Toward Evaluating the Impacts of Virtual Identities on STEM Learning

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ABSTRACT

Studies show that representations of learners' social identities impact performance and engagement, e.g., via triggering stereotypes [27]. When learning occurs with virtual identities as intermediaries, such as avatars in a learning game, it is unknown how the use of virtual identities may impact performance and engagement. This area is ripe for investigation given the proliferation of educational technologies such as games, virtual worlds, and MOOCs. Informed by Papert's theory of constructionism [22] and computational identity research [11, 30], we developed a STEM game to experiment with virtual identities[1]. We are currently evaluating the effects that avatars have on performance and self-reported engagement in our learning game [15]. Preliminary studies show significant impacts for avatars that look like users vs. ones that do not. Early results (446 total participants) found that avatars can trigger stereotype threat: using face photo avatars elicits 1) more negative emotional dispositions towards the game in African American participants compared to white participants, and 2) higher self-reported difficulty for all participants.

Categories and Subject Descriptors

K.8.0 [**Personal Computing**]: General – Games

Keywords

Avatars, educational games, virtual identity

1. INTRODUCTION

Educational technologies such as adaptive learning systems, games, virtual worlds, and Massive Open Online Courses (MOOCs) have proliferated. Given the widespread and growing use of technologies, which invariably involve virtual identities such as user profiles and avatars, it is important to better understand their impacts and to establish innovative and best practices. Previous work has examined the player avatar relationship as a function of attachment [18], identification [13], and intimacy [2]. We seek to empirically examine and understand the impact that avatars have on player engagement and player performance inside of a game of our creation.

[1]http://groups.csail.mit.edu/icelab/mazzy/

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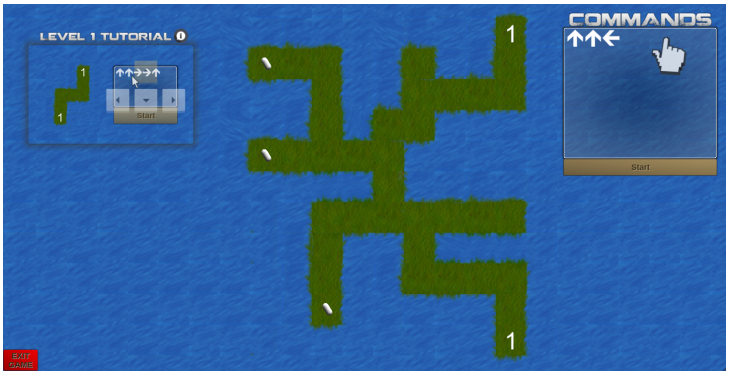
2. MOTIVATION

The work here is based on the premise that, along with factors such as subject mastery and affect toward the subject, a sense of identity as a STEM learner and doer is necessary for developing literacy and agency in computing [12]. The standard paradigm of computer-science education research traditionally focuses almost exclusively on cognitive challenges apparently inherent to particular computational concepts (e.g., [3]). Yet developments in the learning sciences suggest that computer-science curricula should embrace a broader conceptualization of learning: human reasoning, it is proposed, is embodied, distributed, and situated, and learning must be accordingly perceived as inherently collaborative, contextualized, and instrumented [6, 9, 14, 17]. A result of this broader view of human reasoning and learning in the STEM disciplines is the emergence of research on relations between student identity and learning [10, 17, 20].

Studies show that representations of learners' social identities impact learning outcomes ranging from performance to future aspirations [7, 8, 26, 30]. Moreover, it is well known that the underrepresentation of ethnic minority groups and women represents a huge untapped well of innovative, productive contributors to the nation's STEM fields and workforce. For people in groups currently underrepresented with STEM fields there are particular challenges that emerge. For example, stereotype threat is the phenomenon in which triggering awareness of a learner's identity results in his or her performance conforming to social stereotypes regarding that identity [27]. Digital manifestations of such phenomena are important areas for investigation since virtual identities are now frequently used as avatars in videogames, avatars in MOOCs and forums, intelligent tutors, and more. The potential impact of better understanding the relations between real world identities, virtual world identities, and STEM pedagogy holds promise for dramatically improved STEM learning, across all groups of people.



(a) *Mazzy*'s first level.

(b) Tutorials solve a simpler but similar level.

Figure 1: In *Mazzy*, players write "code" to navigate a maze.

3. THEORETICAL FRAMEWORK

Our work is informed by research in the computing and the learning sciences.

3.1 Constructionism

Constructionism is a pedagogical approach in which building objects is central to the process of learning [23]. This approach involves bridging between existing player knowledge, and the new knowledge, such that information can be more readily assimilated. In *Mazzy*, the character is "body syntonic" [22]; this means players can identify with it and its motion in space. Players are learning computing by creating programs via a real concrete object that can be manipulated.

3.2 Computational Literacy

Computational literacy is an emerging form of literacy that will "have penetration and depth of influence comparable to what we have already experienced in coming to achieve a mass, text-based literacy" [5]. Computational literacy involves both using and, crucially, producing computational technologies. This work focuses not only on the learning of the building blocks of "literate programming" [16], but also on "computational literacy" [5], and more generally, "procedural literacy," defined as facility with activities that "encourage active experimentation with basic building blocks in new combinations" [4, 19].

3.3 Stereotype Threat

STEM identity is a necessary component of literacy and agency development for learners of computing [29]. Furthermore, we must attend to the fact that broader social identities and STEM identities are intertwined, for example a mathematician who is female and from an underrepresented ethnic group should not see those aspects of her identity as in conflict. Unfortunately many STEM learners face just that type of conflict. Stereotype threat, the risk of performance confirming to negative stereotypes about one's group [27], has been seen to affect STEM performance [25]. Hence, it is not enough to simply give people avatars that look similar to them in order to help them learn more effectively with educational software.

4. METHODS

Using a between-subjects design, 446 participants (61% male, 39% female) were recruited on Mechanical Turk. Participants were randomly put in a condition. Each session was conducted with a single participant over 10-20 minutes.

For the procedure, each participant was first asked to select (in *Shape* condition) or find (in *Instant Likeness* condition) an image to be used as their avatar. This image became their game character. Participants were told they could exit at any time, even if they did not complete any levels.

After each level, we asked users to report engagement (enjoyment and difficulty) on a 5-point Likert scale. After the game, these two ratings were averaged across levels. Participants then answered a short questionnaire. This consisted of three additional questions, asking participants to rate how they felt towards the game, their progress, and their avatar. Each question was rated on a 5-point Likert scale (1: *strongly negative*, to 5: *strongly positive*). We also tracked how long participants spent playing, the number of levels completed, and the number of bonus pickups. In pilot studies, we fine-tuned the difficulty of the game such that on average participants could complete about half of the levels.

The analysis consists of independent-samples t-tests, and results are reported as significant when $p<0.05$ (two-tailed). The avatar conditions were i) Shape (players select from a list of eight geometric shapes), and ii) Instant Likeness (players find a photo containing their own face).

5. RESULTS

Participants in the Instant Likeness condition had significantly higher affect towards their avatar ($M = 3.29$, $SD = 1.02$) than participants in the Shape condition ($M = 2.98$, $SD = 0.82$), $p<0.001$, $r=0.17$. Participants in the Instant Likeness condition reported significantly higher difficulty ($M = 2.34$, $SD = 0.86$) than participants in the Shape condition ($M = 2.11$, $SD = 0.79$), $p<0.01$, $r=0.14$. African American participants in the Instant Likeness condition had significantly lower affect towards the game ($M = 2.53$, $SD = 1.46$) than white participants in the Instant Likeness condition ($M = 3.20$, $SD = 1.16$), $p<0.05$, $r=0.16$. For both female and African American participants, performance increased in the Instant Likeness condition, but not by a statistically significant amount.

6. FINDINGS

The key findings from this work are:

- Participants using face photo avatars reported that the game was harder. This is despite nearly-identical performance between the two groups.
- Participants indicated preference for the user photo avatars. This is consistent with preferences for self-identification [1, 24].
- African American participants disliked the game in the face photo condition. This suggests activation of stereotype threat [28].

The results suggest that user photo avatars can trigger stereotype threat. It is also worth noting that stereotype threat can *increase performance* on tasks that are not frustrating [21], this could explain the minor performance gain in female and African American participants in the face photo condition. These findings show the importance of virtual identities and point to stereotype threat as an avenue for further research.

7. CONCLUSION

We plan to continue to investigate avatars and their relevance to STEM learning in our framework. Future studies will develop virtual representations that may adapt over time, perhaps appearing abstract in some conditions and reflecting users' social identities in others, not only in terms of appearance, but also in terms of behavior, visual style, reflecting user's interests, and other features strongly associated with their cultures.

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