Holograms as Teaching Agents

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Abstract. Hungarian physicist Dennis Gabor won the Pulitzer Prize for his 1947 introduction of basic holographic principles, but it was not until the invention of the laser in 1960 that research scientists, physicians, technologists and the general public began to seriously consider the interdisciplinary potentiality of holography. Questions around whether and when Three-Dimensional (3-D) images and systems would impact American entertainment and the arts would be answered before educators, instructional designers and students would discover how much Three-Dimensional Hologram Technology (3DHT) would affect teaching practices and learning environments. In the following International Symposium on Display Holograms (ISDH) poster presentation, the author features a traditional board game as well as a reflection hologram to illustrate conventional and evolving Three-Dimensional representations and technology for education. Using elements from the American children’s toy Operation® (Hasbro, 2005) as well as a reflection hologram of a human brain (Ko, 1998), this poster design highlights the pedagogical effects of 3-D images, games and systems on learning science. As teaching agents, holograms can be considered substitutes for real objects, (human beings, organs, and animated characters) as well as agents (pedagogical, avatars, reflective) in various learning environments using many systems (direct, emergent, augmented reality) and electronic tools (cellphones, computers, tablets, television). In order to understand the particular importance of utilizing holography in school, clinical and public settings, the author identifies advantages and benefits of using 3-D images and technology as instructional tools.

1. Background: Holography and Education
What interdisciplinary research documents the effects of holography as a learning tool? Does holographic movement and stimuli impact children differently than adults? Which teaching assessments and Three-Dimensional (3D0 learning environments might support particular learning gains? The ISDH poster presentation, Holograms as Teaching Agents, is designed to prompt viewers to consider these and other questions about the influence of Three-Dimensional images, games and systems on learning science. Three-Dimensional Hologram Technology (3DHT), avatars and images have dramatically impacted the field of education, affecting the design of instructional activities and environments across all disciplines and content areas, particularly in the domain of science. Emergent
hologram technology can represent diverse interactive educational platforms far different from traditional learning settings in conceptual context, time and space.

Holography is the only technique that can record the full tri-dimensional quality of an object, and allow the observer to easily see this as an image that is truly 3-D (Ko, 1998). Holograms of human organs and other figures can be used to teach adults and children simple dissections and health protocols as well as instruct medical students and physicians with the latest surgical techniques, innovative tools and environments. For learners of all ages and backgrounds, tri-dimensional games and systems offer stimulating educational training that can make complex scientific information and health content not only meaningful and instructive but more engaging.

Three-Dimensional medical avatars have been instrumental in driving development, innovation and knowledge around how patients, doctors and students learn about the human body, access medical data and record health conditions. With real-time, full color, 3-D animations and illustrations of the human anatomy, IBM™, Apple™ and Blausen Medical, ™ have taken the lead in designing medical avatars as agents in knowledge-based instruction. Performing as science coaches in immersed learning environments, avatar apps use medical data and instructional embodiment to guide scientific learning. Students’ experience and develop different sensory modalities, memories and perceptions as their brains interact with and in three-dimensional learning settings (Lu, Black, and Huang, 2005).

Holorad™ produces standard and customized sets of transparent Voxgrams®, 3-D images that literally hang in space, to teach as well as test student knowledge and understanding of anatomy. At leading U.S. medical schools, the company’s new instructional tools efficiently provide “x-ray vision” for surgeons, patients and educators, giving a clear visual understanding of the critical relationships between and within anatomical and pathological structures (Holorad, 2012). Educators report that teaching is greatly enhanced with the intuitive “3-D X-Ray” viewpoint of Voxgrams. In addition to patient imaging data, Holorad has also developed popular 3-D entertainment and educational experiences at Disney’s Epcot Center as well as Outer Space Holograms® that are a part of science education programs at national museums, airports and other public spaces (Voxel, 2012).

As educators, students, physicians and patients interact with various 3-D designs, programming cognitive tasks and mental representations in real-time applications, they develop science skills and abilities, building their intellectual capacity for learning science in synchronized stages. Providing immediate 3-D information, holograms uniquely facilitate the spontaneous understanding of human neuroanatomical relationships which cannot be efficiently learned with photographs or diagrams: This points the way toward future educational and biomedical applications of this emerging technology (Ko & Webster, 1995).

2. The Pulsed Brain Hologram: Superimposed Holographic Image-Guided Neurosurgery
The 8 x10-inch reflection hologram at the center of this ISDH poster design presents a Three-Dimensional image of the brain using a pulsed wave (PW) laser technique produced by neurosurgeon Dr. Kathyrn Ko (1995, 1998) in collaboration with Holographics, Inc. This instructional design employs 3-D models and imagery as instructional tools to demonstrate simple and complex scientific information in an interactive setting. As viewers observe the hologram teaching agent and engage in multimodal and multidimensional activities with the poster design, their understanding of human anatomy is enhanced. Subjects demonstrate basic cognitive skills while playing with the game box, and form mental representations when analyzing the holographic brain image.

In this reflection hologram, three-dimensional biomedical data is apparent. Applying this premise to neurosurgery, a sterilized radiological hologram of the brain is superimposed over the skill as a guiding template between the surgeon and subject.

Ko explains the surgical advantages for doctors and patients of representing biomedical data as a tri-dimensional visual guide: Holography is a departure from stereo-viewing in that the image is auto-stereoscopic and 3-D without the need of stereo pairs of stereo pairs or visual appliances. Holograms present multiple digital sets in a unified volumetric and interactive format. The accuracy of the 3-D image position and viewing angle with respect to the patient’s pathological characteristics was
checked in the office, leading to a higher confidence level in the use of this technology in surgery. All patients and their families preferred having their own hologram used as the visual educational aid during explanations of the procedure (Ko, 1998).

Since conceiving these preoperative simulations over 20 years ago, Dr. Ko has employed superimposed holographic images of human organs as an interactive visual map in the operative field. The neurosurgeon posits the potentiality of in vivo use of holography in diverse medical practices is enormous: Holography is not so much a jump into the third dimension, but a logical step along the progressive continuum of representing the human body; from drawing to photography, to x-ray studies, to CT and MR imaging in two dimensions and finally in three dimensions (Ko, 1998).

3. Poster Element Summary: Operation® the Game
Employing holographic images of the human brain as well as elements from the American children’s game Operation®, this ISDH poster highlights the pedagogical effects of 3-D images and games on science education. In the 1960s, American scientists and young science-fiction fans alike would fashion new ways to use 3-D imagery to first entertain and later educate the masses. For the past 50 years, Operation® has inspired generations of children and adults around the world to have “funatomy,” fun learning about human anatomy while playing a simple 3-D science game (Hasbro, 2005).

It was in a University of Illinois classroom that a sophomore instructional design student named John Spinello created what would become one of the world’s most iconic educational 3-D games (Walsh, 2000). Credited with invented the hugely popular Operation, Spinello’s premise was designed after electrified loop games from Americana country fairs and flamer stores (Mannion, 2011). Earning the highest class grade, his winning game box measured 10 x 10-inches with a 12-volt lantern battery that triggered a 6-volt bell. Designed as a 3-D operating table to test players’ fine motor skills and hand-eye coordination, Operation players inserts tweezers into metal-edged holes in an electrified box, carefully removing organs, bones and other body parts without touching the sides of a multimodal, tri-dimensional patient names Cavity Sam. In late 1962, the college student pitched his educational design to Chicago toymaker Marvin Glass: I did my prototype of my magic box and everybody liked it. At first Glass was not impressed, he inserted the probe into the game board, got dinged, jumped, guffawed, and changed his mind and loved it (Walsh, 2000). The game was sold to Glass but not by Spinello who was hired 10 years later after Glass was no longer president and after Operation had become a huge success.

Milton Bradley™ purchased it in 1965 followed by Hasbro™ which continues to produce this world-renowned game in various languages and versions featuring its original 3-D patient as well as other popular children’s characters from Shrek® to SpongeBob® (Hasbro, 2012). Spinello’s design also inspired the 1964 children’s game show, Shenanigans, which featured a life-sized, 3-D Operation game as one of its challenges. Aside from the traditional board game, a hand-held version with a screen in Cavity Sam’s stomach, and a personal computer game was produced in 1998, followed by a brain surgery version (Hasbro, 2012), which required players to pull pieces out of Sam’s head. Today, Hasbro jointly promotes Operation Relay®, currently shown on the television game show Family Game Night (the Hub, 2012), where two families compete through an obstacle course taking turns pulling pieces of out of an oversized Operation board.

In both the traditional game model and the television competition, the varied interactive formats of Operation encourage players to engage some Three-Dimensional version of Cavity Sam as well as science content in contexts that resemble a game, sport or amusement rather than simply an instructional lesson. John Spinello’s college project would become an international educational tool that would motivate countless players of all ages and nationalities to become surgeons: I recall wearing and Operation t-shirt one day when a woman let me know of the game’s impact on her son. She said, ‘Because of your game, my son became a doctor’ (Mannion, 2011).
4. Previous Literature and Cognitive Research
Recent cognitive studies provide a new perspective on what it means for learners to use holograms as teaching agents; specifically how Three-Dimensional images and systems will become more a part of the way that novices and experts understand and interact with the world of science. Research indicates perceptual effects on student comprehension and other strong educational benefits when instruction is mediated by 3-D imagery in immersed learning settings. Findings show objects that move or undergo perspective transformations are potentially more informative (i.e., convey additional information, such as information for an invariant property) than objects that are stationary (Gibson, 1969; Ruff, 1980).

Neuroimaging studies also indicate perceptual effects on comprehension and behavior when learning is mediated by holography. Testing this possibility in perceptual research among adults, subjects reported the three-dimensional effect to be the most salient aspect of holograms (Nelson & Horowitz, 1983). Three-Dimensional avatars used as pedagogical agents improve learners’ conceptual understanding. Data also shows that 3-D medical avatars used as pedagogical agents improve learners’ conceptual understanding. As they construct a concept map, students’ specify propositional, functional and procedural knowledge to the avatar and are able to learn different scientific concepts better and more quickly (Bai & Black, 2005). Acting out stories using 3-D avatars also increased children’s comprehension and memory.

Through innovative technology, customized content and interactive 3-D activities, holograms as teaching agents provide effective instruction to kids and adults by applying contextual and non-verbal cues. Tri-dimensional images, games, videos, storybooks and posters can make difficult health content more meaningful and engaging. By modeling instructional content and behavior in relatable contexts, holographic characters, tools and visuals can uniquely motivate students and promote interactive engagement in learning activities. Whether as a reflection hologram teaching agent, a board game or medical avatar in a computer program, each tri-dimensional tool activates science learning while motivating learners to continue to engage this educational technology.

How learners of all ages achieve greater proficiency and skills in 3-D learning environments in the future will be based on the varying medium (hologram, agent or human instruction), type of 3-D learning system used (game, computer, avatar) as well as a perceptual analysis of holographic stimuli (static or kinetic motion), on behavior and learning. Additional research is needed to examine the degree to which motion itself is a relevant or discriminant component of learning with holograms as pedagogical agents particular to adult learning, as well as 3-D’s perceptual effects on children’s comprehension.

5. Poster Discussion on Holograms as Teaching Agents
This International Symposium on Display Holography poster design is built on the supposition that learners’ exposure to multidimensional and multimedia instructional tools in an immersed learning environment could be associated with specific behavioral changes. Moreover, subjects’ responses to Operation® as a conventional board game as well as to the superimposed holographic brain might affect particular gains in learners’ skills, attitudes and knowledge in the science domain. When players create mental simulations using the 3-D game or the reflection hologram, not only are their perceptions but their knowledge, comprehension and reasoning skills are influenced.

These perceptual and technological motivators significantly impact how children and adults respond to the mental stimuli of holography in this unique learning environment. As viewers examine and engage with this poster design, questions around whether, how and to what extent Three-Dimensional Hologram Technology, images and games mediate their mastery of science content as well as their ability to regulate information in this learning environment are weighed and considered. If as perceptual researchers suspect, holography can be used as a procedure to train young children and adults to elicit scene changes from a holographic stereogram, then educators, researchers and instructional designers must continue to assess how holography performs as a learning tool and begin refinements based on those considerations. In the future, various learning environments (school,
clinical and public), systems (direct, emergent and augmented reality) and telecommunications devices (computers, tablets, cellphones, TV) will be used to measure the short and long-term effects of using Holograms as Teaching Agents for learners of all ages.

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