistency of scenario edits and estimate the risk as a function of the differences between existing and proposed scenarios.

WORKING DEFINITION FOR SERIOUS GAMES

For the purposes of this paper, "serious games" are defined as complex systems of purposefully designed learning experiences with clearly defined learning objectives. Additionally, a serious game involves an assigned problem and employs rewards/penalties for performance (Serious Games Showcase and Challenge, 2009).

Scenario-based serious games are a promising medium for providing direct experience and concrete contexts in military training environments. While the fundamentals of training and learning design are enduring, the design of scenario-based games for learning requires a different, more holistic approach in order to leverage the great promise and power inherent in game design and methods (Johnson & Wang, 2007).

Serious games are most effective when they immerse and engage the learner in a realistic setting that presents authentic situations and relevant tasks. Effective game-based learning links task performance to the larger mission; the context in which learning will take place; cues to indicate the need and timing for activities; and ultimately, the results achieved. The strategy allows learners to use higher-order critical thinking skills as they make choices and experience the consequences of those choices (Federation of American Scientists, 2006; Becker, 2006).

WHY RECONFIGURE GAMES?

For the purposes of this paper, reconfiguring a game means changing the narrative portions of the game. The basic game architecture will typically be reused since it usually is expensive to change.

Reconfiguring a game is an important, low-cost way of adapting the game to the skill level of the learner, which helps to keep the learner in the "flow" (Csikszentmihalyi, 1997). Reconfiguration changes the play each time the player participates in a new scenario, thereby keeping the game fresh for the player. The changes between sessions need to be managed so that the player can be familiar with the game play mechanisms for repeated play, but is challenged appropriately for his or her skill level and the learning objectives.

Reconfiguring a game also adapts the game to the learner's context. For example, if the learner is a soldier in an infantry company, then a serious game set in the context of an infantry unit is more likely to be engaging than a serious game set in the context of an artillery battery. A similar strategy for the reconfiguration of training is described in Brooks & Jesukiewicz (2006).

ANATOMY OF A GAME NARRATIVE

In its simplest form, a narrative is a story with a chronological implication. The stories of players and the characters in a serious game are the elements that drive the player to purposeful experiences and provide meaning to those experiences (see Figure 1). Well-designed stories provide the basis for an engaging, social learning experience. Additionally, learners have

been shown to perform better when the storyline of a scenario was relevant to the training objectives.

Figure 1. Good Narrative Drives Purposeful Experiences and Meaning

The narrative component of a game (Freeman, 2009) can be described in terms of the following:

Context: One of the major roles of the narrative is to provide the social and organizational context of the learner, learning experiences, and the entire game. The story should describe the hierarchy of organizations and social groups, along with where the learner fits. This includes indicating who the learner works for, as well as indicating the learner's peers, subordinates, and adversaries (Ryan, 2001).

A serious game can be reconfigured to provide a more relevant experience for a player by changing the unit of assignment to match that of the player.

Place: A sense of place is provided to show both where (i.e., geographically) and when (i.e., temporally) the experiences take place (see Figure 2).

Figure 2. A Sense of Place Develops Expectations of Action

The game can be reconfigured by changing archetypical buildings and terrain to establish an expectation of types of action or goals for the learner. For example, the expectations of action suggested in Figure 1 (an African village) contrasts sharply with the expectations suggested in Figure 2 (an intensive care station in a hospital).

Character: Good, serious game narratives provide rich development of characters to enable learners to understand how to adapt to the characters of different team members while the team roles stay the same. Changing the personalities of other characters in the game world also changes the social dynamics of the learning experience. For example, the character and motivations of the host nation military officer, civilian, and coalition force officer in Figure 3 are expected to be very different and to vary in different ways.

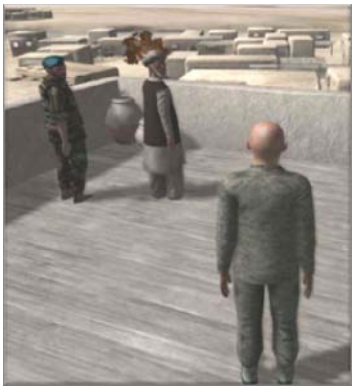

Figure 3. Well-Defined Characters Provide the Basis for Engagement and Social Learning

Drama: Dramatic techniques are used to engage the learner's attention and create suspense in the story. The dramatic techniques of creating a player's desire to solve a mystery and to see the results of their actions are important in creating suspense and maintaining player engagement (see Figure 4).

Figure 4. Narrative Drama Enhances Player Engagement

Serious games can be reconfigured by leveraging these dramatic techniques to progress the narrative and

enhance engagement. Examples of reconfiguration include changes to the back story, cut scenes, flashbacks, foreshadowing, cliffhangers, and red herrings.

Goals: A goal is something the learner will try to accomplish in the game and provides the reason for the learner to take an action. The learner is compelled to take action in the serious game by providing goals (Salen & Zimmerman, 2004; Belanich et al., 2004; Oliver & Nabi, 2004).

A game can be reconfigured by varying the stated goal from the actual learning action to a goal, which places the learner in a situation to take an action caused by a precipitating event. For example, the learner may be given the mission to move to a village, which provides the context for an ambush along the way (Costikyan, 2002).

Conflict: Conflict motivates by providing a foil or disruption to the learner's plans. This creates tension and heightens engagement by creating a sense of overcoming obstacles. The conflict can come in the form of an adversary, such as an enemy, the natural environment, or problems such as supply issues or mechanical breakdown. Conflict can be the starting point, motivator, or dynamic element in a game (Heliö, 2004; Salen & Zimmerman, 2004).

Reconfiguring serious game conflict creates a sense of urgency and the basis for player action. The primary method of increasing the difficulty level of the game is to increase the level of conflict (Lankoski & Heliö, 2002).

WHY STANDARDS FOR GAME SCENARIOS?

Standards can ensure consistency between the elements of the narrative. The relationships between design elements documented by the standards imply consistency requirements. For example, the assignment of a character to a role requires that the character has the ability to carry out the responsibilities of the role. Similarly, standards can ensure consistency between the goals of the game and the learning objectives as a means of ensuring that the end result is a good serious game.

In addition, standards can help developers find games that can be easily reconfigured to meet specific training needs and audiences. The standards discussed in this paper specify extensive metadata that can be used to find games with similar narratives.

Standards also can help to make game requirements explicit, thus facilitating collaboration between instructional designers and game developers. Understanding the relationships between learning objectives and the narrative components of a game can help to prioritize changes to the game architecture or to the growth in the game library components. Our goal is minimize the overall costs for training implementation (and development) while meeting all the learning objectives. This approach is similar to that taken by Freeman and White (2008).

STANDARDS FOR GAME SCENARIOS

This paper focuses on games as a method for a learner to practice how to work as member of a team to accomplish a mission. In this context, we describe two related standards. The first standard, ISO/IEC 19778 (ISO/IEC, 2008a, b, c), is a way of describing a team and its mission that separates reusable aspects from easily varied aspects of the narrative. The second, ISO/IEC 24763 (ISO/IEC, 2010), is a technical report that provides a way of describing learning objectives from the points of view of multiple stakeholders. Both of these documents were developed by Subcommittee 36 of the ISO/IEC Joint Technical Committee (JTC) 1, which is responsible for developing information technology standards for learning, education, and training.

ISO/IEC 19778 is a three-part standard that defines an ontology for specifying the information technology requirements for collaborative workgroups. In this paper, we use this standard as a form of metadata to describe requirements for team player games. ISO/IEC 19778 defines a set of entities and relationships between those entities. The entities define the members of a team, the roles that they take on, and the tools that the team needs to complete its mission. We use the relationships between the entities to specify consistencies that need to be maintained if the game is to be reconfigured for a different purpose. In this paper, we show how ISO/IEC 19778 captures the three "R's" of collaboration: Roles, Responsibilities, and Rights. The three parts of ISO/IEC 19778 are the following:

- A Collaborative Workplace Data Model
- A Collaborative Environment Data Model
- A Collaborative Group Data Model.

ISO/IEC 19778 Data Models

The ISO/IEC 19778 standard defines a "collaborative workplace" as a group of participants working together on a common mission and in a "collaborative environment" as a collection of collaborative tools and their functions. The standard defines a collaborative

workgroup (or team) as a mapping of participants to roles and then associates functions with the roles. The standard describes three data models for this information, as follows:

Part 1: Collaborative Workplace Data Model (ISO/IEC, 2008a) defines a standard set of entities and relations for describing a collaborative workplace (CW). The CW data model describes the purpose and duration of the workplace and links the workgroup to an environment.

Part 2: Collaborative Environment Data Model (ISO/IEC, 2008b) provides a standardized way of describing a collection of resources (services and functions) that can be configured to meet the needs of a range of missions. We include information sources as services and access privileges as the corresponding functions.

Part 3: Collaborative Group Data Model (ISO/IEC, 2008c) provides a standardized way of specifying the roles and participants of a CW and maps the participants to their roles.

Figure 5 shows how the three parts of the ISO/IEC 19778 standard fit together. The bold serif font indicates data elements in the ISO/IEC 19778 specifications, and the plain Arial text indicates refinements of the specification that we have instituted to knit these specifications together. Similarly, the solid arrows are links specified in the standards, and the dotted arrows are enhancements that we have added.

As shown in the top block of Figure 5, the CW data model links together the Collaborative Environment (CE) and Collaborative Group (CG) data models. It also provides a time span for the workplace. We use this time span specification to support the sequencing of multiple scenarios. We have enhanced the CW specification while staying consistent to the data model by including in the description the definition of the mission and the responsibilities (expected outcomes) of the workplace. Adding this responsibility information allows a workplace to be considered as a participant in a larger collaborative workplace.

The second block of Figure 5 (left) presents the CE data model, which includes the services and functions that are available. These components are related to the game play and identify objects that have to be included in the game. We reference these services and functions in the competency models.

The third block of Figure 5 (right) presents the CG data model, which includes the roles and participants and maps the participants to their roles. We have enhanced the CG specification while staying consistent to the data model by embedding definitions of responsibilities in the roles. Similarly, we define role responsibilities in terms of outcome identifiers that are linked to the competency descriptions.

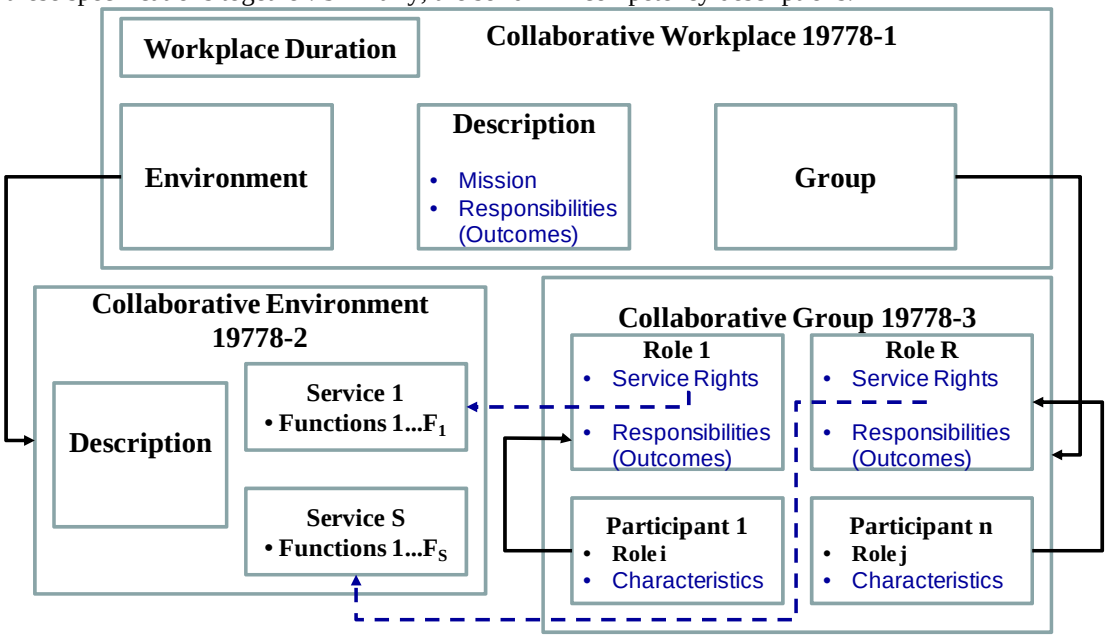

Figure 5. The ISO/IEC 19778 Standard Architecture Showing Linkages between the Data Models

ISO/IEC 24763 Conceptual Reference Model

ISO/IEC 24763 describes a Conceptual Reference Model (CRM) for competencies and related information, which serves as a method for formalizing learning objectives for serious games. Like the data models of the ISO/IEC 19778 standard, the CRM is a high-level entity-relationship model. Figure 6 shows the relevant portion of the CRM, including the entities of actors, actions, outcomes, the environment in which the action takes place, and the methods for evaluating the quality of the outcomes (Blandin et al., in press). We link the CRM Actors to the Participants of the CG and the CRM Actions to the CE functions and Services. We also link the CRM Outcomes to the CG Responsibilities.

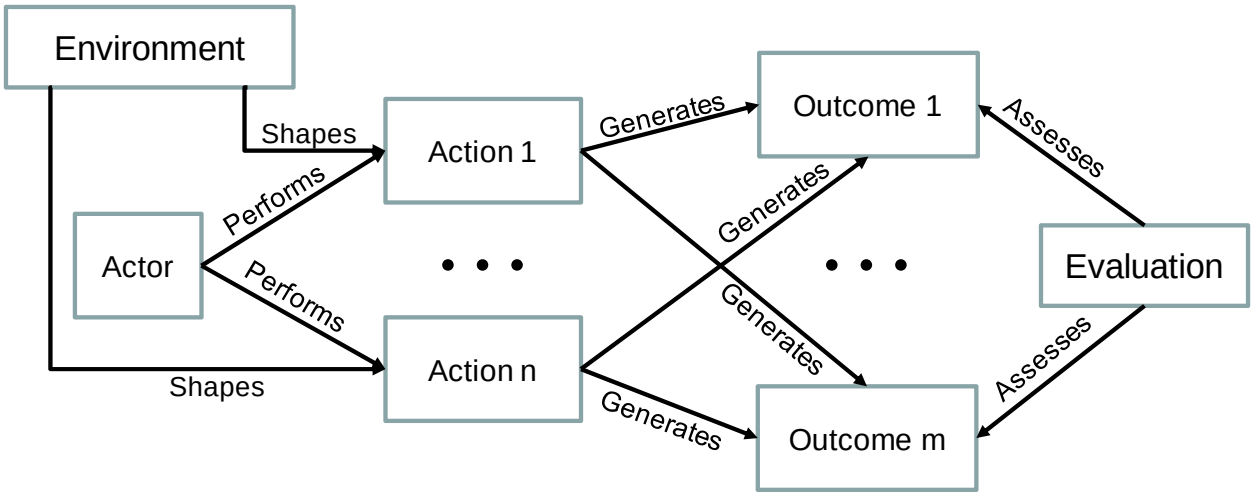

Figure 6. The ISO/IEC 24763 Competency Model Showing Linkages between Components

AN EXAMPLE

The example game scenario that we will use is a simplified oncology surgery example.

Similar to a play, the overall narrative of this example is broken into "acts" or scenarios. For this example, scenarios might include the patient examination and diagnosis, the surgery, and a follow up examination by the surgeon and oncologist. These scenarios will occur in different environments: the doctor's office and the operating room. Different roles will be present in the different scenarios, and different narratives will be used.

USING THE STANDARDS TO DESCRIBE GAME SCENARIOS

In the following paragraphs, we describe how a surgery scenario can be described using the standards.

Using the Collaborative Workplace Data Model

Part 1 of the ISO/IEC 19778 (i.e., *Collaborative Workplace Data Model, 19778-1*) provides a method for capturing key metadata about a scenario for a game. Figure 7 shows how the metadata about the surgery scenario is incorporated into the CW data model. This specification uses links to connect this overall description to the specifications of the environment and the group for the scenario. This linkage supports reuse by allowing different environments or groups to be configured for the same mission.

For the surgery example, the mission is to remove the cancerous tumor and have the patient recover fully from the operation. The time frame is the day of the surgery. The environment is labeled as the hospital operating room, and the team participating in the operation is the oncology surgical team.

The responsibilities of this surgical workplace are to remove the tumor and have the patient recover. The patient is included as a member of the team and has responsibilities that can determine the outcome.

Using the Collaborative Environment Data Model

Part 2 of the ISO/IEC 19778 (i.e., *Collaborative Environment Data Model, 19778-2*) provides a method for describing the physical setting for a scenario of a game. The CE specification provides requirements for the graphics and behavior development of the game. Part of the description of a role is a definition of the functions and tools that are required for the participant in that role to meet his or her responsibilities. In

particular, the CE specification identifies services and functions that the game engine needs to provide for the game play. Figure 8 shows how the metadata about this scenario is incorporated into the CE data model. The CE data model consists of a description field and any number of service fields. Each service field identifies one or more functions provided by the service.

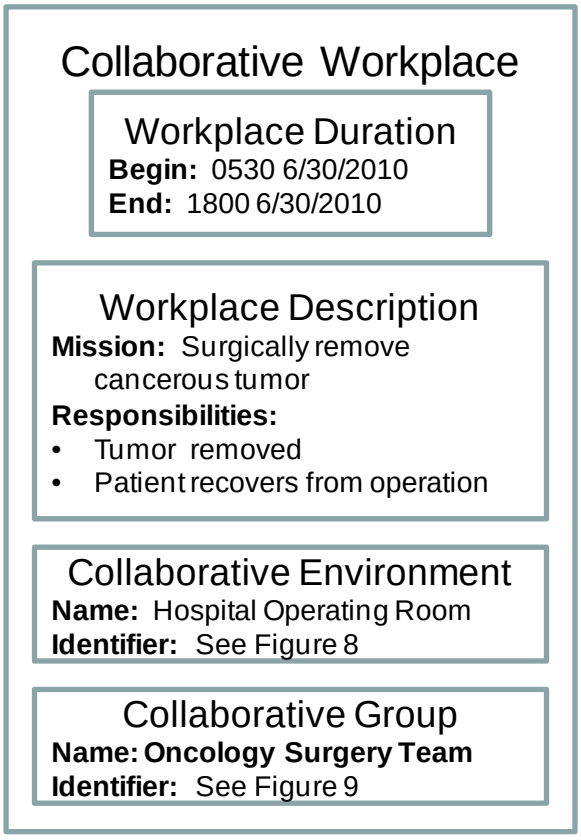

Figure 7. A Collaborative Workplace Description for the Surgery Scenario

We have extended the semantics of the CE specifications by specifying additional information in the descriptions, particularly the physical setting where the scenario takes place. We also list the objects in the environment, distinguishing between interactive and non-interactive objects.

This inventory provides essential information for estimating the amount of work required to adapt a game to a new training need. We distinguish between interactive and non-interactive objects because they require different levels of effort to construct. We link the interactive objects to the associated services and functions as a way of defining requirements for new behaviors that may need to be added to the game.

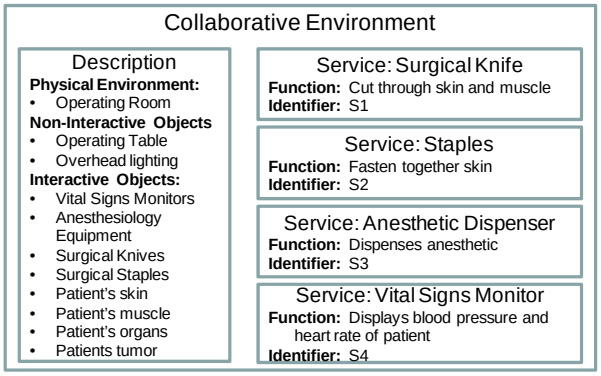

Figure 8. A Collaborative Environment Description for the Surgery Scenario

For the surgery scenario, the static objects include the operating table and the overhead lighting. The interactive objects include the vital signs monitors, the anesthetic dispenser, and the surgical knives and staples. The interactive objects will be part of the game play.

The patient is a special role in this scenario, since the surgery is acting on the body of the patient. The patient's body has functions that interact with the tools being used by the learner.

Using the Collaborative Group Data Model

Part 3 of the ISO/IEC 19778 (i.e., *Collaborative Group Data Model, 19778-3*) provides a method for describing the CW team. Figure 9 shows how the metadata about the team is incorporated into the CG data model. For this example, we include five roles and provide a single participant for each of the roles. In Figure 9, the list of participants is shown in the shaded boxes on the left. The role definitions are shown to the right of the list of participants. The CG specification makes the mapping of the participants to the roles explicit. This mapping is another example of indirection that supports reconfiguration. Multiple variations on a scenario can be constructed by varying the mapping of potential participants to roles.

The roles include a qualification field, which serves to filter out potential mappings so that any participant mapped to a role is qualified for that role. The role description also specifies the rights and responsibilities of the role. The rights of a role define dependencies on the services and the actions of the other roles.

In other applications (Frank & Hubal, 2008), the rights of a role include the access rights to relevant data. This aspect of many tasks, including medical tasks, is relevant. For example, if the scenario indicates that this

is an emergency surgery and the oncologist did not refer the surgeon, then there may be difficulties in the surgeon and the anesthesiologist gaining access to the patient's medical history.

Identifying Group Participants

Participants are people or organizations that are mapped to the roles. From the point of view of a simulation, the choice of participant for a specific role is like a parameter for the role. The role constrains the behavior in terms of meeting responsibilities, but within the envelope defined by the responsibilities, there are a range of possible variations in behavior. One form of variation is introduction of bias in the behaviors of participants (Frank & Hubal, 2008).

The patient is a special role in this scenario because the surgery is acting on the body of the patient.

Mapping Participants to Roles

The ISO/IEC 19778-3 standard describes the mapping of participants to roles as part of the definition of a collaborative workgroup. This level of indirection provides another method for reconfiguring a game.

Varying the characteristics of the group participants is a powerful means of updating a scenario to keep the experience fresh for the learner. With a library of participant characteristics (visual and behavioral), the scenario can be adapted by changing the mapping of the participants to roles.

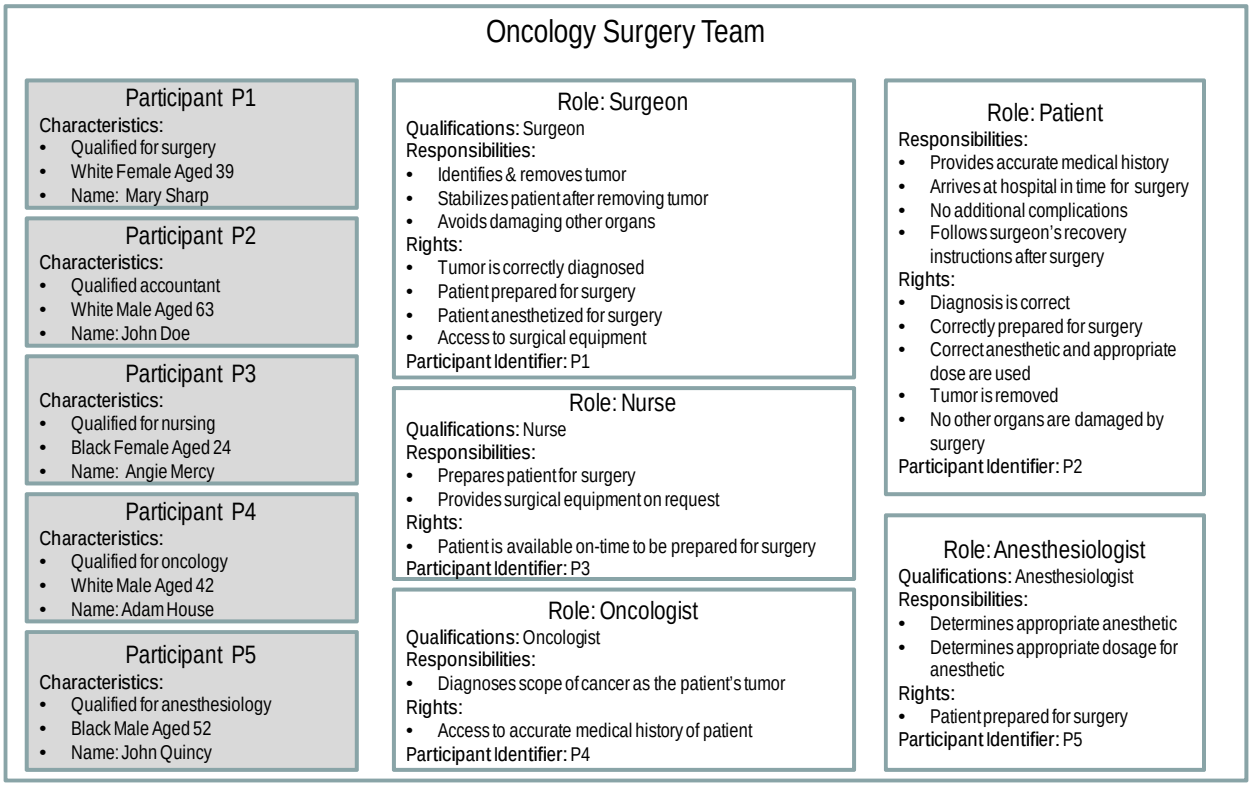

Figure 9. Collaborative Group Description for the Surgery Example

Using the Competency Conceptual Reference Model

We use the ISO/IEC 24763 CRM to describe the actions and outcomes of the collaborative group participants. We have extended the 19778-3 CG data model by linking each participant to a CRM. These conceptual reference models are specific to the participant. Figure 10 shows how the CRM uses information in the CW specification.

The services and functions described in the CE specification are referenced in the Action entities of the CRM. The outcomes of the CRM are linked to the participant responsibilities identified in the 19778-3 CG data model.

The actions in the CRM for the learner's role describe requirements for the game play. Linking the actions back to the services and functions is a way of deriving requirements for interactive objects.

The evaluation methods shown in the CRM define requirements for the game scoring and for evaluation of the learning objectives. Non-Player Characters

(NPCs) may not have evaluation methods defined. However, the same scenario may be adapted to train more than one of the roles by changing which roles are NPCs and which are learners.

FUTURE WORK

We have described how these two ISO standards can specify much of the context of a game narrative, as well as some of the game play requirements. The sequence of actions of the roles provides a guide to the storyline and the control of conflict. While the services and functions are implemented in the game, the learner may not realize the deficiencies or strengths of the NPCs until they are revealed by the storyline. The evolution of conflict in a scenario can be managed by controlling the competencies of the NPCs.

Another aspect of a storyline is the dialog. Information about the roles and their responsibilities provides a framework for most of the dialog in a game. We are working on tools that will aid in the generation of relevant dialog.

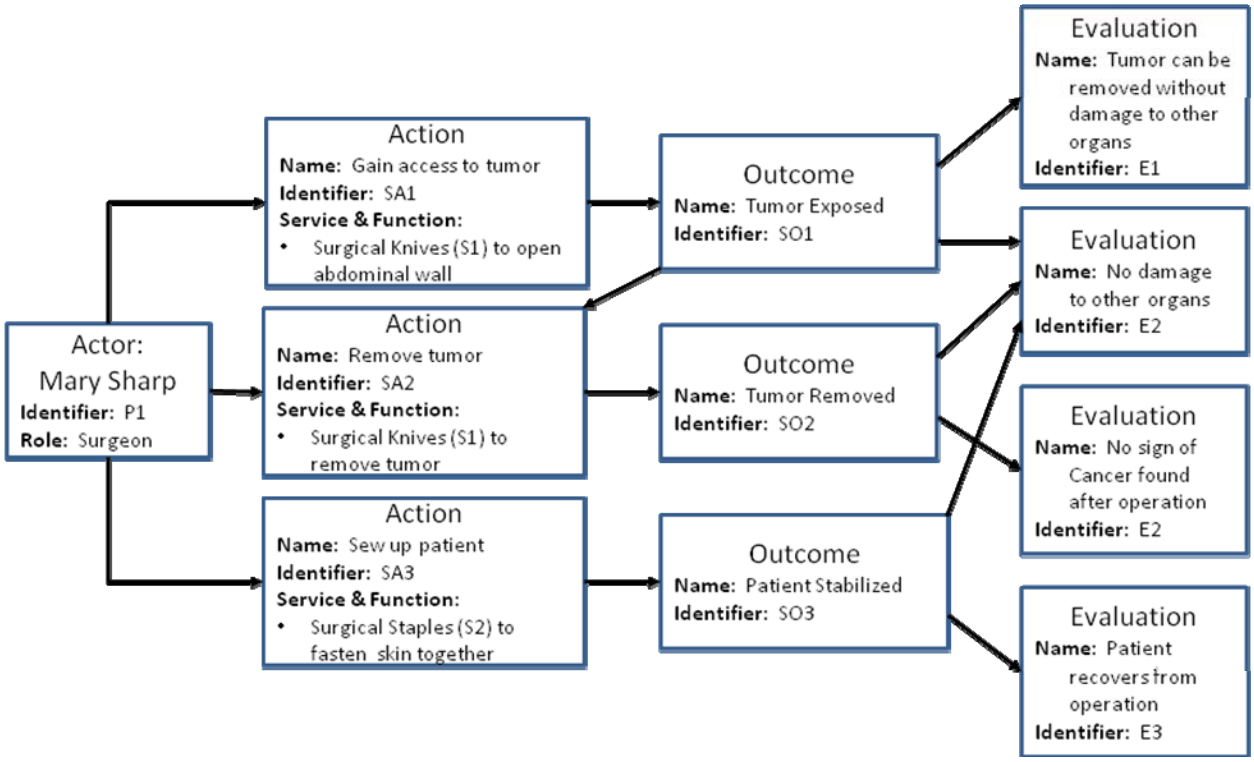

Figure 10. Competency Description for the Surgeon's Role

CONCLUSIONS

The two cited international standards (ISO/IEC 19778 and ISO/IEC 24763), when used in combination, can describe requirements for the narratives of games for training team skills. These standards form an ontology of requirements as a set of entities and relationships between entities. Differences between an existing game and desired roles and their competencies can be calculated as a way of estimating the effort required to reconfigure the existing game for a new purpose. The relationships between the entities imply invariants that need to be preserved when a new game is configured.

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