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Proteus Play on a STEM-Game Platform

Examining the role of avatar identity and self-relevance on STEM attitudes and motivation

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Abstract

This study examines how different aspects of avatar use on a science-game web platform influences motivation to play science games on this platform as well as STEM interest and STEM-learning self-efficacy. We developed a science-game web platform for this research on which we are testing our expectation that using a science-related avatar (compared to a general avatar), especially when this avatar is customized (not simply assigned), will lead to more positive effects on STEM-learning self-efficacy, STEM interest, and motivation to play STEM games.

Introduction

There is an increasing demand for professionals who, in addition to being capable of retaining information, are equipped with the knowledge and skills to understand, evaluate, and make thoughtful decisions based on information. These sets of skills are usually acquired by studying subjects such as Science, Technology, Engineering, and Math (collectively known as STEM). According to the U.S. Bureau of Labor Statistics (2014), if the growth rate of graduating STEM professionals and availability of STEM jobs stay the same, in five years there will be a shortage of professionals working in STEM fields. One approach to addressing this issue is to incentivize students to pursue STEM careers.

However, creating such incentives is a complex task. It involves empowering schools with technological resources while providing training and tools to teachers so they can properly engage students with STEM topics. This last step is especially important not only because students usually fail to see STEM subjects as starting points for their careers (U.S. Department of Education, 2015), but also because students who show interest in technology are more likely to pursue degrees in STEM fields in the future (Maltese & Tai, 2010).

One way of motivating middle school students to learn science is through digital games (Clark et al, 2009; Marino et al, 2013). The *STEM Game Crew* website (http://www.stemgamecrew.org) is an important platform for students to engage with educational game content, while making a strong connection between their actions and the scientific method. Future uses of this platform include

educational use for teachers as well as research on the effects of avatar use in educational contexts, based on the Proteus Effect (Yee & Bailenson, 2007) and Bandura's (1977) Social Cognitive Theory (SCT).

The STEM Game Crew Website

The *STEM Game Crew* website is meant to complement *Curious Crew*, a science-education television show produced by WKAR, the public broadcasting station in Lansing, Michigan. The show follows Rob Stephenson, an award-winning educator, as he and the *Curious Crew*, middle school students from mid-Michigan, explore different scientific concepts during each episode.

According to Clark et al. (2009), games and simulations can be seen as useful tools for science learning not because they are better than traditional classroom teaching, but because they are so customizable (in terms of genre, target audience and expected outcomes) that they can provide many different and even individualized learning experiences. In addition, Marino et al. (2013) showed that students in general prefer learning science through digital games and believe that digital games can make learning science more fun. Building on these findings, the *STEM Game Crew* website displays links to more than 50 games related to 17 different STEM topics. The games that were chosen were intended to be as interactive, learning-oriented, and on-topic with the *Curious Crew* episodes as possibly.

The website also allows users to apply the scientific method with the games listed on this site: namely, players are asked to provide predictive hypotheses before playing the games and then report reflective observations afterwards. It is expected that by applying the *STEM Game Crew* scientific method students will learn how the method can be applied to many different situations, not only science experiments in the classroom.

Moreover, when registering in the *STEM Game Crew* website, users are asked to choose a username and an avatar. In the context of mediated environments, avatars are visual representations of users that can be either 2D (an image) or 3D (a model). Research shows that avatars can influence the user's behavior based on the stereotypes associated with the avatar's characteristics (Yee & Bailenson, 2007). The extent to which these effects of avatar use occur depend on the psychological attachment between the user's perception of self and the avatar (Ratan & Dawson, 2015). Although the science games listed in the *STEM Game Crew* website do not incorporate the site users' avatars, the users' avatars are displayed together with their usernames when posting on the website. Thus, users are still attached to their avatars while using the website because they perceive their avatars as their representation of self with other site users. Such attachment can impact the motivation one has to engage in learning activities (Ratan et al., 2016).

Finally, the *STEM Game Crew* website can also be seen as a tool for changing user's attitudes towards STEM. Social Cognitive Theory (SCT) explores how one's learning, motivation and behavior can be affected by one's self-efficacy and vicarious experience (Bandura, 1977). Playing science games in the website and posting ratings before and after playing are learning activities that can help users to better understand science topics, as well as reflect upon their own learning. Such activities can help change users' belief in their own capacity to learn science content and their interest in STEM fields.

Thus, one goal of this study is to investigate how avatar type can motivate users of the *STEM Game Crew* website to play science games, as well as impact users' self-efficacy and their interest for learning

STEM-related content. Another goal is to explore how avatar customization can impact the motivation to play science games in the *STEM Game Crew* website.

STEM-learning self-efficacy and STEM interest

Social Cognitive Theory (SCT; Bandura, 1977) can give us insight regarding how science learning can happen through digital games or other mediated environments. SCT states that human functioning is dynamic and one way of learning is to build self-efficacy. Self-efficacy is the belief that a specific behavior can be accomplished (Bandura, 1977).

Much research has been conducted on STEM self-efficacy and traditional learning environments (Diekman et al, 2010; MacPhee, Farro, & Canetto, 2013; Rittmayer & Beier, 2008; Soldner et al, 2012). These studies focus on augmenting STEM self-efficacy in order to achieve better learning or a higher interest in STEM careers. However, literature does not encompass STEM learning self-efficacy, defined in this study as the belief that an individual has a capability to learn STEM-related content. Moreover, the concept of STEM interest is usually considered with respect to STEM careers themselves (e.g., interest in becoming a computer engineer) or the interest in performing activities that are part of STEM careers (e.g., interest in computer programming). In this study, we define STEM interest as the interest an individual might have in the content of STEM fields. We believe that previous interest in science content can prime a user to play more STEM games (e.g., previous interest in physics content would increase the motivation to play physics games). Thus, we propose the following hypotheses, within the context of the *STEM Game Crew* website:

- **H1a:** The higher the STEM-learning self-efficacy, the more people will be motivated to play STEM games.
- **H1b:** The higher the STEM interest, the more people will be motivated to play STEM games.

Avatars Effects

One possible way of augmenting engagement in a science related virtual environment is through the use of avatars. Avatars are an important element of educational games because they potentially influence the user in meaningful ways. Specifically, the Proteus effect (Yee & Bailenson, 2007) is a phenomenon in which people conform to the behavioral expectations associated with their digital self-representation (e.g., participants in a mediated environment with taller avatars negotiated more aggressively in a subsequent unmediated task). The Proteus effect is potentially moderated by avatar self-relevance or "the extent to which the avatar user perceives the avatar as relevant to the self" (Ratan & Dawson, 2015). After exposure to an avatar, the higher the avatar self-relevance, the stronger the effects of the avatar's characteristics on the user. Avatar self-relevance is connected to avatar identification (how much individuals perceive themselves as sharing characteristics with their avatars) and avatar embodiment (how much individuals feel capable of performing actions in the mediated environment through the avatar). This explains why avatar customization enhances avatar self-relevance (Ratan & Dawson, 2015). If users perceive their avatars as self-relevant, we would expect that they would be more motivated to use the avatar within the mediated environment. Thus, in the present context, we propose the following hypotheses:

- **H2:** The higher the avatar self-relevance, the more people will be motivated to play STEM games.
- **H3:** When compared to having an assigned avatar, having a customizable avatar will increase avatar self-relevance.

In this study, we explore how the constructs of STEM-learning self-efficacy and STEM interest can be impacted by aspects of avatar design due to the Proteus effect. If users show higher avatar self-relevance in the website, it is expected that users will conform more to the expectations associated with their avatar's characteristics. Specifically, if users have an avatar that contains scientific characteristics, users may increase their STEM-learning self-efficacy and STEM interest. We refer to these avatars which contain scientific characteristics (e.g., are shaped as beakers) as science-related avatars, in comparison to simple-shape avatars who don't have scientific characteristics (e.g., are shaped as squares). Thus, we propose the following hypotheses:

- **H4a:** Compared with using simple-shape avatars, using science-related avatars will increase STEM-learning self-efficacy.
- **H4b:** Compared with using simple-shape avatars, using science-related avatars will increase STEM interest.

The theoretical model for our study and our hypotheses can be seen below (see Figure 1). To simplify our model, STEM-learning self-efficacy and STEM interest were combined into STEM attitudes.

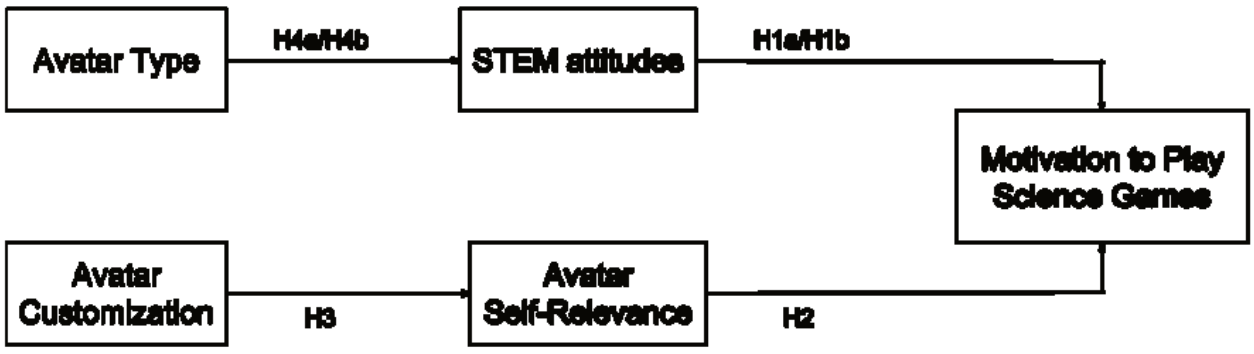

Figure 1: Theoretical Model and Hypotheses.

Methods

Participants

Participants for this study will be approximately 60 middle school-aged children from Greater Lansing who will be attending three different sessions of a technology Summer Camp at Michigan State University from July 11th to July 29th of 2016.

Design and Procedures

For this study, we are conducting a 2×2 online experiment by manipulating avatar type and avatar customization (see Table 1).

	Avatar Customization	
Avatar Type	Non customizable science-related avatar	Customizable science-related avatar
	Non customizable simple-shape avatar	Customizable simple-shape avatar

Table 1. Experiment design.

Participants will be invited to take an online survey on a computer lab at Michigan State University. The first questions will be about STEM-learning self-efficacy and STEM interest. Then, participants will be asked to explore one of the four different versions of the *STEM Game Crew* website. Science-related avatars are defined as beakers and simple-shape avatars were defined as squares (see Figure 2). For the groups with customizable avatars, the customization could happen at any time in terms of avatar color, eyes, eyelashes, eyebrows, and mouth, with 10 different possibilities for each characteristic.

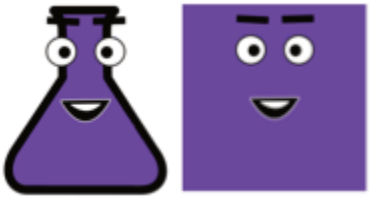

Figure 2: Examples of science-related avatar (left) and simple-shape avatar (right).

Users would be able to see their avatars and usernames in a designed area on the top of every page on the website (see Figure 3). Also, when visiting a game's page, users would be able to see their avatars and usernames in a designed area on the right of the games' information.

Figure 3: Header of the website showing username and avatar

After registering in the website, participants will be asked to play three designated STEM games in the website, chosen based on the researchers' ratings of how fun, educational, and interactive they were. For each game, participants would fill out a form before playing with predictive hypotheses about the game, and another form after playing with reflective observations about the game (see Figure 4). Participants will be also encouraged to explore the website and play more games. After exploring the website for 30 minutes, participants will go back to the survey and answer questions related with their motivation in the website, their perception of avatar self-relevance, STEM-learning self-efficacy, and STEM interest.

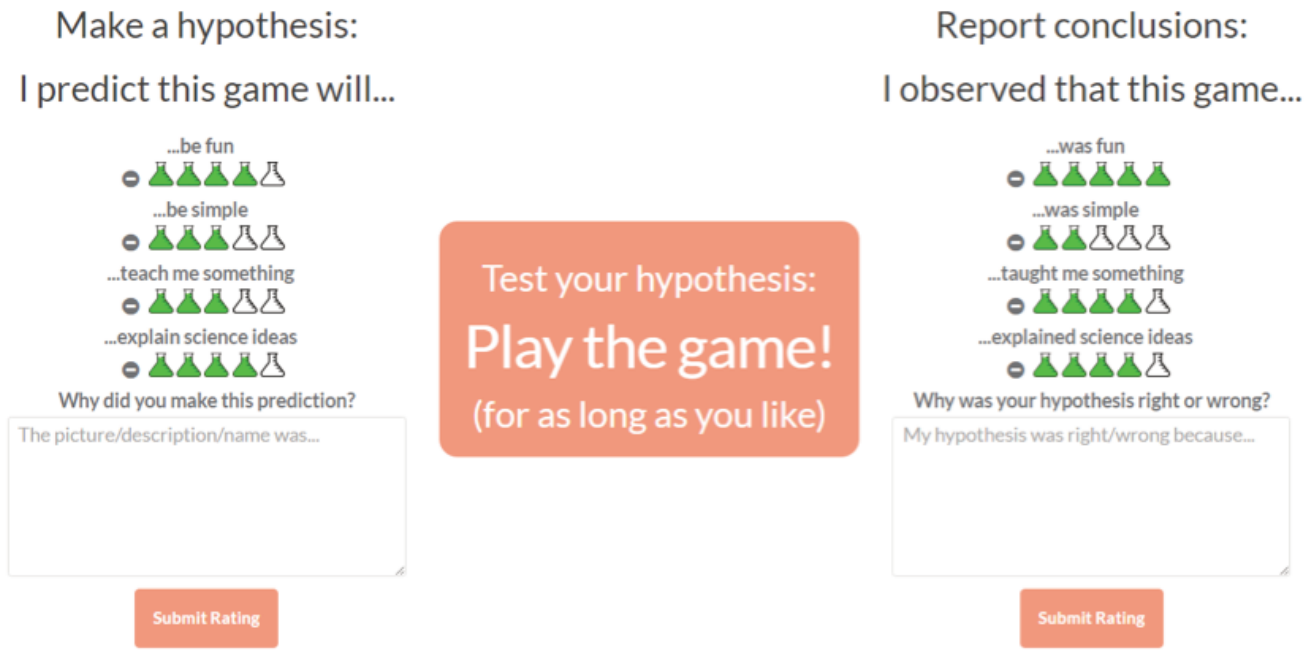

Figure 4: Hypothesis and Conclusion Forms

Measures

Motivation to play STEM games

In the survey, participants will be asked to report the games played in the website, as well as how long they played each game (in minutes), and how many levels they played in each game. The website was built using WordPress with Google Analytics and Google Tag Manager integration to track interactions between users and the website. This approach provides two separate measures of motivation to play STEM games – subjective and objective, respectively – and it was chosen building on the findings of a previous study (Kahn, Ratan, & Williams, 2014) suggesting that participants are sometimes biased in their self-report about video games and the direction of this bias can be informative about any cognitive dissonance they experience while playing.

STEM-learning self-efficacy

To measure STEM-learning self-efficacy, we will be using an adapted scale from Bandura's (2006) children's self-efficacy scale. Items for the question "How well do you think you would be able to perform the following tasks?" should be rated on a 5 point Likert-type scale, from "Not able at all" to "Absolutely able". Items included learning related with STEM subjects (e.g., "Learn Math", "Learn Computer Programming") and non-STEM subjects (e.g., "Learn Arts", "Learn English"). Participants will be asked the STEM-learning self-efficacy questions twice: before they engaged in activities in the website and afterwards.

STEM interest

To measure STEM interest, we will be using our own scale. Items for the question "How interesting do you find the content of the following fields?" should be rated on a 5 point Likert-type scale, from "Not interesting" to "Absolutely interesting". Items include STEM fields (e.g., "Technology Related: Digital Art, Media and Technology, Video Games, etc.") and non-STEM fields (e.g., "Humanities: Philosophy, Theology, History, etc."). The STEM interest question will be asked twice, as done with STEM-learning self-efficacy questions.

Avatar self-relevance

To measure avatars self-relevance, we will be using Van Looy et al.'s (2012) scale for game character identification. Items for the question "Regarding your avatar in the website, rate how strongly you agree with each statement" should be rated on a 5 point Likert-type scale, from "Strongly Disagree" to "Strongly Agree". Items include identification aspects (e.g., "my avatar is like me in many ways"), embodiment aspects (e.g., "I feel like I am inside my avatar when in the website"), and idealization aspects (e.g., "I would like to be more like my avatar").

Results and Discussion

After data collection and analysis, we hope to have conclusive results about avatar effects on players regarding the *STEM Game Crew* website. Through the creation of this website, we hope to give educators and students an engaging platform for STEM learning. By engaging in learning STEM topics on this platform, students may also become more interested in STEM careers and this may contribute to the growth of the field.

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