Teaching Video Game Design Accessibility: Toward Effective Pedagogic Interventions in Accessible Design

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Abstract. Video games are enjoyed as creative, emotional, and social outlets for many. However, for a growing number of people with disabilities and/or those acquiring disabilities due to age-related decline, this kind of media is becoming inaccessible. The future of accessible game design hinges on teaching the next generation of game developer professionals of best practices and providing them experience to create their own accessible games. Still, little is known for effective pedagogic practices that instill domain knowledge and awareness in students on accessibility design. In this early work, researchers explore the impact of one 60-min accessibility lecture on the way student participants sonified a game for those with visual impairments. Results indicate that students receiving the lecture produced a more accessible product for player with visual impairments, while also intimating higher levels of empathy for those with disabilities. Based on these findings, we present recommendations for how instructors can implement a minimum viable pedagogic intervention for accessible game design, if a longer engagement with this material is not possible.

Keywords: Accessibility design · Video games · Human-computer interaction

1 Introduction

Video games provide a number of social [1], physical [2], and cognitive benefits [3, 4] to players. However, games remain or can become out of reach for a growing number of people as the average age of the world increases [5] and age-related decline (e.g. sensory, motor) affects more of the population. Currently in the United States, there are 61 million people [6] with a disability and, of these, there are 33 million gamers with disabilities [7]. This requires increased attention by technology communities towards accessibility design for both hardware (input devices such as smartphones and keyboards) and software (e.g. user interfaces on the web).

Until relatively recently, the part of the gaming industry producing large-scale titles, known as "AAA" games, has largely overlooked early integration of accessibility features into commercial games. Unfortunately, much of the work on accessibility research conducted in academic settings does not find its way into commercial applications because of a balkanization of industry and academic communities, in addition

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to the challenges of appropriately implementing these features in the time pressures these projects face.

Some headway in commercial accessible products has been made, such as the release of the Microsoft Xbox Adaptive Controller [8], which focuses on players with limited mobility. The Adaptive Controller allows players with disabilities to connect their own accessible input devices providing agency over the way the game is played (for example, using a foot pedal for jumping and also a sip-and-puff controller to move the character). However, many accessible devices or software modifications – in gaming or other digital media – remain afterthoughts and add-ons that often work clumsily with the main technology. Additionally, accessible hardware can be prohibitively expensive for a user to purchase on their own (a sip-and-puff controller can cost $450 USD), software documentation for use may be scarce, and/or an accessible software solution simply be non-existent.

Partly, the difficulty of effective implementation of accessibility in technology is due to the substantial challenge in designing for the wide breadth of abilities and disabilities (e.g. sensory, physical, cognitive) that people may experience throughout their lifespans. A first step in promoting the future of accessible design in games, and of technology overall, is through educating the next generation of human-computer interaction (HCI) professionals. We must begin this education practice early in students so that they can employ best practices and principles for the rest of their careers. Professionals must also seek continuing education opportunities to keep abreast of new accessibility requirements, guidelines, and community needs as technology rapidly evolves.

In this early work, we focus on teaching accessible game design to undergraduate students at a university in the United States. As part of a larger project on accessible game design, researchers explored a minimum intervention of an accessible game design lecture given to students and examined how the lecture impacted the ability of students to make a game accessible to visually impaired or blind players, as compared to students that did not receive the lecture. Games are social, creative, and emotional outlets for many, and maintaining the ability to engage in this activity can increase the quality of life for many kinds of people [9–11]. Therefore, new generations of game designers and developers armed with knowledge, awareness, and self-driven interest in accessible game design may serve to support all kinds of gaming communities with the tools needed to successfully play.

2 Related Work

New standards and regulations in the United States, the European Union, Australia, and other large markets continue to be updated with more stringent criteria for accessibility on the web. This growing attention places demands on industry to hire professionals with accessible design skills, and also on higher education institutions to produce these new professionals. Increasingly, universities are implementing accessibility teachings in their program curriculum, particularly in the fields of disability studies and biomedical design. However, encountering this level of instruction in computer science specializations can be more rare [12].

For the field of HCI, several universities (e.g. Universidad Politécnica de Madrid, University of Dundee, University of California Santa Cruz) have successfully implemented stand-alone courses as part of a larger computer science or interactive media program [13–16]. However, many argue [17, 18] that accessibility teachings should be integrated throughout all courses in an undergraduate curriculum, thereby promoting increased experience with this way of thinking, and also to keep students abreast of new developments with rapidly evolving technologies

2.1 Teaching Accessible Design with Authentic Learning Theory

The pedagogic theory of "authentic learning" possesses four main themes of (1) tackling real-world problems reflecting the work of professionals, (2) presenting non-prescriptive problems with open-ended solutions, (3) providing opportunities for discourse and collaboration with other learners, and (4) allowing students agency over directing their learning in the project to develop their own emotional commitments with the subject matter [19]. In a survey of several European Union programs teaching accessibility awareness, researchers found the activities most effective in impacting students reflected themes from authentic learning; particularly in creating meaningful connections between learners and those in disability communities [20].

Videos, including freely available ones from YouTube, have proven successful in instilling deeper connections in learners by raising awareness of accessibility challenges and bringing a human element to those who students are designing for [16, 21, 22]. Additionally, access to design stakeholder members with disabilities also can increase awareness around accessibility domain knowledge, and learner comfort in interacting socially with disabled persons [16, 23]. Laboratory exercises can also be a successful strategy to instill meaningful connections in learners, such as requiring students to use screen readers to interact with the web [24] or using tools to simulate disabilities (e.g. using the Cambridge Capability Loss Simulation gloves or glasses [25]). However, these activities are likely best paired with interactions by those in the disabled community to demonstrate how they can adapt to their abilities, as one study found disability simulator tools can decrease attitudes in the learner about the ability for disabled persons to work and live independently [26].

However, for those educational programs without the luxury of integrating accessibility throughout much of or the entirety of a curriculum, questions remain on the most effective ways of teaching accessibility. What is the minimum viable intervention that can be given to students to instill not only heuristics and procedural domain knowledge, but a sense of awareness of accessibility challenges? Video games are a specific kind of interactive media, and information on dedicated university courses or programs for accessible game design is scarce. Further, less is known for how to teach this kind of accessibility design to new game designers and developers.

3 Study Description

Empirically, we have little understanding of how much and what kind of training is necessary for students to be effective in implementing accessibility design in their work – particularly for accessible games. In this preliminary study, researchers gave a supplementary lecture on sonification accessibility design in video games in a computer audio course to a portion of computer science undergraduate students. The purpose of this study was to examine how a bare minimum intervention (i.e. one lecture of 60 min) impacted the way students made a video game accessible for play by those with vision impairments, as well as how they discussed their justifications behind their design.

A thematic analysis was used to typify the kinds of errors made by participants in each condition to understand how to design the next iteration of pedagogic interventions. Researchers expert in game design and accessibility created a scoring rubric to assess: (1) if critical game elements for accessible play were sonified, and (2) the quality of the sonification (e.g. was the sonification appropriate in communicating its information). Additionally, all student participants submitted a two-page explanation justifying their design and these statements were evaluated using a thematic qualitative analysis for intent, and also evaluated in conjunction with the efficacy of the final product.

4 Methods

In an undergraduate course on computer audio, researchers divided the class into two groups to participate in this study. Both groups of students completed an accessibility design assignment where they were given the same 1-min video of a game called *Bubble Trip* [27–29] to make accessible for visually impaired or blind players. One group of students completed this assignment after receiving a supplementary 60-min lecture on designing for accessibility, while the other group completed the assignment without this lecture. Thirteen students participated in this study, with eight students attending the supplementary accessibility lecture and five not.

4.1 The Lecture

The 60-min lecture on game design accessibility was the first introduction on accessibility for most of the participant students. The lecture introduced topics including the concept of universal design and its intended benefits, multi-modal interaction and feedback design, and how to design sonifications communicating spatial simulation, descriptions of environment, changes in environment, game alerts, player resources, and system controls. Specific instruction on how to map sonifications for loudness, frequency, tempo, and timbre with examples were also provided.

As a technique for students to use in their assignment, Shephard's Tone was described (this creates an auditory illusion of a rising pitch, without exhausting actual rising tones or loudness [30]). Finally, video examples were shown to students exemplifying challenges that visually impaired players experience with games such as Zelda: Ocarina of Time. In this particular example, students watched how a blind player had modified his gaming environment to present himself with stereo sound, and used a Nintendo emulator to frequently and rapidly save game states to return to after failing a level [31]. Other videos shown in the lecture demonstrated games that have been modified for visual impairments using sound, or that were specifically designed for those players with visual deficits.

4.2 The Accessibility Assignment

All students completed the same accessibility assignment, whether they had received the lecture or not. Students were provided a 1-min video clip of the game, *Bubble Trip*, and instructed to use a video editor to add sufficient and appropriate sonifications that would enable a visually impaired or blind player to effectively play the game, while also having an enjoyable experience. *Bubble Trip* was created as a scientifically valid and reliable personality assessment game [27–29], where players read personality questions (from the HEXACO Personality Inventory [32]) and move their fish avatar around the screen to make answer selections. Additionally, players collect bubbles for points and avoid collisions with enemy jellies (see Fig. 1).

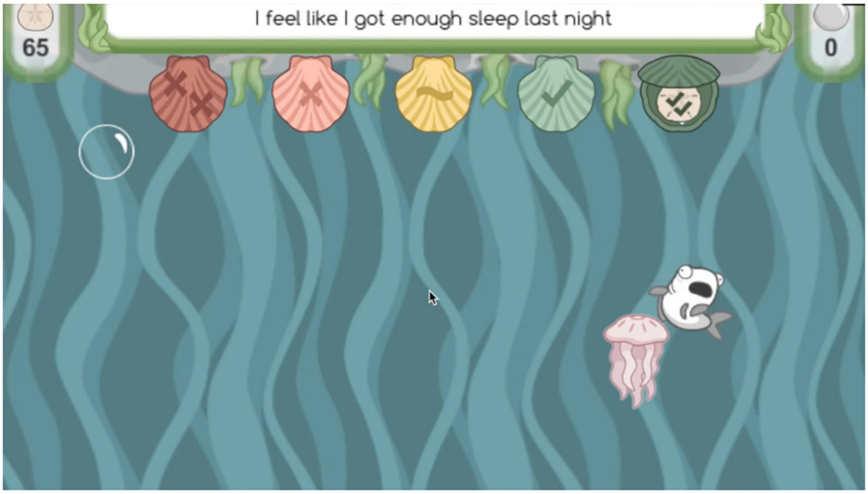

Fig. 1. Student participants added sonification to a video of gameplay from *Bubble Trip* for low vision and blind player accessibility

4.3 Scoring Rubric

The suitability and effectiveness of the student's accessibility sonifications were assessed by experts in both game design and accessibility design. Prior to reviewing student videos, these experts independently described elements from the game that they believed required sonification in order for a low vision or blind player to effectively play the game, while also having an enjoyable experience.

To make *Bubble Trip* accessible for those with low vision, the rubric (see Table 1) identifies three categories that must be sonified: (1) verbal support of text, (2) positions of interactive agents, and (3) player status. For example, a very basic accessibility feature should be a voice read-out of the game instructions, as well as every personality survey question presented to the player. Other game elements that should be made accessible through sonification are the Likert scale items pre-selected and then finally confirmed as a submitted answer, location and velocity information on the player's fish avatar, presence of collectable bubbles, and the motion and position of enemy jellies. Finally, periodic (or sustained) updates on player status are important feedback and would include overall score and number of survey questions remaining.

Table 1. Complete list of possible sonifications, as identified by experts in both accessibility and game design, and items used in the scoring rubric for *Bubble Trip*

Accessibility category	Game element	Example
Verbal support of text	Game instructions	"This game uses the arrow keys on your keyboard to…"
	Survey question text	"I would like to go to an art museum"
	Fish position	Communicating the x and y location of avatar
	Fish motion	If avatar is being moved or not
	Survey answer pre-selection	Likert item indicated before final selection
	Survey answer selected	Likert item confirmed as final selection
Positions of interactive agents	Jelly position	Communicating the x and y location of enemy jelly
	Jelly motion	That the jelly is moving across the screen
	Jelly collision	If the avatar collides with an enemy jelly
	Bubble presence	If bubbles were floating up screen
	Point collection	Upon collection of bubbles by avatar
	Screen boundary	If avatar position is on edge of gameplay screen
	Player score	Communicating number of bubbles collected
Player status	Question number	Communicating number of questions remaining

Two researchers independently coded each video and scored against the rubric the following criteria: (1) if these game elements were coded (or to add any new codes if students identified missing sonification element needs), and (2) the quality of the sonification (e.g. if the sound design was effective and appropriate in communicating its information). In addition to the submitted video, each student included a two-page report justifying their chosen sonification elements and explaining their sound design for each. These reports were also examined in terms of procedural knowledge applied to their sound design, explanations indicating a deep understanding behind the chosen design, and empathetic sentiments guiding their process.

5 Observations and Results

The following sections describe observations of students from the accessibility lecture, the produced sonified videos from all students, and the justification reports submitted with the videos by all student participants.

5.1 Students Not Receiving the Lecture

Results indicated that students not receiving the accessibility lecture omitted more sonifications of *critical gameplay elements,* such as audio that read the personality question aloud for the player. No student in this group added verbal read-outs of the *Bubble Trip* instructions, and including text read-outs of the personality questions to be answered was also rare. If a player cannot read the survey questions, it is still possible to technically play the game but neither effectively nor in the way the game was intended to be played.

Students in the no-lecture group also made more *fundamental* mistakes regarding crucial information, such as positions of interactive agents, that would need to be communicated to a visually impaired player. Standard accessibility heuristics would emphasize the need to communicate position of an interactive element, making this a fundamental basis for accessible design – particularly for games. Since the fish avatar can be moved in any direction on the screen but the survey answers are only available at the top, a visually impaired player must have assistance in knowing the position of their avatar in order to answer the questions. Additionally, sonifying the same aspects for the enemy jellies helps players to avoid colliding with them (though enemy collisions have no punitive aspect, they do freeze the player's character for a brief moment).

In the report justifications, these participants indicated that they were more focused on the aesthetic design of the sound rather than accessibility. For example, one student produced a video with a high number of sonifications fitting the underwater nature of the game (e.g. sounds of flowing water, bubbles popping) but the sounds themselves were not able to effectively convey the requisite information for a visually impaired player to play the game. Although the sounds satisfied hedonic elements of the game, they had low bandwidth in communicating useful information such as player position or proximity to enemies.

5.2 Students Receiving the Lecture

Students that did receive the lecture, however, sonified more overall game elements and their audio design communicated more nuanced information to the player.

These participants opined more empathic statements about putting themselves "in someone else's shoes" and thinking of what the game experience would be like if they could not see it clearly. These students more often explicitly mentioned "the player" they were designing for and what they understood the player's needs to be in relation to *Bubble Trip* specifically. For example, "a visually impaired player would have a difficult time knowing where the screen boundaries are, so I am sonifying these to help them orient themselves in the game".

Students receiving the lecture also used more conditional statements in justifying their sonification design. For example, "if I were visually impaired, I know I would get frustrated with menus so those should definitely be sonified to help guide the player" and "because this element [bubbles] is fun to collect in the game, it should be fun for the player to hear but I want to make sure it doesn't hurt their ears either because if I were blind then I think I would be very sensitive to sounds".

Overall, lecture-receiving participant explanations indicated they had thought more deeply about the gameplay experience from an empathic standpoint, and less from a straightforward heuristic approach. Finally, these students wrote more on how their accessible design would benefit players regardless of visual ability – perhaps a consequence of learning about universal design in the lecture.

6 Discussion

An unexpected outcome of the lecture intervention was the sense of empathy it appeared to instill in students receiving it. Although this makes sense in hindsight, elements of the lecture were not included to purposefully create this awareness and yet it appears an effective vehicle in motivating designers to more appropriately design for accessibility. This follows authentic learning theory in several counts. The project had real-world applications that mimicked that of professionals, there was no one right answer for how to make the game accessible, and students' personal connection to the task may have been influenced by watching videos of visually impaired players play through popular commercial games, like Zelda. In fact, students in the accessibility lecture watching the blind gamer play Zelda writhed in their seats, moaned when the player fell of cliffs, clasped each other's hands, and made sympathetic exclamations on how hard it appeared to play in this way. As in other studies previously discussed [16, 22], videos appeared effective in connecting learners with the subject matter and possibly impacting the quality of their work after.

Participants receiving the lecture may have also been influenced by the discussion on universal design, as they made more comments in their reports for how their sonifications could benefit players of many kinds of abilities. The abilities of humans are changing constantly over our lifespans, from our ability to see without aid to short-term memory capabilities. Although universal design may not be possible in totality, there are examples where it can benefit many kinds of people (e.g. the Curb Cut Effect [33]) and these can be powerful anecdotes to change the way learners navigate and think about the interactions they have with digital media.

6.1 Recommendations for Instructors of Accessible Game Design

The contribution of this paper is to provide some recommendations for instructors on teaching accessible game design – particularly if resources or time only allow for small pedagogic interventions. As elucidated in the previous research on accessible design in HCI and computer science, leveraging authentic learning theory to generate a deeper connection in learners appears effective also in students learning about accessible game design.

There exists a vocal and active community of gamers with disabilities online that spend considerable time providing documentation on modified hardware/software solutions, research into accessible games, and review and experiences with commercial games specific to their abilities. We recommend instructors to, at the least, encourage students to reach out to these communities to learn about their unique needs, wants, and accessibility recommendations. Platforms, like Twitter, and popular forums, like Reddit, are helpful for learners to communicate with these communities online. Additionally, current professionals in these fields would benefit from dialogue with these communities, and can also utilize the structured guidelines and heuristics provided by advocacy groups like AbleGamers [34].

Perhaps even more effective for learning is to invite individuals with disabilities to act as stakeholders and mentors for student projects. Indeed, this was found to be particularly effective for raising accessibility awareness and increasing social interactions comfort in students [23]. As found in this study, supplementing instruction with first-hand accounts and experiences – even those as passive as a YouTube video – may be effective in influencing learners on accessibility design in games.

As stated by other researchers, accessibility design should be interwoven in all of an undergraduate HCI or computer science student's curriculum. Per the professional codes of ethics by computing organizations, like the Association of Computing Machinery (ACM [35]), our profession emphasizes the ethical design of technology that includes all people regardless of ability or status. Instilling this sentiment in the next generation of computing and design professionals is paramount.

7 Conclusions and Future Work

Ultimately, participants that received the lecture produced a more accessible game product that not only communicated more information to the player through sound, but also indicated that the designer had thought more deeply about the target player's needs. Even one 60-min lecture influenced these students' work and thought-processes on design, and provoked deep empathetic feelings on what challenges disabled gamers face playing even simple games, like *Bubble Trip*. Students receiving the lecture reacted strongly to lecture-provided videos of gamers with disabilities playing commercial games and made more comments indicating they had imagined what it would be like to have a visual impairment. The kinds of errors that lecture-receiving participants made could be typified by less appropriate hedonistic sound design, while creating an appropriate level of game design accessibility.

This is early and exploratory work examining how pedagogic interventions may impact the thoughts and final products of game design accessibility in undergraduate students – an area currently lacking in academic research. These results suggest promoting deeper engagement with the content itself, such as through videos, may produce a higher sense of empathy with disabled players, leading student designers to create more accessible interactive media. Stand-alone lectures or courses should be the minimum provided for higher education, but the contribution of this paper is some further understanding for a minimum pedagogic intervention influencing accessible game design for undergraduate students. We hope to build on this work with future cohorts of students to further understand the beneficial impacts of these kinds of interventions on accessible game design.

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