Bison Hacks the Yard: Assisting Underrepresented Students Overcome Impostor Syndrome with Augmented Reality and Artificial Intelligence

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Abstract

The prevalence of impostor syndrome in computer science students from underrepresented backgrounds contributes to low retention rates. Bison Hacks the Yard is an augmented reality game that aims to reduce impostor syndrome in underrepresented students by presenting a novel way to strengthen their knowledge of fundamental data structures and providing specialized videos of Historically Black College or University alumni, sharing their struggles with impostor syndrome.

Introduction

Impostor syndrome (IS) is characterized as an individual's belief they are undeserving of their current position because it was attained by chance. According to Duncan, Eicher, and Joyner (2020), as the field of computer science (CS) has grown, so has the frequency of IS within the CS community. IS affects underrepresented communities more frequently than others. Ramsey and Brown (2018) state that first-generation and ethnic minority students are among the most affected groups by IS.

Increasing diversity within CS is critical, and one way to achieve this is by improving retention rates. Underrepresented CS majors affected by IS are at a high risk of discontinuing their CS undergraduate programs for several reasons. By the very nature of IS, affected CS students believe they are impostors and lack a sense of belonging to the CS community. Additionally, underrepresented CS students have a difficult time developing a sense of belonging due to the lack of representation in CS. According to O'Keeffe (2013), students who lack a sense of belonging are at risk of non-completion of their respective programs.

The goal of this work is to reduce IS in underrepresented students to improve retention rates and increase diversity. We theorize that solidifying CS students' fundamental data structure (DS) skills in a novel way, and providing examples of successful CS alumni will increase students' confidence in their knowledge, thus decreasing symptoms of IS. In this paper, we present a novel approach to this problem of increasing knowledge while decreasing IS: a low-pressure, augmented reality (AR) based activity to teach fundamental DS's and increase underrepresented students' sense of belonging. The AR application will use artificial intelligence (AI) to present questions according to users' performance, and recommend virtual conversations with the alumni. We plan to evaluate our system by measuring IS and performance of DS before and after using the application. We will show whether CS students' IS symptoms will decrease after the study.

Related Work

There is a gap in literature detailing the effectiveness of AR and AI on underrepresented CS students' IS. We build upon prior work to explore this.

AR is an experience that generates virtual objects and overlays them with the real world. In this study, we use AR because prior work has shown it improves students' self-efficacy. Self-efficacy is one's ability to believe they can succeed, which the is opposite of how those with IS feel. Chen et al. (2019) explored the effect of AR on memory recall for human physiology concepts. Results showed that while AR did not improve students' test scores, it did increase self-efficacy and lower anxiety scores for participants. The low-pressure learning environment that AR provides is effective for improving self-efficacy and lowering IS. However, we still aim to improve students' DS foundations. Thus, we will use AI to implement personalized learning pathways for students. This will help students learn both inside and outside of the classroom in engaging ways, and connect theoretical concepts with concept examples of data structures in the real-world.

There are several AI techniques used to achieve adaptive learning pathways (Bajaj and Sharma 2018), but we are interested in decision trees and Bayesian networks. These two techniques can provide valuable information about students' learning processes to adjust the difficulty level of questions accordingly. Decision tree algorithms are supervised learning algorithms used for classification. In Hamoud, Hashim, and Awadh's (2018) study, they explored AI techniques for predicting students' academic performance from a survey. They determined decision tree algorithms to be the best solution. A Bayesian network is a probabilistic graphical model used to estimate probabilities for events. In Choi and McClenen's (2020) work, they successfully utilized Bayesian networks to assess a learner's ability at multiple points through-

out a formative assessment. In our work, this method can be used to adjust the question difficulty based on students' answers to DS assessments, and learn which virtual conversations students should watch.

Methodology

In this work, we explore the effect of a novel AR application on underrepresented CS students' IS.

AR Application

We created an AR game to reinforce DS's to CS students, and demonstrate representation in technology through interviews with the Howard CS alumni. The game, Bison Hacks the Yard (BHY), is hosted on the AR platform, Metaverse. Participants will be given the game's QR code so they can access it throughout the trial. The game has 4 DS questions and 3 IS activities that participants can access in any order.

Each DS question is prefaced with key information about the DS. Due to our participant group being at different points in their educational careers, for some, this will serve as a review while for others it will serve as an introduction to this concept. After viewing background information, the participant will then be asked a series of questions surrounding the DS, along with a diagram presented with AR. The participant will have unlimited tries to answer these questions. Each time the participant gets the wrong answer, they are provided with a hint and an encouraging message. This is in place to ensure the participant stays positive, even if they continue to miss questions. The finished BHY application will use machine learning to cater to the participant's level of understanding. We plan to use either a decision tree or Bayesian learning to adjust the questions' difficulty level depending on the trend of success.

The three IS activities are pre-recorded videos by Historically Black College or University (HBCU) alumni who have struggled with IS. After watching each video, participants are prompted with a question to gauge their connection to the CS community. These videos are in place to help participants build a sense of belonging to the CS community.

Evaluation

We will evaluate our approach in a 3-month study of CS undergraduates. Participants will be recruited from the group of undergraduate students at Howard University who are registered for a CS I, CS II, or CS III class. There will be two participant groups: the control group and the application group. Participants in the application group will have access to the game for three months, while the those in the control group will not. Before and after the trial, both groups will fill out a questionnaire about their sense of belonging to the CS community, their experience with IS, and their knowledge of DS's.

Discussion and Conclusion

With this study, we expect to show the impact of an AR game that reinforces DS's and provides IS interviews, on underrepresented CS student's IS. From the results, we will measure the effectiveness of an AR game that utilizes AI for personalized learning pathways, on DS knowledge retention. We will assess student's confidence in their DS skills relative to their struggle with IS. We will also show the impact of representation on underrepresented students' IS. If AR and AI prove to be effective in students' knowledge retention of CS concepts, it can be used to supplement existing CS curriculum. Also, if students' confidence in their DS skills reduces their IS, novel, low-pressure learning applications like BHY can be used to reduce IS of those in need.

After students are allowed back onto Howard University's campus, we plan to tie each of the DS questions to a landmark on campus. This allows participants to learn in a setting outside of the classroom, making the content more interactive and memorable. BHY aims to help underrepresented students overcome IS everywhere. Once the application is fully functioning, we hope to expand it to other HBCUs.

In this paper, we present a game designed using AR and AI to help underrepresented students overcome IS. This is achieved by allowing students to learn and reinforce fundamental DS's to increase confidence in their skills. Additionally, students have the opportunity to watch virtual interviews regarding IS to develop a sense of belonging. With this project, we aim to decrease IS for underrepresented CS students to increase retention rates.

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