A new paradigm for serious games: Transmedia learning for more effective training and education

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ARTICLE INFO

ABSTRACT

Serious games present a relatively new approach to training and education for international organizations such as NATO (North Atlantic Treaty Organization), non-governmental organizations (NGOs), the U.S. Department of Defense (DoD) and the U.S. Department of Homeland Security (DHS). Although serious games are often deployed as stand-alone solutions, they can also serve as entry points into a comprehensive training pipeline in which content is delivered via different media to rapidly scale immersive training and education for mass audiences. The present paper introduces a new paradigm for more effective and scalable training and education called transmedia learning. Transmedia learning leverages several new media trends including the peer communications of social media, the scalability of massively openonline course (MOOCs), and the design of transmedia storytelling used by entertainment, advertising, and commercial game industries to sustain audience engagement. *Transmedia learning* is defined as the scalable system of messages representing a narrative or core experience that unfolds from the use of multiple media, emotionally engaging learners by involving them personally in the story. In the present paper, we introduce the transmedia learning paradigm as offering more effective use of serious games for training and education. This approach is consistent with the goals of international organizations implementing approaches similar to those described by the Army Learning Model (ALM) to deliver training and education to Soldiers across multiple media. We discuss why the human brain is wired for transmedia learning and demonstrate how the Simulation Experience Design Method can be used to create transmedia learning story worlds for serious games. We describe how social media interactions and MOOCs may be used in transmedia learning, and how data mining social media and experience tracking can inform the development of computational learner models for transmedia learning campaigns. Examples of how the U.S. Army has utilized transmedia campaigns for strategic communication and game-based training are provided. Finally, we provide strategies the reader can use today to incorporate transmedia storytelling elements such as Internet, serious games, video, social media, graphic novels, machinima, blogs, and alternate reality gaming into a new paradigm for training and education: transmedia learning.

1. Introduction

Games have been used for a number of years in fields such as business and management science, economics, intercultural communication, and military science to expose both large and small audiences to complex dynamics. Military use of warfare board games dates back to 17th Century Germany [29]. Centuries later the U.S. Army War College was among the first to use networked, multiplayer simulations in the 1970s to refine mathematical models. The first use of a networked multiplayer computer game for training was by the U.S. Marine Corps. The U.S. Marines were among the earliest adopters of video game-based learning with the development of Marine Doom, a modified version of Id Software's Doom II, in 1995 [41]. Marine Doom was developed to allow four-person fire teams to train real-time teamwork and decision-making in an interactive virtual environment. Thus Marine Doom was the earliest modification of a commercial entertainment computer game for training and learning communication and coordination—not shooting or killing [32]. Since the late 1990s video games have been used by all branches of the Services for training and education, although most of this adoption has occurred in the last eight years. These video games are often called "serious games."

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Serious games can be defined as the use of interactive digital technologies for training and education in private, public, government, and military sectors [35]. While there are many definitions for games, most identify some sort of conflict, rules, structure, goals, and uncertain outcomes as salient elements [5,7,11,19,26,42]. For example, serious games can include role-play experiences, and social-process, immersive simulations for exploring interpersonal development, adaptive thinking, combat tactics, emergency response, diplomacy, governance, health, education, management, logistics, and leadership.

Military and government use of serious games and interactive multimedia instruction has grown steadily. The need for effective use of multiple media, immersive simulations, and gaming approaches for homeland security and defense has never been greater. The United States military adopted serious game-based training for reasons that also appeal to many other organizations. These reasons include reduced cost when compared to the cost for large simulators or live training, reaching digital natives who have grown up with technology, increased motivation to learn [17,32], and the ability to leverage state-of-the-art technology. That said, the use of serious games remains largely stand-alone, lacking interoperability of data models, and failing to adequately support self-paced learning outside of facilitated exercises. In addition many serious games lack the ability to detect the users' context and therefore cannot personalize instruction very well. Nor do many serious games in use scale up to train thousands of learners at any given time as a Massively Open Online Course (MOOC) would. MOOCs are online courses (e.g. Coursera, Udacity, edX) that feature large-scale interactivity and open access via the Internet.

For these reasons, serious game training and education must move beyond stand-alone solutions toward more complete, self-paced, and enduring training experiences that are part of a learning system. Twenty-first century demands on training and education will extend the use of serious games beyond the manner in which they are currently used. If utilized as part of a system of experiences, serious games can serve as entry points into a comprehensive experiential training pipeline in which evolving content is delivered via different modalities and media throughout a learner's career.

The application of transmedia learning is a fairly recent innovation. In 2010 this author began applying transmedia storytelling to training and education while developing graphic novels to support game-based training scenarios with the U.S. Army Program Executive Office for Simulation, Training and Instrumentation (PEOSTRI) Games for Training and TRADOC Capability Manager TCM Gaming [34]. The *transmedia learning* construct has since been refined and defined by this author as the scalable system of messages that represents a narrative or core experience that unfolds from the use of multiple media, emotionally engaging learners by involving them personally in the story [34]. Transmedia learning is a new paradigm for education and training that has the potential to revolutionize the way organizations learn by providing a framework from which to hone learners' abilities to synthesize information across multiple media channels and become more agile thinkers. Transmedia learning leverages several new media trends including the peer communications of social media, the scalability of MOOCs, and the design of transmedia storytelling to sustain learner engagement with memorable learning experiences. This paper introduces the notion of transmedia learning, an approach to connect learners to content and each other through the use of a transmedia learning campaign. A transmedia learning campaign is the purposeful, coordinated, and strategic use of multiple media messages to support a story or narrative over time to engage new learners or keep learners engaged. Integral to the design of transmedia campaigns and measurement of transmedia learning is the ability to track user interaction, feedback, and user-generated content through data mining social media and activity tracking for the future development of computational models of learners.

There are very few integrated applications of transmedia learning in use today by researchers, instructors, or training cadre and therefore few examples of experimental data are available on its effectiveness. Nevertheless the concept merits discussion now, so that the training & education and computational modeling & simulation communities can get in front of the trend. Therefore subsequent sections explore the science, application, and design of transmedia learning. We introduce the Army Learning Model (ALM) which presents a military vision to deliver training and education to Soldiers across multiple media, anytime, anywhere. The Simulation Experience Design Method demonstrates how transmedia story worlds can be created using a framework that has also been used successfully to design serious games [35]. A social media data mining approach under development for tracking learner participation and feedback is described. Mining social media data can inform the development of learner models for future transmedia campaign assessment. An open source method used to track learner activity streams is discussed, and existing research on agent-based approaches introduced as potential applications to transmedia learning. Examples of how the U.S. Army has utilized transmedia for strategic communication and game-based training are provided. Finally, strategies the reader can use today to incorporate transmedia storytelling elements such as Internet, serious games, video, social media, graphic novels, machinima, blogs, and alternate reality gaming into defense and homeland security transmedia learning campaigns are mentioned throughout. The purpose of the present paper is to familiarize the readers with an emerging concept (transmedia learning campaigns) that has great potential for further exploration through computational science. In order to introduce the concept such that readers can reflect on how their own particular computational approaches may apply, we discuss background, examples of transmedia learning in use, how specific elements (individual technologies) and campaigns are designed, and how learners' feedback and activities can be tracked by while interacting with a transmedia learning campaign. We refer interchangeably to transmedia storytelling, transmedia campaigns, or simply transmedia learning as the same concept.

2. Background: transmedia storytelling for learning

The first use of a transmedia model for an entertainment franchise was in 1976 to support George Lucas' *Star Wars*. A publishing group was formed to produce and promote all products such as games, movies, toys, cartoons, books, and comics associated with the film [18]. The objective of this transmedia application was to create a fan base that followed the transmedia experience across different media so as to not miss out on any part of the story. While the films now serve as the basis for the main story, the audience can remain engaged in the *Star Wars* storyline through multiple media such as websites, wikis, video games, books, encyclopedias, comics, animated series, toys, clothing, and jewelry, among many others. In fact, the franchise is so large now that the richness of the narrative content is referred to as a story world, or universe. Whether one's interest is political, social, science fiction, or mythology—the franchise offers unique content to appeal to different interests in order to increase their fan base.

Transmedia storytelling can be defined as crafting a narrative or consistent message (story) across multiple media. According to Henry Jenkins, "A transmedia story unfolds across multiple media platforms with each new text making a distinctive and valuable contribution to the whole" [21]. In other words, transmedia storytelling for learning allows learners to engage with expanded parts of a narrative for a variety of reasons—to learn more deeply, gain a

different perspective, or to reinforce. Transmedia learning, then, consists of sustained experiences that result in measurable behavior change. The behavior change can be physical and overt, intellectual, attitudinal, or a combination. Achieving learning goals via transmedia learning requires systems thinking and forethought. Therefore, it may be useful to consider transmedia learning projects as "campaigns." The term "campaign" as used in this paper will refer to a coordinated effort to link several media and training approaches to a single idea, experience, or theme. The use of transmedia learning campaigns for training and education is a cutting-edge approach that can help with retention, remediation, and knowledge reinforcement because, much like the example of the *Star Wars* franchise, learners are able to access content in a self-paced manner, anytime, anywhere. Utilizing transmedia learning campaign strategies, integral elements of a training narrative (e.g., warrior-diplomat ethos, first responder practices) get dispersed systematically across multiple delivery channels for the purpose of creating a unified and coordinated learner experience. Ideally, each medium makes its own unique contribution to the unfolding story. In this way, designing transmedia learning is akin to designing a *system of experiences* that conveys consistent communication messages [35].

When crafting transmedia learning for training, a designer can follow a typical framework for telling stories that involves taking the learner on an emotional journey from setting up the situation and characters, introducing a conflict or challenge, allowing the tension to reach a high point or climax, and finally providing an opportunity for resolution [37]. This framework is often used in narrative game design and scenario-based simulation. Games provide players with experiences [42]. These experiences are often identified as being emotionally engaging [15], although as David Freeman [13, p. 10] has stated, "you can't just suggest an emotion and assume the player will feel it." Creating true affect in games (as well as in transmedia learning) requires satisfying learners' emotional needs or presenting different opportunities to explore emotions that learners may find appealing to try [27]. Similarly, serious games for homeland security and defense training can be interactive scenarios in which the learner is engaged by being the protagonist of his or her own story. Live Action Role Play (LARP) and multi-player games often involve the learner from the first-person perspective. This first person buy-in is also key to transmedia learning storytelling. When learners are emotionally invested in the story and, in the case of training and education, see themselves as protagonists of their own training story, they remember it better and continue to respond to new or strategically repurposed content that is associated with familiar emotional triggers.

In the next section we introduce an ambitious vision for training. The Army Learning Model (ALM) will require games and tools that not only interoperate, share data models, and tell their own unique stories but also deliver cohesive, cross-platform training that is memorable and increases retention. Transmedia learning provides a practical approach to designing cohesive learning instances that support a larger goal of motivating learners to train anytime, anywhere.

3. Army Learning Model: why we need transmedia learning

In 2011 the U.S. Army formally identified a learning model to meet new requirements outlined in a Training and Doctrine (TRADOC) document, called the U.S. Army Learning Concept 2015 (Pamphlet 525-8-2). According to Ref. [44, p. 3], "although the Army was an early adopter of distributed learning nearly 20 years ago, the program did not fully realize its intended goal of anytime, anywhere training." Army institutional training is still primarily comprised of instructor-led courses that are difficult to modify to meet individual

learner's needs [6]. However, the Army has not abandoned its goal of anytime, anywhere training.

The ALM is a learning model that leverages personalized, self-paced instruction, and opportunities for peer interactions. The learning model can be best understood by applying distributed cognition theory and the notion of "cognition in the wild." *Cognition in the wild* refers to human cognition as it naturally occurs and adapts in the everyday world—situated in culturally constituted human activity [20]. The ALM vision describes learner assessment while the learner naturally encounters content and experiences. "The future learning model must offer opportunities for Soldiers to provide input into the learning system throughout their career" as well as account for Soldiers' prior knowledge and experiences [44, p. 6]. Thus, the learning model represents training the way that people learn naturally—by formal and informal learning experiences in and out of the classroom and across learning platforms, or other media.

In order to realize the ALM vision, blended, multi-media deployment and storytelling strategies will need to be leveraged effectively to motivate personalized, self-paced training and education. These media may include serious games, immersive simulations, intelligent tutoring systems, virtual environments, machinima (video or short films made with game technology), mobile learning, graphic novels, motion comics, film, radio, print, and social media. ALM presents a very ambitious vision that will require a paradigm shift in defense and homeland security training. ALM training and education can leverage transmedia learning campaign strategies.

3.1. Army Learning Model use case

For example, recall the vision of a Soldier who trains anywhere, anytime. As described by the ALM, a Soldier trains in the field, with different simulators, on different platforms, in the classroom, and with her peers (both co-located and distributed). The use of different media allows her to engage in the training from different platforms and entry points. Her training may be comprised of interacting with one or more of the following technologies: intelligent computer-based tutoring, mobile performance aids, MOOCs, immersive virtual environments, serious games, augmented reality, machinima, graphic novels, peer-generated content, and social media. For instance, if she is learning the art of being a Soldier–Diplomat, she may begin her language and culture training with an intelligent tutor and continue with a single-player scenario on cultural awareness that is delivered via a serious game. She also engages in an alternate reality game on cultural awareness with her peers. Later she blogs about what she learned and shares this information with her team. The conversation about cultural awareness continues on Twitter. She reads about case studies via digital graphic novels or by watching videos available from the MOOC. Her learning is self-paced, collaborative, adaptive, and/or mediated by instructors, virtual mentors [30], and embodied agents [31]. She creates content, tracks her own learning, and monitors her progress. A transmedia learning campaign could allow her to track her actions as she trains and store these data in her learning record store, learner profile, or learner model. This notion is explored in subsequent sections. Most importantly, her training is delivered via a variety of media, making it more dynamic, accessible, and engrossing. Her training leverages best practices and advancements from the commercial game industry. Her training and education is delivered and reinforced via a *transmedia learning campaign*.

4. Transmedia learning for more effective training and education

According to Mark Long, Transmedia Producer and CEO of Meteor Entertainment, "We are in a transitional period where our

relationship with media is shifting to multiple screens. Our audience is growing up in a digital world. The playing, reading patterns, and habits of young and old are changing as reading extends from the printed page to tablets and to a future of a myriad of diverse devices" (Defense GameTech Keynote, March 2011). As noted by our ALM example above, transmedia storytelling supports learning across a spectrum of devices by allowing the trainee to stay connected with training content throughout the day as she interacts with the devices and media with which she is accustomed. While it may not be possible to train all instances of a learning objective with a serious game, or any other technology for that matter, the training that is introduced can nearly seamlessly unfold while content is reinforced by other media. This is a big idea, representing a paradigm shift in the way we think about modeling, simulation, and executing training and education. To achieve a paradigm shift in training we will need to move beyond serious games as stand-alone digital learning instances. Current and future training and education realities necessitate a broader vision toward supporting serious game content with storytelling across multiple media to extend learning experiences beyond a single session. Even when learners are not playing a serious game they can remain engaged with the training content, especially if we apply transmedia learning. Transmedia learning can augment serious game-based training because it blends story experiences to achieve buy-in from the learner by allowing multiple entry points into the narrative, over several media. Transmedia learning does not imply design control over content—transmedia learning storytellers must allow learners to co-author the narrative by contributing their own experiences and interpretations [18]. We allow for co-creation in transmedia learning because we seek to involve the learner cognitively and emotionally. That is to say, transmedia learning engages the brain and it behooves designers to understand how.

4.1. Transmedia learning, emotions, and the brain

Why does transmedia learning appeal to us on an emotional level? Why have stories been central to the human experience? Research indicates that it is primarily because the human brain is wired to pick up on messages crafted as stories because we feel real emotions when we connect with content or a character in a story. One potential explanation from LeDoux [24] is that the brain uses two mnemonic systems to process information. The brain processes information both rationally and emotionally, although emotions about rational content are usually processed by the brain split seconds before rational or logical interventions by the cerebral cortex. The brain's limbic system (thalamus, amygdala and hippocampus) reacts to information by interpreting sensory organ impulses sent by the thalamus to produce an emotion in the amygdala [24]. LeDoux claims that perceptions (thalamus) and emotional responses (amygdala) always occur first—followed by judgments of like or dislike formed in the hippocampus. The limbic system generates emotional memories that make it easier for us to categorize and remember information. Put simply, LeDoux's research indicates we best remember information presented in the form of a story. When done well, transmedia learning campaigns can evoke emotions that tap into sensations processed by the brain that may motivate a learner to have better retention of and connection to the content even when explored across several media.

5. Transmedia strategic communication with a serious game

Transmedia campaigns have also been used for strategic communication by the America's Army franchise. The America's Army first person shooter game was conceived by Colonel Casey Wardynski of the U.S. Army Office of Economic and Manpower Analysis (OEMA) as a strategic communication tool to aid with recruitment, and to reach a fan base of young people who were not likely to have had a family member that was in the Army. Widely popular since 2002 with millions of fans worldwide, there have been over 26 publicly available versions released. The game is available by free download (http://www.americasarmy.com).

A successful transmedia campaign example of the America's Army franchise was the Real Heroes program. Real Heroes was launched in 2006 to give the fan base an opportunity to form emotional connections with real men and women of the U.S. Army who represented elite Soldiers serving their country with valor, courage, and bravery. Real Heroes were rendered in the America's Army game and sold as action figures. Players read their biographies and watched videos about how they received commendations from the U.S. Army. Some Real Heroes participated in the Virtual Recruiting Station where they interacted with game players who then won bonus honor points for interacting with the Real Heroes (http://manual.americasarmy.com/index.php/Real_Heroes). The Real Heroes made public appearances at NASCAR events (sponsored by the U.S. Army) and other venues promoting the values and ethos of U.S. Army Soldiers.

The America's Army official website offers links to graphic novels (comics) that are available for viewing online or in print. The online versions are available on mobile devices and feature the use of motion comics. Examples of how narratives supporting Soldier operations can be communicated via a digital graphic novel are available from the America's Army website (http://www.americasarmy.com). The use of dramatic colors, deliberately spaced panels on the page layout, and emotions on the faces of the characters are all crafted purposely to engage the audience and draw them into the story [28].

America's Army first person shooter game assets have been repurposed for a serious game. Although the public game was initially meant for boosting recruitment, it was not long after the public game was released before America's Army Government Applications was formed to develop serious games for training and education. The present author led the development of the first application of America's Army for training purposes in 2003–2004 [39]. The serious game was developed by Sandia National Laboratories and America's Army Government Applications (now known as Army Game Project) for the U.S. Army Special Forces John F. Kennedy Special Warfare Center and School. The Special Forces cultural awareness and adaptive thinking multi-player game was called *America's Army Adaptive Thinking & Leadership* and was used to hone negotiation skills, cultural awareness, leadership, and adaptability [39]. There have since been a number of follow-on government applications used in the United States by the Secret Service, Army, and others. Currently the Army Game Project is part of the U.S. Army Software Engineering Directorate located at the Redstone Arsenal near Huntsville, Alabama.

The *America's Army Adaptive Thinking & Leadership* serious game was evaluated by 51 Special Forces Officers [39]. All respondents were male, ranging between 26 and 38 years old. They varied in degrees of field experience and familiarity with the content of the course. The respondents reported playing computer games 0–5 h per week. The respondents completed questionnaires on their experience with the serious game after its use in the classroom. The questionnaires were self-report, Likert-type scale instruments measuring the participants' attitudes toward their simulation game play experience. Frequency statistics on the two items described above indicate positive user expectations after having participated in the simulation game. With regard to (1) "I anticipated being engaged by the simulation," 1 respondent strongly agreed, 34 respondents agreed, 8 were neutral, 5 disagreed, and 3 strongly disagreed. On the item (2) "I learned more about my strengths and

weaknesses by participating in this simulation than I would have if I did not participate" 1 respondent strongly agreed, 36 agreed, 12 were neutral, 4 disagreed, and 0 strongly disagreed. In addition, 18 Officers evaluated the culturally relevant content and scenario of the single-player tutorial. They agreed that the interface was easy to use and that they learned how to navigate the game environment and use the nonverbal gesture menu in an engaging manner. A subsequent empirical study on the training effectiveness of a serious game designed to replicate *America's Army Adaptive Thinking & Leadership* indicates similar results [36].

6. Army games for training: training support packages

An example of transmedia learning implemented by the U.S. Army in 2011 links training tasks in a digital graphic novel to a serious game. The PEOSTRI Games for Training Program produced 160 complete tasks from training support packages (TSP) into graphic novels and machinima. Graphic novels similar to those utilized by the Army Game Project are in use to augment game-based collective training. The graphic novels set up the stand-alone scenarios in the serious game and provide interactive vignettes made from in-game machinima that demonstrate the right way to execute certain tasks. The interactive digital system includes instructor and student guides, tactical materials, After Action Review guides, and Virtual Battle Space 2 game scenario files. The use of graphic novels to augment the serious game training allows learners to review tasks before and after game play. The graphic novels are reminiscent of the U.S. Army comic book series popular in the 1960s called the U.S. Army Preventive Maintenance Manual published by PS magazine. Since the content of the TSP tasks must be accurate, this stylistic approach allows more tolerance for lengthy sections of text as it ties the TSP graphic novel to a format that is familiar. The comic book format focuses on episodic story elements [27]. At the time of publication no results from an empirical study or self-report evaluation were available.

7. Creating transmedia learning: Simulation Experience Design Method

The Simulation Experience Design Framework and Method has been used to create problem-based learning in virtual environments [39,37], transmedia learning campaigns [34,35], and the serious games *America's Army Adaptive Thinking & Leadership*, and *DARWARS Ambush! Non-Kinetic* [35,36]. The Framework treats game design as the creation of a *system of experiences* that exists within an emergent training context that the designer strives to reinforce throughout game play, as well as before, between, and after game play has concluded [35,38]. The Simulation Experience Design Framework and Method depicted in Fig. 1 [38,35] is based on human–computer interaction (HCI) experience design principles that have been adapted for the design of serious games and transmedia learning storytelling. HCI experience design methods require that designers understand what makes a good experience first, and then translate the elements of the experience, as well as possible, into desired media without the technology dictating the form of the experience. Experience designers strive to create desired perceptions, cognition, and behavior among users, customers, learners, or the audience. For training and education purposes the Simulation Experience Design Framework and Method is employed in the design of the entire transmedia learning campaign or game system, from the design of scenarios, characters, roles, assessment interfaces, and associated media. This design method is based on the notion that one's total experience is integral to the transmedia learning process. Also note that the Simulation Experience Design Framework and Method is used to design each training instance—a

Fig. 1. Simulation Experience Design Framework and Method [37].

serious game module, a scenario, instructional content, etc. Therefore the methodology can be used to design at several levels of transmedia learning storytelling—from the campaign level to the level of the individual medium.

There are at least four transmedia storytelling design principles applied in Simulation Experience Design (see Fig. 1): the development of Character (Interaction and Personas), Story (Narrative and Scenarios), Worldbuilding (Place), and Audience Performance (Participation and Emergent Culture). We will use the example of the Real Heroes Program provided earlier in this paper to illustrate each stage as well as provide insights for training.

7.1. Interaction

In the interaction stage of the cycle, emphasis is placed on identifying personas [10] and roles. In this stage the transmedia learning designer would focus on understanding how the learners will interact with characters in the story. Focus is on developing an approachable character with which the learner can form an emotional bond. In the case of the Real Heroes Program, the audience is the fan base and the characters are the Real Soldiers who embody the Army values the transmedia storytelling campaign is attempting to convey. Their interaction in-game, through blogs, videos, photos, and Twitter feeds, provides emotional ties to backstories and sidestories for the fan base playing the America's Army game. However, in the case of training or education, the learners are often both the audience and the main characters at any given time. Learners must see themselves as contributors to their own training story as first persons, as well as have the opportunity to evaluate their performance from third person points of view. For these reasons transmedia learning designers should allow for co-creation of narratives, characters, and interactions that position the learner as the protagonist. In training and education, the objective is often to improve performance—or strive to become a future self. As such, transmedia learning designers should allow learners to contribute to how their particular story unfolds. Often learners will use social media to provide feedback about their experiences. These media can be mined computationally for insights that in turn

inform the design and development of subsequent training content. Data mining social media is discussed in a subsequent section.

7.2. Narrative

In the narrative stage, designers co-create stories or scenarios that serve as the background or structure for learners to explore concepts. Here we ask the question, what is the core experience of your training story? In the case of Real Heroes, their story is one of enduring Soldier ethos. The scenarios that play out are grounded in reality and open-ended—we are with them when they make public appearances, and we can talk to them in-game. In the case of transmedia learning campaigns we ask the same question and this time build serious game scenarios and experiential content that convey a believable, consistent message with which learners can easily connect. A narrative at the campaign level can unfold over time—over various serious game sessions and scenarios. Learners can explore facets of unfolding episodes of a narrative through game modules, mobile devices, videos, radio or podcasts, web, and print. We use a narrative framework of media elements that invite the learner into a world that goes beyond each individual medium to tell the story and also allows for learner co-creation during game play or scenario exploration.

7.3. Place

In the third stage, place, designers consider the impact of the physical and virtual environments, or worlds, on narrative. In the case of the Real Heroes Program as well as training, "place" may be the serious game's immersive virtual environment, an alternate reality game that occurs in both virtual and physical places, or the physical training environment in LARP. These environments allow the learner or audience to explore the world in the story interactively. Designers can carefully design places that provide clues about the unfolding narrative. Places can invoke emotions and memories. Additionally there are a number of sidestories that might develop through social media as learners ask questions about a place and seek to situate themselves in the story world. For

example, a mock village located at the National Training Center (NTC) in the desert of Barstow, California, may invoke memories of places visited while Soldiers were deployed overseas. Learners may utilize social media to share nuances about a place to other learners that will result in a richer, more connected experience for all.

7.4. Emergent culture

Finally, the emergent culture stage presents an important component to successfully designed training—the opportunity to reflect on experiences in the situated context (environment) in which the transmedia learning takes place [25,43]. Reflecting collaboratively in groups, whether synchronously or asynchronously creates an emergent culture of audience participation and performance that acts as a foundation for the subsequent transmedia learning experiences [35]. Learner feedback and performance assessment at the emergent culture stage allow for measurement of transmedia learning. In most military training feedback is provided during an After Action Review (AAR) that follows the training session. It has often been said that most of the learning occurs during the AAR. However, peer-based, real-time assessment feedback provided in-game during a training session also contributes to the development of emergent culture and ensures that most of the learning occurs during game play [35]. In transmedia learning the interaction with messages communicated by each individual medium should reinforce performance improvement, reflection, and behavior change. At the emergent culture stage, social media can also be used for commentary on the transmedia campaign and training story as it evolves. Emergent culture is an opportunity to explore the broader training story in different ways to enrich the core experience.

8. Military transmedia learning campaign example

Fig. 2 illustrates a hypothetical transmedia learning campaign for the U.S. Army. Fig. 2 was adapted from an example of a franchise transmedia project introduced by Robert Pratten in the 2011 book entitled Getting Started in Transmedia Storytelling
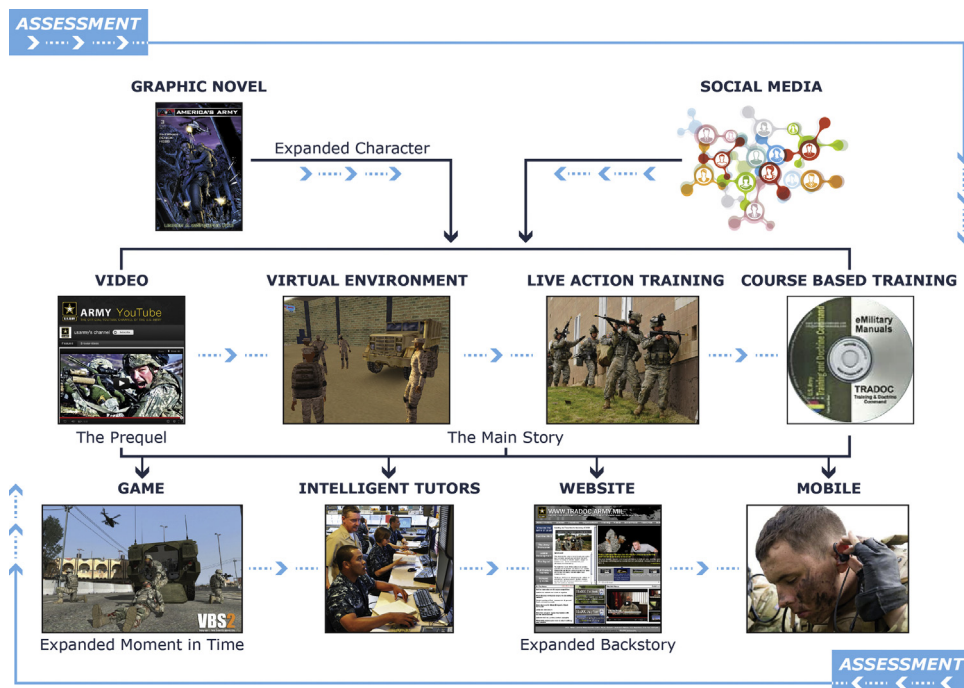

Fig. 2. Transmedia learning campaign[36]. Images courtesy of U.S. Army, U.S. Navy, Bohemia Interactive, and YouTube.

and available from his website (http://www.tstoryteller.com/types-of-transmedia). The illustration depicts how individual media reinforce the overarching narrative with content that expands character development, supports the main story, offers interactive episodes, and reinforces experiences with opportunities for further exploration.

Recall the ALM use case discussed in Section 3.1 of this paper. In this use case, a Soldier learns the art of intercultural communication for her role in the U.S. Army as a Soldier–Diplomat. A transmedia learning campaign for this use case would treat live action training in intercultural communication as the main story experience, with other individual media offering unique entry points into the narrative of Soldier–Diplomat. The live action training she would receive at the NTC before deployment would be preceded by instructional material in the form of videos that prepare her for live action training, and graphic novels that tell real stories to expand the character development of Soldier–Diplomats. She may also practice concepts with a serious game at Home Station before going to the live action training event at the NTC. After her live training, she can continue to review concepts by accessing manuals, watching other videos, using mobile performance aids, or perusing websites dedicated to reinforcing the Soldier–Diplomat training. Throughout the campaign, she is able to provide feedback by posting comments via social media, blogging, creating machinima, etc. She is a protagonist in her own training experience.

Note that the process can be approached sequentially if unique media need to be deployed at specific points in the training pipeline (e.g., virtual training with serious games before live action training). Otherwise, it is also valuable to consider this process as one that evolves and is emergent as learner feedback from social media outlets is incorporated into the total transmedia learning design. Finally, assessment is a large part of a transmedia learning campaign. During the campaign, assessment can be executed before, during, and after the use of individual media, as well as at different points within the training pipeline. In the following section, we propose assessment at the campaign level utilizing social media data mining techniques and learner activity tracking with the Experience Application Programming Interface (xAPI). Transmedia learning occurs across the use of several media and platforms. Instead of focusing on assessment at the level of the individual medium, we discuss how social media can be used to automatically populate learner models that track transmedia learning. We also review relevant agent-based e-learning management. These are not the only event tracking approaches that can be used in transmedia learning campaigns and readers are encouraged to reflect on how their own computational approaches might also apply.

9. Activity tracking and social media data mining for transmedia learning

By now the reader should be familiar with the concept of designing a transmedia learning campaign. The campaign can be designed as an open system utilizing any number of heterogeneous, stand-alone technologies that together contribute to a holistic experience, or the campaign may be designed as a closed system with the linkages determined a priori. The approach taken by this author is to leverage stand-alone technologies because it is most likely that in today's environment of constrained resources, training and education may need to make use of existing technologies, especially web-delivered serious games and other immersive applications.

Learner performance may be tracked by serious games and other adaptive technologies. These systems may utilize what is known as a student model to "provide knowledge that is used to determine the conditions for adjusting feedback" for purposes of description or prediction [45, p. 49]. These student models are usually local to the application—that is, they are treated as a component of a stand-alone application limited to tracking a learner's performance within a particular system and are not shared among other platforms or other serious games that the learner may use. One alternative is to foster interoperability among existing and future heterogeneous systems. Therefore we are exploring the use of Advanced Distributed Learning (ADL) specifications beyond the Sharable Content Object Reference Model (SCORM) [1], to include new standards and frameworks such as the Training and Learning Architecture (TLA) [2], of which the xAPI is a component [3]. The xAPI is a service which allows for the secure delivery, storage, and retrieval of learning experience statements to a Learning Record Store (LRS). The xAPI relies on activity providers to create, track, and share these experiences. The ADL Initiative has released an xAPI specification (which is meant to be extended) that provides a core data model and associated elements to accomplish this [4].

In addition to tracking learner performance, learner comments, feedback, and inputs are also an integral part of a transmedia learning campaign. For this reason, transmedia learning campaigns utilize social media. Via social media learners make comments and provide informal feedback related to their transmedia learning experience as a whole. The subsequent sections explore activity tracking via the xAPI and computational techniques for mining social media data. Complementary approaches for the development of personalized learning paths or shareable transmedia learning objects (TLO) utilising intelligent multi-agent systems are also introduced.

9.1. Tracking transmedia learning experiences

The xAPI specification, 1.0.0 as of April 26, 2013, defines a Representational State Transfer (REST)ful API to track, capture (store), and expose data about the interaction between a learner and a learning experience [3]. The xAPI allows tracking outside of an LMS making it an attractive approach for use by a transmedia learning campaign. It was designed to support the e-learning community including the support of SCORM as well as enabling use cases that were difficult to meet with SCORM [3]. Although outside the scope of the present paper, ADL is collaborating with the Aviation Industry CBT (Computer Based Training) Committee (AICC) on developing a profile for the SCORM community applying CMI5 to the xAPI so it can address topics such as the launch of traditional web content, statement verbs, and results for reporting success and completion. The xAPI allows for flexible user experience tracking in content elements including serious games, intelligent tutors, mobile applications, simulations, some virtual environments, augmented reality, etc. making it useful to consider for a transmedia learning campaign. When creating a transmedia learning campaign with existing technologies, it is helpful if the content elements are web-based or can access web services since activity metadata is stored as JSON. According to Ref. [4] "The xAPI consists of 4 sub-APIs: Statement, State, Agent, and Activity Profile. Agents are defined as individuals, personas, or systems. These four sub-APIs of the Experience API are handled via RESTful HTTP methods. The Statement API can be used by itself to track learning records." Data collected via the xAPI can be exposed for assessment, statistical analyses, data mining, traditional reports, and data sharing [3]. According to Ref. [4] "the xAPI is a specification that describes an interface and the storage/retrieval rules that developers can implement to create a learning experience tracking service. The service works by allowing statements of experience (typically learning experiences, but could be any experience) to be delivered to and stored securely in a Learning Record Store (LRS) [4]. The format of these statements is based on Activity Streams (<Actor, Verb, Object> or 'I did this.')." The Actor may be a learner, mentor, teacher, agent, or more than one entity such as a group. The Verb describes

the action in the statement such as read, viewed, completed, passed, taught, etc. Finally the Object is the artifact the actor interacted with such as book, video, test, and class. More information about the specifics of the xAPI and LRS are found in Refs. [2–4].

In a transmedia learning stand-alone technology could access the xAPI web service and share activity stream data to be stored in a LRS. The example in Fig. 3 is a typical statement for a learner completing a computer-based training (CBT) course.

The xAPI statements stored in the LRS may then be used to automatically populate a transmedia learner model along with data mined from the learner's interactions with social media.

9.2. Collecting learner comments and feedback via social media for assessment

Social media sites typically expose machine interfaces, which can be used to populate transmedia learner models. Profile, career, education, awards, and training history, and qualifications may be captured from sites such as LinkedIn. Daily experience, links, feedback from peers or instructors, and sources of reflection could be captured from sites such as Facebook and Twitter. In certain instances, educators have begun to use Twitter to crowdsource tutoring sessions or provide answers to homework questions. Interactive approaches for adding feedback data may be through conversational agents such as chatbots [23] or embodied conversational agents [30,31].

Social media sources allow external applications to pull out an individual's data through an opt-in procedure. Much of the data available from Twitter and other media are in the form of unstructured, free-form text. We are currently developing an open source, web-centric, proof-of-concept for potential use in transmedia learning campaigns by expanding on text analysis algorithms developed at Sandia National Laboratories. The goal is to aggregate social media data and impose a structure on them which can be visualized. These algorithms have been used by Sandia National Laboratories in combination with parallel Latent Dirichlet Analysis to cluster 17 million PubMed abstracts. Using open source parallel clustering algorithms developed in Titan [36] as the analysis pipeline and web-crawling technology, we mined Twitter feeds and collected individuals into groups based on a similar preference for activities (e.g., shared conversations about video games and e-learning). The proof-of-concept under development allows learners to opt-in to a web-based interface to access their publicly available social media data. These data are visualized in aggregate. No web-crawling is used to unobtrusively obtain the URLs for the social media sites; learners have the agency to add links to the social media sites of their choosing. Additionally learners may add or delete data at any time resulting in reprocessing of the results in the Mongo database. The visualization code runs on a webpage that updates (queries new data) when the page refreshes.

The data analysis pipeline consists of Parallel Latent Dirichlet Allocation (pLDA), document clustering, word cloud preprocessing, and user clustering. Raw, unstructured text was converted into a set of features using Parallel Latent Dirichlet Allocation (pLDA) [8,12]. pLDA works from a corpus of documents. From these it constructs a set of topics representative of the whole, each a collection of weighted terms. Then it assigns weights for each individual document to each of those topics. This effectively projects each document into a "topic space" that encompasses the collection. By placing all documents into one unified high dimensional space, we are able to combine and compare data coming from the disparate sources mentioned above. We can treat these topics as features and the locations of the documents within this space to use for input into clustering. We have used this feature creation method to make predictions about communication effectiveness by creating features from in-game conversation transcriptions [36].

Global document clusters are then processed into word clouds. Words clouds serve to visually summarize the collection of documents—increasing the font of frequently used terms, and decreasing the font of those that are infrequently used. The cluster visualization allows learners to understand personal neighborhood, i.e., cluster. They can compare and contrast among anonymous individuals within the neighborhood. Word clouds also serve for verification of sense-making in the pLDA/K-means clustering processes. The results are stored in the Mongo database to enable the visualizations. These exploratory visualizations could allow learners to browse data obtained from social media outlets to understand their own personal history as well as how they compare with peers engaged in transmedia learning. While learners use social media to make comments, provide feedback, and generate content, they are also able to use the visualizations to see how they are positioned within a "stereotypical group identity" or archetype. This should provide learners with additional context about what topics are trending, and what the universe of learners looks like. Learner social media activity in the form of xAPI statements could also be generated from data stored in the Mongo database and used to stimulate the learner's LRS since Mongo stores data as JSON-like documents. The goal of this research is to foster the development of interoperable and shared transmedia learner model data that can be represented and made available in standard ways to support its use by as many applications as possible [40]. For these reasons our approach was kept straightforward, as it were. We explored other possibilities that were abandoned during development. For instance, we noted that while LDA was effective for our purposes, it treats all terms as similar regardless of their grammatical or semantic use. Two methods we could have also explored as a way of providing more information to the terms used were Named Entity Recognition (NER) [5] and Sentiment Analysis [9]. NER categorizes words by their parts of speech, such as verb, adjective, and noun, as well as, distinguishing proper nouns such as names of people or locations or organizations. An activity, for instance might have been defined as a verb–noun pair within this context. Sentiment Analysis provides information about the quality of the words used, especially adjectives and adverbs, such as positive or negative or relative strength, e.g., a strong positive affirmation versus tepid verbiage. While these approaches were not pursued by our initial research these treatments may be useful in the future.

9.3. Multi-agent approaches for transmedia learning

The previous sections described approaches under development to (1) track learner performance across interoperable and heterogeneous, multiple media, and (2) data mine user-generated content from social media sites in a transmedia learning campaign. Another approach that merits exploration is the use of intelligent, multi-agent platforms to inform the development of shareable Transmedia Learning Objects (TLO) and multimedia SCORM-compliant course content [16]. For example, the xAPI approach does not currently address the development of personalized learning paths or the circulation of organizational knowledge. There is a need for models addressing the co-creation of new transmedia learning content versus cross-media content adaptation that is not currently addressed by the xAPI and social media data mining approaches discussed in previous sections. Additionally the definition of a standard format for the development of interoperable and reusable Transmedia Learning Objects (TLOs) would go far in enabling the development of personalized transmedia learning paths that could recommend skill or competency enhancements for learners. More research is warranted on the use of multi-agent and artificial intelligence techniques for next generation e-learning systems.

```
"actor":{

    "objectType": "Agent",

    "name":"Example Learner",

    "mbox":"mailto:example.learner@adlnet.gov"

},

"verb":{

    "id":"http://adlnet.gov/expapi/verbs/attempted",

    "display":{

        "en-US":"attempted"

    }

},

"object":{

    "id":"http://example.adlnet.gov/xapi/example/simpleCBT",

    "definition":{

        "name":{

            "en-US":"simple CBT course"

        },

        "description":{

            "en-US":"A fictitious example CBT course."

        }

    }

},

"result":{

    "score":{

        "scaled":0.95

    },

    "success":true,

    "completion":true

}
}
```

Fig. 3. Example xAPI statement for 'example learner attempted simple CBT course' [4].

An example of a multi-agent platform for e-learning is the Multi-Agent System for E-Learning and Skill Management (MASEL) [16]. MASEL supports enterprise knowledge management by defining competencies, mapping the skills of an organization, managing gaps and assisting employees with personalized learning paths, optimizing courseware based on learner feedback, and by helping project managers build teamwork. MASEL is comprised eight agent types including Chief Learning Officer (CLO) assistant agents, Skills Manager Agent (SMA), Student Assistant Agent (SAA), Learning Paths Agent (LPA), COntent Agents (COA), Chief Content Officer assistant agent (CCO), Project Management Assistant (PMA), and User Profile Agent (UPA) [16]. Agents are FIPA compliant and LO metadata are IMS compliant and stored in a database managed by a COntent Agent (COA). MASEL provides insights into how automated Transmedia Learning Objects (TLOs) could be conceived. Another multi-agent approach that is similar to MASEL is X-Learn [14]. Both follow IMS (learning materials) and FIPA (agents) specifications and utilize XML to exchange information connected to the learning activities. However, while MASEL is a complete solution for enterprise management, X-Learn allows the flexibility for learners to choose the skills they want to focus on. Detailed descriptions of MASEL and X-Learn including comparison with other multi-agent systems is available in Refs. [16] and [14], respectively. Additionally Ref. [33] provides a description of a multi-level approach to mapping and clustering course content to that can be instantiated at the course ontology level. These approaches complement those discussed in previous sections as they address issues concerning learning object and course content development that are applicable to how TLOs might be conceived and implemented. More research is warranted to determine a path forward that allows for the flexibility of learner tracking across their formal and informal learning. Investigating multi-agent approaches for reusing and developing transmedia learning content, as well as the creation of automated, personalized learning vectors will certainly be a focus in the 21st century.

9.4. Toward the development of transmedia learner models

Another area of research that merits attention is user or learner modeling. We are currently using learner experience tracking and computational techniques to mine social media data toward the automated population of transmedia learner models from observer-based, self-reported, or system-generated events. We believe it is valuable to track activity streams and events via the xAPI as well as mine the informal digital artifacts learners leave among several applications such as Twitter, LinkedIn, and Facebook. The aggregate data then may serve to automatically populate transmedia learner models or inform assessment measures. A useful transmedia learner model may resemble what is known as a lifelong learner model. This type of model is a distributed technical framework that provides comprehensive management of personal learning data [22]. It enables learners to aggregate information about themselves from diverse sources, manage which applications have access to read and/or write information, directly input personal information, and share information with others. Two key challenges for future learner model research are (1) the user interfaces to large collections of information and (2) the ontologies necessary for understanding information from diverse sources [22]. Additionally there is a role in the development of intelligent multi-agent approaches for the automated population of transmedia learner models. Future research should consist of further exploration of new models for the co-creation of transmedia learning content that address standards for the reuse and production of interoperable LOs. Although we are focusing initially on learner models, models of interoperable, automated content object

co-creation will foster the development of future transmedia learning applications.

10. Conclusion

New paradigms for 21st century training and education require transformational strategies. Transmedia learning is a transformational technique that is applicable to training and education. In summary, this paper described why transformational training experiences are necessary, and how transmedia learning campaigns suppot design requirements for a new serious games paradigm. We discussed why transmedia learning storytelling is compelling and how these designs engage the human brain and emotions. We demonstrated how the Simulation Experience Design Framework and Method [35] can be applied to both serious games and transmedia learning campaign design. Examples of how the U.S. Army utilizes transmedia strategic communication and transmedia learning for serious game training were offered as examples. Finally, a proof-of-concept toward tracking, clustering, and visualizing transmedia learning data was provided.

Further investigation regarding the development of transmedia learner models is needed. Future research could focus on models that are independent and applicable to multiple adaptive training systems, open to learner inspection and manipulation, and responsibly unlimited in what they could know about learners (relationships, training on diverse platforms, historical learning, culture, region, accessibility, mood, daily activities, etc.). Natural representations of cognition for use in a variety of intelligent and adaptive systems for training and education should also be a focus of future research [20]. Such an exploration may further include understanding how informal learning data can be harvested from sensors, multi-agent systems, and social media such as LinkedIn and Facebook for automated population of transmedia learner models. A candidate open source tool for large-scale data analysis called the Titan Informatics Toolkit may also be used for ingestion, processing, and display of informatics data [36].

As indicated throughout, 21st century demands on training and education will require that we transform current practices. In particular there is a need to deliver training and education across multiple, heterogeneous media, providing the learner multiple entry points into the training. Transmedia learning was presented in this paper as a candidate to address this need. This paper addressed approaches inspired by the entertainment and commercial games industries that can be leveraged for transmedia learning with serious games and other immersive media. Future growth can be expected in the areas of serious games and transmedia for education and training as momentum gains and these approaches become more mainstream.

Transmedia learning campaigns are the purposeful, coordinated, scalable, and strategic use of multiple media to relate a story or narrative as it unfolds over time to engage new learners or keep learners engaged. Transmedia learning campaigns represent a unique opportunity to transform serious games and other tools for education and training from stand-alone learning instances into complete training experiences that transcend time and any one medium. This approach provides a practical framework for developing media-rich training that presents cohesive and integrated content. Transmedia learning goes far beyond the use of stand-alone serious games and other solutions—toward a new paradigm supporting more enduring and memorable learning.

Initiative, U.S. Army Game Project, TRADOC TCM Gaming, and U.S. Army Games for Training Program. Finally, thanks to Nathan Fabian, JT McClain, Tim Shead, and Warren Davis of Sandia National Laboratories for their contribution to the section on social media data mining.

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