Playing with Gender: Examining How Learning Games Can Adapt to User Characteristics to Maximize Positive Outcomes

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Abstract: This study explores the role of gender—treated as a construct that includes multiple potential identities—within interactions between media users and game characters in digital learning games. Using a museum-based science-learning game with scientist characters designed to serve as experimental stimuli, we examined how the relationship between character gender, player gender and player age influenced motivation in the game. Analyses suggest that the scientist characters' masculinity or femininity influenced male and female players' motivation differently, but that the specific manifestation of such influence appears to vary for different age groups. These results suggest that the characters in science-learning games could be designed to adapt to the players' characteristics in order increase their science content learning or interest in STEM fields. More generally, this study highlights the importance of considering player characteristics in game design and the potential of adapting to such characteristics in order to maximize meaningful outcomes.

The depiction of scientists in media is a widely researched topic, with a variety of studies showing that the ways in which scientists are depicted influences people's attitudes about science fields and their own potential role in them (e.g., Brossard & Dudo, 2012; Gerbner, 1987; Shanahan, 2004). Scientists are often portrayed in popular media as white males (Dudo et al., 2011), or when females, in roles that emphasize their femininity (Steinke, 2005). Exposure to such depictions may contribute to some children's narrow views of scientists (Losh, Wilke, & Pop, 2008), potentially reducing the likelihood that such children will identify personally with science and thus pursue STEM fields (Adams & Gupta, 2013). While increased public awareness of this issue over the past decade may have contributed to increased diversity in scientist depictions, such disparities are still evident (e.g., Perryman & Theiss, 2014; McIntosh, 2014). However, much of the research on scientist depictions focuses on traditional, one-way media, not interactive media, such as digital learning games, within which scientist depictions are less constrained than in traditional media. The present research addresses this issue by focusing on scientist depictions within digital learning games.

This issue of scientist depictions in digital learning games is important because such games are becoming increasingly incorporated into informal education worldwide (including museums, science centers, enrichment activities in K-12 classrooms, and home use) and thus the populations of people using such information technologies are becoming increasingly diverse. This creates the need for games to appropriately adapt to the diverse user bases in ways that maximize learning potential for all users, which is challenging to accomplish for traditional media platforms. However, the flexible nature of such software offers a potential solution for this challenge. Namely, digital learning games can be designed to adapt to the user's characteristics in ways that are likely to increase the users' engagement in the learning process. But in order to do so, the design of such technologies must incorporate a sufficient understanding of how different types of users connect with different types of content.

Additionally, the present project examines how users' identity characteristics may impact whether and how they identify with scientist characters in learning games. Identifying with the characters may motivate users to engage more deeply with content. STEM-oriented games and programs that involve players personally have been found to increase players' self-efficacy in STEM fields (Dietrele, 2009) as well as increase STEM interests (Giarratani et al., 2011) and identification with science for underrepresented populations (McCreedy & Dierking, 2013). Through such development of identities that are associated with science, young people become more likely to pursue STEM fields (Adams & Gupta, 2013). Thus, by focusing on the relationship between users' and scientist characters' identity characteristics in digital learning games, the present research aims to contribute to the broadening of participation in STEM fields.

The particular identity characteristic on which we focus in this project is the construct of gender, which is one of the most powerful identity characteristics in human beings, with many biological, cognitive, and social influences on its development and expression over the lifetime (Connell, 1987). Further, we consider gender as more than a binary male/female construct. Instead, we consider the potential for multiple gender identities, drawing from the conceptualization of gender on a continuum, with masculinity and femininity as neither mutually exclusive nor always derivative of biological sex (Bem, 1981).

Game character gender plays an important role in users' motivation. Hypersexualized game characters have been found to reduce female players' motivation (Behm-Morawitz & Mastro, 2009). However, user motivation has been found to increase through identification with characters (Bailenson, Beall, Blascovich, Raimundo, & Weisbuch, 2001; Fox & Bailenson, 2009). This suggests that scientist character gender in a learning game should be designed to increase user identification as much as possible without exaggerating gender characteristics.

Identification with media characters can shape users' identity and behaviors. Through the act of game play, users adopt a character's viewpoint and thus develop an "understanding of his or her plight and motivations" (Cohen, 2013, p. 194). This process may create a shift in self-perception, in which the media user's perception of herself is modified to incorporate elements of the character's identity (Klimmt, et al., 2010). Identification with characters has been found to promote social learning and affect the sense of self (Cohen, 2001; 2013; van Reijmersdal, et al., 2013). As it relates to gender, identification with media characters influences the construction of gender roles (Jose, 1989), including gendered representations of scientists (Steinke, Applegate, Lapinski, Ryan, & Long, 2012). Specifically, Steinke and colleagues found that children's identification with scientists was explained by homophily (boys identified more with males, girls more with females) in some but not all cases (e.g., depending on characters' dominance).

In the present context, when considering multiple potential gender identities, this suggests that a science learning game may increase player identification—and thus motivation—by matching the scientist character's gender to the player's gender in some but not all cases. For example, it is not clear whether masculine males should be matched with masculine male scientists, feminine females with feminine female scientist characters, and so forth.

Such homophilous matching may be detrimental because it reinforces male-dominant stereotypes. These stereotypes may be demotivating to users—especially women or girls—because of the ways in which they influence the users' self-efficacy. This is explained by Stereotype Threat Theory (Steele, 1997; Steele & Aronson, 1995), which suggests that people subconsciously conform to negative stereotypes about demographic groups to which they belong when they are reminded of such stereotypes. In this context, scientist characters in which their gender is exaggerated (highly masculine or highly feminine) may serve as reminders of negative stereotypes about female performance in science, thereby demotivating some players, depending on their own gender identity.

In contrast, when stereotype threat is not potentially triggered by exaggerated gender in a homophilous match, the positive effects of identification with a homophilous scientist character may increase motivation. Further, recognizing that the conception of gender identity and attitudes about gender change throughout childhood, we would expect the effects on motivation caused by scientist character gender to differ between age groups.

Given this uncertainty, we examine these relationships between scientist character gender, player gender, and player age within the context of an open-ended research question:

Research Question: Does the relationship between scientist character gender, player gender, and player age influence user motivation in a science-learning game, such that more masculine and/or feminine characters lead to more motivation for male or female users?

Method

In order to examine this research question, we helped design a digital STEM learning game to use as stimulus material in a field experiment. The game, called *Hungry Birds*, was developed by the Ohio-based educational games design company Digital Glass (http://digitalglass.biz) to teach natural selection concepts. Through a partnership with the game's producer, we helped design the scientist characters in the game—who serve as guides to the game and learning content—to reflect four gender categories: high/low masculine male and high/low feminine female (see Figure 1). Given limitations on the project scope and thus number of scientist characters included in the game, we chose these four categories to provide both a stereotypical "high gender" role for each sex as well as a simple, contrasting "low gender" option we expected would be familiar and identifiable for younger participants.

Figure 1: Scientist characters: low/high-masculine, low/high-feminine.

The design of these characters' appearance and voices went through multiple iterations, including informal surveys in which we attempted to identify the characters' identity characteristics that represented gender while not being confounded with other elements of identity. For example, we found that eye glasses signaled a reduction in perceived masculinity but also an increase in perceived intelligence, so we chose to not put eye glasses on any of the characters.

The game is designed to be played by museum visitors on a large touchscreen monitor. In the game, the user plays as a bird flying through trees, eating black or white peppered moths by touching them on the touchscreen monitor (see Figure 2).

Figure 2: Gameplay screen.

Black moths are initially easier to eat because the trees are light in color, but partway through the game, the trees get darker (because of pollution), and thus it becomes easier to eat white moths. This actually happened during the Industrial Revolution in England, leading to significant changes in the peppered moth population. This example teaches and reinforces understanding of the biological concept of natural selection in a fun and accessible way. Visitors may play the game alone or with a partner, encouraging dynamic group learning.

From October through December 2014, we conducted an IRB-approved pilot research study at the university's museum, a Smithsonian Institution Affiliate which holds collections related to the natural sciences, anthropology, history and culture. The game was placed on a touchscreen within a larger exhibit on evolution and natural selection and was available for all museum visitors to play.

We used the players' score for each session as the measure of motivation to perform well in the game. We reason that performance motivation in a learning game task would translate into motivation to engage in the STEM learning involved in the game, drawing from Cognitive Dissonance Theory (Festinger, 1957) and Balance Theory (Heider, 1946; Petty & Cacioppo, 1996). These theories suggest that people strive to maintain consistency (i.e., balance) between related cognitive elements in order to reduce discomfort with inconsistency (i.e., dissonance). Specifically, using the triangle in Figure 3 as a template, the relationship between cognitive elements A, B and C (with x, y, and z representing the valence of connection between the elements) is in balance if 1) x, y, and z are all positive or 2) if one of the connections is negative and the other two are positive.

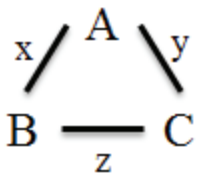

Figure 3. Template triangle illustrating Balance Theory, with x, y and z representing valence connections between cognitive elements A, B, and C.

In the current case, if the player (A) is positively oriented (x) toward game task performance (B; as reflected by performance motivation) and the player recognizes that the game task (B) positively relates (z) to STEM learning (C), then the player should feel positively oriented (z) toward STEM learning (C). Another possible interpretation is that if the player (A) is positively oriented (x) toward the scientist character (B; as reflected by following the character's instruction to perform on the game task) and the player recognizes that the scientist character (B) positively relates (z) to STEM learning (C), then the player should feel positively oriented (z) toward STEM learning (C). More simply put, if the player identifies with the game and/or scientist character, as reflected by game task performance, then the player should also identify with STEM learning. While this reasoning requires additional empirical testing, it was sufficient to justify our use of the measure of game score as a proxy for motivation in this study.

Results

In our analysis, we included the randomly assigned scientist character's gender, which we classified into a 2 (male or female scientist) by 2 (high or low gender) design, as our main independent variables, as well as the players' biological sex as inputted into the game (only a binary male/female classification) and age as inputted into the game (i.e., seven categories of age ranges from "9-10" to "23 and above").

Results from a series of Analysis of Variance (ANOVA) tests suggested that the relationships between these constructs influenced motivation, but the specific manifestations of such influence appears varied for different age groups. Due to space constraints, we only report some of the models here. Namely, for 19-22 year-olds, across both male and female players, there was a significant interaction effect between the two scientist gender measures, with players who had the masculine male scientist scoring highest ($M = 31.46$) relative to those with the low-masculine male ($M = 21.38$), the feminine female ($M = 23.41$), and the low-feminine female ($M = 25.87$), $F(2, 66) = 5.15$, $p < .05$, $h2 = .07$. For 17-18 year-olds, across high- and low-gendered scientists, there was a significant interaction effect between player gender (male/female) and scientist gender (male/female), with male players scoring higher with a male ($M = 34.17$) than a female scientist ($M = 25.16$), but female players scoring higher with a female ($M = 35.91$) than a male scientist ($M = 26.50$), $F(2, 30) = 4.53$, $p < .05$, $h2 = .13$. Lastly, but perhaps most interestingly, for 13-14 year-olds, across male and female scientists, there was a significant interaction effect between player gender (male/female) and scientist gender (high/low), with male players scoring higher with a high-gender ($M = 26.83$) than a low-gender scientist ($M = 22.38$), but female players scoring higher with a low-gender ($M = 30.83$) than high-gender scientist ($M = 21.25$), $F(2, 42) = 6.31$, $p < .05$, $h2 = .13$.

Discussion

The present research explored how characters in digital learning games can be designed to adapt to players' characteristics in ways that maximize positive learning outcomes. The results suggest that the relationships between character gender and player gender influences performance motivation, but the specific manifestation of such influence appears to vary for different age groups. Specifically, for 19-22 year-olds, a masculine male scientist appeared to be most motivating across all participants. For 17-18 year-olds, male users were more motivated by male scientists, while female users were more motivated by female scientist (i.e., homophily). And for 13-14 year-olds, male users were more motivated by high-gender scientists (i.e., high-masculine male or high-feminine female) while female users were more motivated by low-gender scientists (i.e., low-masculine male or low-feminine female).

We do not have a strong basis for reasoning about the differences between the three age ranges, but we would like to highlight that the results for the 13-14 year-olds are most interesting because they illustrate the importance of considering the continua of gender when designing learning technologies. The theory of stereotype threat (Steele & Aronson, 1995) may help explain why the females in this age range (early teen years) were less motivated by the high-gender scientists. According to this theory, people conform to negative stereotypes about a demographic to which they belong when they are reminded of such stereotypes. In this case, the high-gender scientists may have

served as reminders of negative stereotypes about female performance in science and/or video games, thereby demotivating the female players. This suggests that digital learning technologies should aim to do the opposite, namely, to avoid cues that would serve as reminders gender differences (e.g., high-gender characters) for female users.

Overall, these results suggest that there is a potential for matching user and scientist character gender in ways that increase motivation. By considering how gender, as a continuous construct, and age influence users' connections to science content, games could be designed to offer characters that maximize such outcomes. The present study was limited in its ability to assess gender along a full continuum, i.e., there were only four scientist characters and gender was still treated as a binary construct for players. Future research and games could address this limitation by increasing the number of gender identities considered along the continuum and developing ways to better assess the user's identity characteristics. In the case of biological sex, this is relatively easy: The game can simply prompt the user to input his or her sex on a two-point scale. However, it is more difficult to assess more-complicated facets of identity that may have similar effects, such as gender on a continuum, race, cultural background, or sexual orientation. Future games and studies are necessary to find ways to incorporate more complex aspects of identity to help facilitate appropriate adaptation to users.

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