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DEPARTMENT: EDUCATION

Design Considerations for Virtual Self-Representation in Educational Games

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Virtual self-representations, commonly known as avatars, play a critical and often underexplored role in the design and effectiveness of educational games. This article explores various dimensions of avatar design and their impact on educational game outcomes. We examine how an avatar's voice can influence player identification, how certain colors can distract from educational material, and how the presence of a digital role model of a similar ethnic background and gender can help drive interaction. In addition, this article addresses scenarios where avatar identification might be less desirable. Specifically, when players struggle, our data suggest that abstract avatars might be more beneficial than humanoid avatars. These insights can help lead to the design of more effective educational games.

Educational games have become a common sight both in and out of the classroom, spanning a seemingly limitless spectrum of topics.[1] However, while the legitimacy of educational games is now virtually taken for granted, many questions remain about how to design them well. Of particular interest to our lab is the topic of virtual self-representations, also known as avatars. We believe that avatar customizations can help learners identify with those avatars and, in doing so, reap greater benefits from educational games.[2]

As Joshi et al.[1] pointed out, educational games can help level the playing field for a diverse spectrum of students with wildly different demographic backgrounds. Identification with a fictional character is not a phenomenon unique to games; it may happen any time one cuddles up with a good book or sits back to enjoy a movie. However, as with more traditional role-playing activities, games bestow upon players a fictional identity, which may or may not be customizable, as well as a context in which they have some form of agency. This agency may be very limited and consist entirely of how quickly to progress, or it may consist of meaningful social, strategic, or plot-related choices.

Because players are embodied by these fictional characters, instead of merely observing them, a partial and temporary fusion of identities occurs during play. This phenomenon is what Van Looy et al.[3] referred to as avatar identification. It has been shown to drive motivation, enjoyment, and engagement, and—through them—indirectly affect outcomes, such as user retention,[4] feelings of empowerment,[5] and self-efficacy.[3] Van Looy et al.[3] categorized avatar identification into three nonexclusive components: similarity identification, wishful identification, and embodied presence. The first is the degree to which the player feels their avatar accurately represents themselves, the second is the degree to which it represents a version of themselves they aspire to be, and the last is used in the same sense as the phenomena of embodiment in which a screwdriver, computer mouse, forklift, or, in this instance, an avatar, becomes an extension of a person's body.[10] Embodiment is related but not

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identical to the health sciences concept of body ownership. Body ownership is a person's sense that a physical body part, such as a hand or a foot, belongs to them. Body ownership has been repurposed for use in virtual reality applications to describe a player's sense that their avatar is their body, and the avatar's hands are their hands. Embodiment and embodied presence are used in a broader sense than body ownership, including avatars seen from a third-person perspective, as well as tools external to the body. A game may prioritize certain components of avatar identification over others, and players with different gaming motivations may experience these components at different extremes. For instance, a game with purely geometric avatars will not elicit similarity or wishful identification, but may elicit embodied presence.[10]

Games that permit players to customize an avatar allow players to express themselves through that avatar and thereby improve identification with it.[4] This enhanced identification can help make players of diverse demographics more comfortable in a virtual setting.[1] In this article, we examine an eclectic spread of topics involving virtual self-representation and educational games, which we believe are easy to overlook but deserving of serious consideration. To achieve this, we have built two platforms as testbeds for our research.

The first of these platforms is *MazeStar*, a combination of an educational game titled *Mazzy* and its level editor.[6] *Mazzy* leverages a game mechanic that has been popular in educational computer science games since its debut with the *Logo* turtle robots of the late 1960s; players instruct avatars to solve a maze using programming concepts, such as conditionals and loops. *MazeStar* also allows players to import images for use as avatars. Together, these two simple features enable the exploration of research questions concerning virtual identity in educational games. We can easily modify the platform for use in different studies by providing curated collections of images, randomly assigning images, or providing explicit instructions for image creation.

While *MazeStar*'s simplistic, top–down, 2-D presentation makes it easy for anyone to quickly customize, our second platform *CodeBreakers*, as seen in Figure 1, allows us to explore educational game design principles in 3-D spaces.[4] *CodeBreakers*, as the name implies, is another educational game for teaching introductory programming. Players explore a digital environment and solve problems by "throwing" code snippets. *CodeBreakers* teaches a variety of topics, such as data types, control flow, object-oriented programming, and recursion. Players follow a simple narrative in which they heroically travel from land to land, solving problems to save people from literal bugs. The increased complexity of *CodeBreakers*, especially when contrasted against *MazeStar*, allows us to ask different questions concerning avatar customization.

FIGURE 1. Scenario from *CodeBreakers*. The player (blue) must find a piece of code that can save the poisoned knight (orange) from dying.

One of the keystones of our research has been the manner and degree to which players identify with their avatars. Avatar identification is a strong predictor of enjoyment in games and has been found to play a critical role in mediating many of their effects.[3] These effects may be desirable, such as increased self-efficacy, or undesirable, such as increased aggression. They may occur in serious games just as they occur in entertainment games.

To rigorously measure both avatar identification and other beneficial effects of educational games, we have employed validated instruments, the three most important of which we will briefly address here. The first is the player identification scale (PIS), which measures three subcomponents of avatar identification through constructs, such as role-playing and discovery.[3] We rely on the PIS because it was designed specifically for the context of digital avatars.

The second is the independently validated player experience of needs satisfaction (PENS) instrument.[7] PENS is grounded in a theoretical framework of motivation called self-determination theory (SDT). SDT has been applied to education and was brought to games by its cofounder, Richard Ryan. It describes motivation as a function of autonomy, competence, and presence. As a game-specific instrument, PENS also measures the construct of intuitive controls; this is in part to mitigate interference with the original three constructs. We rely on

PENS because its results can be contextualized in games and educational literature.

Lastly, we have also relied on the independently validated game experience questionnaire (GEQ), explicitly designed for games to measure player experiences.[8] It is divided into the constructs of flow—as described by psychologist Mihaly Csikszentmihalyi—immersion, positive and negative effects, challenge, tension, and competence. We rely on the GEQ because it was designed specifically for the context of games and experiential design.

AUDIO CUSTOMIZATION

In most games, avatar customization includes visual, roleplaying, and/or game-mechanics-driven options. However, many avatars also have an audio component, a voice.[4] In some role-playing games, the player is given an option to customize that voice. To the best of the authors' knowledge, no other lab has investigated the impact of an avatar's audio component on a learner's ability to identify with that avatar. It is possible that voice is just as important as any other component of customization, such as gender, hair, or eye color. As we had already seen positive results from giving players avatars with self-similar voices, we decided to leverage our *CodeBreakers* platform to further investigate how audio customization impacts avatar identification, especially when compared to visual customization.

To accomplish this, we modeled four humanoid figures, as seen in Figure 2, and captured four distinct voices. The visual components were not meant to be realistic; they were a flat gray color and roughly representational of two feminine and two masculine figures. The voices were provided by two professional voice actors.

Great care was taken to validate the voices as being both distinct from one another and evenly distributed across the available genders; we used a two-step process involving three expert speech pathologists and a crowdsourced sample taken from Amazon Mechanical Turk (MTurk). Two voice actors were employed, rather than four, to help standardize the variance between voice options available for each gender.

To model avatar identification and its ability to mediate outcomes, we used both the complete PIS and the autonomy subscale of the PENS. The outcomes we looked for were intrinsic motivation, immersion, time spent playing, motivation for future play, and the likelihood of game recommendation. We measured these outcomes using the interest/enjoyment subscale of the Intrinsic Motivation Inventory, the immersion subscale of the player experience inventory, a direct measure of time spent playing, and a small inventory of questions about future play and recommendations developed for previous projects. Participants were recruited through MTurk.

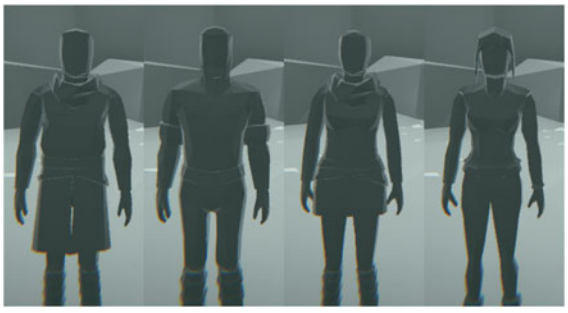

FIGURE 2. Four visual customization options, arranged with the "male" options on the left and the "female" options on the right.

What we found was unexpected. We had hypothesized that there would be no interaction effect between audio and visual customizations. Instead, we discovered that while audio customization did impact avatar identification, it was *only* in the presence of visual customization. Far more surprising was that almost all of the mediation effects of the visual customizations were negligible without the audio customizations. Audio customization heavily moderated these pathways. It seems that when players had no choice regarding which humanoid figure or voice they received, the other customization option held little to no meaning to them. This does not seem to align with a vast preexisting body of research that has shown visual customization improves avatar identification.[1,2,3,6,10]

It is possible that players perceived a greater difference between the avatar's audio components than its visual ones. We may have offered too few options to really see visual customization's full power. Our audio components were very realistic, and our visual components were abstracted and unrealistic; this could have affected our results. It is also possible that the majority of players would look at each visual component and perceive it as having a "matching" or "correct" audio component, and therefore experienced dissonance if assigned the "wrong" component. For example, they might associate a hairstyle or body weight with certain vocal characteristics. This issue, in particular, surely deserves further research because it is common for voices to be assigned by character

archetypes in the commercial games industry. Of course, it remains possible that few research games incorporate any avatar voice at all and, therefore, do not witness whatever the impact might be from assigning players' voices.

ROLE MODELS

In a phenomenon they coined "the Proteus effect," Yee and Bailenson[5] discovered that alterations in a player's self-representation have impacts upon a player's in-universe behavior. Players appear naturally inclined to role-play, whether consciously or not. If they perceive their in-game avatar has a specific characteristic, they will often unknowingly emulate it. Yee and Bailenson[5] demonstrated the Proteus effect using avatars with different attractiveness ratings and avatars of different heights. Participants were made aware of their avatar's appearance but interacted with experimenters who were blind to them. This ensured that only self-perceptions influenced the data collected. The results showed these self-perceptions could influence social behaviors, which in turn had real-world effects on participant skills and success rates. For instance, participants given taller avatars exhibited greater success in monetary negotiations. In short, the Proteus effect suggests that users are inclined to display behaviors or attitudes according to the appearance and features of the avatars they embody.

We were interested in this ability to impact performance and decided to explore whether the Proteus effect might be invokable using role model avatars. In the previous section, we discussed how identification with one's avatar is not simply a function of how similar that avatar is to oneself, but also factors in whether the avatar represents an idealized version of the self.[3] This ability to identify with wishful embodiments led us to believe that players would be able to identify with avatars styled after role models.

There is a long-established value associated with using role models in education.[2] They may be abstract and generic, such as "a scientist," or they may be concrete and specific, such as "Albert Einstein." While they are valuable tools for boosting academic performance in general, role models also tackle an arguably more important task: combating stereotype threat.[9] Stereotype threat can be thought of as the "evil twin" of the Proteus effect. The Proteus effect works because of stereotypes we assign to arbitrary characteristics, such as height or beauty. However, just as Yee and Bailenson[5] found they could boost the performance of participants with tall avatars, they also found they could hamstring the performance of participants with short ones.[5] Stereotype threat is a phenomenon where people exposed to negative stereotypes about themselves, often stereotypes associated with their gender or race, perform poorly in related tasks.[9] Regardless of whether they believe the stereotypes to be true, people appear to suffer disruptive effects from them. Offering a player the option to play as a highly capable person of their own gender and/or ethnicity might safeguard against these threats; alternatively, it might accidentally activate the threat through self-deflation.

To explore whether role model avatars could forestall stereotype threat and leverage both avatar identification and the Proteus effect, we ran a series of studies on the *MazeStar* platform. The avatars studied included scientists, athletes, and geometric shapes, as seen in Figure 3.[2] The studied outcomes included levels attempted, bonus items collected, self-reported enjoyment, perceived difficulty, and game experience as measured by the GEQ. Each study produced a variable amount of evidence to support the validity of using role models to enhance outcomes among learners, whether in general or when race and gender were taken into account.

In one study, we primarily found evidence that role models benefited students of different races, whereas in another, we primarily found evidence that role models benefited female students. Collectively, these studies paint a complicated picture of the relationship between role model avatars and outcomes and leave uncertainty as to what confounding variables are in play.

Despite this, the results remain promising. In one study, female participants with gender-matched role-model avatars exhibited an increase in the experiential constructs of flow, immersion, competence, and positive effect, as well as decreases in challenge, tension, and negative affect. On every metric measured, the presence of role model avatars in an educational game improved the experience of female players.[2,8]

BADGES AS CUSTOMIZATIONS

The composition of an avatar does not necessarily end with its visual and auditory components. Other customizations abound. Online communities may reward various forms of engagement with customized titles, badges, or colors. Video games frequently give players the ability to customize their avatar's skills or abilities, choices that both allow for self-expression and have a meaningful impact on gameplay. Games and gamified apps award "achievements" for the accomplishment

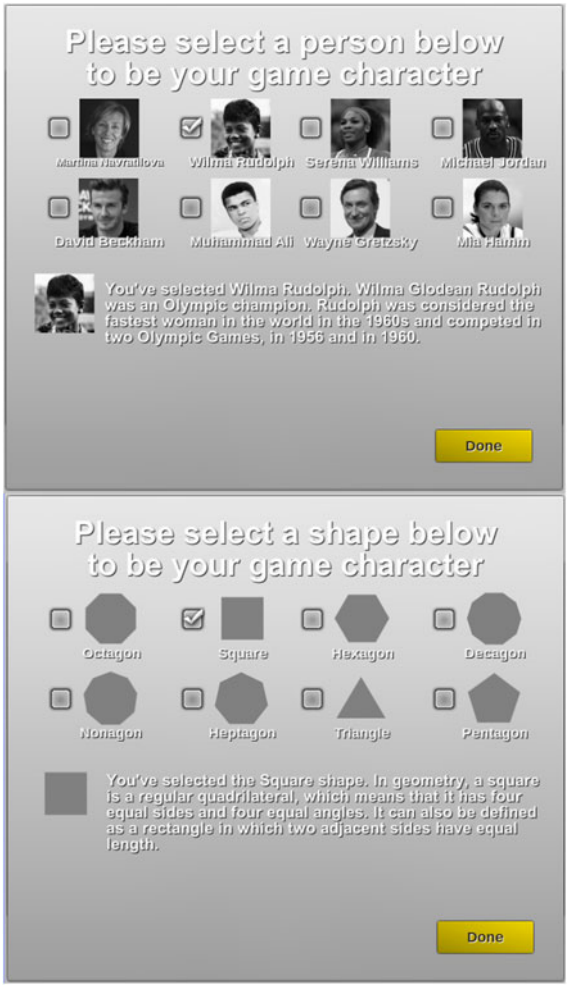

FIGURE 3. Selection screen for an athletic role model avatar (top) compared with the control, an abstract avatar (bottom). Republished with permission from the original author.

of difficult in-game tasks, which players may go on to collect and display as trophies. Some of these customizations affect the visual form of the avatar, but others exist independently of it. We set out to explore the latter.

Drawing from our previous research, we leveraged the *MazeStar* platform to investigate the effects of "badges" on measures of avatar identification.[6] These "badges" covered a range of customizations, all of which were visual in nature but none of which impacted the avatar's bodily form. These badges spanned three categories: achievement badges, which signified certain milestones in the game had been reached; role model badges, which allowed players to associate their characters with a chosen role model; and personal interest badges, which allowed them to associate their characters with an assortment of hobbies. To avoid confounding variables associated with game balance, as well as the design overhead associated with making meaningful gameplay customizations, we chose to restrict our investigation to purely cosmetic badges.

We planned to test our three categories of badges against an assortment of controls, including receiving no badges at all, as well as the option to earn badges from any category. Given the number of variables in play, we took special care when crafting the badges to ensure their breadth of representation, relevancy, and overall quality remained consistent from category to category. Badge ideas were generated, sorted, categorized, ranked, and ultimately validated through crowdsourcing, which took place on MTurk. From the 1000 scientist names and 1000 interests generated in the first step of our process, we ultimately distilled 30 scientists and 30 personal interests. While the majority of all badges were selected through ranking by the majority, 10 scientists from the generative step were curated by researchers to ensure they represented a diverse spread of race and gender combinations. An analysis performed at this stage showed that the interests did not skew toward either gender.

This same level of procedural attentiveness went into selecting badge images. Several potential images per badge were taken from Internet searches using a straightforward and randomized procedure and were then rated via crowdsourcing to determine whether they fit the intended badge. Conversely, we generated the achievement badges in reverse order: a graphic designer was employed to collect and create five potential achievement images per game level, and these achievements were both rated and named by crowdsourced participants who played the game.

Badges underwent processing and stylization, as seen in Figure 4, using filters to create a uniform graphical style and pixel intensity. This was to ensure no badges attracted the eye more than any other. At the end of processing, these badges were then rated and validated again.

Having ensured to the very best of our ability that our method for designing the badges was replicable and robust, and had accounted for as many confounding variables as possible, we began our experiment. Participants were asked to create and use self-similar avatars to ensure negative effects from inappropriate avatars did not skew results. For measurements, we employed the PENS and PIS instruments. We also utilized the Intrinsic Motivation Inventory and the Computer Programming Self-Efficacy Scale. Our experiment looked at both time spent playing the game and

FIGURE 4. Player has successfully completed a level of *Mazzy*, and their avatar is shown surrounded by the badges they have earned so far.

spent in the level editor, where participants were asked to create their own scenarios. As these artifacts were also a source of information, we employed three quality assurance testers to evaluate them.

We found that badges promoted avatar identification, player experience, intrinsic motivation, and programming self-efficacy, both while playing the game and while designing maps in the editor. Different badge types corresponded to different benefits. Interest badges corresponded to avatar identification. Achievement badges corresponded to intrinsic motivation. Role model badges were effective across the board, in all categories, and were especially effective during map-making. Ironically, except for in a control condition, badges were not visible during the editor and were only shown briefly on completion of a level during the main game.

Despite the demonstrated effectiveness of each set of 15 badges, especially the role-model badges, both conditions in which we allowed players to choose any badge of any category appeared to be ineffective, perhaps because the players were overwhelmed by the number of options available to them. Additional research is also needed to assess when and how badges should be visible to the learner, as well as how long learners can go without seeing the badge before the positive effects dissipate.

SEEING RED

In investigating identity and its impact on educational games, we stumbled across something of a contradiction. It is true that enabling avatar customization helps foster a greater sense of identification with that

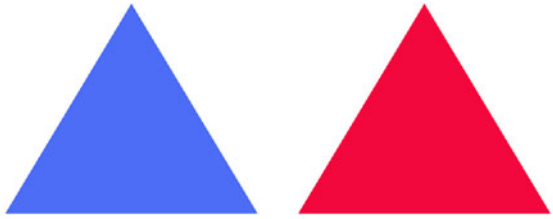

FIGURE 5. Blue avatar (left) and red avatar (right). The blue color is 7.5 PB 5/18 in the Munsell color system. The red is 5R 5/18.

avatar and thereby promotes the advantages associated with avatar identification. However, it is possible that players might select customizations that indirectly undermine themselves. For instance, consider the aforementioned benefits of using role model avatars. If students are given the option not to use a role model and avail themselves of that option, they will not be able to reap any benefits associated with role model avatars.

In researching more nuanced options for avatar customization, we came across a similar dilemma. Certain colors have been shown to impact success in cognitively demanding tasks.[2] There is evidence this may be true, even when those colors are present in relatively small quantities. We were concerned about the extent of this impact, given that it might have implications for the avatar customization options we offer to students.

We observed that a large amount of research on disruptive colors has been done in sports, and the most commonly identified color of concern is the color red. Research on sports jerseys suggests that player performance is negatively impacted if the opposing team wears red. The same effect has been observed in multiplayer video games. While the exact mechanism by which this diminishing effect on cognitive ability is not fully understood, an aversion to red has been witnessed in nonhuman animals, suggesting that whatever the mechanism is, it may be partially instinctual, such as an aversion to blood, fire, or other indicators of danger. This gave us reason to suspect that the color red might also negatively impact students of educational games, even in a single-player context.

To test our hypothesis, we conducted an experiment on our *MazeStar* platform to see how players responded to two different avatar colors: red and blue, as seen in Figure 5. To ensure that the colors were standardized, we utilized the Munsell color system so that the colors were equal in lightness and chroma, did not clash with the game interface, and were

displayed accurately on calibrated monitors. We measured player experience using the GEQ instrument and recorded the number of levels each participant completed. Participants were recruited through MTurk. There was a roughly even split between genders.

While there was no difference in levels completed between the two test groups, there was a statistically significant difference in how successful the players *felt* they had been, as well as how deeply they reported being immersed and within a state of flow. As all three factors are understood to affect game experience, and game experience is understood to affect motivation, this experiment provides evidence to suggest that red does negatively impact players in single-player educational game settings. As it did not impact tension or negative effect, it seems that the color red may have functioned as a distraction rather than a sign of hostility or danger.

It is worth noting that the effect was stronger among male participants. For instance, the impact on flow was 12 times greater in male participants than in female ones. We must also raise the issue of ethnicity and cultural background. All our participants were from the USA, and the vast majority of them were white. It is unclear whether we would have seen different levels of effect on participants from, for example, China, where the color red is regarded as lucky and celebratory rather than an indicator of danger. Even if a negative reaction to red has some instinctual component, it is possible that the ubiquity with which red is found in some cultures may offset this biological component.

VICTORY CONDITION

Most of our abovementioned work has focused on improving avatar identification and has sought to increase a player's attachment to that avatar as a form of self-expression or wishful embodiment. However, there are times when educational game designers might desire just the opposite, when learners may benefit from a decrease in attachment to their avatar.[10] For example, a learner might benefit from a sense of detachment during times of intense cognitive exertion. If the avatar is not the learner, then its struggles do not reflect poorly upon the learner. This detached mindset might insulate the learner from emotional responses to a game state that could otherwise impair the learner's experience or performance.

In these situations, we suspect that the ideal avatar may not be a manifestation of the learner's identity but rather a tool under the learner's control, with which they become capable of accomplishing complex tasks. However, our prior research has already shown that self-similar avatars and role model avatars improve educational game outcomes.[2] With these perspectives in apparent contradiction, we hypothesized that each level of attachment might be appropriate at a different time. We created a dynamic avatar: an abstract avatar with low potential for avatar identification during cognitively demanding problem-solving, which transforms into a self-similar avatar whenever the learner experiences success.[2]

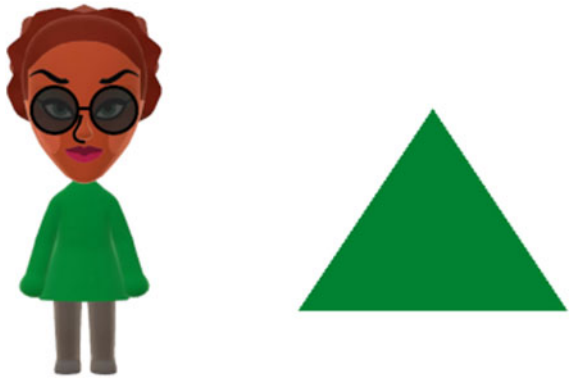

FIGURE 6. Example of a likeness avatar (left) and shape avatar (right).

In order to test our hypotheses, we conducted an experiment using the *MazeStar* platform. Participants in our test group created two forms for their avatar: a geometric shape and a humanoid figure, as seen in Figure 6. The avatar would remain geometric for the majority of play and transform into the humanoid form upon completion of a level. We used three control groups: one in which the avatar was always abstract, another in which it was always self-similar, and a third in which it transformed in the reverse, from self-similar to abstract, to ensure the transformation itself was not a confounding variable. We measured time spent playing, levels completed, and measures of user experience taken through the GEQ instrument.

While there was no evidence to support the idea that player experiences changed between the test and control groups, we found players in the test group completed more levels and spent more time playing, and this held true against all three controls. It appears that while the players were not consciously aware of their avatar's effects, the transformation ability of the dynamic avatar was able to improve the test group's performance in cognitively demanding tasks.

This study looked at only a single transformation among many possible transformations during play. It is unknown how the results may have differed if participants were instead greeted by a geometric avatar only when submitting incorrect maze solutions but enjoyed a self-similar avatar at all other times. Our participants were recruited through MTurk, but the majority of them were white. As such, we cannot draw conclusions about whether these results hold constant across all cultures and ethnicities.

We also restricted our study to self-similar avatars. Thus, we cannot draw conclusions about wishful identification or whether dynamic role-model avatars would have exhibited an enhanced or diminished ability to mitigate stereotype threat compared to static avatars. While it may not be practical for all educational games to have "transforming" avatars, these results may still be applicable when designing how visible an avatar should be, at what times, and whether its presence should be replaced by alternative, abstract imagery during cognitively demanding activities.

CONCLUSION

Avatar customization options in educational games help increase inclusivity,[1] promote avatar identification,[4] combat stereotype threat,[6] and leverage the Proteus effect.[2] However, we are only just beginning to understand the multitude of effects that avatar customization options have on players. Our research has shown that things as small as the color of an avatar's shirt or the sound of their voice may have a measurable impact on learners.[2] We have sought to investigate how these and other easy-to-overlook aspects of virtual self-representation impact player experience in educational games. Yet at the same time, our work raises as many questions as it answers. For instance, is it better to disallow certain color options during avatar customization because they may distract the learner, or does the benefit gained by being able to play as one's favorite color outweigh any potential negatives?

For this reason, we present our results as a spread of design considerations for virtual self-representation in educational games, not as hard rules. Our primary goal is to encourage conversation among educational game designers regarding the following: 1) whether to use avatar audio customization as a tool for improving avatar identification, 2) the potential benefits of role model avatars with learners from underrepresented populations in a given field, 3) the use of badges over the course of a game to extend the benefits of avatar customization for learners, 4) the pros and cons of using certain colors, knowing that they might negatively impact performance in cognitively demanding tasks, and 5) when and why to promote attachment to or detachment from the player's avatar.

More generally, we also hope to encourage designers to pay attention to how virtual self-representations can enhance educational games and broaden their appeal. Our work invites educational game designers to take a closer look at seemingly small customization aspects, such as color theory and sound design. It implores developers to consider an assortment of ways to counter stereotype threat by leveraging the Proteus effect. It also asks designers not to view avatar identification as a silver bullet that works in all situations. Lastly, it addresses how avatar identification is not a monolith, and how learning can be promoted through different types of identification, including similarity identification,[2,4,6] wishful identification,[6] and embodied presence.[2]

We also present our work as a lattice or scaffolding, a structure on which new works can be anchored and which offers up new research opportunities. For example, we found evidence that the color red can negatively influence learners, but we must leave it to further research to investigate whether the influence extends across cultures. We found evidence that role model badges can benefit minorities and female players, but we are not entirely sure why different studies did or did not influence each group. We learned that audio customization matters, but we have generated many new questions about how different audio customization options influence players. We also know that avatar identification and avatar detachment both have a role to play during different parts of an educational game, but we are not entirely clear on where the line should be drawn between the two.

We are interested in pursuing answers to some of these questions and in seeing what the research community makes of others. In the end, our goal remains to better understand the role of self-representation in improving player engagement and educational game outcomes. We have and will continue to study the impact of customization on avatar identification and how these concepts can be used to improve educational game design.

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