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Investigating Avatar Representation in Computing-Infused Curricula

Dr. Amy Isvik, North Carolina State University at Raleigh

Dr. Amy Isvik has spent 6+ years engaging in efforts to infuse computing into K-12 classrooms through supporting and providing teacher professional learning opportunities in North Carolina and Rwanda and by mentoring high school students interested in educational software development.

Dr. Veronica M Catete, North Carolina State University at Raleigh

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Introduction

Previously, researchers have investigated the impact of role model avatars by comparing scientist role models, athlete role models, and non-role model avatars (geometric shapes) in a STEM learning game[32]. Their results showed that providing scientist role-models resulted in the highest immersion and enjoyment for women[32]. Undergraduates who learned from pedagogical agents with the same ethnicity viewed these agents as more credible, engaging, and affable, than undergraduates who learned from agents of a different ethnicity[33]. Avatars that share users' external characteristics have been found to promote intrinsic motivation, player experience, self-efficacy, and better learning outcomes[34,35]. The application of avatars as a culturally-relevant education technique[10] can often be successful, and can sometimes be implemented at the discretion of educators, but is more often incorporated by curriculum or technology developers directly.

In this work,we investigate the prevalence of avatars as potential role models through the examination of 312 computing-infused Snap*!* programming activities created by secondary teachers and high school interns for non-computer science K-12 classrooms.

We seek to answer the following research questions:

1. How do computing-infused lessons created by teachers and high school interns differ in inclusion and usage of avatars?
2. How do creator and avatar demographics correlate?

Related Work

According to Bandura's theory of self-efficacy, similarities between a role model and a learner increases the likelihood that that model will raise the learners' beliefs in their own capabilities[11]. Identity-based role models have been shown to influence career choice by providing an opportunity for learners to evaluate their own abilities and conception of what is possible for them in the future, empowering learners to envision themselves in the place of the role model[12]. Expectancy-value theory states that learners are motivated to complete tasks that they believe they can complete and that they believe have value, including utility value for their future[13,14]. When students connect with an identity-based role model, their expectations for value and task feasibility may increase, leading to increased engagement. Individuals from media, including avatars, may serve as potential role models. Miller and Kocurek lay out several principles for educational games, one of which is the inclusion of diverse content and ensuring a diversity of characters[15]. We focus more specifically on computing-infused lessons, which overlap with a subsection of educational games. Computing-infused lessons focus on infusing computing into other disciplines to provide access to computing education outside of standalone computing education opportunities, so that all students have a chance to explore computing[16]. Many computing-infused lessons utilize visual block-based programming languages[16,17,18]. While not all block-based programming activities meet the requirements to truly be considered a game (ex. may not have a scoring system or economy), the visual nature of the output of these programs result in lessons and educational activities where many of these principles are still relevant and which can allow for the inclusion of avatars which may serve as role models for learners. Similarly, Annetta outlines a framework for serious educational game design with identity at the center, stating that without identity the other elements of game design are 'not as impactful because students become less invested in the rest of the game content'[19].

One way to incorporate diversity and identity is through avatars. However, results from a sample of over 150 video games showed an over-representation of white, male avatars and an systematic under-representation of Black, Hispanic, Native American, and female avatars[20], revealing that game creators need to be intentional about the inclusion of diverse avatars. Researchers have investigated the impact of avatars in both games and other multimedia learning environments[21,22,23,24]. Avatars that players can identify with can help to create an emotional connection and a more compelling game experience, which may lead to a higher degree of engagement with the information being presented[25]. Identification with the characters is one of the main factors behind media enjoyment[26]. For example, one reason the Phoenix Quest math computer game appealed to girls was because they identified with the main character, Julie[27].

People choose avatars for a variety of reasons, including representation, aesthetics, and appropriateness to game context[28]. For members of underrepresented groups in terms of gender and race, these individuals are statistically more likely to select an avatar that shares these demographic features with them[29]. In one study, 83% of college students chose their avatar because of representational similarities[30]. In addition to demographic similarities, users are also more likely to select avatars that reflect their cultural norms[31].

There are a variety of gains from avatars that represent individuals from underrepresented groups. In one study, students from all groups had a greater transfer of learning when the "expert" agent they interacted with was represented by a Black avatar rather than a White avatar[24]. Additionally, students from all groups who learned from agents with a female avatar showed higher self-efficacy beliefs[24]. While there are many benefits to the inclusion of diverse avatars, it is also important to consider the quality of this representation. For example, women in video games are often portrayed in stereotypical manners and relegated to be nonactive characters (ex. a princess waiting to be rescued)[36]. Furthermore, Black avatars are often depicted as being stereotypically violent or athletic, rather than being showcased for other interests or abilities[37]. According to cultivation theory, media affects and builds people's view of reality by providing a template by which to expect the world to look and behave; therefore, stereotypes in media can be internalized by the users[38]. Interacting with stereotypical representations can also negatively impact users from the identity group in question[39]. To help combat stereotypes, research suggests game designers should prioritize game play elements that "encourage players to engage with cognitive, emotional, and communicative experiences of peoples from other cultures"[40].

The characteristics of avatars within a game or educational activity are only one element of the larger user or learner experience. Based on their work examining the impact of an educational game focused on the aftermath of the Haitian earthquake, Bachen and her team provide the following suggestion: "One implication is that game designers and educators may need to acknowledge that developing identification with people who are perceived as psychologically or geographically distant requires more extended interventions in surrounding lesson plans and supplementary materials that prepare students to immerse themselves in a different culture"[40].

We examine avatars within computing-infused lessons to provide insight into how novice curriculum creators may start to consider diversity and inclusion within their work. This is a proxy to help determine where the baseline of consideration for diverse groups may be for these creators. When a group is invisible or not included in the lesson materials, there is less opportunity for more in-depth culturally-responsive pedagogical approaches to be implemented.

Methods

Data

We start our analysis with a data set of 312 computing-infused lessons created by teachers in an infusing computing professional development (ICPD) program[41] and by high school interns as part of an educational software design internship[42]. Of these lessons, 177 were created by teachers and 135 were created by interns. Of these 312 Snap*!* projects, 230 contained avatar(s) and of that subset, and 131 projects included at least one human avatar. (Note: some projects may not have any avatars because they only include an instruction page and buttons for running a simulation or playing a memory game, for example). For our analysis, we consider these 131 projects and the 207 human avatars within these projects. 44 of these projects contain multiple avatars, while 89 of these projects contain only one avatar. This leaves us with 85 projects created by teachers and 46 projects created by interns, corresponding to 137 teacher-created avatars and 69 intern-created avatars

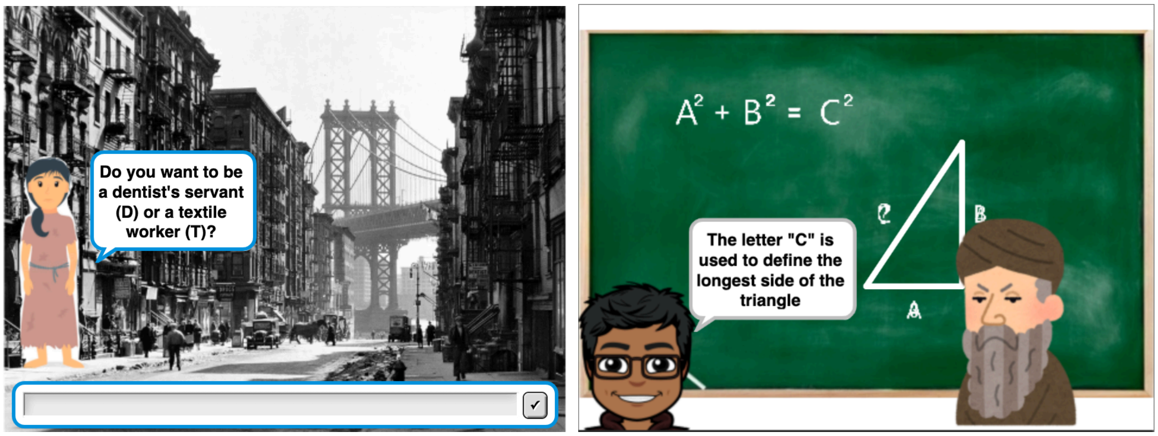

Fig 1: Examples of Snap! projects with human avatars

Project and avatars were tagged for their gender, race, age, historic/literary status, costume source, and role. With regards to gender, the categories were male, female, and non-binary. For an avatar to be considered non-binary, there needed to be explicit identification in the lesson. Avatars whose gender could not be determined (ex. an astronaut in full space suit) were not considered in the analysis for gender. We made this decision as we do not view these avatars as meaningful non-binary representation. With regard to race, avatars were identified as either White or as a Person of Color, as it was not possible to be more specific without speaking to the creators of the projects. If neither identification was possible, these avatars were not considered in the analysis for race. With regard to age, researchers tagged if the character represented a youth or not, as these lessons are designed for a K-12 audience. Researchers also tagged if the avatar was representing a specific historic or literary individual. We also tagged if the avatar's costume (visual appearance) was a resource from the Snap! library or an image imported or created by the project author. Finally, we tagged for the avatar's role in the activity. Avatars can take on a variety of roles; in educational games, avatars typically represent either the student's self or a virtual teacher/tutor[43]. We categorized our avatars as either player characters, guides (fulfilling the role of teacher/tutor), or non-player characters. Technically, guides would be non-player characters but we separated out this sub-category because when an avatar is a guide, they serve as an expert to the player and we view this as a significant relationship that represents the avatar as a holder of knowledge.

For the intern-created projects, we were also able to link demographic information (see Table 1) about the creators to each of the lessons. We were able to identify if they were created by women, men, or a team consisting of both men and women, as well as if they were created by a person of color, a White person, or a team consisting of both. For race we elected to stay at the same granularity of information as we had for the avatars rather than being more specific about these demographics when conducting our analysis.

Table 1: Demographic information of high school interns

	White	Person Of Color				Total
		Asian	Black (Non-Hispanic)	Black (Hispanic)	Multi-Racial (Hispanic)	
Female	5	38	7	1	1	52
Male	3	6	3	0	0	12
Total	8	44	10	1	1	74

Context
The data set in question consists of computing-infused lessons from the infusing computing professional development program (in 2019 and 2020) and from the high school internship program (in 2020 and 2021). The four-day professional development program utilized the 'Code, Connect, Create' model to train teachers on computational thinking[41]. The high school internship program was designed for participants to help create computing-infused activities for K-12 classrooms. Participants attended one week of training including a coding bootcamp and several lessons on pedagogy[44,42]. Afterwards interns created computing-infused lessons in five, week-long development sprints. The hosts of the professional development program chose Snap*!* as the programming environment, which was later carried through to the intern program. Snap*!* is one of many block based programming environments used for education, others include Scratch, Blockly, Netsblox, Tynker, and Stencyl.

Results
When examining the data set, we found that 52.7% (106) of the total avatars are women, 2.9% (6) are non-binary, and 44.6% (86) are people of color. 56.1% (78) of the teacher-created avatars are women, 0.7% (1) are non-binary, and 49.2% (67) are people of color. 45.1% (28) of the intern-created avatars are women, 8.1% (5) are non-binary, and 33.3% (19) are people of color.

We first investigated the differences between the lessons and avatars created by ICPD teachers and high school interns. Teachers were more likely than interns to create lessons that contained avatars ($\chi2(1) = 20.873$, $p < .001$). We found that teachers were more likely than interns to create an avatar who was a person of color ($\chi2(1) = 5.694$ $p = 0.017$); teachers were also more likely to create an avatar who was a woman of color ($\chi2(1) = 4.321$, $p = 0.037$). There was no statistically significant difference between teachers and interns in terms of avatar gender.

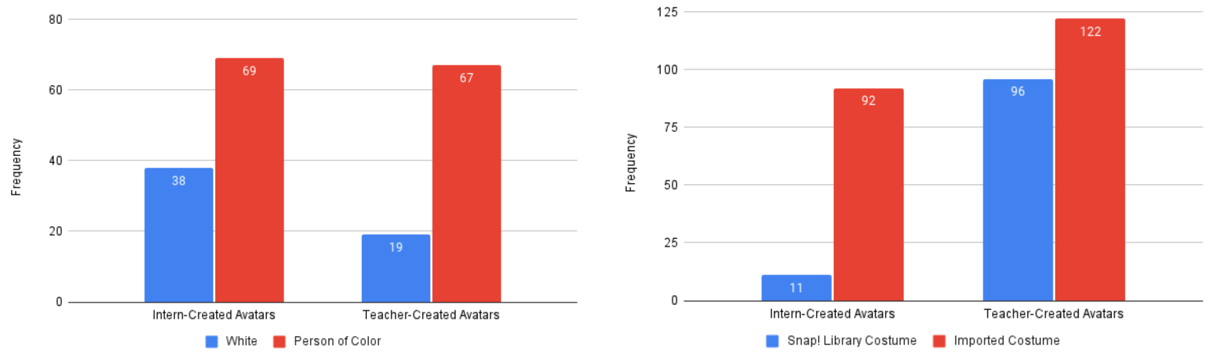

Fig 2: Comparisons in frequency between intern-created and teacher-created avatars

Teachers were more likely to create a lesson containing multiple avatars ($\chi 2(1) = 5.896$, $p = 0.015$). There was no statistically significant difference between lessons with multiple avatars and single-avatar lessons in terms of avatar gender or race. However, there was a correlation between multiple avatars and avatars that are women of color ($\chi 2(1) = 5.896$, $p = 0.015$).

There were no statistically significant differences between teachers and interns in terms of avatar age, historical/literary origin, or avatar role. There were no statistically significant correlations between avatar role and avatar gender or race.

Teachers were more likely to use pre-loaded costumes for their avatars than students ($\chi 2(1) = 17.265$, $p < .001$). There was no correlation between costume source and avatar gender; however, we did find a statistically significant correlation between costume source and avatar race ($\chi 2(1) = 19.936$, $p < .001$).

When investigating potential correlations between creator and avatar demographics using the intern data, we found a significant correlation between creator gender and avatar gender ($\chi 2(4) = 15.383$, $p = 0.003$). We also found a significant correlation between creator race and avatar gender ($\chi 2(4) = 14.068$, $p = 0.007$) as well as creator gender and avatar race ($\chi 2(2) = 16.438$, $p < .001$). There was no statistically significant correlation between creator race and avatar race.

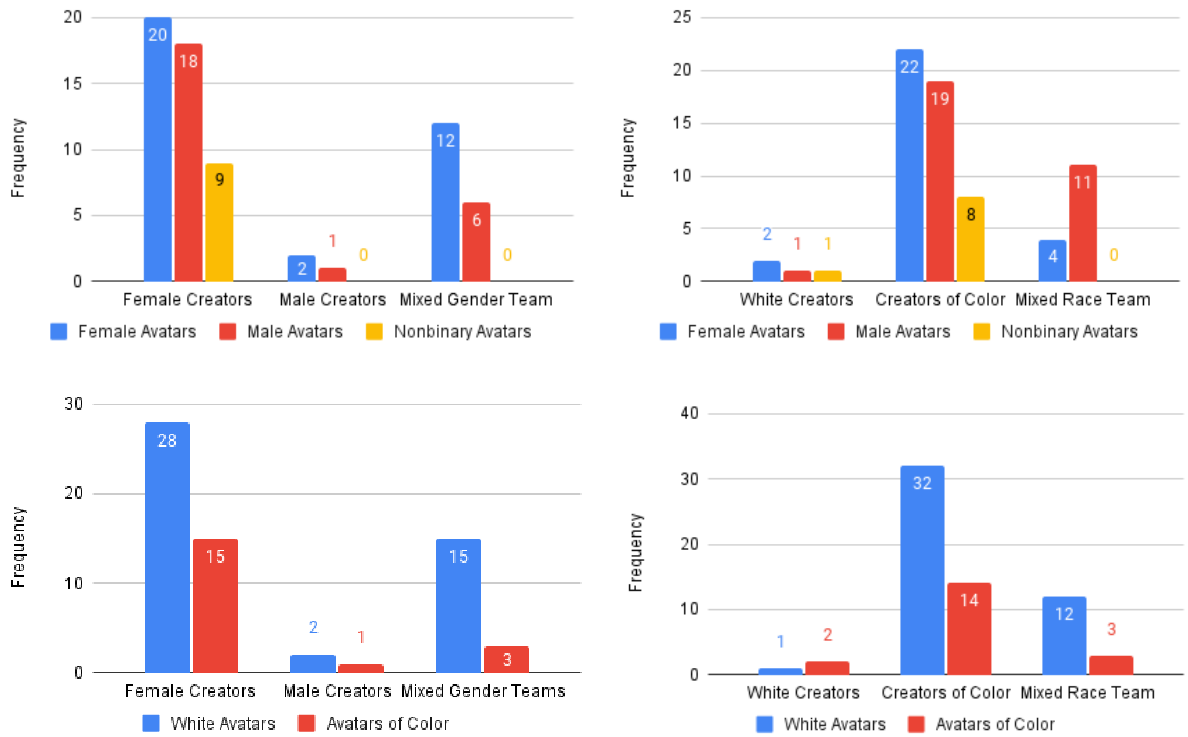

Figure 3: Comparisons of frequency regarding creator and avatar race and gender

Discussion

We will first discuss the results in relation to research question 1: 'How do computing-infused lessons created by teachers and high school interns differ in inclusion and usage of avatars?'. Teachers were more likely to create lessons containing multiple avatars and lessons containing avatars at all. Teachers were more likely to create an avatar who was a person of color as well as more likely to create an avatar who was a woman of color. Finally, teachers were more likely to use pre-loaded costumes already in Snap! for their avatars.

Teachers may be more likely to create lessons containing avatars for a variety of reasons. One potential reason is that interns often created computing-infused lessons that were simulations (ex. projectile motion) that didn't contain any avatars. Additionally, where interns might provide instructions through a text pop-up accessible from the title screen, teachers often utilized an avatar (potentially representing themselves) to say the instructions to the user, reflective of what might happen in the classroom.

Many of the teachers in the ICPD were intentionally recruited from schools with large populations of Black or Hispanic students and were creating lessons for use in their own classrooms. Therefore, it makes sense that these teachers would create lessons including avatars of color. The high school interns, on the other hand, were not making lessons for a specific classroom but for an online repository and also would not have as much experience as teachers in considering the needs of students of color within the classroom.

Finally, teachers had less time to create their computing-infused Snap! activities than students (afternoon create' sessions during a 4-day professional development vs. a week-long full-day development sprint), so it makes sense that they would be more likely to use pre-loaded costumes for the sake of time. Additionally, teachers might have planned to return to the code after the ICPD and update the avatars before using them in the classroom while the interns were creating lessons that they did not intend to edit after the internship. Teacher use of pre-loaded costumes highlights the importance of ensuring that diverse costumes are available to help promote the inclusion of diverse avatars.

One thing to note is that while we were not able to provide an in-depth investigation into representation within these lessons, it is encouraging that there is not correlation between avatar role and race or gender. This means that unlike in the traditional gaming sphere[45], where avatars representing women and people of color are often relegated to secondary characters and not meaningfully included in the main story, the created lessons integrated avatars in meaningful roles. In the lessons made both by interns and by teachers, women and people of color were found in all avatar roles, including the main player character. As according to Tajfel's social identity theory, individuals understand their identities based in-part due to their relationship to various in-groups and out-groups; this prompts individuals to look for representations of themselves and their in-group and compare those representations with those of other groups[46]. A marked difference between the roles of different groups within the computing-infused lessons could therefore have negative effects for members of groups relegated to less meaningful roles.

This leads into research question 2: 'How do creator demographics correlate to avatar demographics?'. We found that mixed gender teams created a higher percentage of male avatars while female teams had a higher percentage of female and non-binary avatars. As there were not many non-binary avatars overall, part of this correlation may be due to a social-emotional-learning project created by a team of young women that included several non-binary characters. Additionally, some of this corresponds with the research behind avatar selection (where students are likely to select avatars that share the same gender as them) and for the mixed-gender teams this might interplay with team dynamics and who was taking lead on making decisions about activity; perhaps the young men in the group were making the decisions about the avatar's appearance rather than doing so collectively.

We also found a correlation between creator race and avatar gender. This could be because the majority of white interns were also men or because many of our interns were women of color. Additionally, the team who created the social-emotional-learning project were all women of color, leading to a higher proportion of non-binary avatars from teams containing only people of color. Similarly, there was a correlation between creator gender and avatar race. As the majority of our female interns were women of color, it is understandable that avatars from female creators were more likely to be people of color.

Very few teams contained only White individuals, so when considering creator race and avatar race, all avatars were created with the input of at least one person of color (depending on team dynamics). This could be why there is no statistically significant correlation between creator race and avatar race.

In general, we observed that, similar to choices about avatar selection; educational game developers are likely to create avatars that they identify with, just as players are likely to select avatars they identify with[30].

Limitations

This work presents a surface level investigation into representation in computing-infused lessons focused on race and gender characteristics of avatars. We recognize that presence of a diverse avatar alone does not necessarily mean that there is meaningful representation or that a lesson will be effective for underrepresented students, as avatars and the coding activity more generally are only one part of the full lesson. We were unable to consider the demographics of the intern creators and avatars intersectionally, as this would result in subgroups too small for analysis. Additionally, the labels were based on rater perceptions rather than creator intentions, so some avatars could have been unintentionally misinterpreted. However, the students targeted to use these lessons also would not have this knowledge and the raters were intentionally peers or near-peers to the end users and provide a proxy for the perceptions of the students who would learn from these lessons.

Conclusions and Future Work

The work investigates how teachers and novice computer science curriculum developers, particularly computing-infused lesson creators using block-based programming languages like Snap!, may provide representational role models through use of avatars. We found that teachers are more likely to create computing activities that contain avatars. We examined what factors influence avatar gender and avatar race and found that teachers are more likely to incorporate avatars of color and avatars that are women of color. When considering correlations between creator identities and avatar identities, we found that female creators are more likely to create female or non-binary avatars than male creators. We also saw correlations between creator gender and avatar race and creator race and avatar gender, likely due to the large cohort of creators who were women of color. When providing support and training to curriculum developers, creators should be supported so that they can make sure they are intentionally considering the race and gender of the avatars in their lessons. We also identified that pre-loaded costumes are heavily used resources by computing-infused lesson creators, particularly teachers, so block-based programming environment developers should ensure that their costume libraries contain diverse avatars. Future research could investigate creator's motivations for avatar usage and design, and look more closely at other strategies creators use to incorporate equitable practices into computing-infused lessons.

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