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An Educational Glance into the Future: Holodeck as a Future Enacted Narrative Learning Technology

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Abstract: This article describes how the fictional concept of Holodeck can be seen as a future immersive learning technology, as well as a new medium for future enacted, narrative experiences. In essence, the article illustrates how this fictional media has been recently studied within the art education context; particularly with the emphasis on how the medium has been considered through the holonovel writing activity. At first, the literature review presents earlier Holodeck-related research, innovation and applications, which, subsequently, provide important terminology for the holonovel writing process. The terminology includes the setup, important stakeholders and those critical units and entities that are needed for defining the pre-conditions for the Holodeck. Thereafter, the article introduces content of the holonovel course and the creation process for such holonovels that take the form of science fiction prototypes. Finally, the article presents some student-created examples of holonovels that employ the Holodeck for educational and pedagogical purposes.

Keywords: Holodeck, Holonovel, Science Fiction Prototype, Art education, 4D/AR/VR/MR experiences, Immersive Reality Innovation
Categories: J.5, L.3.6, L.5.0

1 Introduction

This article describes how the fictional concept of Holodeck can be seen as a future immersive learning technology, as well as a new medium for future enacted, narrative experiences. In general, the Holodeck may be understood as a plot device used in stories set within the *Star Trek*[1] ® universe [Gerrold, 73] and it permits stories with locations and characters that could not otherwise exist in the settings of *Star Trek*. In the television series, Starfleet personnel use Holodecks mainly for leisure and educational activities, such as training, diagnostics or scientific experimentation (see Figure 1).

From the technological side the origins of the medium can be traced back to Gene Dolgoff, whose holography laboratory in New York City, built in 1964, stood as the background for the conversations with Star Trek creator Gene Roddenberry. Since

those days, the technological redevelopment has been slow, as even today the Holodeck technology still remains fictional. It is anticipated, however, that similar virtual reality tools may become consumer-ready products in the reasonably near future. Contemporarily, the technology may find reference e.g. from the emergent 4D/VR/AR/MR environments.

[1] STAR TREK ® is a science fiction television and film franchise, http://www.startrek.com

Figure 1: Holodeck used in Star Trek for education, training and scientific experiment (courtesy of Paramount Pictures/CBS Studios).

When considering the ingredients of a Holodeck in more detail, the technological aspect includes different simulation types, which change their status seamlessly as the person interacts with the environment. For example, if the person inside Holodeck sees a distant tree, the projection is created in the walls of the environment. Then, if the person decides to approach the tree, the image of it will be projected into the space as a hologram. These holograms can further be augmented with "force beams" that simulate solid, tangible objects, which is the case if the person, for example, leans on the tree. When s/he breaks off a branch, the simulation type changes for the "Holodeck matter". Holograms and force beams can be augmented with replicator technology to provide actual substances like food, which is the case if the person picks and eats an apple off the tree. In current mixed reality environments (see Figure 2), the projected reality may be referred to in the Virtual Reality (VR), whereas the force beams and transported matter may be seen as the visual layer of Augmented Reality (AR) technologies. The metaphor for the replicated matter may further be seen to present the Real or Mixed Reality, or in some cases, 3D printing technology.

Figure 2: Contemporary "Holodecks" in the VTT Technical Research Centre of Finland. Virtual-Reality environment with a power-wall (left) and the Experience Centre with multiple screens and co-creation space (right).

As the Holodeck technology remains fictional, this paper takes a stance that more important than the material aspect is highlighting how the medium may be used as a means to explore the aesthetic, sociological, ethical and even philosophical questions it promotes. As for that, the medium requires a design perspective, which, in the Star Trek franchise, has been described by the authoring process for creating the holographic novels. This writing process has been explained in the episodes more explicitly as an activity pursued by holonovelists. These holographic novels, i.e., holonovels, have been described including at minimum a narrative story with a protagonist, characters and a

plot, and the holographic program that runs the narrative. If the role of the protagonist and characters are considered more closely, most Holodeck programs seem to run in the first person "subjective mode" and the other characters are usually computer-created holograms or other personnel onboard the spacecraft.

This article describes how the concept of Holodeck and, in particular, the holonovel activity has been practiced within the art education context. The main methodology to carry out the work has been the creation of short science fiction stories, i.e., science fiction prototypes (SFPs) [Johnson, 11] [Kymäläinen, 15], within a formal art education course. The main effort has been placed in the creation of artistically complete holonovels (taking the form of SFPs) that deliver complete, absorbing experiences, i.e., they are complete stories of a Holodeck experience. An important criterion for the evaluation has been that these SFP stories stand as their own as a piece of art, independent of the prevailing technical limitations, which provide a system for analyzing, critiquing or re-thinking the fictional Holodeck technology. The intent has been to remove the constraints from the normative design processes and encourage also looking at the technologies in the technophilia/technophobia-axis, as explained, e.g., in the socio-technical 3C framework [Callaghan, 09]. The other stance is to highlight the co-evolutionary spiral between science and science fiction [Johnson, 11] [Bleecker, 09] [Dourish, 14], which, for example, Johnson illustrates by saying that, "Science fiction stories told in movies and novels come to shape the course of real-world invention, and these in turn serve as a seed stock for ever more elaborate imaginings". In this sense, the intent has been to create "scientifically credible" myths for future pedagogical purposes that increase social awareness, and write them for the explicit purpose of acting as prototypes for people to explore a wide variety of Holodeck-related futures. The article concludes with the summary of two student-created, peer-reviewed holonovels that describe altogether four different cases of how the Holodeck may be used as a future learning environment.

2 Key Theory and Applications

The concept of Holodeck, from the theoretical aspect, has been most thoroughly introduced by Janet Murray in her seminal work "Hamlet on the Holodeck – the Future of Narrative in Cyberspace" [Murray, 97]. Murray's ideas are in great debt for Brenda Laurel's earlier work "Computers as Theatre", 1991, which focused on the different type of interactive forms and, in particular, first person, computer-enabled storytelling [Laurel, 91]. Basically, Laurel explains how Aristotelian dramatic experience is the model toward which interactive computer experience designers should aspire. She extricates how the dramatic, Aristotelian stories can be distinguished from narrative stories by three tension properties: 1) enactment vs. description, 2) intensification vs. extensification, and 3) unity of action vs. episodic structure. In essence, Laurel introduces the concept of interactive drama, whereas Murray uses the term Cyberdrama, and explains that it is an attempt to marry the structures of games and stories. The most profound idea in both is to turn the attention towards those new media artifacts that resemble theater, cinema and television, and emphasize the enactment of the story in the particular fictional space of the computer-enabled environment.

Murray's work elaborates Laurel's ideas by explaining three important concepts that are vital for experiencing the holistic narrative form: agency, immersion and

transformation. Agency is described as the pleasure of interactivity, which "arises from the two properties of the procedural and the participatory". Agency is the feeling of empowerment that comes from being able to take actions in the world whose effects relate to the enactor's intentions. In research that combines human psychology and computer science, the agency model has been described most profoundly by [Bratman, 99]. Bratman's Beliefs-Desires-Intentions (BDI) model describes how the person will commit to his/ her goals, formulate plans and, consequently, execute the intentions. According to Murray, the most important aspect of experiencing the agency, in an interactive story world, is that it can be intensified by the dramatic effect. Rendering that, Murray's second concept, immersion, can be seen as the feeling of being present in another place and engaged in the action therein. This is highly related to Coleridge's "willing suspension of disbelief", which suggests that when the spectator is immersed in a narrative experience, s/he is willing to accept the internal logic of it, even though this logic deviates from the logic of the real world. The third concept Murray introduces is transformation, which can be seen as the most difficult one to interpret. Mateas, who considers Murray's concepts from a gaming standpoint, has elicited three distinct and expletory meanings for it: transformation as masquerade, transformation as variety and personal transformation [Mateas, 01]. Transformation as masquerade means that the game experience allows players to transform themselves into others for the duration of the experience. Transformation as variety means that the game experience offers a multitude of variations on a theme and players are able to exhaustively explore these variations and thus gain an understanding of the theme. Personal transformation means that the game experience takes players on a journey of personal transformation. The transformation as masquerade and variety can be thus seen as a means to effect this personal transformation.

The first concrete applications for the Holodeck have been pursued in parallel with the theoretical research (see Figure 3). One of the first experiments was conducted within the Oz Project, by Carnegie Mellon University, in which the focus was on the interactive characters and story [Bates, 90]. The inspiration for the application came from a contemplation that traditional storytelling media, such as cinema and television, draw much of their emotional power from the characters and story. In essence, the aim of the Oz Project was to help artists to create high-quality interactive drama, based in part on artificial intelligence (AI) technologies, which in this case meant building believable agents in dramatically interesting micro-worlds. A Parallel Ray-caching Rendering System was a much more technical research endeavor than was stated to resemble the Star Trek Holodeck both by its form and function [Larson, 98]. The project studied technical data structure for light field rendering, in which a "Holodeck server" coordinated separate ray evaluation and display processes, and the grid on the Holodeck section acted as a four-dimensional rendering target for a ray-tracing algorithm.

Figure 3: The Oz Project (left), Façade (center) and Madame Bovary on the Holodeck (right).

Cavazza et al. introduced an immersive storytelling environment, Intelligent Virtual Environment, in which the participants were able to interact with artificial actors through speech, while sharing the same physical environment [Cavazza, 00]. In addition, they were able to participate in the generation of the story by influencing the virtual actors, by altering the common environment and by leaving the set to watch how the story unfolded in their absence. Façade introduced a first-person, real-time, one-act interactive drama [Mateas, 01] [Mateas, 02] [Mateas, 05]. The process involved three major research efforts: designing ways to deconstruct a dramatic narrative into a hierarchy of story; engineering an AI system that responded and integrated the player's moment-by-moment interactions; and the study of writing an engaging, compelling story within the Holodeck framework. In Teesside University, there was an immersive interactive storytelling environment that was labeled Madame Bovary on the Holodeck [Cavazza, 07]. It was constructed on top of an AI-based storytelling system, which relied on explicit plot representations. The main idea was to include excerpts from Madame Bovary and investigated the concept of interactive storytelling in a fully immersive context. In University of Southern California, the Holodeck was entangled by creating an interactive story experience with pedagogical goals [Swartout, 06]. In this application, the participants were immersed in an environment where they could encounter sights, sounds, and circumstances of real-world military scenarios. This is one of the first applications that exploited the Holodeck-concept as a learning environment, and in practice the simulation included virtual humans that acted as characters and coaches in the virtual environment.

In more recent work the Holodeck has been employed more comprehensively for pedagogical purposes. Thornburg envisioned Holodeck as engaging and powerful 21st century learning environment that exploits the metaphor of a campfire, signifying to a storytelling style of teaching [Thornburg, 13]. With this notion Thornburg criticizes traditional lecture-based learning environments that should be replaced by a model with more "game-like" qualities that arise from the problem solving associated with simulation. Prior to this e.g. Paras has highlighted the importance of game and motivation in effective learning. He perceives that game-like environments have vast potential to support immersive learning experiences and consequently he introduced an integrated model for educational game design [Paras, 05]. Zheng et al. support the idea of rethinking pedagogies based on input/output models that imply a linear progression from an initial to a goal state [Zheng, 11]. They see virtual worlds as a catalyst for change and consider this through language learning that go beyond task-based learning.

Ferguson postulates that virtual worlds open new possibilities for learners, prompting a reconsideration of how learning takes place, and setting education in a context of playfulness and creativity [Ferguson, 11]. In her study Ferguson focused on a group of teenaged learners who worked together online in the virtual world of Second Life® generating and trying out ideas. Rendering this in their brief abstract Mateas & Wardrip-Fruin postulate an interesting new research area for personalized and interactive literature [Mateas, 16]. They expect the interactive storytelling transform our key experiences of fiction – namely thorough empathy, curiosity, and responsibility – that will inflate from computer games towards various other fields, including education.

From the technical perspective Sommool et al. introduce more recent practice-oriented case of the Holodeck classroom that is based on gesture commands and includes a framework for Holodeck presentation and assessment in the classroom context [Sommool, 13]. In practice, their interactive framework employed Microsoft Kinect Sensor for e-Learning and it was experimented together with teachers and students. In addition, Schmidt et al. provide a topical example of physical facilitation of the Holodeck mixed-reality teaching and learning environment [Schmidt, 13]. In their Holodeck@UH – project the aim is to bring the virtual world and the real world together as a mixed-reality "mash-up" with the focus of enhancing students' sense of social presence. Chu and Quek consider the learning aspect from the information point of view and issue holodeck by considering it as a technology ecology [Chu, 13]. More implicitly, they explore how technological display and device ecosystems in the physical world may function to support human thinking, learning and sensemaking. In the article they describe a study that employs a theoretical framework to investigate how students think of the technological ecosystems and affordances that they form, and especially their implications for learning.

To conclude, this brief literature review reveals how, although the Holodeck-related investigations have been studied for three decades and the research has been multidisciplinary, it still remains on its infancy with large research gaps in the field and numerous streams to advance. In addition, the recent Holodeck-related pedagogical research highlights the notion from Thornburg, who encourages to not use the technology simply to "replicate" what have always been done or "amplify strategies that have never worked for all learners", but to look for completely new opportunities of education and learning.

3 Terminology

As the literature review demonstrates, the referenced research has used a colorful mixture of terminology when describing the interactive experiences of the Holodeck. This can be seen as evitable when the research combines multidisciplinary efforts covering such disciplines as education, humanities, art, literature, dramaturgy, screenwriting, game design, VR-, AR-, AI- and other engineering and computer science domains. Although previous research has defined several important concepts relating to the Holodeck, the lack of a theoretical framework for guiding the design exploration created a problematic gap in the art education context. Based on the previous research, it was clear that the future medium required more unison and contemporary terminology for the holonovel writing activity. The consequent solution was to make a

list of used terminology, units and entities, in the earlier literature for defining what would best suit the purpose. The investigations included the following, topical research questions:

- What should the overall (Holodeck/holonovel) experience be called?
- What should the protagonist be called?
- How should the side characters be named?
- How should the units and entities be defined (and at the same time address the temporal considerations of the experience)?

3.1. The H Experience

Murray called the enactment of the story in the particular computational fictional space *Cyberdrama* [7]. As described above, she explained that this definition provided the human participants an experience of agency, immersion and transformation. Murray described Cyberdrama as an attempt to marry the structures of games and stories in which case the participant's actions would have an appropriate impact on the computer-generated world. The other terms in research literature that aimed to describe the holistic, interactive experience were:

- Interactive Drama [Laurel, 91] [Mateas, 01]
- Interactive Experience [Laurel, 91]
- Interactive Cinema [Bates, 90]
- AI-based Interactive Experience [Bates, 90]
- Emergent Narrative [Cavazza, 00]

None of these seemed to be applicable as such to holonovel course, and in the end the most suitable term was defined as the *H experience*. In this conceptualization, 'H' stands equally for the Holodeck and the activity of writing the holographic novel. During the writing process, it soon became evident that as the students were not actually creating holonovels (but science fiction prototypes), there seemed to be a redundant double effort of explaining both the Holodeck concept and the holonovel activity, even though a fluent story seemed to require no further explanation. As for the semantic meaning of the word, the H experience seemed suitable to contain a reference to most of the above-mentioned previous literature contemplations. Perhaps the most appropriate definition for the H experience is presented in the "narrative practice hypothesis" by [Hutto, 08]. In this assessment, the experience should include various different embodied practices, with a reference to emotional, sensory-motor, perceptual, and non-conceptual dimensions. These practices lie in the embodied action or expressive behavior that are represented in, e.g., bodily movements, facial gestures or, for example, gaze direction. The essential division for defining the most suitable interaction metaphor for the H experience, is also presented in the hypothesis. According to the narrative practice [Cavazza, 00], the interaction can occur:

A. Through physical interactions with objects in the environment
B. Through on-stage conversation with artificial actors
C. Through off-stage intervention (through advice, interjections, etc.)

3.2. The Protagonist, the Enactor

In previous literature, there were equally several options for defining the role of the H experience protagonist. The first-person experiencer was labeled, as:

- User [Cavazza, 00] [Cavazza, 07]
- Player [Mateas, 02]
- Interactor [Mateas, 05]
- Spectator [Cavazza, 00] [Bates, 90]
- Enactor [Murray, 97] [Marek, 10] [Carney, 14]

Murray's consideration of the Enactor seemed most suitable for the H experience context, because enacting, as an activity, refers delicately to the complete and complicated "sense-making" process. This finds justice from the contemporary enactive literature, in which the enacting refers to "sense-making" instead of taking the perspective of a spectator/user presented with a world. Enactive relation suggests to the larger concept that "a living organism enacts the world it lives in" [Marek, 10] [Carney, 14]. Furthermore, as Murray explains, the effective, embodied action in the world actually constitutes its perception and thereby grounds its cognition. Although Cavazza et al. use the term "user" and "spectator" instead of enactor, they also see the protagonist as "an active on-stage participant or spectator that is able to manipulate objects in the environments" [Cavazza, 07]. In this sense, they refer also to the enacting aspect that includes embodied interaction, which, in turn, includes, e.g., the act of moving from one location to another, picking up an object, or touching another character. Although the first-person experience is highlighted in most literature, it is by no means mandatory, as Mateas and Stern have clarified [Mateas, 02]. They emphasize that during the experience, the enactor's perspective may occasionally shift "automatically" to a third-person perspective.

3.3. Side characters, VAs= Virtual Actors & Virtual Avatars

In the H experience, the enactor is usually surrounded by other richly interactive, intelligent and emotionally behaving characters or creatures. Bates see that the central requirement for "users be able to suspend disbelief" demands that these creatures are highly competent [Bates, 90]. Mateas and Stern understand that the primary mechanism by which an enactor interacts and influences with the story is a dialogue with the other characters [Mateas, 02]. These autonomous characters are described, e.g., as real-time animated figures that can emote, have personality and who are able to speak. In previous research, they have been called:

- Interactive Characters [Bates, 90]
- Animated Characters [Mateas, 02]
- Autonomous Characters [Mateas, 02]
- Virtual Actors [Cavazza, 00]

- Intelligent Agents [Swartout, 06]
- Artificial intelligence (AI) [Cavazza, 07]
- Virtual Avatars [Cavazza, 07]

The most suitable term for the characters that exhibit rich personalities, emotions, and social interactions were chosen to be Virtual Actors and Virtual Avatars (combined together as VAs). The distinction here is important as the Virtual Actors can be understood as completely artificial personalities, whereas Virtual Avatars are real-life persons, for which a contemporary reference can be found from, e.g., simultaneous online players with a telepresence. Although in earlier research the characters' dialogue and "intelligence" were narrowly focused around some specific topic of the story, in this context the Virtual Actors are understood to be highly autonomous and have a large variety of responses to "off-the-wall remarks" from the enactor.

3.4. Scene, State and Triggering Event

The holonovel narrative is constructed of some units and entities that are completely different as compared to, e.g., screenwriting principles. In order to adequately describe the Holodeck affordances for theholonovel, the following units should essentially be described:

- The scene (available affordances of the Holodeck environment)
- The state (the extant status of the Holodeck environment)
- Trigger/triggering event (which initiates the change in the state of the scene)

The term *scene* has been commonly used in dramatic literature as well as within the studies relating to computer vision and pattern recognition. Oliva and Torralba define an environmental (real world) scene as mainly characterized as "a place in which we can move and most of the objects are within reach" [Oliva, 01]. In this context, the scene represents the combination of selected preconditions, triggering event(s), and the intended state of the environment. A scene thereby consists of:

- Preconditions, i.e., the available affordances of the environment
- A category of triggering event(s)
- A category of the value(s) intended to be changed by the scene
- The success and failure of the conditions

In short, the precondition evaluates whether the scene is appropriate given the current story (or character) state. This is constant as the next scene evaluates whether it is suitable to be the next scene.

The state is the current status of the environment constructed by the state of an individual device or aggregate state of a group of devices as defined by [Kymäläinen, 15]. Mateas and Stern further describe that the (story) state consists of the current story values and other global states such as active conversational topics, physical locations occupied by the characters, etc. [Mateas, 02]. Triggers, triggering event/story event changes the states of the scenes. For example, in the case where action is being carried by a dialogue, the trigger may simply consist of one character speaking a line of a

dialogue. McKee calls these triggers "story events" that will change the story values [McKee, 97]. Accordingly:

- A story event is precisely any activity that turns a value [McKee, 97].
- A value can be a property of an individual or relationship, such as trust, love, hope, hopelessness, etc. [Mateas, 02].

Mateas and Stern find that in order to deliver an engaging H experience, a major value change should occur in each scene, which can then be seen as a large-scale story event. Thus, one of the primary goals of the H experience should be to confirm that all activity turns values, and thus the story event(s).

3.5. Temporal Considerations

Cavazza et al. remark that, as compared to traditional media, an absorbing H experience is likely to be episodic in nature [Cavazza, 00]. This means that the enactor is practically only present in the H experience some of the time. This is vital because all activity is not intrinsically interesting and, in in this case, it is better suited to happening offstage. This leads to a problem where an enactor, who is not permanently present, must have an "in-character" method for joining and leaving the world. However, and this is strongly emphasized, they can only be able to leave the world in a justifiable fashion.

Another important remark is that the holonovel is inherently a bottom-up interactive narrative, which means that the enactor cannot 'turn the clock back' as in traditional media. The ability to return to earlier (saved) states and make different choices is characteristic in games, but in the case of the H experience, it would be expected to be a destroyer of narrative coherence [Cavazza, 07]. This leads to the concertation of 'onstage' and 'offstage' action, i.e., such action that the enactor does not see or directly participate in, or, for example, one that may involve only the VA's actions. The main possibilities for the enactor to influence the H experience would be thus:

- The modification of the parameters or states of the settings
- Action bearing on key objects within the scene
- Modification of the cognitive state of Virtual Actors
- Influencing Virtual Actors to take or stay away from specific actions.

4 The Holonovel Course

The holonovel course (H-course) was arranged at Aalto University (department of Film, Television and Scenography) during February-April, 2018, with 14 students (11 female, 3 male) attending. The department responsible of the organization was Production Design, but the attending students were also from e.g. New Media Design and Production, International Design Business Management and Visual Culture & Contemporary Art. The course began with a brief introduction to the Star Trek™ Franchise history and by watching some Holodeck-related Star Trek episodes. In the chronological review the very first appearances of the Holodeck (then called the *Recreation Room*) was in the episode, "The Practical Joker" [Star Trek episode, 74]. In

practice, it demonstrated a control console in the center of a large room and illustrated a holographic simulation in which the weather conditions chanced rapidly. The most recent Holodeck episode (at the time of the course), "Lethe" [Star Trek episode, 17], depicted a much more advanced holographic battle simulation with Starfleet officers onboard the spaceship. Besides a dozen other Star Trek-related examples, the film review included some illustrating, contemporary examples of similar fictional technologies, such as those presented in the Black Mirror episode titled *U.S.S. Callister* [Black mirror episode, 17]. Based on the reference material, the H-course students were requested to define the Holodeck building blocks and what they had learned from the holonovel creating activity.

The subsequent task of the H-course was to learn about the science fiction prototyping process. Together by learning the process, the students gained a brief introduction to how the method was previously applied to technology and engineering research; foresight, futures and business studies and what similar practices there are in the human-computer interaction discipline (such as critical design, speculative design and design fiction) [Kymäläinen, 16]. Moreover, the students were requested to read the SFP "If Alice Arrives Wonderhome incites" [Kymäläinen, 13] and the holonovel "Kill Your Darlings" [Kymäläinen, 17]. In addition, given that these two examples illustrated the SFP process in a concrete manner, they presented two opposing ways to mediate fictional future society: the first SFP presented a Utopia, whereas the latter described a Dystopian future for the Holodeck.

This division led the students to think about the overall saturation for their personal holonovels: whether they wanted to issue fear or hope (tragedy or comedy) and how they positioned their work in the technophobia vs. technophilia axis (which in the science fiction context can be understood as technocriticism vs. positive sci-fi) [Callaghan, 09]. After considering the saturation and topic, the students were requested to think about the more specific educational context for the H experience (e.g., education, training, diagnostics or scientific experimentation). In the process of selecting the learning context, the general Star Trek themes from the example films were issued, those being, e.g., religion, racism, human rights, sexism, feminism, value of personal loyalty, war and peace, economics, and the role of technology in human interactions. Also, the typical Holodeck themes in the example episodes – "holo-addiction", i.e., crew trapped in the Holodeck and the philosophical and sociological issues of virtual realities – were discussed for elaborating the selection of the topic.

During the topic selection process there was a further discussion about the possibility to transfer literature/films into the Holodeck context. In Star Trek episodes, this was observed to be a key activity in the holonovel creation process (including, e.g., Sherlock Holmes stories, Bronte's Jane Eyre character and an imaginary Dickson Hill film noir character). Also, in prior Holodeck-related research, there were frequent references to such celebrated literary characters as Hamlet and Madam Bovary. This procedure was believed to support students when they tried to create a secondary world for their holonovels – a process that would obviously be easier to begin with some reference material. When considering Holodeck as a new medium, it seemed important to think about the new emerging possibilities for the H experience. One intriguing prospect was the Star Trek fandom, which has been very active in elaborating, extending and exploiting the Star Trek canon. The examples of exploitable material is too numerous to count, as it includes fan productions, parodies, dark comedies, fan

fiction, Kirk/Spock slash fiction and the very active do-it-yourself (DIY) culture, e.g. [Jenkins, 88]. The fans (known as trekkies or trekkers) themselves have reformed almost a quasi-religion around the franchise [Jindra, 94].

4.1. Holonovel creating process

In the story creation phase, it was referred to the neo-Aristotelian theory by Mateas, which combines Aristotle's dramatic theory and modifies it to address the interactivity added by the enactor agency [Mateas, 01]. In more detail, Mateas' theory integrates Murray's proposed aesthetic categories for interactive stories and Aristotle's structural categories for drama [Murray, 97]. In addition, the H experience concerns itself with building dramatically interesting virtual worlds inhabited by computer-controlled characters, within which the enactor experiences a story from a first-person perspective [Bates, 90].

In the practical world-building process, the pre-defined terminology became convenient. The specification included:

- The H experience (H=Holodeck/Holonovel)
- The protagonist = the enactor
- Side characters: VAs= Virtual Actors & Virtual Avatars
- Units and Entities: the scene, the state and trigger/triggering event/story event

The pre-consideration included selecting of the mode for the activity: was the H experience about interaction with VAs, interactions with objects or more abstract off-stage intervention?

In the educational context, the science fiction prototyping process required more elaboration than just the five categorical steps it contains. This was achieved by employing a narrative story creating structure, as described e.g. by [Phillips, 04]. When the main ingredients were established, the practical work started by defining a story goal for the holonovel. In essence, the story goal explained what the story is fundamentally about, as seen through the enactor's main objective or problem (what the s/he wants to achieve, or the problem s/he wants to solve). In the SFP context, the story goal included organizing the idea around a plot in order to make the story meaningful and allowing the reader to become emotionally involved with the experience. The other critical tasks included the defining of consequences (what will happen if the story goal is not achieved) and requirements (what must be accomplished in order to achieve the goal).

After these elements were more or less settled, they were organized around the W-plot outline structure by Moore[2] (see Figure 4). The W-plot presents the events of the (Aristotelian) acts, with a reference to the key science fiction prototyping steps:

- Triggering Event
    - Act 1: setting up the problem (creating tension)
- 1st Turning point (scientific inflection point)

[2] The W-Plot vs. The Dramatica Model of Story Structure, Retrieved: February 2, 2018: https://www.how-to-write-a-book-now.com/w-plot.html

  - Act 2: recovering from the problem (new ideas, positive momentum)
- 2nd Triggering Event (ramifications of science on people)
  - Act 3: deepening of the problem
- 2nd Turning point (human inflection point)
  - Act 4: the resolving of the problem (new light or understanding)
- Resolution

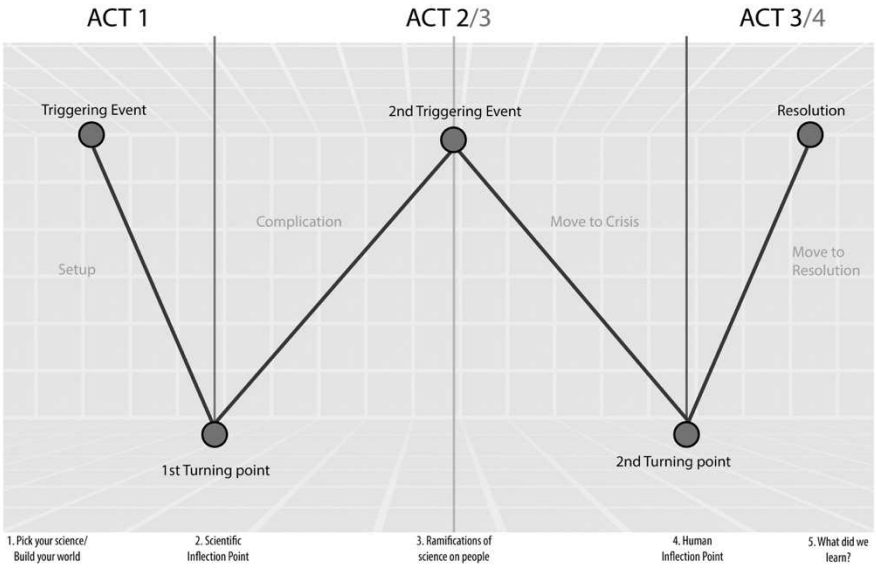

Figure 4: Aristotelian drama integrated with the W-plot and science fiction prototyping process for the creation of the holonovels.

In the organizing phase, special contemplation was given to the climax and ending of the story. A climax can be seen as the moment of greatest emotional tension in a story, and the point at which the protagonist's fortunes will turn. The ending must make emotional and logical sense: it should be surprising, yet as connected to the holonovel as a whole which, in retrospect, will seem inevitable to the experiencer. In essence, the ending defines whether or not the story goal will be achieved. As the temporal conditions in the Holonovel context are exceptional, as compared to traditional narrative form, this might bring afore some interesting alternatives to the ending. One option is that the holonovel has no ending, the second one is that it will have multiple and/or parallel endings and the third is that the whole plot structure can follow the wormhole type of so-called Kelvin timeline ending(s).[3]

[3] The "Kelvin timeline" is a concept created for the Star Trek franchise. The name was first revealed to the public in 2016, although it does not appear in any canon material, but is CBS Television's internal name for the alternate timeline.

4.2. H-course Holonovels

In creating the holonovels the motto for the 2018 H-course crew was: "The holonovel is made of stories, not of transported or replicated matter", which was revised from an American poet Muriel Rukeyser's (1913 –1980) famous quotation: "The universe is made of stories, not of atoms." Because all of the H-course students had present, widespread and intimate knowledge about the varietal aspects of education, the overall topic for the stories was outlined as the emerging possibilities of the Holodeck for future immersive learning. During the course, the students were requested to consider the type of thematic connotations they wanted to emphasize in their stories – did they want to present futuristic situations as analogies for current problems (such as the "Me too/Time's up" -campaigns), or, e.g., discuss about some controversial disruptive technologies. The intense discussions included some very abstract topics, for example, how to make the world around us more visible, the complex and constructed nature of our environment and the role of artificial intelligence in the H experience. Other important topics were e.g. how everyday experiences have come to seem increasingly game-like and the predestine rules by which we act out and interpret our real experiences.

Two course holonovels were able to engage all the complex aspects relating to the Holodeck as a future immersive learning environment, and as such they act as excellent examples of the H-course outcome. These holonovels were chosen by an international peer-review process to the workshop proceedings of EAI International Conference on Technology, Innovation, Entrepreneurship and Education (TIE 2018). The holonovels were 'The Holodeck is my Oyster', by Eve Koivurinta [Koivurinta, 18], and 'Bake Believe', by Lena Bennedsen [Bennedsen, 18].

'The Holodeck is My Oyster' depicted a future where, according to Koivurinta, having a Holodeck in every home was the newly established norm. In essence, the holonovel presented three different tactile learning cases in which the enactors were inhabitants of the same, newly constructed apartment building. Each inhabitant used their prefabricated Holodeck for similar immersive and interactive, yet individual, purposes, which essentially were about learning new skills. Through three very different kind of plot developments and enactor motivations the prototype discussed about how to employ the Holodeck for new learning habits. More specifically the H-experiences focused on how to investigate, manipulate and construct the learning strategies within the Holedeck environments, and how the feedback from VAs shaped the learners understandings of the world and what the systems make possible.

Bennedsen's 'Bake Believe' presented a sugarcoated dystopian future, in which the Holodeck had become the main learning and entertainment technology through which people upload their personal knowledge and experiences to be used as an immaterial currency within the Holodeck. In the prototype a young woman, Madeleine, aspires to win "The World Championship of Cake Design" and during her journey she engages with a baking program and Virtual Avatars. From the pedagogical point of view the prototype presents a keen-sighted case of time pressure and problem solving associated with the simulation program. More implicitly, Bennedsen's prototype illustrates a social simulation that places distinct focus on the enactor's experiences with identification and compassion. The holonovel was able to weave multiple "AI-hard" topics – such as ethics, aesthetics and empathy – to the structures of the prototype, and as a proof of that, the prototype won the best workshop paper of the conference.

5 Conclusion

In essence, this article presented the design process for creating science-fiction prototyping-driven holonovels that can be associated with the fictional Holodeck-technology that still does not exist. The holonovel writing activity was introduced within the art education context with the main intent to create "scientifically credible" myths around topics that students found to be interesting at that time. The overall process included severe literature research, defining of terminology, introduction of the holonovel course content and a brief presentation of the outcome with two student-created holonovels.

The most important new contribution of the article has been the defining of basic terms and elements for the holonovel construction process. These were:

- The *H experience*, in which the H stands equally for the Holodeck technology and holonovel activity
- The protagonist of a holonovel is called *an enactor*
- The side characters are called *VA*s, which presents equally (if not specified) the (non-human) Virtual Actors and (human) Virtual Avatars
- The most important units and entities of the holonovel: the scene, the state and the trigger/triggering event/story event

The defining of terminology was based on literature research and the contribution deforms the minimum set of components that are needed for structuring the design process of a holistic H experience. In the terminology evaluation there is still more research needed, especially for those units and entities that are based on existing terminology from several different disciplines.

The previous research had discovered that the "Holy Grail" for creating the Holodeck experiences was in the high sense of agency creation process for the Virtual Actors. Conversely, the H-course and the created holonovels highlighted the role of enactor and described more complex and compelling manners to design for their experiences. The students' holonovels were able to illustrate extraordinary new ways for people to use Holodecks for immersive learning purposes and, among many other contributions, their tales highlighted the sustainable role of virtual (non-material) artefacts as the main learning material. From the pedagogical aspect, the stories illustrated emotionally engaging ways to learn, tangible ways of helping students to make sense of the world, and processes that often led to behavioral change. Within the art education context the main intent was to define the social drivers for the Holodeck technologies, and by that study the hidden expectations, values and ethics, while simultaneously increasing social awareness towards the emerging technologies.

6 Future work

In future work the intent is to find extravagant means to engage more diverse set of disciplines to the mutual effort for creating and exploring the holonovel futures. Based on this research, that would seem to be the optimal way to harness the full power of the

new interactive art form, and, simultaneously, weave transparent ethics, aesthetics and values to the shaped force fields and transported matter of the forthcoming Holodecks.

The organizing of subsequent H-courses will evidently provide new future visions and material for considering more diverse use for the Holodeck technologies and detail the design process for the holonovel writing activity. At the time of writing this article, the most productive future work would seem to be related to the online Immersive Reality Innovation laboratory (i-Lab) research[4] e.g. [Callaghan, 16] and in the consideration of how the Holodeck/holonovel activity could be explored in that context. Bearing in mind the fictional aspect, it would certainly seem that the contemporary prototyping technologies are not sufficiently advanced to facilitate appropriate research for the rapidly evolving possibilities of the Holodeck. In the real-time virtual innovation laboratories, the participants could nevertheless utilize such Holodeck-specific tools that do not exist yet in the physical world. The i-Lab facilitation would assure also that the simultaneous enactors could be physically located anywhere in the world. Consequently, the topics for the immersive learning in i-Labs might include e.g. the facilitation of distance learning and interactive collaboration through the virtual H experience. When considering again the fictional context, the emphasis of the physical building for the i-Labs should exploit such future-oriented methods, as e.g. Science Fiction Prototyping (SFP) [Johnson, 11], Diegetic Innovation Templating (DIT) [Zheng, 2017] and Imagination Workshops [Wu, 2013].

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References

[Bates, 90] Bates, J.: Computational drama in Oz. In: Working Notes of the AAAI-90 Workshop on Interactive Fiction and Synthetic Realities, Boston, MA, 1990.

[Bennedsen, 18] Bennedsen, L.: Bake Believe, EAI International Conference on Technology, Innovation, Entrepreneurship and Education, TIE 2018, London, UK, 2018.

[Black mirror episode, 17] Black mirror episode: "USS Callister", Season 4, Episode 1, 2017.

[Bleecker, 09] Bleecker, J.: Design Fiction: A short essay on design, science, fact and fiction. Near Future Laboratory, 2009.

[4] An innovation-lab (i-Lab) has been described as an "*inspirational facility designed to transport users from their everyday environment into an extraordinary space encouraging creative thinking and problem solving*" [Susnea, 2015].

[Bratman, 99] Bratman, M.: Faces of intention: Selected essays on intention and agency, Cambridge University Press, 1999.

[Callaghan, 09] Callaghan, V., Clarke, G. Chin, J.: Some socio-technical aspects of intelligent buildings and pervasive computing research. In: Intelligent Buildings International, vol. 1, no. 1, 56–74, 2009.

[Callaghan, 16] Callaghan, V., Davies M. and Zhang, S.: An Online Immersive Reality Innovation-Lab", iLRN'16, Santa Barbara, USA, 2016.

[Carney, 14] Carney, J., Wlodarski, R., Dunbar, R.: Inference or enaction? The impact of genre on the narrative processing of other minds. In: PloS one, 9(12) 2014.

[Cavazza, 00] Cavazza, M., Aylett, R., Dautenhahn, K., Fencott, C., Charles, F.: Interactive storytelling in virtual environments: Building the "holodeck". In: Proceedings of VSMM, 678–687, 2000.

[Cavazza, 07] Cavazza, M., Lugrin, J. L., Pizzi, D., Charles, F.: Madame Bovary on the holodeck: immersive interactive storytelling. In: Proceedings of the 15th ACM international conference on Multimedia, pp. 651–660, ACM, 2007.

[Chu, 13] Chu, S. L., Quek, F.: Information holodeck: thinking in technology ecologies. In: IFIP Conference on Human-Computer Interaction, Springer, Berlin, Heidelberg, pp. 167–184, 2013.

[Dourish, 14] Dourish, P., Bell, G.: Resistance is futile: reading science fiction alongside ubiquitous computing. Personal and Ubiquitous Computing, vol. 18, no. 4, 769–778, 2014.

[Ferguson, 11] Ferguson, R.: Meaningful learning and creativity in virtual worlds. In: Thinking skills and creativity, 6 (3), 169-178, 2011.

[Gerrold, 73] Gerrold, D.: The World of Star Trek. New York, Ballantine Books, 1973.

[Hutto, 08] Hutto, D. D.: The narrative practice hypothesis: clarifications and implications. In: Philosophical Explorations, 11(3), 175–192, 2008.

[Jenkins, 88] Jenkins III, H.: Star Trek rerun, reread, rewritten: Fan writing as textual poaching. In: Critical studies in Media communication, 5(2), 85–107 (1988).

[Jindra, 94] Jindra, M.: Star Trek fandom as a religious phenomenon. In: Sociology of Religion, 55(1), 27–51, 1994.

[Johnson, 11] Johnson, B. D.: Science fiction prototyping: Designing the future with science fiction. Synthesis Lectures on Computer Science, Morgan & Claypool, 2011.

[Koivurinta, 18] Koivurinta, E.: The Holodeck is my Oyster, EAI International Conference on Technology, Innovation, Entrepreneurship and Education, TIE 2018, London, UK, 2018.

[Kymäläinen, 13] Kymäläinen, T.: IF Alice Arrives THEN Wonderhome Incites. In: Workshop Proceedings of the 9th International Conference on Intelligent Environments, Athens, Greece, 2013.

[Kymäläinen, 15] Kymäläinen, T.: Science Fiction Prototypes as Design Outcome of Research, Doctoral Dissertations, Aalto University publication series, Aalto ARTS Books, 2015.

[Kymäläinen, 15] Kymäläinen, T., Plomp, J., Tuomisto, T., Heinilä, J., Urhemaa, T.: Designing smart living for ageing Alice–and the persons next door, Intelligent Buildings International, 9(1), 3–22, 2015.

[Kymäläinen, 16] Creative Prototyping as an Inter-Dimensional Portal Between Disciplines. In: Workshop Proceedings of the 12th International Conference on Intelligent Environments, IOS Press, London, UK, 2016.

[Kymäläinen, 17] Kymäläinen, T.: Kill Your Darlings (a Holonovel), EAI International Conference on Technology, Innovation, Entrepreneurship and Education, TIE 2017, Canterbury, UK, 2017. [Larson, 98] Larson, G. W.: The holodeck: A parallel ray-caching rendering system. In: Proceedings Eurographics Workshop on Parallel Graphics and Visualization, Vol. 10, 1998.

[Laurel, 91] Laurel, B.: Computers as Theatre. Addison-Wesley, Reading, MA, 1991.

[Marek, 10] Marek, C.: Perceptual modalities: Modes of presentation or modes of interaction? Journal of Consciousness Studies, 17.1-1, 2010.

[Mateas, 01] Mateas, M.: A preliminary poetics for interactive drama and games, Digital Creativity, 12(3), 140–152, 2001.

[Mateas, 02] Mateas, M., Stern, A.: Towards integrating plot and character for interactive drama. In: Socially intelligent agents, Springer, Boston, MA, 221–228, 2002.

[Mateas, 05] Mateas, M., Stern, A.: Structuring Content in the Façade Interactive Drama Architecture. In: AIIDE, 93–98, 2005.

[Mateas, 16] Mateas, M., Wardrip-Fruin, N.: Personalized and Interactive Literature, In: Bainbridge W., Roco M. (eds) Handbook of Science and Technology Convergence, Springer, 501–515, 2016.

[McKee, 97] McKee, R.: Story: Substance, Structure, Style, and the Principles of Screenwriting. HarperCollins, New York, 1997.

[Murray, 97] Murray, J.: Hamlet on the Holodeck, The Future of Narrative in Cyberspace. MIT Press, 1997.

[Oliva, 01] Oliva A., Torralba A.: Modelling the Shape of the Scene: a Holistic Representation of the Spatial Envelope. In: Journal of Computer Vision 3(42), 145-175, 2001.

[Paras, 05] Paras, B.: Game, motivation, and effective learning: An integrated model for educational game design. In: DiGRA 2005: Changing Views: Worlds in Play, 2005.

[Phillips, 04] Phillips, M. A., Huntley, C.: Dramatica. Write Brothers, 2004.

[Schmidt, 13] Schmidt, M., Kevan, J., McKimmy, P., Fabel, S.: The best way to predict the future is to create it: Introducing the Holodeck mixed-reality teaching and learning environment. In: Proceedings of the 36th Annual Convention of the Association for Educational Communications and Technology, pp. 578-588, 2013.

[Sommool, 13] Sommool, W., Battulga, B., Shih, T. K., Hwang, W. Y.: Using Kinect for holodeck classroom: A framework for presentation and assessment. In: International Conference on Web-Based Learning, Springer, Berlin, Heidelberg, 40-49, 2013.

[Star Trek episode, 74] Star Trek episode: “The Practical Joker”, The Animated Series, Season 2, Episode 3 (1974).

[Star Trek episode, 17] Star Trek episode: “Lethe”, Discovery, Season 1, Episode 6 (2017).

[Susnea, 2015] Susnea, I., Pecheanu, E., Tudorie, C. and Cocu, A.: The education for creativity–the only student’s tool for coping with the uncertainties of the future, Multidisciplinary Academic Conference on Education, Teaching and E-learning (MAC ETEL 2014), Prague, 2014.

[Swartout, 06] Swartout, W., Hill, R., Gratch, J., Johnson, W. L., Kyriakakis, C., LaBore, C. et al.: Toward the holodeck: Integrating graphics, sound, character and story. University of Southern California Marina del Rey Ca Inst for Creative Technologies, 2006.

[Thornburg, 13] Thornburg, D., From the campfire to the holodeck: Creating engaging and powerful 21st century learning environments. John Wiley & Sons, 2013.

[Wu, 2013] Wu, H.Y.: Imagination workshops: An empirical exploration of SFP for technology-based business innovation, Futures, 50, 44-55, 2013.

[Zheng, 11] Zheng, D., Newgarden, K.: Rethinking language learning: Virtual worlds as a catalyst for change, International Journal of Learning and Media, 3 (2), 2011.

[Zheng, 2017] Zheng, P., and Callaghan, V.: The Role of Science Fiction and Fantasy in Facilitating Innovation: Empirical Evidence from China, Futures, 2017.