Designing Instructional Animation for Psychomotor Learning
A Conceptual Framework

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Keywords: Instructional Animation, Psychomotor Learning, Virtual Human Representation, Instructional Video Design, Conceptual Framework, Instructional Media, Visual Communication.

Abstract: Research on the effectiveness of animated virtual human representation towards psychomotor learning is still lacking. Recent studies show that animation is effective in learning procedural tasks. Instructional animation is a form of animation designed to educate viewers. The purpose of this paper is to lay out a conceptual design framework for studies of the instructional animation design for psychomotor learning. Three theoretical approaches are considered in constructing the conceptual framework: (1) Learning Theories; (2) Instructional Video Design; and (3) Virtual Human Representation. Together, these theoretical fields complement one another and explain different viewpoints on this complex subject. Relating to earlier studies on types of visual representation may elucidate the ways in which animation can be applied for motor skill acquisition.

1 INTRODUCTION

Instructional videos are commonly used as supplemental materials to enhance learning during lecture or tutorials (Kay, 2014). Instructional videos can be in a form of live action video or animation or even both (hybrid). In addition, there are numerous Web 2.0 technologies and platforms that can provide many options for video creation (Martin, 2012). Besides that, viewers can also view these videos from the comfort of their computer desktops at home to their handheld devices on the go. Simultaneously, educational video is gaining back its popularity due to the adoption of Massive Open Online Course (MOOC) to counter the rising cost of higher education (Baggaley, 2013).

Animation and live action video possess different visual characteristics. According to Ploetzner and Lowe (2012), live action video cannot readily portray the explanatory abstractions as well as expository animations. Live action video may unable to demonstrate hypothetical cases or non-visual aspect of a subject matter. Compared to animation, live action video may unable to show visual information that is hidden form the camera and may only be able to present information in a non-selective manner. They also added that animation has more flexibility as it can manipulate portrayal of the subject matter through abstraction and visuo-spatial reorganization (Ploetzner and Lowe, 2012).

Several studies have shown that instructional animation can facilitate motor skill learning (Ayres, Marcus, Chan, and Qian, 2009; Höffler and Leutner 2007; Wong, Marcus, Ayres, Smith, Cooper, Paas, and Sweller, 2009). A study conducted by Ayres et al. (2009) shows that animation allows learners to learn faster than learning with static graphics. In this study, participants were asked to learn knot tying and solve ring puzzles. Based on the study, in which learning was purely based on observation, the researchers concluded that students learn more from the animation mode then the static one. They believed that the reason instructional animation was more effective than static graphics was, perhaps, due to the human's inherent ability to learn human-movement based task through observation of the activity being performed. Interestingly, learners with low spatial ability can also benefit by learning via animation as such form of visualization "provides learners with an external representation of a process or procedure that assists them to build an adequate mental model" (Höffler, 2010, p.249) and "helps in reducing the processing demands necessary to forming a mental model and encoding it into long-term memory" (Höffler and Leutner 2011, p.210). For instance, there are usually instructional graphics located on most gym equipment. A beginner may find it more useful

Lucas T. and Abdul Rahim R..
Designing Instructional Animation for Psychomotor Learning - A Conceptual Framework.
DOI: 10.5220/0005477303130318
In *Proceedings of the 7th International Conference on Computer Supported Education* (CSEDU-2015), pages 313-318
ISBN: 978-989-758-108-3

to learn about the proper usage of the exercise machine via instructional animation as compared to static instructional graphics.

Hence, this position paper proposes a conceptual design framework to create instructional animation for psychomotor learning or motor skill acquisition. The framework focuses on integrating three deemed relevant components which are: (1) learning theories; (2) instructional design; and (3) virtual human representation.

2 CONCEPTUAL DESIGN FRAMEWORK

2.1 The Learning Theories

In order to design an effective instructional animation or video for psychomotor learning, a few relevant learning theories need to be briefly discussed. These theories are Psychomotor Learning, Experiential Learning, and Cognitive Theory of Multimedia Learning.

2.1.1 Psychomotor Learning

Motor skills are activities or tasks that require voluntary head, body and/or limb movement to achieve a goal. Modeling is a way to acquire new motor skill movements. It is the "interaction between a model and an observer where the observer's behaviors are adapted to match the technique and outcome of the model" (Sakadjian et al. 2013). Therefore, it is imperative that the demonstrator perform the skill precisely (Magill, 2011). The quality of the performance resulting from observing a demonstration is related to the quality of demonstration as coordination information and perceived strategic information are acquired. Both Magill (2011) and Sakadjian et al. (2013) agreed that the transfer of information from the model to the observer is crucial. Plus, they asserted that the retention of information is essential in order to have positive gain from such activity.

2.1.2 Experiential Learning

Experiential learning is defined as "the process whereby knowledge is created through the transformation of experience. Knowledge resulted from the combination of grasping and transforming experience" (Kolb 1984, p.38). The theory assumes that learning is an reiterative process of creating knowledge through the interaction between the person and the environment (Kolb and Kolb 2005). According to Kolb, there are four cycles of actions in an experiential learning. The stages are as follows: (1) Reflective Observation is gained when the learner consciously reflect and review on the experience; (2) Abstract Conceptualization is gained when the learner can conceptualize a theory or model and utilize these generalizations as guides to engage in further action (Chan, 2012); (3) Active Experimentation is gained when the learner plans and tries out the knowledge learned from the experience; and (4) Concrete Experience is gained when the learner is performing, doing or having an experience.

2.1.3 Cognitive Theory of Multimedia Learning

Cognitive Theory of Multimedia Learning is a collection of evidence-based multimedia learning principles. Mayer (2009) explained that this theory is based on three assumptions: (1) people have separate visual and auditory channels; (2) the channels are limited in capacity; and (3) meaningful learning involves actively selecting, organizing, and integrating incoming visual and auditory information. He also asserted that multimedia is especially useful for learners who have low-prior knowledge about the subject matter. It is also suitable to teach complex materials in a faster paced to learners. The principles of this theory are divided into three main categories such as: (1) managing essential processing (pre-training principles, segmenting and modality principle); (2) minimizing extraneous processing (coherence principle, redundancy principle, signaling principle, temporal contiguity principle, and spatial contiguity principle); and (3) facilitating generative processing (multimedia principle, personalization principle, voice principle and image principle) (Mayer, 2009).

The application of Cognitive Theory of Multimedia Learning Theory in designing of the instructional animation for motor skill acquisition can be significant as the theory may be able to make the animation effective for learning.

2.2 Instructional Video Design

It is essential that the instructional design of instructional animation or video is based on the grounds of established learning theories. Several studies (Baggaley 2013; van der Meij and van der Meij, 2013; Swarts, 2012) have proposed guidelines and principles that can be incorporated into the design of instructional animation or video.

Baggaley (2013), Swarts (2012) and Carliner (2000) classified characteristics that constitute to good instructional video design. Some of their findings (refer to Table 1) are similar in terms of Simplicity, Specificity and Appeal (S.S.A.).

Table 1: Common findings on characteristics of good instructional videos.

Carliner (2002)	**Baggaley (2013)**	**Swarts (2012)**	**Similarity (S.S.A.)**
Cognitive Design	Straight forward & consistent	Easy to understand	Simplicity
Physical Design	Explicit	Detailed demonstration	Specificity
Affective Design	Motivating	Engaging	Appeal

To note, Physical Design is a design that directs users to a desired message. Cognitive Design is a design that assists users to comprehend the desired message. Affective Design is a design that facilitates viewers to be engaged with and feel comfortable about the desired message (Carliner, 2000).

Meanwhile, van der Meij and van der Meij (2013) provided eight design guidelines of instructional videos for software training. Despite that these guidelines are meant for software training, it is also possible to apply it in the instructional video for motor skill acquisition because the essence of motor skill learning is also procedurally based. The guidelines are as follows: (1) provide easy access; (2) use animation with narration; (3) enable functional interactivity; (4) preview the task; (5) provide procedural rather than conceptual information; (6) make tasks clear and simple; (7) keep video short; and (8) strengthen demonstration with practice (van der Meij and van der Meij, 2013).

Aside from the principles and guidelines provided above, there are also several studies that have tested several multimedia techniques that can facilitate learning. Such related multimedia techniques are the use of captioning, highlighting and video prompting. To note, these multimedia techniques are also based on the Cognitive Theory of Multimedia Learning.

Despite being commonly used, the use of captioning in videos receives mix responses. By using captions, viewers will be exposed to spoken language, digital text and visual information simultaneously. Depending on the usage, it can either be distracting or it can improve reading comprehension, vocabulary and motivation (BavaHarji, Alavi, and Letchumana, 2014). However, after conducting their study on the effects of captioning on English as Foreign Language (EFL) learners, BavaHarji et al. (2014) concluded that the use of captioning can facilitate language proficiency and content comprehension.

According to Kay (2014), highlighting serves to visually emphasize and direct viewers' attention to a certain issue, topic or mark. Highlighting can be created by assigning different color, underlining, circling or pointing arrow to the subject of interest (Sweller, 2010; Pekerti, 2013).

Another recent study shows that the use of video prompting can facilitate learning. Video prompting is a modeling technique that allows the viewer to perform a demonstrated step before moving on to the next step (Cannella-Malone, Fleming, Chung, Wheeler, Basbagill, and Singh, 2011). This technique can be useful to teach action-based motor task to beginners (Yanardag, Akmanoglu, and Yilmaz, 2013).

2.3 Virtual Human Representation

There are several design considerations to create a digital character for demonstrative purposes. These considerations can play significant roles in improving the knowledge transfer through instructional animation. Two points that need to be considered are the target audiences' preference and the types of visual rendering (fidelity level) of the digital character. These aspects can have an impact towards the effectiveness of an instructional animation or video.

2.3.1 Target Audience's Preference

Understanding the preference of the target audience that the instructional animation is designed for is vital. Recently, there are two studies that focus on the impact of animated characters on children's perception (Johnson, DiDonato, and Reisslein, 2013; Tinwell and Sloan 2014). According to Johnson et al. (2013), K-12 students prefer similar or relatable physical dimensions such as age, gender and realism. These findings can be attributed to the assumption that humans are attracted to individuals who look and act similarly to themselves (Byrne and Nelson, 1965). In addition, Tinwell and Sloan (2014) conducted a study on children's perception of uncanny human-like virtual characters. In this study, children between the age of 9 and 11 years rated humans and human-likeness figures. Their findings show that, similar to adults, children also perceived human-like virtual character as stranger, less friendly, and less human-like than videos of real humans.

2.3.2 Realism, Fidelity and Believability

Realism is defined as “attributes of a character where the designer has intended that it be perceived as realistically human-like and this covers aspects of, and relationships between, appearance, motion, behavior, sound and, in some cases, context” (Tinwell, Grimshaw, and Williams, 2011, p.328). Barrett (2003) stated that many assume that looking ‘realistic’ usually means looking like photograph. He adds that in order to look realistic, the image has to be ‘closest to looking like’ things in the real world (Barrett, 2003). Meanwhile, Fidelity is defined as “the enjoyment of games that have realistic graphics and sound effects, three-dimensional graphics, and lifelike animation” (Quick, Atkinson, and Lin, 2012, p.72). According to a study by Quick et al. (2012), fidelity has an impact on player’s enjoyment in learning through games. They urge that player’s preference for fidelity should be gauged and educational games should be constructed to match the relevancy of the players’ preference on aesthetic. Therefore, this fidelity characteristic can also be considered while designing an effective and enjoyable instructional animation.

Gulz and Haake (2005) conducted a study on realistic versus iconic characters with respect to involvement and engagement effects in users. They have found that the types of visual style used to represent a character depends on the function of the character (Gulz and Haake, 2005). They argued that pictorial realism can increase involvement and the sense of presence in the digital environment (Gulz and Haake, 2006). An iconized character allows viewers to construct their character with their subjective imagination, whereas, a highly realistic character lack such allowance. For example, iconic visualization may be more suitable if the focus is to design a character that is rich in subjectivity and more relationally oriented. On the other hand, if the focus is to design an objective, task oriented character; a realistic representation may be more suitable.

Humans are skilled at perceiving subtle details of human motion (Hodgins, Wooten, Brogen, and O'Brien, 1995). In order to create believable human motion, Hodgin et al. (1995) suggested creating digital character and virtual environments that appear realistic when they move. The ways objects and character move play a vital role in the creation of believable animation (Coros and Martin, 2012). They added that a realistic human motion is consisted of two components: (1) the kinematics and dynamics of the characters must be accurate; and (2) the computational algorithm system must be able to allow these characters to perform movements that appear natural to the human eyes.

To add more realism to a character, its acting or movement can be captured using motion capture system. Motion capture can capture complex movement in an accurate, smooth and fast way. Lasseter (2001) stated that motion capture is more suitable to capture realistic movement of human actors. However, the drawback of using motion capture is that it can be expensive and motion data could not the reused for different kind of characters (Sanna, Lamberti, Paravati, and Rocha, 2012).

Another point to note when creating believable human-like performance is the secondary motion. Secondary action is “an action that results directly from another action” and “always kept subordinate to the primary action” (Lasseter, 1987, p.42). Secondary motion can add greatly to the perceived realism of an animated scene (Hodgins et al., 1995). Examples of secondary motions are random blinks to the eyes, sinusoidal motion to the body to simulate breathing, splashing of water and subtle cloth movement upon collision (Hodgins et al., 1995; Ribeiro and Paiva, 2012). In addition, another technique to produce secondary motion is the use of ‘moving hold’ (Lasseter, 2001). For example, there should be a slight movement of the body parts (i.e. head or arm) to keep a character looking alive.

Apart from the secondary movement, the location or setting of the character performing the movement is important. The environment in the animation scene has to be able to accommodate the action of the character easily (Guttmann, 2000). Guttmann (2000) also suggested giving the background of the scene a perspective because a background with perspective lends realism and makes the animation portrayed to be more natural.

3 DISCUSSION

Instructional animation can play important roles at the Cognitive Stage of the Psychomotor Learning. The authors believe that the cognitive stage of Psychomotor Learning process intersects with two of the Experiential Learning stages (refer to Figure 1). As a viewer watches the demonstration of the motor skill in the animation, the viewer is engaged in two stages of experiential learning. Firstly, the viewer will reflect and review the demonstration shown from the animation. Then, the viewers will process the information and form a model of the movement based on the viewer’s comprehension and visual perception.

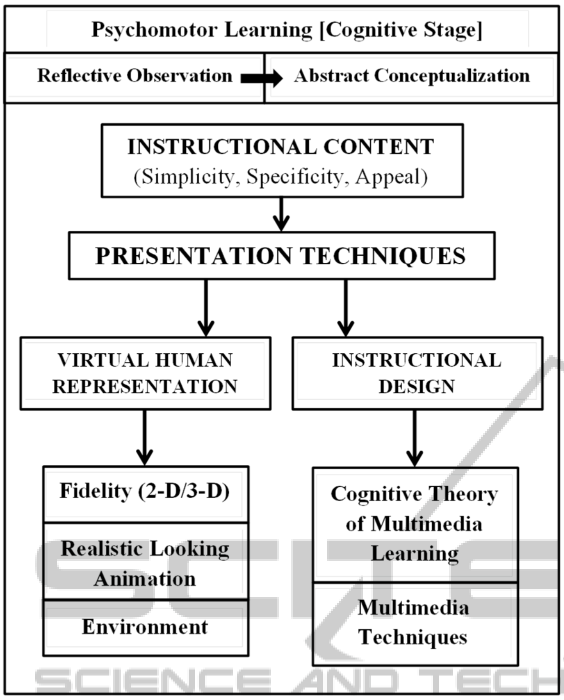

Figure 1: The Proposed Conceptual Design Framework for Instructional Animation for Psychomotor Learning.

The proposed design framework is comprised of Instructional Content and Presentation Techniques. Based from previous studies, it can be implied that focusing toward simplicity, specificity and appeal are recommended in developing the content. For example, the content has to be effortless, clear-cut and interesting for the viewers. 'Interesting' can also mean approachable for the viewer.

When it comes to the presentation techniques, two areas that can be considered are the design of human representation and the instructional design. The criteria to consider for the digital character demonstrating the motor skill are fidelity, realism of animation and the environment in the digital space.

The instructional design aspect covers the multimedia aspects of the instructional animation. Here, Cognitive Theory of Multimedia Learning and its Multimedia Techniques are to be considered in the design because learning via animation involves the visual and auditory modalities.

4 CONCLUSIONS

In sum, instructional animation has the capability to facilitate psychomotor learning. Several fields of studies such as learning theories, instructional video design and virtual human representation are considered in developing this framework. Although the areas covered may not be exhaustive and the framework is still at the conceptual stage, the authors hope that this proposed design framework can be utilized as a reference to design an effective instructional animation that can be benefited in various disciplines such as disability and rehabilitation training, artistic performance training, and sports training. Further study of this framework is required to improve the design and determine the potential and effectiveness of the framework.

ACKNOWLEDGEMENTS

This research is supported by the SLAI scholarship scheme from the Ministry of Education Malaysia.

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