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The Use of STEM Gaming to Promote Hearing Health in Youth

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THE USE OF STEM GAMING TO PROMOTE HEARING HEALTH IN YOUTH

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ABSTRACT

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Hearing loss prevention programs targeting youth have been implemented in many forms to teach younger populations about hearing health to prevent noise-induced hearing loss. Some hearing loss prevention programs, such as Dangerous Decibels®, are based on health communication science and aim to not only increase youth's knowledge about noise-induced hearing loss, but positively change their attitudes, beliefs, and behaviors towards safe listening practices. The purpose of this project was to investigate how an educational computer game called Song of the Starbird could potentially be used as an effective hearing health promotion tool for students with normal hearing and students with hearing loss. Exposure to this game could improve knowledge and change attitudes, beliefs, and behaviors in youth related to hearing health. It can also be a fun way for youth to learn about how we hear, the effects of damaging sound levels, and what they can do to reduce their risk of noise-induced hearing loss. In Chapter 1, an extensive literature review was performed to establish a rationale for using a video game as an appropriate hearing loss prevention resource targeting youth 9-12 years old. In Chapter 2, the game's application within the field of audiology, methods, and examples of implementation opportunities are offered. Audiologists play a key role in disseminating the game within their practice settings. Finally, Chapter 3 reviews gaps in the research literature and future research needs.

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LIST OF ABBREVIATIONS

ADA	Americans with Disabilities Act
AVG	Active video game
dB	Decibels
ENT	Ear, nose, and throat
ESA	Entertainment Software Association
FM	Frequency Modulation
HBM	Health Belief Model
HL	Hearing loss
IDEA	Individuals with Disabilities Educational Act
I.T.	Information Technology
NHANES	National Health and Nutrition Examination Survey
NHANES III	Third National Health and Nutrition Examination Survey
NIH	National Institutes of Health
NIHL	Noise-Induced Hearing Loss
OMSI	Oregon Museum of Science and Industry
SCM	Stages of Change Model
SCT	Social Cognitive Theory
SOTSB	Song of the Starbird
STEM	Science, technology, engineering, mathematics
TPB	Theory of Planned Behavior

TRA	Theory of Reasoned Action
US	United States
WHO	World Health Organization

CHAPTER I

REVIEW OF LITERATURE

Hearing loss that is caused by high sound levels can affect youth in many areas of their life. Hearing health promotion programs are used to educate youth about noise-induced hearing loss and what they can do to limit their risk of hearing damage. Several programs exist to increase youth's knowledge about hearing health and change their attitude, beliefs, and behaviors about hearing health. A new hearing loss prevention strategy in the form of a video game may be an effective way to teach youth about noise-induced hearing loss and change their perspectives about hearing health.

Hearing Loss in the United States

Hearing loss (HL) is a prevalent health issue around the globe. 1.5 billion people worldwide have some degree of HL. The World Health Organization (WHO) projects that 2.5 billion people will have some degree of HL by 2050 (WHO, 2022). In the United States (US) alone, approximately 37.5 million adults currently have some degree of HL (National Institute on Deafness and Other Communication Disorders, 2021). HL can be caused by many factors including genetics, chronic ear infections, trauma, and exposure to loud sound. HL is identified when an individual has hearing thresholds above 20 decibels (dB) in one or both ears (WHO, 2021). The severity of HL can range from mild to profound. Severity is classified based on where dB level thresholds are present (i.e., a mild HL corresponds to thresholds between 20 and 40 dB). An individual with HL can experience perceptual hearing difficulties. Some of these difficulties include having trouble recognizing and understanding speech especially in the

presence of background noise, communication breakdowns, tinnitus (ringing in the ears), and sensitivity to sound (ASHA, n.d.) These symptoms can lead to more serious consequences like self-isolation and withdrawal from activities and events (Shukla et al., 2020). While HL can affect anyone, those most at risk for serious, life-long implications is the younger population.

Although HL is typically thought to affect older individuals, HL can occur at any stage of life. The National Institutes of Health (NIH) estimates that 2 to 3 out of every 1,000 children have some type of HL (National Institute on Deafness and Other Communication Disorders, 2021). Data from the most recent National Health and Nutrition Examination Survey (NHANES) from 2009-2010 suggests that approximately 15% of youth ages 12 to 19 years of age have some degree of HL. That equates to around 3 million children in the US who have HL. Su and Chan (2017) examined that these instances of hearing loss might be consistent with exposure to loud sound. It is estimated that more than 1 billion young people between the ages of 12 and 35 are at risk of HL due to exposure to loud sound (WHO, 2022). This type of HL is known as noise-induced hearing loss (NIHL).

NIHL due to high level sound exposure is dependent on many factors including the type of sound, intensity level, duration of the sound, and number of exposures to high level sounds (Hidecker, 2008). Some types of sound can be particularly damaging, like machinery, firearms, and music (Pienkowski, 2021). Youth can be especially vulnerable to NIHL. The Third NHANES (NHANES III) conducted from 1988-1994 concluded that approximately 12 to 15% of children ages 6 to 19 years old are estimated to have “threshold shifts” in one or both ears due to exposure to loud sound (Niskar et al., 2001). These results indicate that even youth younger than 10 years of age can acquire permanent hearing damage due to prolonged exposure to loud sound.

The number of children that are possibly acquiring NIHL is concerning, especially since NIHL is preventable. Even mild HL in children can cause decreased access to information in the classroom. This can impact academic performance (Qi & Mitchell, 2012; Traxler, 2000). HL can also cause communication difficulties in children, resulting in social isolation (Patel et al., 2021). To prevent complications due to NIHL, there are many educational opportunities for youth to learn about hearing health (Harrison, 2012). However, the effects of HL can impact a child's ability to access and learn about hearing health.

Effects of Hearing Loss

HL can have many negative implications on an individual and society throughout a lifetime. This is especially true for individuals who have HL starting at infancy or childhood. HL doesn't disappear or get better over time. Therefore, those who have HL early on will be prone to the consequences of HL longer than those who acquire HL later in life. The longer an individual has HL, the more it also affects society. Overall, the cost of HL can be both non-monetary and monetary.

Access to Information

HL can limit an individual's access to information. HL can affect an individual's ability to hear environmental sounds, speech (including consonant sounds) especially in the presence of background noise, music, television, etc. This can cause social withdrawal and avoidance of social settings (Shukla et al., 2020). An inability to hear what is being said and withdrawal from social situations can decrease the amount of information an individual with HL has access to. Besides environmental and speech information, individuals with HL can miss out on important health information. Emond et al. (2015) recruited 298 participants from 20 to 82 years old who identified with the Deaf community. The purpose of the study was to examine the overall health

of the participants. It was found that the participants had poorer overall health than the general population. Specifically, more participants tended to be obese, have high blood pressure, be prediabetic, and seek out medical treatment less than the general population. It was determined that missing health information due to HL can cause gaps in pertinent health knowledge. This can lead to underdiagnosis and undertreatment of health conditions. Youth with HL are just as susceptible to the negative effects of missing out on health information (S.R. Smith et al., 2015). Limited access to health information can impact an individual's health over time and can have detrimental effects, especially on youth who will be destined to live with poorer health for longer periods of time than those who develop HL later in life.

Academic Performance

Implications of HL on access to information can also impact academic performance in individuals with HL. Not being able to hear what is being said can impact a person's ability to hear novel, unknown words. In youth, less access to information can cause language and vocabulary deficits (Qi & Mitchell, 2012; Traxler, 2000). Such deficits can decrease the overall academic performance of students, particularly in language arts and math (Hyde et al., 2003). Similarly, performance in reading, math, science, and social studies can be affected (Marschark et al., 2015; Rogers & Clarke, 1980). HL can also impact behavior. Children with HL exhibit more behavior problems than their normal hearing peers (Le Clerq et al., 2019). Children with HL also exhibit lower self-esteem in social domains (Theunissen et al., 2014). Lower self-esteem can cause lower self-confidence and social withdrawal. This can negatively impact academic performance (Giofrè et al., 2017). Poorer outcomes associated with HL are true for children with even mild HL. Children, parents, and teachers may not recognize the signs of HL if it is mild, but

mild HL can negatively impact the child both academically and socially. This can impact a child's future educational and career endeavors.

Job Opportunities

For people with HL, obtaining, maintaining, and succeeding at jobs and careers can be difficult. This can start at a young age. Young individuals with hearing loss often have lower career maturity levels and career decision-making abilities (Furlonger, 1998). This can impact an individual's ability to make age-appropriate career decisions. Lower career maturity can also lead to decreased career satisfaction and success (Ochs & Roessler, 2001). Lower career maturity and career decision-making abilities can make it difficult for individuals with HL to find and keep a job. The Americans with Disabilities Act (ADA, 1990) prohibits workplace discrimination of those with disabilities in all employment-related activities. Employment-related activities include hiring, pay, benefits, and firing. Despite the ADA, individuals with HL are more likely to be unemployed or partially employed than those without hearing loss. Individuals with HL are also likely to receive lower wages and decreased yearly salaries (Jung & Bhattacharyya, 2012). If a HL is acquired later in life due to age or noise exposure, it may impact a person's ability to work at their current or future jobs. This can impact a person's individual economic status and can affect their quality of life. HL may also limit opportunities for careers that require a particular standard of hearing before employment can be obtained (e.g., aviation, military, etc.).

Economics

HL can also affect personal and societal economics. Individuals with HL are typically unemployed or underemployed, which can lead to low-income disparities and economic hardship (Emmett & Francis, 2015). Additional costs of HL can compound economic hardship. Additional

costs can include necessary health care visits, medical hearing devices, and/or education about HL as a condition and its implications. While most HL cannot be prevented, NIHL can. In the context of the bigger society, the prevention of NIHL can equate to an economic benefit of up to $58 to $152 billion dollars (Neitzel et al., 2017). Personal and societal economics can be improved if NIHL is prevented. This can be a good incentive to promote hearing health to youth who will enter adulthood and the workforce, and to adults who can be exposed to excessive sound levels. Promoting hearing health in youth could start at the educational level. However, there are special educational considerations that must be made with students with HL.

Educational Considerations for Students with Hearing Loss

Hearing loss can affect accessibility to all types of sound including speech and language. Without adequate access to speech and language, children with HL don't receive the same information as their normal hearing peers (Nelson et al., 2020). Therefore, children with HL require educational accommodations so that they can receive access to the same information. The Individuals with Disabilities Educational Act (IDEA) requires by law that students with HL are to receive accommodations in the general education classroom to ensure equal access to information. Equal access to information is critical for students to receive a free appropriate education in a least restrictive environment (IDEA, 2004). Without equal access to information, students with HL can fall behind academically. Individual life factors of each student can contribute to lack of access and lowered academic success, as well (Marschark et al., 2015). Life factors and accommodations need to be considered when educating students with HL (Luckner et al., 2012; Luft, 2017; Reed et al., 2008).

Factors Contributing to Lack of Academic Success

Each student with HL has a set of intrinsic or internal factors that can affect their academic performance. Factors include severity of hearing loss, the presence of additional disabilities, and race/ethnicity. Le Clerq et al., (2019) used a sample of nearly 5,000 children and found that students with even slight to mild HL have more behavior problems and worse performance in language and math than their normal hearing peers. It has also been found that severity of hearing loss and the presence of additional disabilities can affect achievement in both reading and math (Rogers & Clarke, 1980). Students who experience HL and additional disabilities like learning deficits, attention deficit disorder (ADD/ADHD), dyslexia, and others can affect academic achievement in language, math, science, and social studies (Marschark et al., 2015). Socioeconomic status and parental education are also factors to consider, but they don't play as much of a role in the academic achievement of students with HL (Powers, 2003).

Teacher Knowledge. While accommodations need to be made to create an inclusive classroom for students with HL, teachers need to how to implement accommodations to meet students' needs. Eriks-Brophy and Whittingham (2013) indicate that teachers generally have positive attitudes and feel confident that they have the knowledge and attitude to provide inclusive classrooms to students with HL. Teachers who are given direct instruction on inclusion have more positive attitudes towards teaching students with HL than teachers who do not have direct instruction (Sari, 2007). Increased knowledge of inclusion in general education classrooms can prepare teachers better to be able to fully accommodate students with HL in their classrooms. This can also help teachers be aware of when and what kinds of accommodations need to be made for each student.

Hearing aids and Cochlear Implants. Hearing devices are important to get students with HL access to information. Hearing aids and cochlear implants are critical medical devices used in the treatment of HL (Banerjee & Garstecki, 2003). A hearing aid is a device that amplifies sound so it can be heard by the user. If the user has more severe hearing loss, a cochlear implant may be needed for them to hear. A cochlear implant works by replacing hair cells in the hearing organ (the cochlea) and sending sounds directly to the auditory nerve to be processed by the brain (Torborg, 2016). Hearing devices give the user more access to sound and linguistic input. Children who are identified with HL and given a hearing aid or cochlear implant early have better language outcomes than those who are not provided with these technologies (Ruben, 2018; Tomblin et al., 2014). Usage time of hearing devices is also a factor in language growth success (Tomblin et al., 2015). Better language outcomes could equate to better language and vocabulary in students with HL, which could improve academic success. However, it can be difficult to get children to wear their hearing devices consistently, especially for children in 5th-7th grade (Gustafson et al., 2017). Students who use hearing devices still fall behind their normal hearing peers (Sarant et al., 2015). Therefore, it may be necessary to make additional accommodations to enable students with HL to succeed academically.

FM Systems. Frequency modulation (FM) systems might also be beneficial to students with HL. Typical classrooms are noisy environments that can pose a challenge to those with HL (Finitzo-Hieber & Tillman, 1978). Classrooms have general noise, but they also reverberate sound that can compound existing noise. Troubling listening situations like a classroom can cause excessive effort and fatigue that can result in lower academic performance in students with HL (Flexer, 1995; Gustafson et al., 2021). To overcome noise, FM systems can be used to increase signal-to-noise ratios (SNRs). A SNR refers to how loud a signal is (i.e., a teacher's

voice, speech) compared to the background noise that's present. Better SNRs provide better access to speech recognition with both normal hearing students and students with HL (Anderson & Goldstein, 2004).

There are two main types of FM systems – sound-field systems and personal systems. Sound-field FM systems work by amplifying a speaker's voice using a microphone and strategically placed speakers in the classroom. Personal FM systems pick up a speaker's voice via an FM microphone. The speaker's voice is then turned into signal that gets transmitted to a receiver worn by a listener (Kreisman & Crandell, 2002). The receiver can be body-worn or behind the ear on a hearing device. FM systems and hearing devices can work independently or together to improve SNR in the classroom and to the student with HL (Larsen & Blair, 2008).

Sound-field FM alone can be beneficial to students with HL. Furno et al. (2020) found that the use of sound-field FM not only increased students' access to speech, but improved attending behaviors and the student's ability to follow directions. However, the use of both hearing devices and personal FM systems has the greatest positive effect on students with HL (Anderson & Goldstein, 2004). Access to speech and better speech perception in the classroom with the use of FM systems could increase academic performance of students with HL (Bertachini et al., 2015). However, there are other accommodations that could improve listening situations in the classroom.

Classroom Modifications. There are a few physical accommodations in the classroom environment that can be made to help students with HL have adequate access to information. Preferential seating allows the student with HL access to more visual information while being in closer proximity to a speaker. Limiting background noise provides students with HL a better listening environment. Noise can be decreased by reducing sound-reflective surfaces. Adding

rugs, curtains, sound-absorbing material on walls and floors, and hanging objects from the ceiling such as paper lanterns can reduce noise in classrooms (Dyre, 2016). Guardino and Antia (2012) wanted to see if modifying the classroom environment would increase academic performance and decrease disruptive behavior in students with HL. Participants ranged from 9 to 11 years old in elementary classrooms. It was determined that classroom modifications like altering seating arrangement (providing preferential seating), limiting background noise, and changes in lighting increased academic performance and decreased disruptive behavior of the 9 participants. Therefore, physical accommodations can create better attentive behaviors in students with HL and can positively impact academic performance. Modifications may also need to be made to technological equipment in classroom.

Technology. Accommodations for instruction involving technology like computers and tablets may also need to be made for students with HL. Digital learning is often implemented into mainstream education. It is becoming increasingly important to give students with HL the same access to technology that their normal hearing peers receive. Firstly, some hearing devices can be directly connected to computer and tablets via wireless Bluetooth connection. This works much the same as connecting hearing devices and FM systems together. Personal FM systems can also be connected to computers and tablets through Bluetooth. Hearing devices and FM connectivity increases SNRs so that students with HL can hear what is going on during the technology activity. Direct connectivity also means direct streaming, where sound coming from the computer or tablet will transmit directly into the student's hearing device (Mecklenburger & Groth, 2016). Separate Bluetooth streaming devices can also be used to wirelessly connect hearing devices and other technology. However, the hearing devices, FM systems, and computers/tablets may not be compatible with each other to connect through Bluetooth. Hard

wire connections are also possible with FM systems if Bluetooth is not an available option. Personal FM systems can be connected directly into audio jacks of computers and/or tablets. A cord can hard wire a computer's audio output directly to the FM system, which could then transmit to the hearing device (Phonak, n.d.).

If connecting hearing devices and computers is not an option, closed captioning/subtitles can be used (Burke et al., 2016). Closed captioning is a real-time transcription of sounds that may occur in digital media. This could be transcription of a talker's speech, music lyrics, or an identifier when instrumental music or environmental sounds (i.e., birds chirping, wind blowing, etc.) are occurring. Closed captions can give students with HL more access to the media that they are consuming via technology in the classroom. Amann (2006) showed the captioned media improved vocabulary scores in middle schoolers with HL and possibly exposed them to novel words they would not have been exposed to previously. This finding may indicate that closed captioning can also be used as a literacy tool for students with HL. The teacher of the student would have to be mindful to choose digital content that provides captions.

While the connection of hearing devices and technology and closed captioning are available, accommodating students with HL while they are using technology has proven difficult. Schafer et al. (2021) found that while more schools have moved to remote learning during the COVID-19 pandemic, accommodations for students with HL have been lacking with the increased use of technology in education. Specifically, closed captioning, notes, and resources to help with technology issues are not implemented as they should be by teachers and administrators. This can cause students with HL to lose access to digital information and miss out on educational content.

STEM Education in Primary Grades

In the primary grades and beyond, there are standards or benchmarks for education in topics like English, social studies/history, mathematics, and science. Educating youth to become problem solvers and critical thinkers is the goal of education in general and is imperative for the framework that focuses on teaching those skills through science, technology, engineering, and mathematics (STEM). STEM can provide youth with the skills they need to gather and evaluate evidence to make decisions and give them the knowledge they need to solve problems in our quickly developing world (U.S Department of Education, n.d.). The use of STEM in education is growing, and there is need for discussion on the rationale for STEM, implementation, and outcomes for youth in the US.

The US and the world have become increasingly complex with problems like those of global warming, depleting energy resources, and overpopulation. The need for knowledgeable individuals who can come up with creative solutions to these problems has drastically increased. This is known as the “STEM surplus”. However, low enrollment and poor student motivation towards science learning does not meet the demand of the STEM surplus (Ali & Shubra, 2010; Elías, 2009). This is the “STEM crisis” referenced in education and government circles. There is both an increase in STEM workforce positions and a decrease in those who are qualified to fill those positions (Xue & Larson, 2015). Those who are going into the STEM workforce also are not being adequately prepared with the skills or knowledge for the challenges that face them once working in their fields (McGunagle & Zizka, 2020). With the combination of a growing demand to fulfill STEM positions in the workforce and insufficient numbers of individuals qualified to fill them, the integration of STEM in our education system has been gaining traction

in recent years. Exposing students to STEM and educating them on STEM-related concepts might aid in both averting the STEM crisis and address the STEM surplus in the US.

Like other educational topics such as English and reading, there are standards for how STEM should be implemented in classrooms across the country. Currently, there are no national standards for STEM education in the US. However, the Committee on STEM Education (2018) of the US Department of Education has devised a 5-year strategy plan to provide life-long access to STEM education and strives to make the US a global STEM leader. To do this, the committee hopes to build STEM literacy for every American, increase inclusion in STEM, and encourage and prepare individuals for the STEM workforce. While the strategy plan will be active until 2023, it has concluded that appropriate steps have been taken by the government to meet the plan's aforementioned goals (Office of Science and Technology Policy, 2020).

Even though there are not any national standards for the implementation and instruction of STEM, there are state standards. The state of Colorado separates STEM into mathematics and science standards. While STEM involves more than mathematics and science, the concepts of technology and engineering can be integrated into these topic areas. STEM education should be seen as an interdisciplinary approach. The interdisciplinary approach enables students to apply what they learn in STEM subjects to other content areas and to the real world (Tsupros et al., 2009). The general Colorado STEM standards are based on Common Core State Standards (Common Core State Standards Initiative, 2021) and are uniform across grade levels including primary grades and beyond. All information about STEM (mathematics and science) standards have been retrieved from the Colorado Department of Education (2020). The Colorado STEM standards are described verbatim as follows:

Mathematics Standards

1. Number and Quantity

   From preschool through high school, students are continually extending their concept of numbers as they build an understanding of whole numbers, rational numbers, real numbers, and complex numbers. As they engage in real-world mathematical problems, they conceive of quantities, numbers with associated units. Students learn that numbers are governed by properties and understand these properties lead to fluency with operations.

2. Algebra and Functions

   Algebraic thinking is about understanding and using numbers, and students' work in this area helps them extend the arithmetic of early grades to expressions, equations, and functions in later grades. This mathematics is applied to real-world problems as students use numbers, expressions, and equations to model the world. The mathematics of this standard is closely related to that of Number and Quantity.

3. Data Analysis, Statistics, and Probability

   From the early grades, students gather, display, summarize, examine, and interpret data to discover patterns and deviations from patterns. Measurement is used to generate, represent and analyze data. Working with data and an understanding of the principles of probability lead to a formal study of statistics in middle and high schools.

   Statistics provides tools for describing variability in data and for making informed decisions that take variability into account.

4. Geometry

Students' study of geometry allows them to comprehend space and shape. Students analyze the characteristics and relationships of shapes and structures and engage in logical reasoning. Students learn that geometry is useful in representing, modeling, and solving problems in the real world as well as in mathematics.

Modeling Across the High School Standards

Modeling links classroom mathematics and statistics to everyday life, work, and decision making. Modeling is the process of choosing and using appropriate mathematics and statistics to analyze empirical situations, to understand them better, and to improve decisions. When making mathematical models, technology is valuable for varying assumptions, exploring consequences, and comparing predictions with data. Modeling is best interpreted not as a collection of isolated topics but rather in relation to other standards. (p. 9)

Science Standards

1. Physical Science

   Students know and understand common properties, forms, and changes in matter and energy.

   PS1 Matter and Its Interactions

   PS2 Motion and Stability: Forces and Interactions

   PS3 Energy

   PS4 Waves and Their Applications in Technologies for Information Transfer

2. Life Science

   Students know and understand the characteristics and structure of living things, the processes of life, and how living things interact with each other and their environment.

LS1 From Molecules to Organisms: Structures and Processes

LS2 Ecosystems: Interactions, Energy, and Dynamics

LS3 Heredity: Inheritance and Variation of Traits

LS4 Biological Evolution: Unity and Diversity

3. Earth and Space Science

Students know and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space.

ESS1 Earth's Place in the Universe

ESS2 Earth's Systems

ESS3 Earth and Human Activity

Science and Engineering Practices

1. Asking questions (for science) and defining problems (for engineering)

2. Developing and using models

3. Planning and carrying out investigations

4. Analyzing and interpreting data

5. Using mathematics and computational thinking

6. Constructing explanations (for science) and designing solutions (for engineering)

7. Engaging in argument from evidence

8. Obtaining, evaluating, and communicating information (p.7)

STEM-Related Academic Outcomes

The definition of STEM and its standards may vary in each state, but the aim is to achieve the same educational outcomes in students, increase their access to STEM material, and prepare

them for possible work in a STEM-related field (Carmichael, 2017). Honey et al. (2014) conducted a meta-analysis of studies that examined STEM integration in education and educational outcomes. They found few studies that correlate STEM integration and student's educational outcomes. Specifically, it can be difficult to promote mathematic achievement using STEM. The National Science Foundation (2014) has found that the average math and science scores of students in primary grades stayed the same from 2007 to 2013. Scores showed that less than half (42%) performed at or above proficient level for their grade level. While most research in this area is limited and inconclusive, it can be argued that a more balanced STEM integration approach could boost student outcomes, specifically in math (English, 2016). This would mean creating curriculums that provide equal instruction in science, technology, engineering, and mathematics.

Students with disabilities are also struggling to achieve well in STEM education. Students with disabilities are often under-represented and less likely to pursue STEM education and career fields (American Association for the Advancement of Science, 2014; National Science Foundation, 1996). Limited access to learning and the lack of accommodations for students with disabilities can hinder their access to, and interest in STEM topics (Mutch-Jones et al., 2012). Students with hearing loss are no exception. Historically, students with HL consistently perform worse in math and problem solving than their normal hearing peers (Traxler, 2000). Weak performance in math and other concept areas could be due to lack of teacher education dedicated to teaching about the provisions of accommodations and/or lack of accommodations themselves in the schools as it relates to students with disabilities. Lack of accommodations can greatly affect the academic performance and outcomes of students with HL. The implementation of STEM has not improved the educational outcomes for students with

HL, and students with HL perform worse in STEM subjects than their normal hearing peers (Luft, 2017). There are many factors that can affect the STEM performance of all students. These include but are not limited to teacher qualifications and training, school factors like time, curriculum constraints, money, and student factors that were previously described.

Teacher Qualifications And Training

The first is the availability of qualified teachers. Lack of STEM teachers contributes to low science and mathematics achievement in students (National Research Council, 2002; U.S Department of Education, 2002). There is also a lack of resources and professional development pertaining to STEM for general education teachers (Morrison et al., 2007; Tsai, 2006). Nadelson et al. (2013) created a 3-day STEM seminar for elementary teachers and found that afterwards, the teachers had increased knowledge, confidence, and efficacy toward teaching STEM. Access to more quality professional development resources could help general education teachers teach STEM.

School Factors Influencing STEM Performance

Time, curriculum constraints, and limited budgets can also contribute to the lack of student access in STEM learning opportunities. The National Science Teaching Association (2018) provides a position statement that mentions that in elementary grades, science instruction tends to suffer compared to mathematics and reading. There are some teachers who cannot provide science instruction more than once a week due to time and curriculum constraints. The same is true for technology and engineering content. It also costs money to implement STEM activities whether it be in the classroom, for special projects, trips, or afterschool STEM programs. If these instructional opportunities cannot be provided to students because of lack of

funding, students will not be able to learn STEM concepts. However, there are several funding opportunities that can help administrators and teachers implement STEM instruction. Funding opportunities in Colorado can be found on the Colorado Department of Education website (https://www.cde.state.co.us/stem/fundingopportunities). General funding options can be found on the US Department of Education website (https://www.ed.gov/stem). As mentioned previously, school factors and student's personal factors (including but not limited to environment, disability, and school accommodations) can impact STEM learning opportunities.

Socioeconomic Status of Students. The socioeconomic status (SES) of students is another factor in student STEM success. Research in this area has consistently shown that high school students who come from lower SES perform worse in science than their peers (Ma, 2001; Maerten-Rivera et al., 2010; Von Secker, 2004). Cooper and Berry (2020) in Australia argue that economic disparities are a crucial factor to consider when determining STEM achievement in school and beyond. This is because those students of lower SES tend to have less access to science concepts which results in lower science literacy and interest. A few studies have even investigated whether lower SES causes poor science achievement in primary grade students. Indeed, lower SES, lower parental income, and lower levels of parental education can decrease science achievement in primary grade students (Betancur et al., 2018; Duncan et al., 2011).

Sex and race also play a role in science achievement in the lower grade levels. There are achievement gaps between those of white ethnicities and those of black, Hispanic, and Asian ethnicities, and a gap between sex (males and females). Quinn and Cooc (2015), found that students of white ethnicities have better science achievement than those of black or Hispanic ethnicities. On the other hand, students of Asian ethnicities achieve slightly better than students of white ethnicities. Similarly, females perform poorer in science than males. SES, sex,

and race can affect the STEM literacy, achievement, and interest of students of all ages.

While there are barriers to STEM education like the ones mentioned above, implementation of STEM in schools is an ongoing process. If initiating a new STEM program in a school, the first place to start would be in science and mathematics curricula that already exist. Common Core and individual states have standards for STEM implementation into the general education curriculum. These standards expand on science and mathematics standards to incorporate hands-on project-based learning. One major implementation of STEM is the integration of STEM subjects (Davison et al., 1995). STEM subjects are often taught in isolation from one another. Integrating subjects together creates a more real-world, multidisciplinary learning experience that STEM strives to provide students (Dare et al., 2018).

Outside of curriculum-based integration, STEM can be implemented in a variety of other ways. Summer programs are effective in engaging students and providing them with STEM content (Anand & Dogan, 2021). Field trips to museums, lectures by guest speakers in the STEM field, and at-home activities can increase students' exposure to STEM content, as well. Virtual, online, and gaming programs are also effective ways of implementing STEM (Halabi, 2020; T. Smith, 2014). Virtual activities can be implemented in the general education classroom during regular instruction, during after school programs, and can also be utilized by students at home. Exposure to STEM content by these means can increase STEM literacy, achievement, and interest for students in general education classrooms. This is the goal of STEM related educational policy and implementation in schools.

Educational Gaming in Primary Grades

The Entertainment Software Association (ESA) studies video games and their use in the US. Based on recent research, about 227 million Americans play video games. Almost 20% of

players are younger than 18 years old, and nearly 80% of all Americans believe that video games can be educational (ESA, 2021). With statistics like these, places of education for preschool up through high school grade levels have tried to harness the power of video games for educational purposes. Student-centered digital game-based learning (educational gaming) is the use of video games to teach students educational concepts (Coleman & Money, 2020). Technically, educational gaming has been included in classrooms for 50 years with the advent of The Oregon Trail in 1971 (Visit Oregon, 2021). The Oregon Trail was an educational computer game that taught students about the life of Americans in the 1800s. Since the 1970s, educational gaming has become more popular in classrooms, especially for the primary grades (Thomas, 2021). Emerging research shows the benefits of engaging in game-based learning and provides rational for implementation in education. Game-based learning can be used for general educational content as well as STEM subjects. Educational games are also used for health learning and promotion for students in primary grades (Bosworth, 1995; Haruna et al., 2021b).

Research describing the positive effects of educational gaming on student achievement and better access to technology has increased implementation of game-based learning in classrooms. Video games are digital media that can be accessed through computers, tablets, mobile devices, and can be displayed via interactive white boards (smart boards). Students can access educational games with electronics that are available in the classroom. Students can also access games at home using personal digital devices. This can increase student access to educational content in environments besides the classroom, promoting anytime, anywhere learning (Shippee & Keengwe, 2012). Educational games can be used for almost any subject including reading, history, art, science, and math. Popular sources for educational video games

for primary grade students include ABCMouse®, Go Noodle®, FunBrain, National Geographic Kids©, and PBS Kids Games© (Croteau, n.d.).

Teachers who had their own positive experiences with game-based learning as students are more likely to implement educational gaming into their classrooms (Stieler-Hunt & Jones, 2015). Learning through educational gaming can have positive effects on students of all ages, even if the gaming is done outside of the classroom. Adachi and Willoughby (2013) examined the relationship between video games, problem solving skills, and academic grades in adolescents. They found that role-playing and strategy video games played outside of the classroom increased self-reported problem-solving skills. Higher self-reported problem-solving skills can predict an increase in academic grades and achievement. Inside the classroom, middle school and primary students who engage in game-based learning also have increased perceptions about their problem-solving skills and critical thinking abilities (Asbell-Clarke et al., 2021; Hwang & Chen, 2017). Game-based learning can also increase student's positive attitudes toward school and overall motivation to learn and participate with material (Miller & Robertson, 2011; Tüzün et al., 2009). Hwang et al. (2012) found that educational gaming can increase learning achievement and promote positive learning attitudes, learning interest, and acceptance of technology use in primary grade students. Sáez-López et al. (2015) report that while educational gaming in middle school students may not directly impact academic performance, students had fun and experienced increased creativity using game-based learning. Educational gaming can increase learning achievements in students and might increase student's perceived problem-solving skills, academic performance, motivation to learn, and enjoyment while learning.

Educational gaming and game-based learning has gotten attention for its applications in STEM. Educational games can focus on many different areas of STEM, including primary grade mathematics, life science, biology, physics, computer programming, and more (F. Gao et al., 2020). The benefits of educational gaming apply to STEM subjects as they do with other subjects. Educational gaming can support STEM learning, problem-solving skills, and increase student performance (Hodges et al., 2020; Lester et al., 2014). The Committee on Science Learning (2011) describe that educational gaming even has the potential to advance learning goals, improve student's motivation to learn, and their overall understanding of STEM concepts. Games promoting STEM education can be used on their own or as additional activities to supplement conventional classroom instruction.

While educational gaming can be implemented into any content area, games can also be implemented with students who have a wide range of abilities. Educational gaming needs to be made accessible to students with disabilities per the IDEA. The IDEA requires by law that students receive equal access to all educational content and information (IDEA, 2004). Accessibility features within digital devices and in games themselves can improve access to students with various disabilities including hearing loss. Specifically, computer-based devices can provide Bluetooth and/or hardware connectivity for students who have HL and utilize hearing devices such as hearing aids and cochlear implants (Mecklenburger & Groth, 2016). Closed captioning and subtitles can also make educational gaming more accessible to students with HL (Burke et al., 2016).

Educational video gaming can also have applications in health promotion for students (Bosworth, 1995; Tolks et al., 2020). The WHO defines health promotion as "the process of enabling people to increase control over, and to improve, their health" (WHO, n.d.). Health

promotion for students is typically achieved through health curriculum in schools. Health promotion curriculum can involve topics including (but are not limited to) physical education (Fu et al., 2019), nutrition (Leong et al., 2021), sex education (Haruna et al., 2021a), and general safety and health practices (Rebollo et al., 2021). Implementing health promotion and education in primary school can increase student's health literacy and can impact health behavior and attitudes as they mature (Campbell et al., 2012). Just as video games can increase motivation and learning enjoyment, they can also be effective in increasing health knowledge and creating health-related behavior change in youth (Baranowski et al., 2008). Educational games that target health promotion concepts use health communication science to change heath attitudes and behaviors in youth while providing fun, interactive environments for students to learn in. Not only is this true for school environments, but educational games can be used by students at home in the same capacity (Shippee & Keengwe, 2012). Having access to health information in school and at home can increase exposure to health-related education.

Health Communication Science

Health communication science is the basis for creating health promotion resources and programs. The goal of health communication is to engage and influence individuals and communities to adopt and maintain healthy behaviors (Schiavo, 2013). Health communication can help individuals maintain and improve health, reduce disease risk, receive health education, and improve health literacy. Health communication theories provide a framework to understand health behaviors, how they change over time, and the environments in which they occur (National Cancer Institute, 2005). The health belief model (Rosenstock et al., 1988), stages of change model (Prochaska & DiClemente, 1983), and the theory of reasoned action/planned behavior (Fishbein & Ajzen, 1975) are the foundations of health communication science. Health

promotion resources need to be grounded in these theories, or they will not be as successful in educating individuals and promoting sustainable, healthy behavior change (National Cancer Institute, 2005). Although the theories are distinctly labeled, they integrate many of the same fundamental constructs. Health communication might also include prevention of risky behaviors. Preventative measures can be primary, secondary, or tertiary.

Health Belief Model

The Health Belief Model (HBM) was one of the first health communication science theories (Rosenstock et al., 1988). This model states that there are six constructs that can influence an individual's decision to make and implement health-related behavior changes: perceived susceptibility, perceived severity, perceived benefit, perceived barriers, cues to action and self-efficacy. Perceived susceptibility is a person's opinion about whether they are susceptible to a certain health condition. Perceived severity is a person's opinion of the severity of a health condition. Perceived benefit is a person's opinion of the benefit they will receive from taking action to change a health-related behavior. Perceived barriers are a person's opinion about the costs of taking action to change. Cues to action are events that can cause a person to want to implement action. Self-efficacy is a person's opinion about whether they can successfully perform and integrate an action. These six constructs relate to a person's motivation to act on a health-related behavior.

Stages of Change Model

The Stages of Change Model (SCM) or the Transtheoretical Model states that there are six stages a person must go through before being ready to act toward creating healthy behaviors (Prochaska & DiClemente, 1983). A person can move through the stages in a nonlinear fashion. Precontemplation is the stage in which a person is not aware of a problem and either has not

thought about acting or has no intention of acting against it. Contemplation occurs when a person becomes aware of a problem and has an intention to act soon. Preparation occurs when a person plans how they are going to act and adjusts their action plan beforehand. Action occurs when a person implements their plan to act and makes a behavioral health change. Maintenance occurs when a person continues to implement their plan and change their behavior but may struggle to prevent slipping back into their old habits. Termination occurs when a person has changed their behavior permanently and there is no risk of slipping into old habits. These six stages relate to behavioral change as a process, not singular event.

Theory of Reasoned Action & Theory of Planned Behavior

The Theory of Reasoned Action (TRA) is a person's intention to perform a certain behavior based on their attitude and the influences of their environment (Fishbein & Ajzen, 1975). A person's attitude toward a certain behavior can be positive or negative. Intention and attitude can be influenced by a person's perceptions of the outcomes of their actions, perceptions regarding the beliefs of others about the behavior change, and the person's motivation to conform to other's ideas or desires. The Theory of Planned Behavior (TPB) is a person's opinion on their ability to control their behavior. These theories are based on a person's intentions, attitudes, beliefs about their environments, and beliefs about their ability to change and control their behavior.

Social Cognitive Theory

Social Cognitive Theory (SCT) or the Social Learning Theory states that personal factors, behavior, and the environment influence one another (Bandura, 1986). There are six concepts that can influence behavior change. Reciprocal determinism (reciprocal causality) refers to the

relationship between the person, their behavior, and their environment. Expectations are a person's view of the intended outcomes of a behavior change. Behavioral capability is the knowledge and skills a person needs to exhibit a certain behavior. Self-efficacy is a person's sense of self and their confidence in taking action despite possible obstacles. Observational learning/modeling refers to the outcomes that can arise from watching the actions and behaviors of others. Reinforcements are the responses to behavior that help a person determine whether they will repeat a behavior or act to change it. Reinforcements can be positive or negative and can impact a person's decision to engage in certain behaviors.

Prevention

Health communication can also include prevention of unhealthy behaviors and habits that can cause harm to an individual. There are three types of prevention. Primary prevention aims to avoid the development of a disease altogether. Secondary prevention aims to diagnose and treat a disease before it causes significant affects. Tertiary prevention seeks to reduce the negative effects of a disease by restoring function and reducing complications. Hearing health promotion can include any of the three types of prevention, but it is most commonly a primary preventative measure.

Summary

The theories of health communication influence how health promotion resources are planned, implemented, and how successful they are in influencing people to make positive health-related behavior changes. Health promotion can be geared towards individuals of all ages, knowledge, and abilities. Disseminating health knowledge to youth can be especially critical. Health promotion can increase youth health literacy over time and can help youth integrate healthy behaviors sooner (Knisel et al., 2020). However, it is important to consider the type and

content of health promotion programs, the medium through which they are provided to youth, and the audience they are targeting. Polivka and Ryan-Wenger (1999) suggest that health education and promotion need to be tailored to different subgroups of children. Age, sex, ethnicity, and socioeconomic status are factors to consider when selecting an appropriate health promotion initiative that will be affective. There is also a myriad of ways health promotion can be presented to youth. Health information can be included into health curriculum, internet-based, activity-based and/or game-based (sports games, board games, and video games). Health interventions that utilize digital media can be just as effective in providing positive outcomes as direct instruction (Fedele et al., 2017). Considering the health communication theories and the extent of health promotion initiatives can be crucial in promoting health literacy and health behavior in youth.

Hearing Health Promotion for Youth

Health promotion for youth can include critical information about all areas of health. Health concepts like nutrition, exercise, and mental health are just a few examples of areas that can be covered in health promotion initiatives. Hearing health can also be included. However, hearing health is not an area of focus of many health promotion initiatives. HL, specifically NIHL, should be considered a health problem that needs addressing. This is because NIHL can have negative implications on a person over a lifetime. It is also prevalent in younger populations. Up to 15% of youth ages 12 to 19 years of age have some degree of NIHL (Su & Chan, 2017). NIHL is preventable if an individual has the information and knowledge about how to lower the risk of NIHL. However, knowledge about the risks of listening to excessive sound levels and prevention of NIHL is lacking (Gilles et al., 2013). In fact, most individuals do not know that NIHL is a problem and that there are steps they can take to reduce their risk (Gilliver

et al., 2015). Therefore, it is important to promote early access to knowledge about hearing and healthy hearing behaviors using health promotion. Hearing health promotion can have a greater impact early on if it is geared towards youth. Early awareness of hearing health can ultimately prevent NIHL and reduce its prevalence in the population (Jiménez-Tejada et al., 2012).

Dangerous Decibels® Program

Hearing health promotion targeting youth has been implemented in many forms. An example of a hearing health promotion classroom instruction program is Dangerous Decibels®. Dangerous Decibels is an interactive program that teaches youth about sound, anatomy of the ear and hearing mechanism, NIHL, and how to prevent NIHL (Griest, 2008). Indeed, Chermak et al. (1996) found that classroom educational content can improve elementary students' knowledge about NIHL, what causes it, and what can be done to prevent it. However, gaining knowledge often is not enough to change risky behaviors. Sobel and Meikle (2008) describes that health communication theories need to be implemented into hearing health promotion programs. This can help individuals increase their knowledge and change their attitudes and behaviors about a health problem. The Dangerous Decibels classroom instruction program implements health communication science and theories into its curriculum, not just educational content. The Dangerous Decibels curriculum is intended to communicate three core messages related to hearing health. These three messages are:

1. What are sources of dangerous sounds?
2. What are the consequences of exposure to dangerous sounds?
3. How can I protect myself from dangerous sounds?

The three core messages of the Dangerous Decibels program help youth increase their knowledge about hearing health, change their attitudes about their hearing health, and change their behaviors to protect their hearing (Martin et al., 2013).

Dangerous Decibels activities have branched into many forms including classroom instruction, museum exhibits, and internet-based virtual content. These are platforms for engaging youth in hearing health content. Martin et al. (2013) found that all three of these platforms improve knowledge, attitudes, and behaviors regarding hearing health in youth. Fifty-three fourth grade classrooms (a total of 1,120 students) from Oregon and Southwest Washington participated in the study. Participants were grouped into four intervention groups and one control group. Baseline, immediately post-intervention, and 3-month post-intervention questionnaires were given to students to determine the effectiveness of each platform in terms of positive changes in knowledge, attitudes and intended behaviors. Each of the Dangerous Decibels activities and their effectiveness as described by Martin et al. (2013) are detailed below.

Classroom Instruction. Two of the experimental groups were given the Dangerous Decibels 50-minute interactive classroom instruction programs. Both school nurses (health professional educators) and high-school students (older-peer educators) were used to deliver the program to the study participants. Delivery by the school nurses yielded significant improvements between baseline and immediately post-intervention questionnaire scores in 11 of 11 knowledge-based questions. Improvements were also noted 3 months post-intervention for 9 of the 11 knowledge-based questions. Significant improvements were also noted in both attitude and behavior-related questions immediately following the intervention and 3 months-post intervention. Program delivery by high-school students also yielded significant improvements between baseline and immediately post-intervention questionnaire scores for 10 of the 11

knowledge-based questions. Improvements were maintained 3 months post-intervention for 8 of the 11 knowledge-based questions. Significant improvements were found in 1 of two attitude questions post-intervention but was not maintained at 3 months post-intervention. Intended behavior improvements existed both immediately post-intervention and at 3 months post-intervention. These results confirm that the Dangerous Decibels program can be delivered by health professionals or older-peer educators with positive effects. This could be because the use of role-models can influence health behaviors in youth (Reding et al., 1996; Starkey et al., 2009). It was determined that implementing the Dangerous Decibels classroom program can improve knowledge, attitudes, and behaviors regarding hearing health better than the other two other platforms (museum exhibit and internet-based virtual content).

Museum Exhibit. There was a museum exhibit that modeled the Dangerous Decibels classroom instruction that was hosted by the Oregon Museum of Science and Industry (OMSI) for ten years. The museum exhibit aimed to teach youth about the three core messages of the Dangerous Decibels program. The exhibit also provided a space for students to take responsibility for their learning and explore concepts on their own. Components of the exhibit included a giant ear, a puzzle of ear structures, HL simulations, hearing protection options, and an activity on how to select proper hearing protection devices. This specific exhibit produced improved knowledge-based questionnaire scores for only 6 of 11 questions. Improvements were sustained 3 months post-intervention for only 2 of the 11 questions. Improvements were also obtained for 2 of the intended behavior questions immediately post-intervention, but those improvements weren't sustained 3 months post-intervention. There was no significant improvement in attitude questions. These findings suggest that the museum exhibition approach was not as successful at providing long-term benefits of hearing health attitudes and behaviors

when compared to the classroom program delivery. This could be because the exhibit was more self-directed than the other forms of the program. Despite this, museum exhibits can be a fun, interactive way to expose youth to the effects of sound on hearing.

Virtual Exhibit. A virtual Dangerous Decibels exhibit (now called dBZone!) was also available as a hearing health promotion activity geared towards younger audiences. Students could access the dBZone! through computers in their school computer labs. Much like the in-person OMSI museum exhibit, the virtual exhibit was centered around the core messages and content that were involved in the Dangerous Decibels classroom program. Students could navigate without guidance (on their own) through eight online activities to teach them about hearing health. The virtual content produced significant improvement between baseline and post-intervention scores for 10 of 11 knowledge-based questions. Improvements were maintained 3 months post-intervention for 7 of 11 of the knowledge-based question. Both behavior items and 1 of 2 attitude items were significantly improved immediately post-intervention but diminished 3 months post-intervention. Even though this format did not achieve long-term positive outcomes, virtual content platforms should be considered for future hearing health promotion programs. This is especially true for digital/virtual content. This is because youth value collaborative and technology-rich learning. They also see value in virtual learning environments (Bekebrede et al., 2011). Student enjoyment in virtual learning environments has implications for hearing health promotion using computer-based technology and can evolve to using computerized gaming as a potentially effective hearing health promotion platform.

Martin et al. (2013) examined the value of different hearing health promotion formats on youth. While classroom instruction provided the most significant benefits to the study participants, there is value in exploring other platforms. A gold standard option would be to

provide classroom instruction and then a "booster" program afterwards so that attitudes and behaviors can be maintained over time more effectively. Knobel and Lima (2014) implemented a workbook intervention following the Dangerous Decibels classroom program. Other "booster" programs could be used in the same way. The promising effects of educational video games on youth might point to success in implementing a computer game-based hearing health promotion tool as a booster to classroom instruction.

Serious Games

Health promotion video games have some potential to increase health knowledge and change attitudes and behaviors. Most research in this area targets physical activity and nutrition. Peng et al. (2013) reviewed seven studies that examined the effectiveness of active video games (AVGs). AVGs incorporate movement into their gameplay. Some examples of AVGs include Wii U Sports and Xbox One Connect. Across these studies, it was concluded that AVGs enable young players to engage in light-to-moderate physical activity. Players also tended to be so engaged with the game that they were unaware of any physical exertion. Z. Gao (2017) also evaluated research examining at the effectiveness of AVGs on physical activity and overall health. Across 9 studies, it was found that AVGs can increase physical activity in children and adults. Augmented reality games that require a player to walk around and explore their surroundings can also elicit health behavior changes. Pokémon Go was a popular augmented reality game that encouraged players to be physically active while interacting with nearby players, local neighborhoods, and historical sites. In conclusion, AVGs and augmented reality games could be legitimate, entertaining ways to improve physical health behaviors in youth.

Espinosa-Curiel et al., (2020) studied the effectiveness of an educational video game called "FoodRateMaster" in 60 children between 8-10 years old. The game was designed to

promote physical activity, increase players' knowledge about healthy and unhealthy foods, decrease their intake of unhealthy foods, and increase their intake of healthy foods. Participants played the game 2 times a week for 6 weeks. They were given a food frequency questionnaire before playing the game and one day afterwards. After playing the game, participants significantly improved their knowledge about healthy and unhealthy foods. Post-game, participants' ability to identify healthy and unhealthy foods increased by almost 11 points out of 90 items. Participants also self-reported an increase in their food frequency intake of healthy foods (cauliflower and broccoli) from 0 to 3 points. They also decreased their consumption of unhealthy foods. These findings suggest that video games can be useful in providing health knowledge and behavior change.

Other research has emerged that examines video games that promote other health topics. There are games that focus on asthma-related knowledge and self-care behavior (Bartholomew et al., 2000), skin cancer and sun protection (Hewitt et al., 2001), diabetes (Lieberman, 2001), and many more. The findings of these studies point to increased knowledge about health topics and increased healthy behaviors. If video games can help improve health knowledge and behaviors regarding those listed above, a video game for youth that focuses on NIHL could also increase knowledge and change attitude and behaviors towards hearing health. It might also be fun, engaging, and entertaining at the same time.

Recently, a computer-based game (which can be accessed using computers, tablets, and smartphones) called Song of the Starbird (SOTSB) has been designed to promote hearing health in the context of STEM education. This game leverages the constructs within the Dangerous Decibels programs and targets students in 4^{th}-5^{th} grade (youth ages 8-12). SOTSB is set in an alien world where the inhabitants' hearing has been damaged. The aliens can no longer hear the

Starbird's music, so the Starbird has disappeared. The player is the hero of the game and must find a way to bring music and the Starbird back to the inhabitants of the alien world.

In level 1 (The Yard), the players (students) start out as a creature without hearing, whose silent world is muted in sound and color. Players then build their own artificial ear from parts they have discovered while navigating through the game. Once the ear is built, it allows them to experience the game with lively sound and vibrant colors. Figure 1 depicts level one of the game.

Figure 1

Song of the Starbird Level 1: The Yard

A

B

C

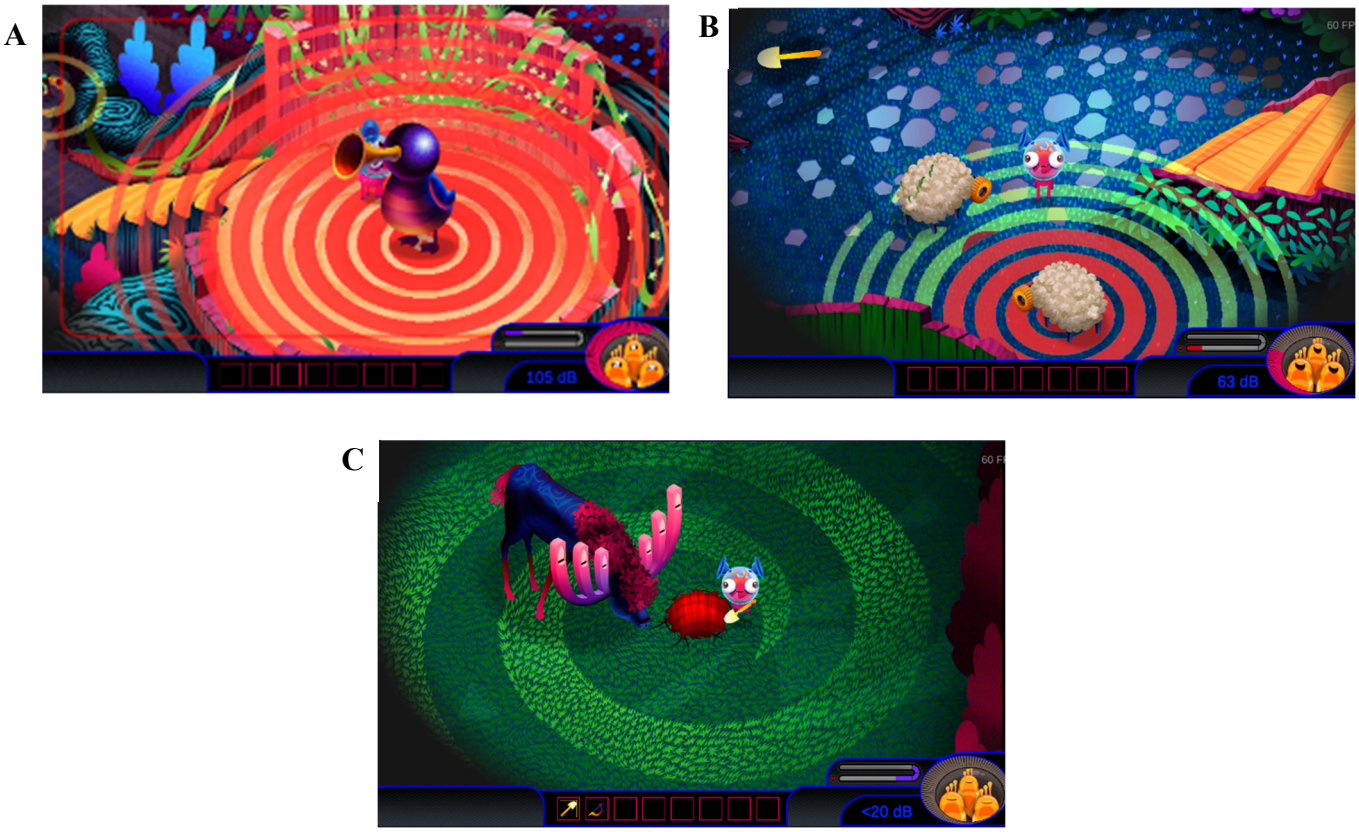
Note. Screenshots from Song of the Starbird. Images used with permission. Panel A: The Yard void of color. Panel B: Building of the artificial ear. Panel C: The Yard in color.

In level 2 (The Forest), the players use a dB meter within the game to navigate their character through a forest filled with creatures that produce loud sounds. These sounds can

damage the tiny sensory cells in their character's cochlea. They learn that hearing can be damaged by high levels of sound. They practice the strategy of "walking away" to avoid hearing damage. Figure 2 depicts level 2 of the game.

Figure 2

Song of the Starbird Level 2: The Forest



Note. Screenshots from Song of the Starbird. Images used with permission. Panel A: Loud sound rings. Panel B: The Forest with creatures. Panel C: Creature in the Forest.

In level 3 (The Swamp) players explore how the sense of hearing is needed to hear quiet sounds. They learn that earmuffs can be worn to protect the ears from dangerous sound levels. Figure 3 depicts level 3 of the game.

Figure 3

Song of the Starbird Level 3: The Swamp

A

B

Note. Screenshots from Song of the Starbird. Images used with permission. Panel A: The Swamp. Panel B: The Swamp creatures and sound rings.

In level 4 (The Caverns), the players learn how sound is shaped by the materials around them. Here, players explore the concepts of sound reflection, absorption, and transmission. Figure 4 depicts level 4 of the game.

Figure 4

Song of the Starbird Level 4: The Caverns

A

B

Note. Screenshots from Song of the Starbird. Images used with permission. Panel A: The Caverns. Panel B: Sound reflections in The Caverns.

In level 5 (The Canyon), players vary sound amplitude (loudness) and frequency (pitch) using a sound adapter ring. The sound adapter ring breaks apart crystal formations blocking the player's way forward. Here, players learn that sound has power. The final challenge in the game is to put together all the shattered pieces of the lost musical instrument they find along their journey to play a long-lost melody to call the legendary Starbird back to the planet. Figure 5 depicts level 5 and completion of the game.

Figure 5

Song of the Starbird Level 5: The Canyon

A

B

C

Note. Screenshots from Song of the Starbird. Images used with permission. Panel A: The Canyon. Panel B: Sound has power. Panel C: Song of the Starbird.

The goal of SOTSB is to teach youth about the dangers of listening to high levels of sound for long periods of time. There are also opportunities for youth to learn about the anatomy of the ear, the effects of hearing loss, and strategies to prevent NIHL. The formative and summative study regarding the hearing health promotion and STEM learning outcomes is currently underway. It is likely that the SOTSB game will have applications in classrooms, libraries, after school programs, and in homes. It might also have applications in other settings where hearing health care is provided. Hearing health promotion using serious gaming can be carried out in educational, clinical, medical, and private practice settings. SOTSB can be

implemented into any of these settings and may give youth the hearing health information based upon health communication science to prevent NIHL.

CHAPTER 2

CLINICAL APPLICATIONS

Hearing health promotion is needed to decrease harmful behaviors that can lead to NIHL. In turn, the prevalence of NIHL within the population can be decreased. Preventing NIHL is important because NIHL can cause negative effects on both the individuals who acquire NIHL and the economy. Effects of NIHL include decreased quality of life, communication barriers, economic hardship, etc. By using hearing health promotion to teach individuals about the possible dangers of sound, NIHL and its effects can be limited. Audiologists can provide education about the risks involved with acquiring NIHL and how NIHL can be prevented.

Primary prevention for NIHL can be provided to individuals of any age. However, hearing health prevention and promotion can be especially effective at limiting NIHL and risky listening behaviors when it is directed to youth (Centers for Disease Control and Prevention, 2022). Early access to hearing health knowledge can increase health literacy and improve hearing hygiene in young people before any hearing damage occurs. For this reason, audiologists can provide tools to youth in ways that are effective in changing attitudes, beliefs, and behaviors regarding hearing health.

Implementation of the Song of the Starbird Game

A tool that has the potential to support the goal of hearing loss prevention in youth is a computer game based on health communication science and STEM concepts. The SOTSB hearing health promotion game can be implemented in a variety of clinical and educational

settings. Providing a fun, interactive way for youth to learn about hearing health in places they are familiar with can increase their access to hearing health information. Audiologists can be the first to provide this game in their places of work. As detailed by IDEA, audiology services should include "provision of services for the prevention of hearing loss" for children birth to 2 years of age and "creation and administration of programs for prevention of hearing loss" for school-aged children (IDEA, 2004). Therefore, provision of the game could help audiologists fulfill their role in public health and education targeting youth and their guardian(s).

Audiologists have access to and work in a wide range of environments. They can provide services in the military, academia, and industry (American Speech-Language-Hearing Association, n.d.). Of particular interest are the settings in which audiologists provide services to children (pediatric populations). These settings include schools, hospitals, medical clinics, and the greater community. These are all environments in which the SOTSB game can be implemented for the enjoyment and education of youth and their guardian(s). The game can be incorporated into audiological practice settings in many ways, as each setting has unique opportunities for educating youth about hearing health. Ideas about the clinical applications of the SOTSB game will be detailed by each work setting that an audiologist might occupy.

Educational Setting

Audiologists can work in educational settings for school systems that serve students from early Head Start to 12th grade. Audiologists have a pivotal role in providing hearing health care services to students and making sure that students with HL have access to accommodations. While audiologists serve students of all ages, the SOTSB game is catered toward 4th-5th grade students. There are unique opportunities for audiologists working in educational settings to implement the SOTSB game to 4th and 5th grade students to educate this age range (8-12) about

their hearing. Some of the methods of implementing the game in an educational setting have the potential to be used in other settings, as well.

The most effective way to implement the SOTSB game in schools and classrooms would be to provide the Dangerous Decibels program to students and use the game as a booster activity following the program. Using the game as a booster would encourage long-term knowledge, attitude, and belief changes regarding hearing health in youth. Providing the Dangerous Decibels program and a booster with game play for students in 4th and 5th grades would be the most impactful method of disseminating the game in an educational setting. This is because the Dangerous Decibels program is an evidence-based hearing health intervention that has been shown to encourage knowledge, attitude, and belief changes in youth (Martin et al., 2013). A series of steps to implement the Dangerous Decibels Program and the SOTSB game are as follows and are described further:

1) Become a certified Dangerous Decibels Educator.
2) Participate in "Song of the Starbird" game training.
3) Deliver the Dangerous Decibels Program to youth.
4) Provide the SOTSB game to students.

Become a Dangerous Decibels Educator

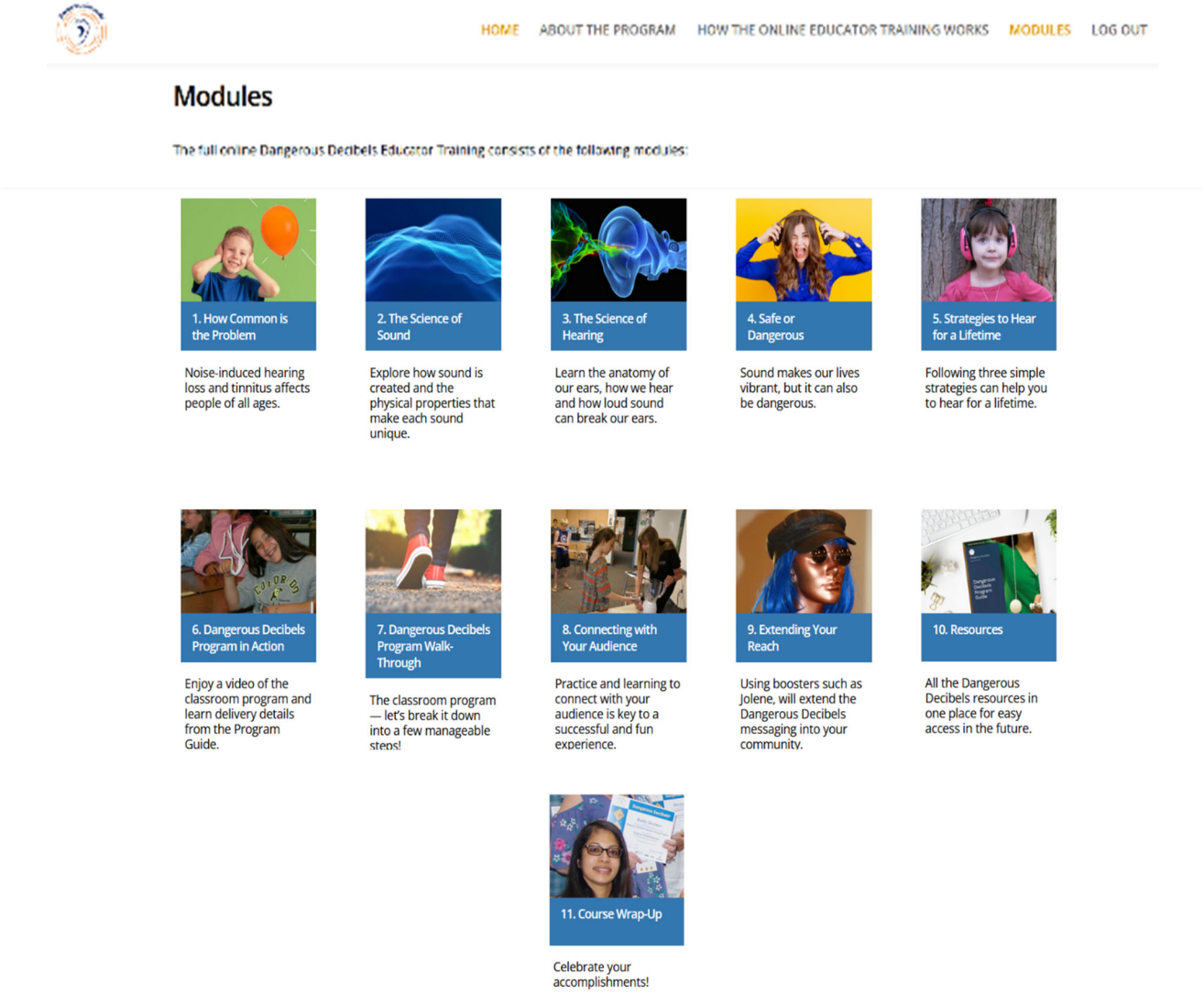
To become a certified Dangerous Decibels Educator, an audiologist could visit the Dangerous Decibels website (https://dangerousdecibels.org/) to learn more about the program. If they are interested in providing the program to students, they will need to contact Dangerous Decibels (dd@unco.edu) and participate in a Dangerous Decibels training program to become a certified Dangerous Decibels Educator.

The Educator training program is a 2-day workshop that prepares anyone interested in providing the Dangerous Decibels program to deliver the program to youth and adults. Educator workshops have temporarily been suspended due to the COVID-19 pandemic, but by emailing the program, audiologists can request updates about possible upcoming educator workshops and can attend one in or close to their area. The educator workshop is open to all who want to provide the Dangerous Decibels program to youth, so teachers and other professionals in the district where the audiologist works could also attend. A sample email to Dangerous Decibels can be found in Appendix A.

Online training is being developed to provide wider dissemination of the training workshop content. The online training is currently being utilized in a research project with 4th and 5th grade teachers and high school students. It is expected that the online training will be an option for individuals to become certified Dangerous Decibels Educators in 2023. Currently, the online training consists of 11 modules that provide background on sound, hearing, hearing protection, how to deliver the Dangerous Decibels program, and resources for future use. Figure 6 below displays the 11 learning modules included in the online training.

Figure 6

Dangerous Decibels Online Training Modules



Note. Screenshots from the Dangerous Decibels® Online Training program. Images used with permission.

The information provided in the Dangerous Decibels training is essential for an individual to understand the concepts that are covered in the SOTSB game. Having knowledge about the concepts in the game can help those disseminating the game articulate its possible benefits to others and those who are playing the game.

Participate in Game Training/Practice

While learning the underlying concepts of the SOTSB game is important, it is also important to learn how the game itself works. Audiologists and individuals who disseminate the game to others should first participate in game training. This includes reading the guide that comes with the game and completing a playthrough of the game a few times to get an idea of its mechanics and playability. The game includes help links if a player needs further coaching while playing the game to help them move through the levels of the game.

Game Guide. The first step to the game training would be for participants to read and understand the SOTSB game guide. An instructor can print out the game guide and provide it to participants who take the training. While the game guide is specific to providing the game in an educational setting, anyone can read it to learn more about the rationale for implementation of the game and how to play the game. The guide includes information about game mechanics (controls), a walkthrough of each level (labeled maps), and pictures with identifying markers about important information (i.e., "sound is dangerous"). Troubleshooting information is also provided for various issues that may occur when playing the game. The instructor can highlight key components of the game guide and provide detailed information about how to access, play, and troubleshoot the game. The game guide can be found in Appendix B.

Game Playthrough. After reading the game guide, training participants should play the game a few times through. This can give them an idea of how the game works, but it can also provide a way for participants to understand and connect concepts from the Dangerous Decibels training and apply them to the game. Since everyone who wants to disseminate the game may not be able to participate in the Dangerous Decibels program, playing the game a few times through can help them learn about the concepts in the game and how they relate to hearing

health. Participants can also practice pointing out important aspects of the game and explaining them in ways that can be understood by a wide audience who may be playing the game (especially young children). The help buttons within the game can provide further assistance if needed throughout the game play process. Following game practice, an individual is better equipped to provide the game to people of all ages.

Provide Dangerous Decibels Program To Students

Once the Dangerous Decibels Educator and game training has been completed, the audiologists, teachers, or other professionals are equipped to provide the Dangerous Decibels program to students. Audiologists and teachers who have become certified Dangerous Decibels Educators can advocate for the Dangerous Decibels program to be integrated into school instruction. An audiologist who wants to provide the program to students may have to get special permission from district/school administration and teachers before doing so. The audiologist will also need to coordinate with teachers and their class schedules to find ideal times to provide the program to students. The program might be most effective if given during STEM or health instruction, during special instruction, or during after school programs. Ideally, because the audiologist is the expert in prevention and hearing health, they should deliver the program directly to students. However, any trained Dangerous Decibels Educator (like teachers) can adequately provide the program.

Provide the SOTSB Game To Students

After providing the Dangerous Decibels program, the SOTSB game could be provided to students to supplement their long-term learning about hearing health. This can either be done immediately after providing the Dangerous Decibels program, or a few days or weeks following

the program. An audiologist who has access to the game may need to work with school administration, information technology (I.T.), and/or teachers to make the game available to students. Most schools will have the technology needed to provide the game like computers, tablets, etc. However, accessing the game via internet connection may be difficult. This is because schools typically have extensive firewall protection. Internet protection may make the game inaccessible, unless given certain permissions from I.T. or administration. Once internet access to the game has been granted, students can play the game on technology they have in the classroom, the library, or computer lab. The SOTSB game could be implemented any time students are using these devices and are allowed by the teacher. Often, students will participate in "centers" where they rotate around the classroom and participate in various activities. Centers can include playing educational games like SOTSB on tablets or computers in the classroom. Students can interact with the game freely while being reminded about the hearing health knowledge they have received via the Dangerous Decibels program. While this would be the ideal implementation of the SOTSB game following the Dangerous Decibels program, there are other opportunities audiologists have to expose students to the game and the hearing health information it provides.

Hearing Screenings

Outside of classrooms, a major role educational audiologists have in the school system is providing or supervising annual hearing screenings to students. IDEA requires schools to identify, locate, and evaluate all children with disabilities (IDEA, 2004). Hence, hearing screenings are necessary to identify children who may have hearing loss. Hearing screenings are often mandated by state departments of education. In Colorado, the Colorado Department of Education (2017) requires school hearing screenings and sets standards of implementation.

Hearing screenings are used to assess hearing status in students from preschool up to 12th grade. Educational audiologists typically oversee school hearing screenings, even if they do not perform the screenings themselves. During these screenings, audiologists, technicians, and/or community volunteers go to each school in the district or area where they provide services and students will come get their hearing screened. During this time, students are typically waiting for their turn to be tested. This could be a convenient opportunity for an audiologist to implement the game to school-aged children. Students could play the game on tablets or computers before, while waiting for, or after testing so that they can learn about hearing health. To do this, the audiologist would first have to talk with I.T. and administration to allow the game to be accessed past internet connection firewalls at the school. Once the game can be accessed at the schools, the audiologist can send out flyers to teachers letting them know when hearing screenings are occurring and how they can provide the game to their students. A sample flyer to teachers can be found in Appendix C. The person who is performing the screenings could also provide flyers to students who have passed their hearing screening. Students could take them home and give them to their parent(s)/guardian(s). These flyers could indicate that the student passed their hearing screening and encourage the child to play the SOTSB game to learn more about hearing health. Parent(s) and/or guardian(s) can play the game with their child and learn about hearing health, as well. A sample flyer for parents can be found in Appendix D.

Special Instruction

There are also opportunities to disseminate the game to students during special instruction, after school, and during the summer. School libraries would be a great place for students to participate in the Dangerous Decibels program and play the SOTSB game to explore hearing health. If classroom time is difficult to access, the educational audiologist might have an

opportunity to provide the Dangerous Decibels program to students during times when they are in the library. Educational audiologists can contact and work closely with librarians to create resources for students regarding knowledge about hearing, hearing health, and hearing loss. Librarians can incorporate hearing health content to a daily lesson and have students play the game during or afterwards. Librarians can also help audiologists provide the game to youth during after school programs and over the summer months when school is not in session. After school programs and summer programs are offered to students for various reasons. Programs are often geared towards enrichment content and activities. Implementing the Dangerous Decibels program and including the SOTSB game would be a good way to educate youth about hearing health in an environment where students may not even know they are learning. This could also eliminate barriers that may come with trying to get that content incorporated into the school curriculum and classrooms. A sample after school program flyer can be found in Appendix G. Outside of schools, there are other settings where the SOTSB game can be implemented.

Hospital Practice Setting

Audiologists can provide inpatient and outpatient hearing health care services to individuals receiving care at a hospital. Audiological services can be provided at general hospitals, Veterans Affairs hospitals, field hospitals, and children's hospitals. Children's hospitals are unique because their patient population can include individuals from birth all the way up to adulthood (18-21 years old), including their families and siblings. If SOTSB is implemented into a children's hospital setting, a broad range of individuals could have access to the game including children, adolescences, teenagers, and adults. The game can be provided via computers and tablets in common areas, email, and Quick Response (QR) codes on flyers around the hospital. Children's hospitals also often have special programs and activities for patients and

families to be involved in. Opportunities for art, music, and entertainment can be provided to young patients throughout the hospital and even their own personal rooms. Enrichment activities are often created and provided by hospital volunteers. With the help of hospital audiologists, volunteers could participate in Dangerous Decibels Educator training and game training to help them implement hearing health activities and the SOTSB game in both outpatient and inpatient settings.

The first step for an audiologist planning to implement the use of the SOTSB game within a children's hospital might be the hospital's volunteer or internal activities coordinator(s). Contact information for volunteer coordinators can often be found in hospital staff directories or through a Google search for volunteer programs for specific hospitals. If no volunteer coordinator is listed, the person in charge of handling volunteer applications would be the next point of contact. From there, the audiologist can work with the volunteer coordinator to get permissions to implement the game into existing enrichment programs or set up an entirely stand-alone program. The audiologist and volunteer coordinator can also communicate to set up and implement a training program where volunteers can participate in the Dangerous Decibels training and game training. This way, volunteers can learn about hearing health, the SOTSB game, and the game's message. Volunteers will also be able to assist children and families while they are playing the game and can communicate supplemental information players may need to know to make the activity effective. Audiologists would be the initial trainers, but the volunteer coordinator or a designated volunteer that is a certified Dangerous Decibels Educator and who have received game training could provide training to other volunteers.

Computers and Tablets

Children's hospital settings provide an opportunity to implement the game even to patients who are not receiving audiological services. The SOTSB game is internet-based, so a traditional CD or computer download is not necessary for players to access it. They must also have access to the internet and have technology like a smartphone, computer, or tablet to access the game. Volunteers could access the game on computer and tablets and provide them to children between appointments or during activity times. Volunteers could also bring tablets to the bedside and provide patients with the opportunity to be entertained while learning about hearing health. Hospitals that implement the game have the potential to reach a wide range of individuals that could increase overall hearing health knowledge in a large group of people.

Patient Communications

The game could easily be attached to email or newsletter communication to patients and their families. Email communication would be an appropriate approach to disseminating the game. If the patient is a child, email communication can be established with their parent(s) or guardian(s) following an appointment with an audiologist. A post-appointment email could contain notes, results, recommendations from the appointment, and a link to the SOTSB game. The email communication might include information about what the game is, who it is designed for, and the importance of early prevention of NIHL to help youth understand their responsibility to practice safe listening behaviors and habits. This could motivate guardian(s) and children to take the opportunity to play the game and learn about hearing health together. Providing access to the game via email can enable younger patients and their families to play the game at home following their appointment with an audiologist. Not only can this provide hearing health information to youth, but it can also help young patients retain information they might have

learned during an audiological appointment. Retaining basic knowledge about hearing health with the help of a computer game could likely make youth more apt to engage in heathy listening behaviors. Sending the game through email can be a quick, low-cost way for clinical audiologists to disseminate a hearing health promotion game to youth, providing those patients have the tools necessary to access it at home. A sample email to guardian(s) can be found in Appendix E.

Quick Response (QR) Codes

A QR code can store data (including internet links) that can be read by smartphone cameras. Quick response codes containing the link to the game could be posted on flyers on the walls anywhere throughout the hospital. Guardian(s) and older children can scan the QR codes with their smartphone cameras and the game will pop up on their phone. Then, they can play the game anywhere in the hospital. Access to the internet would be necessary to play the game, and information about how to access wi-fi in the hospital can be provided on the flyer as well as the QR code. A sample flyer can be found in Appendix F.

Clinical/Medical Office Setting

Most audiologists practice in clinical or medical settings. Clinical or medical settings include outpatient audiology and/or ear-nose-and throat (ENT) practices, along with speech and hearing clinics. The SOTSB game can be implemented in many ways in this type of setting using some of the same strategies as a hospital practice setting. The first way would be through email. Email communication can be established with adult patients who come into the clinic, as it is likely that they will know children or families that could benefit from playing the SOTSB game. Another application of the game in a clinical setting could be via laptop or tablet computers in waiting or counseling rooms. To accomplish this, clinics need to already have or acquire a laptop

or tablet that patients can use to access the game while in the clinic. This can give young audiology patients access to the game before an appointment as an easy way to spend wait time. Additionally, children who accompany their parents to an appointment can also have access to the game and learn about hearing health. The game could be used to keep children occupied in an engaging task while they are in the office. The game can also be given to children when they are taking a break from longer testing sessions. While a standard hearing evaluation can last 20-30 minutes, cochlear implant candidacy and auditory processing evaluation can be long enough to warrant a break for younger patients. Playing the game during a break time could be entertaining, invigorating, and educational for younger patients.

If a clinic does not want to invest in extra computers or tablets needed to access the game, having patients access the game themselves with smartphones is another option. To achieve this, a flyer with a QR code could be hung on walls in various rooms of the clinic. Young patients and/or their guardian(s) can scan a QR code with their phone's camera and gain access to the game through their own mobile device. If the clinic has poor phone connectivity, access to guest Wi-Fi may be needed for devices to connect to the game. If this is the case, the Wi-Fi information can be included in conjunction with link or QR code for the game. Providing a flyer with a QR code and Wi-Fi access instructions could give young patients and their parent(s)/guardian(s) access to the game without the clinic needing to provide extra resources to incorporate the game in the office. These avenues of implementation could easily be used in a clinical audiology setting to disseminate the game and the hearing health information that it can provide.

Community Settings

Since audiologists have a role in and contribute to public health, there are several opportunities to implement the game in community settings. Some of these settings include libraries, community health fairs, and community organizations.

Libraries

Public libraries often provide events and education to individuals of all ages in the community that they serve. Events organized by libraries include lectures, symposiums, field trips, fairs, and other activities. Hearing health is a topic that libraries create events around. An audiologist might contact a library and work directly with librarians to organize events or times for youth to play the SOTSB game as an exploratory activity. Audiologists might also educate librarians about hearing health and the game so that they can give youth access to it when they are using computers in the library or help disseminate the game to parents who are interested in providing fun, educational resources to their children. Audiologists can provide the Dangerous Decibels Educator training and game training to librarians so that they can create events to teach youth about hearing health. The SOTSB game can be made available to youth during the school year, the summer, and during supplemental activities provided by the library. Involving a public library could help audiologists reach more youth and give them access to the game. It would also give more people access to hearing health information in general.

Community Health Fairs

It is possible for audiologists to provide hearing services to individuals through community health fairs. Community health fairs typically provide free education and health screenings of various kinds to any community member who is willing to participate. Health fairs can provide blood pressure screenings, demonstrations, and education about the dangers of

smoking, education on healthy eating/exercise, and hearing screenings. Audiologists can perform hearing screenings and hearing health education to community members at health fairs. The SOTSB game can be implemented into an activity for youth that teaches them about hearing health. A participating audiologist might set up a booth at a health fair with activities and materials from the Dangerous Decibels program including the SOTSB game. If hearing screenings are taking place, those who get their hearing screened and their families could receive information about hearing health and gain access to the SOTSB game. Computer tablets can be provided, or community members can play the game using their smartphone. If follow-up after a hearing screening is suggested by the audiologist, that could get community members inside of an audiology practice setting where they can access the game. Information about the game can also be provided in a flyer or pamphlet at an audiology booth or for families to take home after the health fair.

Community Organizations

There may also be opportunities for audiologists to provide hearing health information and the SOTSB game to youth who participate in community organizations. Community organizations can include clubs like 4-H, Boys and Girls Clubs, boy scouts, girl scouts, and homeschool and/or daycare groups. Audiologists can contact organizations like these by conducting a Google search and filling out contact forms on the organization's websites. An audiologist may also contact a public library to receive contact information for organization directors/planners. The audiologist can provide the Dangerous Decibels Educator training and game training to adults who can then disseminate the Dangerous Decibels program and the SOTSB game to the youth involved in their organizations. In this way, audiologists can reach a much wider audience within the community and provide youth with access to hearing health.

Conclusion

Audiologists work in a variety of settings including schools, hospitals, and private practices. Audiologists also have a responsibility to educate their communities about hearing and hearing loss. Children are an especially vulnerable population at risk for hearing loss because hearing loss has the potential to impact many aspects of their lives (including access to information, education, future employment, etc.). Educating youth early and often about heathy hearing habits is essential to preserving their hearing for as long as possible. There are many opportunities for an audiologist to teach youth, adults, and entire families about hearing health no matter the setting that they work in. The SOTSB game can be used as a hearing health promotion tool to expose youth to hearing health information. Presenting the Dangerous Decibels program to children and then using the game as a booster later may be the most effective use of the game. This would most likely occur in a school setting. However, if it is not possible to deliver the Dangerous Decibels program, the game can still be disseminated to people in audiology clinics, hospitals, and communities. While the Dangerous Decibels program has been shown by research to be effective hearing health program in changing attitudes, beliefs, and behaviors (Griest, 2008; Martin et al., 2013), more research is needed to see if the SOTSB game would be an effective tool to teach youth about hearing health and how they can prevent hearing loss.

CHAPTER 3

GAPS IN LITERATURE & FUTURE DIRECTIONS

Research is an ongoing endeavor. There are always more questions to answer and unknowns to explore. There are many gaps in the current literature that need to be filled regarding STEM learning, educational video gaming, hearing health promotion programs, and technology in a general context and for children with hearing loss. This chapter will highlight these gaps as well as possible future directions and challenges that may come with conducting future research.

STEM Learning

The National Science Foundation (2014) found that less than half of primary grade students performed at or above proficient math and science levels for their grade level in the US. There are several factors that can affect STEM performance of students including teacher qualifications and training, school factors, and individual student factors (socioeconomic status, race, family education and size, etc.). More research is needed to determine what factors affect groups of students differently and why US students are performing worse than students from other countries (Xie et al., 2015). Students with disabilities like HL who have limited access to STEM concepts and lack accommodations in an educational setting are no exception. Students with HL consistently perform worse in STEM subjects compared to their normal hearing peers (Luft, 2017). Students with HL do not receive the same information as their normal hearing peers (Nelson et al., 2020). This can affect their overall performance in STEM. Kuku and Adeniyi (2020) determined that exposing students with HL to gamification and alternative instructional methods can improve mathematics achievement. However, more research is needed to study

ways in which students with HL are lagging in STEM achievement and what other methods are effective in improving their STEM achievement long term.

Educational Video Gaming

While educational gaming has been around since the 1970s, it is becoming more popular in primary grade classrooms (Thomas, 2021). Educational gaming and game-based learning have been shown to increase students' positive attitudes towards learning and school, motivation to learn, and learning achievement (Hwang et al., 2012; Miller & Robertson, 2011; Tüzün et al., 2009). Although educational gaming can create a fun learning environment, it is not known if there is a direct link between educational gaming and an increase in academic achievement (Adachi & Willoughby, 2013; Sáez-López et al., 2015). More research is needed to determine if educational gaming can create long term educational growth and support increased knowledge in children.

Research is also needed to evaluate how children with disabilities interact with educational games. A systematic review of the small sample of studies that examine gamification specifically and its effects on students with HL is needed (Bratu et al., 2018). There have been a small number of research studies evaluating the use of adaptive video games for individuals with physical disabilities and blindness (Giannakopoulos et al., 2018; Malone et al., 2017). However, even fewer studies have considered how best to adapt video games for individuals with hearing loss. It would also be beneficial to compare implicit and explicit game learning in individuals with hearing loss and those without. A challenge with studying whether there is a link between educational gaming and increases in academic achievement is that it can be difficult to control for each educational factor that influences problem-solving skills and academic achievement. For example, Adachi and Willoughby (2013) discuss that it is difficult to determine if an increase in

self-reported problem-solving skills occurred in their participants due to the use of educational gaming or natural growth that occurs while developing skills during school years. This can be especially true when conducting longitudinal studies with children as they grow, develop, and learn over time. Moore et al. (2020) discuss that even children with mild HL can exhibit decreased cognitive abilities that are related to language and reading. It is possible that students with more severe HL can have more severe cognitive deficits, especially when compared to their normal hearing counterparts. It is possible that differences in cognitive deficits in children with HL can affect their problem-solving skills and impact their experiences with educational gaming.

Serious Gaming as a Hearing Health Promotion Tool

Baranowski et al. (2008) determined that video games containing health-related content and messages can promote health-related behavior changes in children. However, more research is needed to determine what types and combinations of game mechanics are needed to produce the best knowledge, attitudes, and behavior outcomes in players. A game's story, genre, its ability to immerse its players, design, and structure all play a role in the games ability to capture the attention of players and help them retain information. Most studies involving hearing health promotion typically evaluate pre- and post-intervention questionnaires or tests to determine if participants show improvements in hearing health-related knowledge, attitudes, and beliefs (Chermak et al., 1996; Griest, 2008; Martin et al., 2013). More research needs to be conducted to see what kind of outcome measures would be best to determine changes in hearing health knowledge, attitudes, belfies, and behaviors following a gaming experience. It might be challenging to implement pre- and -post gaming outcome measures that are uniform across participants. Intervention studies are typically designed so that all the participants have the same

experience and are compared to a control group. A hearing health educational game will be played differently by each child, and they will come away with different intervention experiences depending on how they strategize during the game, how much time they spend in each game level, and how many times they utilize the "help" button during the game. Tracking game-play behaviors will likely be a tool to help categorize different types of players to facilitate analysis of the outcomes.

Song of the Starbird Game

The SOTSB game is the first of its kind in the attempt to use video gaming to increase hearing health knowledge and change attitudes and beliefs in youth and is based upon the Dangerous Decibels program. However, because it is currently being developed as part of a research grant, a formative study was conducted in 2021 to evaluate what players think of the game and inform further development of the game (Uckermann et al., 2022). More research is needed to determine if the SOTSB game can effectively increase knowledge and positively change attitudes, beliefs, and behaviors in youth. This research should evaluate the SOTSB game as a booster to the Dangerous Decibels program and the use of the game independently, as the primary hearing health promotion tool.

There may also be a need for the game to become more developed than it is now. For example, the game currently only has two levels that convey the "Walk Away" and "Protect Your Ears" strategies to prevent NIHL. An additional level could be added that teaches players the "Turn it Down" strategy to prevent NIHL. The game could also be developed to include interactive gameplay between players. More developments to the game can be implemented, and future research could evaluate the effectiveness of each level of the game or of the entire game.

Some challenges with researching the SOTSB game include reaching diverse youth with technology access, allowing "natural play" versus requiring students to access each level of the game, assuring independent game play without support from siblings, parents, teachers, or peers and determining a time limit for adequate game play experience. More research is also needed to determine if and how the SOTSB game supports STEM learning and long-term changes in hearing health. Long-term changes are the most ideal outcome for hearing health promotion programs, so longitudinal research is important.

Need for Longitudinal Studies Of Hearing Health Promotion Program Effectiveness

Hearing health promotion programs have been studied since their inception. The Dangerous Decibels program and its adaptations have been shown to increase knowledge and change attitudes, beliefs, and behaviors regarding hearing health in youth (Chermak et al., 1996; Griest, 2008; Martin et al., 2013). However, Martin et al. (2013) found that improvements in knowledge, attitude, beliefs, and behaviors decreased in youth 3-months following the program. This indicates that there is a need for longitudinal studies that demonstrate exactly when increased improvements start to fall off and when boosters need to be implemented to maintain improvements over time (Martin et al., 2013). There is also a need to better understand whether knowledge, attitudes, beliefs, and behaviors rebound at a later point in time when peer pressures and other influences change. Longitudinal studies of hearing health promotion are challenging because these studies are time consuming, expensive, and retention of participant tends to decrease over time. Loss of participant retention causes a loss of statistical power (Hanna et al., 2014). Therefore, it is important to learn from longitudinal studies of other types of health behaviors evaluating youth transitioning into young adulthood. Longitudinal studies have the

potential to tell us more about the effectiveness of hearing health promotion programs over time. There also haven't been any studies that specifically evaluate how children with HL respond to hearing health promotion programs. More research is needed to see if children with HL come into a hearing health promotion program knowing more about hearing health, if they learn, and change their attitudes, beliefs, and behaviors in the same way as normal-hearing peers, and if these changes are maintained for the long term in this population. The impact of the SOTSB game may be directly related to access to technology.

Technology

Sounds in the SOTSB game have been designed to implicitly influence the game's effectiveness in increasing knowledge and changing attitudes, beliefs, and behaviors in children with HL. Students with HL typically need accommodations to fully access sound and computer technology in the classroom. FM systems or hearing assistance devices can be used to enable students with HL to connect their hearing device(s) directly to computer technology in the classroom (Mecklenburger & Groth, 2016). In the same manner, auditory assistive devices might be needed to enable students with hearing loss to play the SOTSB game. This would be beneficial so that they can be fully immersed in game play. More research will need to be conducted to determine what accommodations might be needed for students with HL to play the game in a similar manner as their normal hearing peers. Facilitating auditory or auditory/visual input from the game is critical since the SOTSB game incorporates elements of sound throughout the gaming experience to implicitly convey and reinforce hearing health concepts (e.g., a silent world becomes musical after the ear is built in game level one). Research is needed to determine if the sounds in the game are audible and interpreted in the same way. Learning from children with HL would be helpful to determine how the game can be adequately accommodated for these

types of players. Audiologists are equipped to facilitate the computer technology accommodations that each student with hearing loss may need.

Summary

Overall, there are several areas that need more research in the context of STEM learning, educational video gaming, hearing health promotion targeting youth, and computer gaming technology adaptations for youth with HL. Educational video gaming provides new opportunities in education, but it is important to consider learning modalities and perspectives of players. The SOTSB game has the potential to be used as a hearing health promotion tool for youth, either on its own or as a booster to the Dangerous Decibels program. Research is needed to determine if the Song of the Starbird game creates short- or long-term increases in knowledge and positive changes in attitudes, beliefs, and behaviors in youth with HL. Public health initiatives to prevent NIHL might benefit from game-based hearing health promotion via the SOTSB game. Ultimately, dissemination of the game to youth and adults alike (with or without HL) has the potential to increase hearing health knowledge and create changes in attitudes, beliefs, and behaviors in individuals all in the hope of preventing NIHL. Audiologists are encouraged to contribute to the research by conducting field-based studies when implementing the SOTSB in their practice settings.

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APPENDIX A

SAMPLE EMAIL COMMUNICATION

TO DANGEROUS DECIBELS®

To: dd@unco.edu

Dear Dangerous Decibels,

I am an educational audiologist interested in participating in a Dangerous Decibels training workshop. I would like to receive updates on future training workshops so I can attend. If you could, please save my contact information so I can receive updates.

Contact information:

[Enter information here]

Signed,

[Audiologist]

APPENDIX B

GAME GUIDE

Use with permission from Creare, Inc.

Game Guide: Song of the Starbird

Pedagogy: Using Games in the Classroom

Learning is play. Games provide a unique way of presenting curriculum material and introducing critical learning skills. When teaching students, it is key to provide multiple examples of concepts. Not only do students have different learning styles, but they are also likely to use their skills in a variety of ways. Online games can provide diverse examples and contexts in which students can practice.

Games can also allow teachers to differentiate their instruction to cater to students' needs. For example, online games can appeal to visual and kinesthetic learners who need to see and touch or move and manipulate virtual objects to embrace a concept.

In addition to catering to different learning styles, online games can adapt to individual learners and provide the scaffolding they need to progress to the next level. Though a class of students may be engaged in the same game, they might each experience the game in different ways and on a different "level".

Online games can also help track and motivate students' progress. Teachers can use online games to help students keep their skills sharp during the school year or provide a more focused review at the beginning or end of the school year or before an important test.

Within a teaching pedagogy, there are four core learning profiles:

- Auditory learners, who benefit from listening to the information presented to them in class. They learn orally from both listening to instruction from the teacher and audio recordings.
- Tactile/kinesthetic learners who absorb knowledge through touch and movement. They prefer to work with hands-on devices and learning aids.
- Visual learners, who prefer to see information in order to visualize the relationship between ideas and concepts to understand them
- Reading and writing learners, who prefer to take on information by reading texts. These learners can further absorb information by condensing and rephrasing it.

Today, teachers have the advantage of utilizing traditional learning practices while incorporating new educational technologies to create a diverse, differentiated classroom, ready for mixed-ability pupils.

Games and their accompanying curriculum can often be adapted for both individual and collaborative use in the classroom. We recommend that students first explore a new game on their own, either taking a tutorial or just freeform playing in order to practice essential skills such as risk, strategy and persistence. Once some familiarity is developed, the teacher can employ the criteria for gameplay and the academic expectations that accompany it.

After a new concept or level is reached, consider a debriefing session to encourage students to think beyond the game itself. The point of "playing to learn" is key and students will start to inherently connect the game to the larger curricular objectives.

Getting Started

Song of the Starbird is an online game that can be accessed from the link below.

Click to Play Song of the Starbird

To play, students will need a desktop computer or tablet with access to a web browser, such as Microsoft Edge,, Google Chrome,, or Firefox

After navigating to the game site, students will need to log in. This will take them to the opening scene of the game. Note: If they choose to play as a "guest", then their progress won't be saved.

Classroom Account

To set up an account for your classroom, please contact the study organizers.

Troubleshooting

Game doesn't load

When internet speeds are slow, the game can take a very time to load (20 minutes). Once loaded once on a computer, the information should be cached, which means in will load quickly the next time the page is

visiting. However, the browser settings may prevent caching, in which case it could take a long time to load each time.

Other

Please let the study organizers know if you have any additional technical issues running the game.

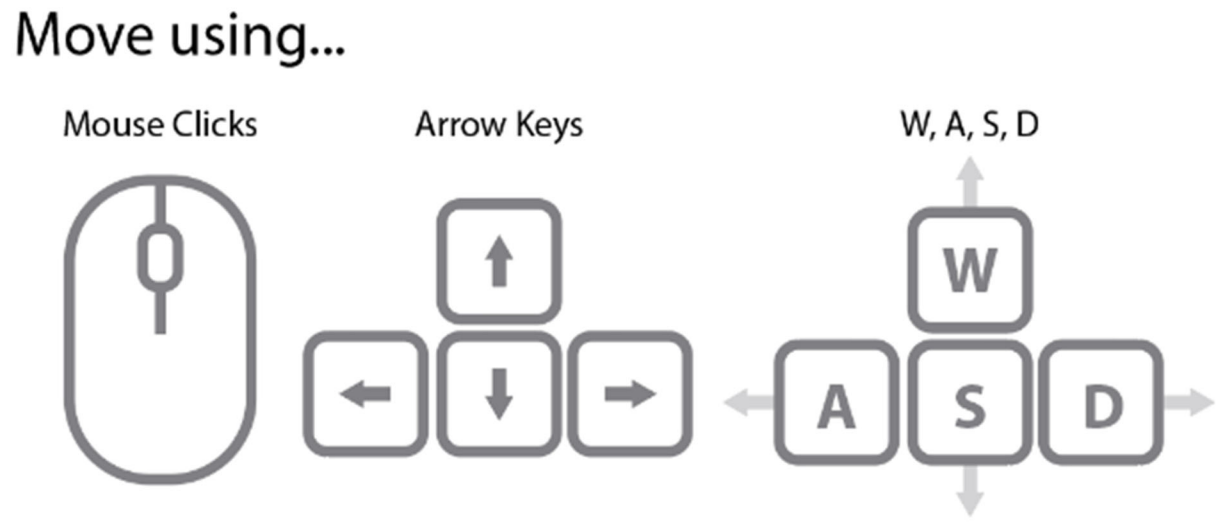
Introduction

In *Song of the Starbird*, players take on an intergalactic explorer in search of a musical instrument that can call forth the legendary Starbird. Legend has it that the Starbird can restore hearing to the creatures on the planet Whisperwell who lost their hearing long ago. The trouble is, the musical instrument was shattered and its pieces scattered among the loud (and obnoxious) creatures of a distant planet. The student's objective is to build an artificial ear, then search for the lost instrument while avoiding damage from loud sounds.

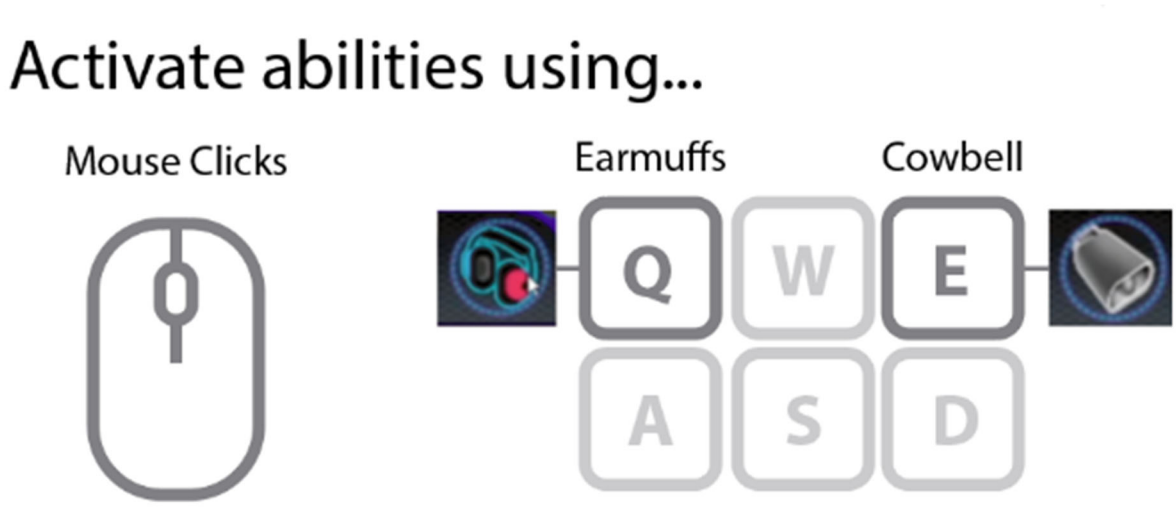
As players navigate the five levels of the game, they learn about the delicate and sensitive workings of the ear, how to avoid loud sounds from damaging their ear, and how to use the properties of frequency and amplitude to solve challenging obstacles. For a detailed description of learning concepts and how they meet national standards, please check out the Curriculum Guide.

Game Mechanics

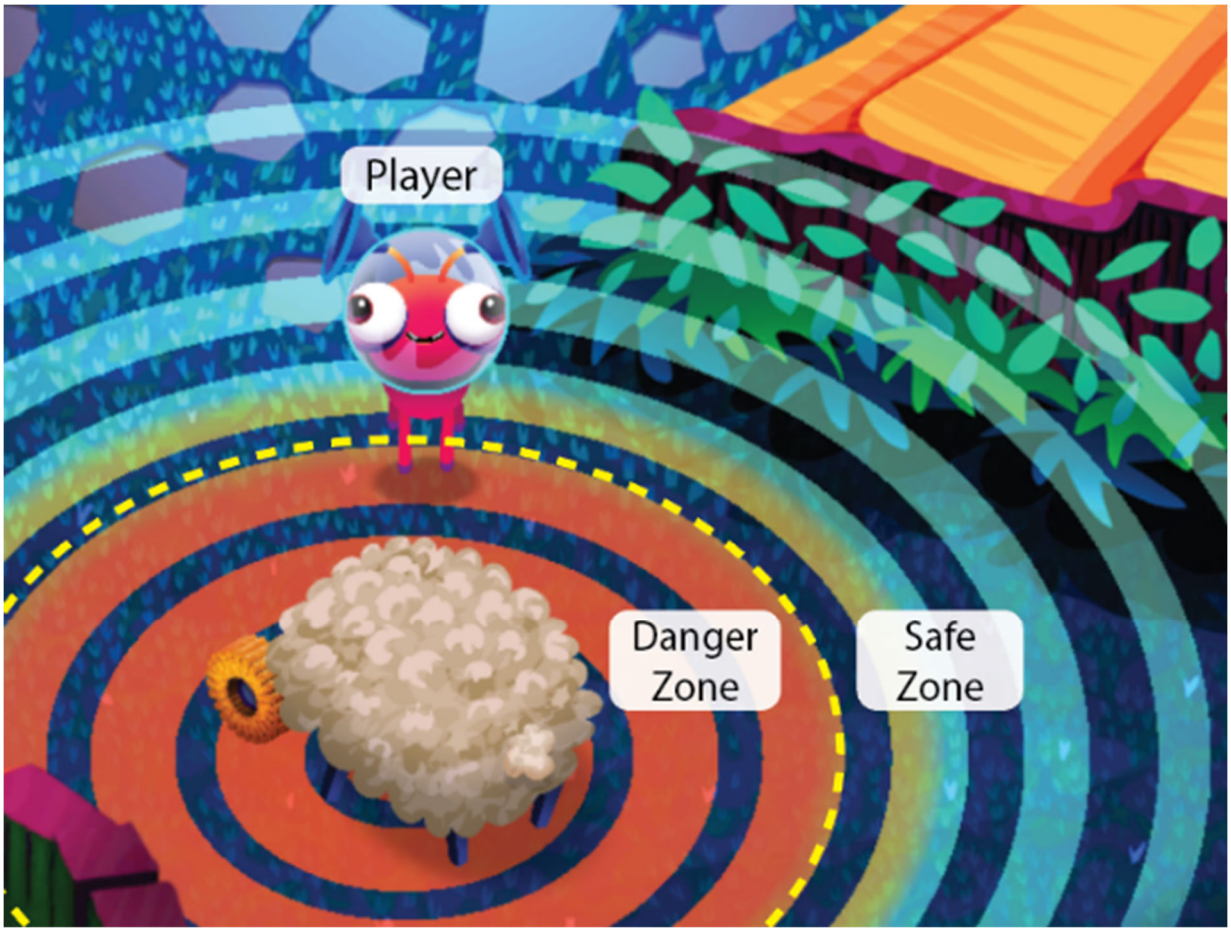
First, a bit about how the game is played. Players move around the game by clicking with their mouse, using the arrow keys, or pressing keyboard letters ("W, A, S, D").



To perform an action, such as picking up an object or using an ability from the dashboard, players click on the icon with their mouse. Players can also perform abilities with special hotkeys "Q" and "E".

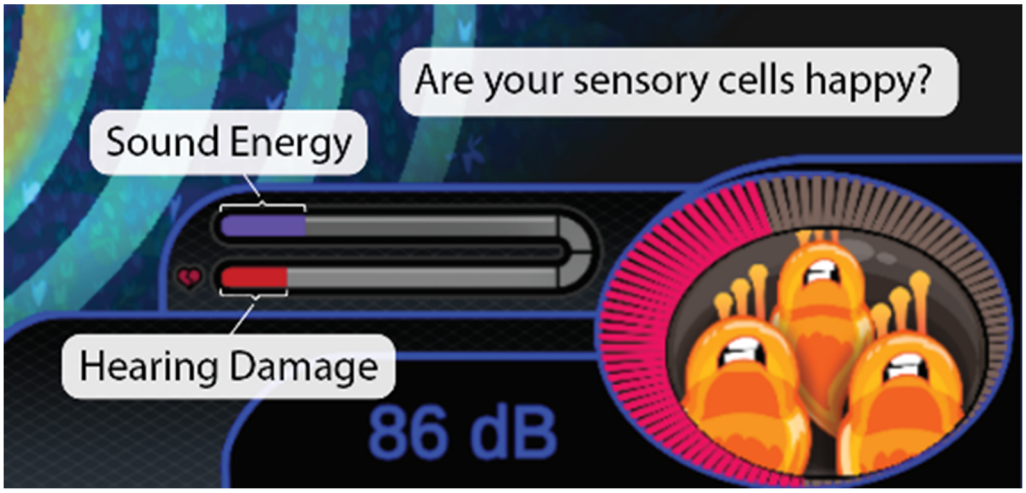


After passing the first level, players will encounter creatures who make loud and dangerous sounds. These show up as sound waves, with the red color indicating the danger zone and the green area indicating the safe zone. If players stay in the danger zone for too long, they will damage their hearing.



Game Dashboard

The game dashboard shows how much hearing damage the player has taken and the current sound level. Players need to watch this sound level, or else they will risk damaging their hearing.



The dashboard also provides slots to store items and activate new abilities they gain as they pass each level. Shown below is what the dashboard looks like by the end of the game. Next to each dashboard item, the parentheses show the level where players gain the new ability.

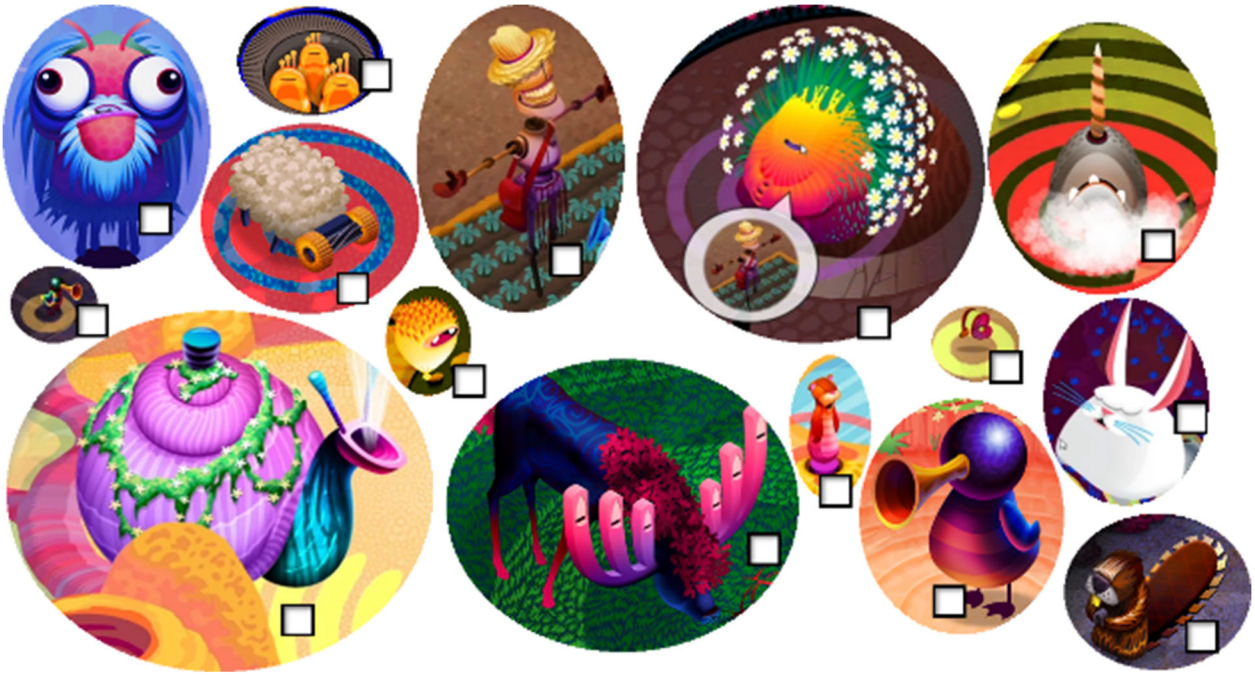
Game Dashboard: Each level introduces a new dashboard item

Each level provides players with new abilities

- Level-1 Inventory: The inventory holds items the player picks up.
- Level-2 dB Meter: The dB meter measures the sound level so players can safely navigate dangerous sounds. Consider asking students to discover how much energy (dB level) they can be exposed to before their ears start being damaged.
- Level-3 Earmuffs: The earmuffs help protect your ears from dangerous sounds. However, at times, the player needs to take them off to hear quiet sounds.
- Level-4 Cowbell: Striking the cowbell generates sounds that can be used to navigate dark passageways, by listening to its echoes, or vibrate and shatter crystals that are in the way.
- Level-5 Cowbell Tuner: The tuner allows players to change the amplitude and frequency of the cowbell, useful for shattering crystals.

Meet the Characters

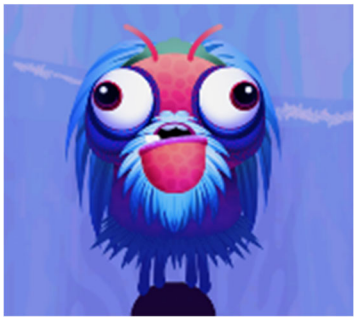
Along the way, players will meet a lot of wacky characters. To provide an additional incentive, students can check off when they meet each character and try to guess what real-life object they are modeled from.



Walkthrough of Each Level

Opening Scene

On entering the game, the backstory is introduced by the Librarian of Legends, who recounts a prophecy of the "SoundSeeker", a hero that will bring music back to the silent world of Whisperwell. Long ago, a legendary Starbird visited Whisperwill to give its inhabitants ears to hear its beautiful song. But out of jealousy, a Thumperdump arrived, letting out a mighty roar that damages the inhabitants' ears and frightens the Starbird away. Legend has it that there is an enchanted instrument that can lure the Starbird back to Whisperwell and restore the inhabitants' ears, but alas, its pieces have been scattered across the planet. It is now up to the Soundseeker to locate and reassemble the enchanted instrument to call back the Starbird.

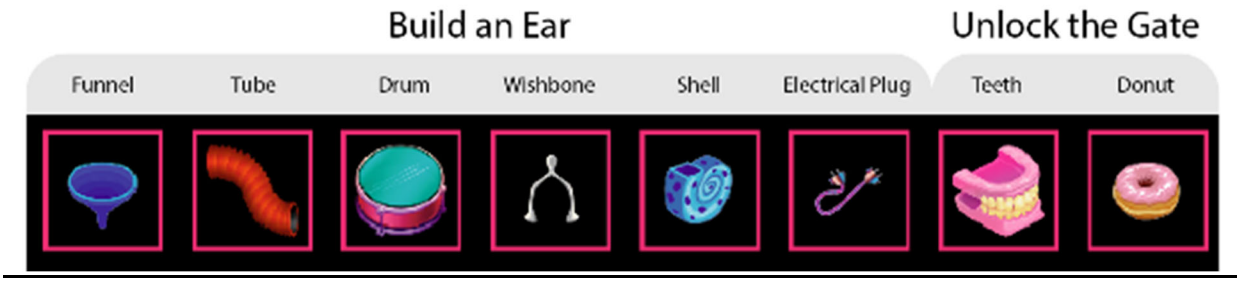


Level One: The Yard

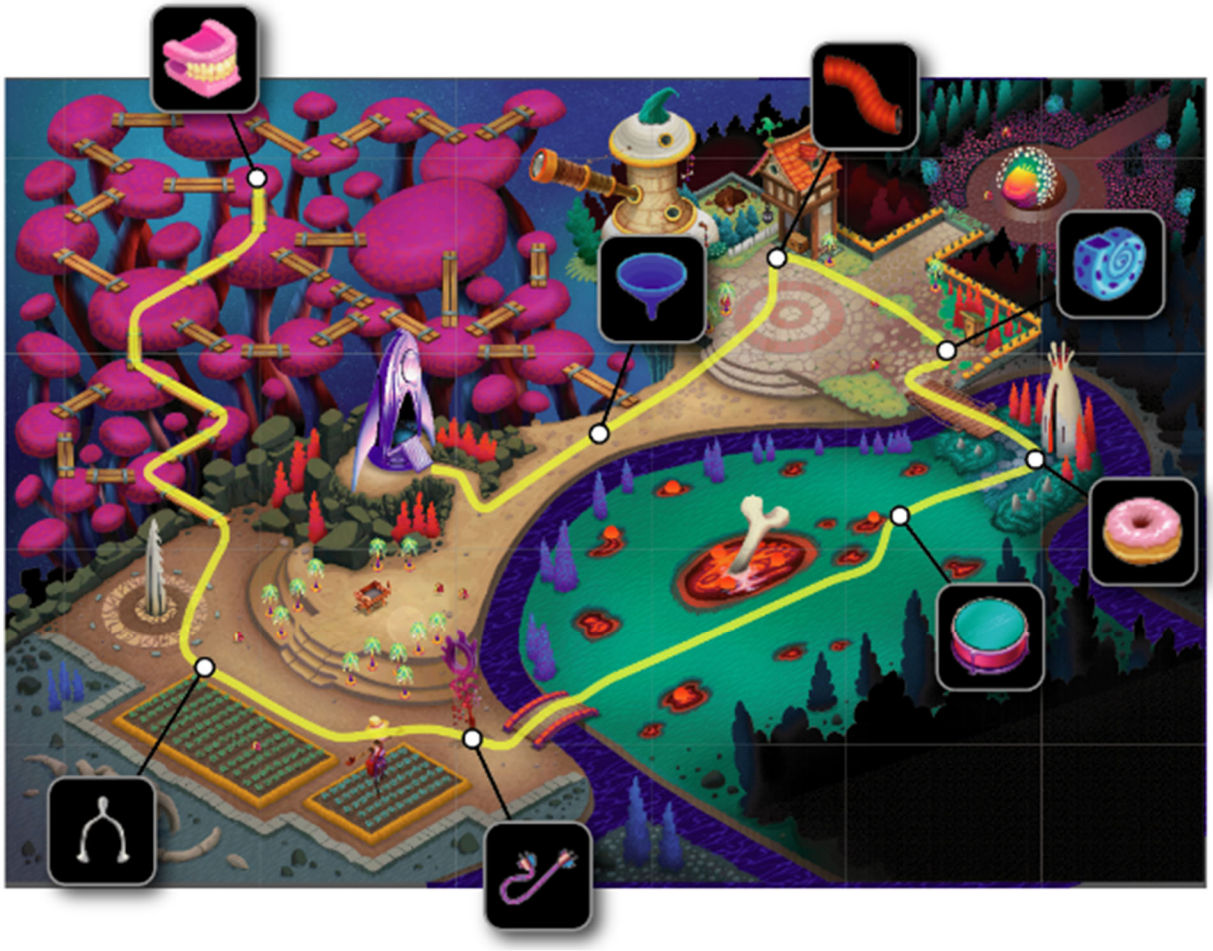
The player's spaceship lands on a dull-looking planet. The door opens and there are small creatures moving about, but no sound or color. Throughout the level, there are familiar-looking objects scattered around the landscape that the player can "pick up" and deposit in their inventory at the bottom of the screen. The player will need to collect (6) pieces to assemble an artificial ear that will allow them to perceive sound in the game. There are also (2) pieces that are used to unlock a gate to the next level.

<u>Step-1: Collect Parts to Build an Artificial Ear</u>

Players roam the level looking for (6) parts to build an ear and (2) items to unlock a gate.



Here is a map of Level-1 that shows where to collect the objects.



If players get stuck, the question mark at the top left of the screen can provide a hint on where to go next.

Step-2: Build an Artificial Ear

Once players have found all the objects, they need to go to the Workbench to build a pair of artificial ears.

At the workbench, a new window will pop up with a diagram of an ear. Players will need to drag items from their inventory over to the ear diagram to complete the ear.

Each item corresponds to part of the ear anatomy:

- Funnel — The pinna, or outer ear, which funnels sound inside the ear
- Tube — The ear canal, which allows sounds to reach the middle ear
- Drum — The eardrum, which passes sound vibrations to the middle ear bones
- Wishbone — The middle ear bones, which amplify vibration to the inner ear
- Shell — The cochlea, which contains sensory cells
- Electrical Plug — The auditory nerve, which sends signals from sensory cells to the brain

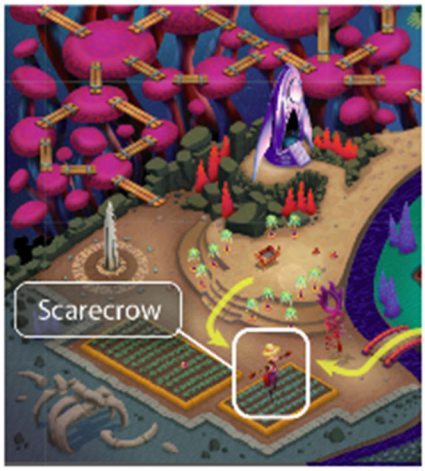
Once their ears are built, players can now experience the level in full sound and color. The creatures in the game now have colored concentric circles that indicate the sound levels. The dashboard now shows the player's happy sensory cells and the sound level in decibels. Note that the player's artificial ears can take damage if they are exposed to dangerous sound levels for too long. This damage is shown in the dashboard as a red health bar.

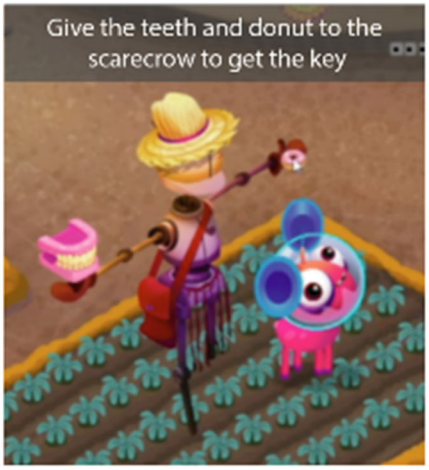
After building artificial ears, players can now experience the game in full sound and color.

The player is almost ready to move onto Level Two. At this point, they have a donut and a set of teeth in their inventory, which will be used in the next step to unlock the gate to Level Two.

<u>Step-3: Unlock the Gate</u>

The gate to Level Two is blocked by a guardian, who tells them to retrieve the key from the scarecrow. To access the key, the player must place teeth in one hand of the scarecrow and the donut in the other. Once this is done, the key is dropped and the player can walk through the gate to Level Two.





Level Two: The Forest

Once the player walks through the gate, the creatures are emitting more damaging noises and the player can monitor the damage by looking at the dashboard and the hair cells. As the concentric circles get brighter and larger, the decibel meter on the dashboard will also register its level. There is also a tuning fork above the hair cells that gets red when the sounds are too loud. The hope is that players will understand the range of healthy hearing in decibels.

Notable interactions in this level are as follows:

1. Player hears the first dangerous sound to understand what to look out for [go]
2. Player finds a shovel [go]
3. Player digs a hole [go]
4. Player retrieves the first instrument piece [go]
5. Player encounters the pipe deer near a place where they need to dig [go]
6. Player needs to dig for a while then run away to let ears rest to avoid damage [go]

7. Once player complete hole after multiple digging sessions, the hole leads to the next level [go]

Level Three: The Swamp

Emerging from the hole, the player finds themselves in a swamp. Here the sounds are even more dangerous, but fortunately they find a set of earmuffs they can use to protect their ears. However, they need to listen carefully for rocks that emit sound hiding turtle bells -- needed to navigate the swampy maze. They navigate this maze to find turtle bells needed to bridge gaps in the swamp, all the while avoiding loud sounds.

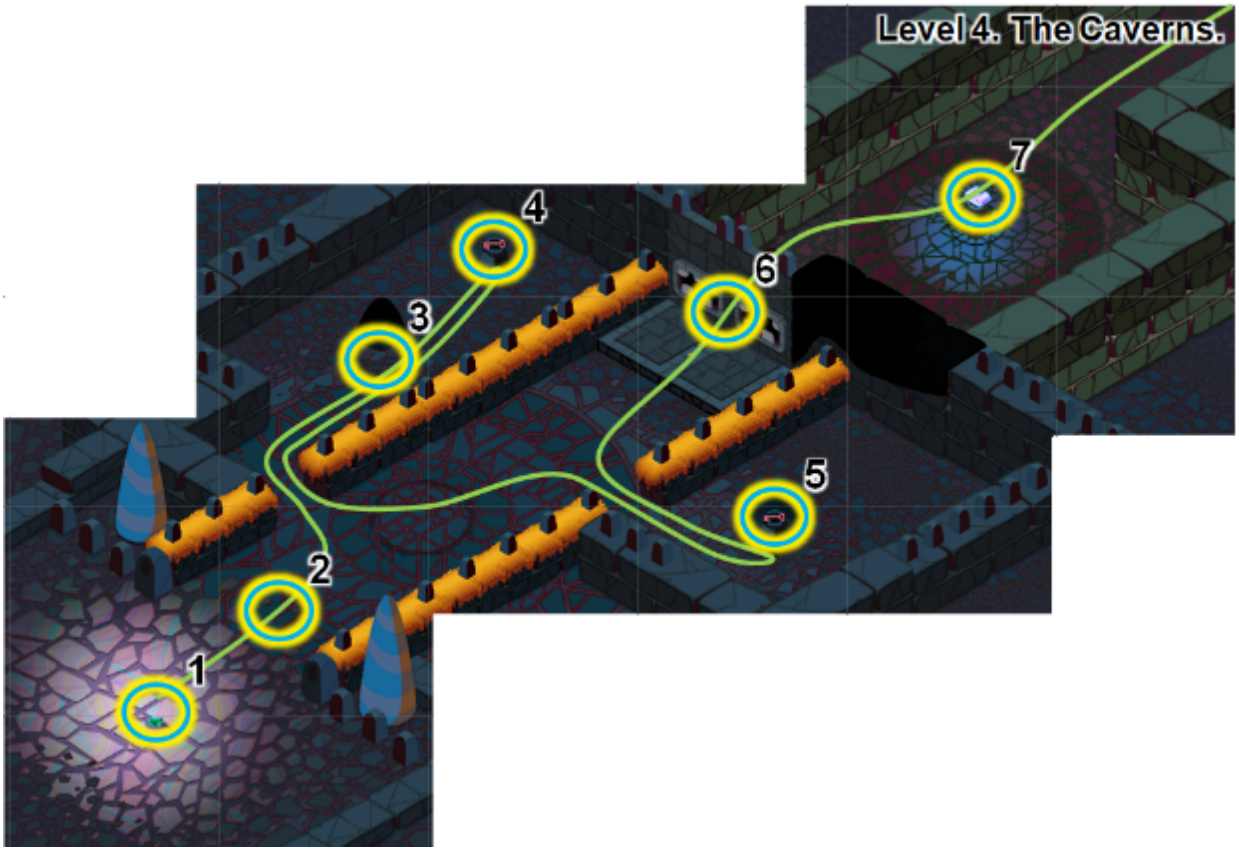
Notable interactions in this level are as follows:

1. Player discover a rock that is making a sound [go]

2. Player pushes rock away to discover a “turtle bell” [go]
3. Player places turtle bell in monument [go]
4. Turtle shells rise from the swamp [go]
5. Player can then cross the section [go]
6. Player discovers ear muffs [go]
7. When players wear ear muffs, they are protected from loud sounds. Ear muffs can be worn by click on the icon, or pressuring the ‘q’ key on the keyboard [go]
8. Player discovers loud sounds [go]
9. Player may wear earmuffs to protect ears from loud sounds [go]
10. Player discovers the second turtle bell. Note, they cannot ‘see’ the rock where it is hidden while wearing the earmuffs. [go]
11. Player places second turtle bell in second monument [go]
12. Player finds third turtle bell [go]
13. Player places third turtle bell in third monument [go]
14. Player discovers first puffer fish – they need to wear earmuffs to be able to pass safely [go]
15. Player finds fourth and final turtle bell [go]
16. Player places final turtle bell in final monument [go]
17. Player exists level [go]

Level Four: The Caverns

After entering the Cavern, the player finds themselves in a dimly lit place. How will they navigate in the dark? Fortunately there is a cowbell for making sound, and these sounds are absorbed by the walls and obstacles hidden in the dark. In this level, the player uses sound to “see”, helping them navigate the dimly lit level.



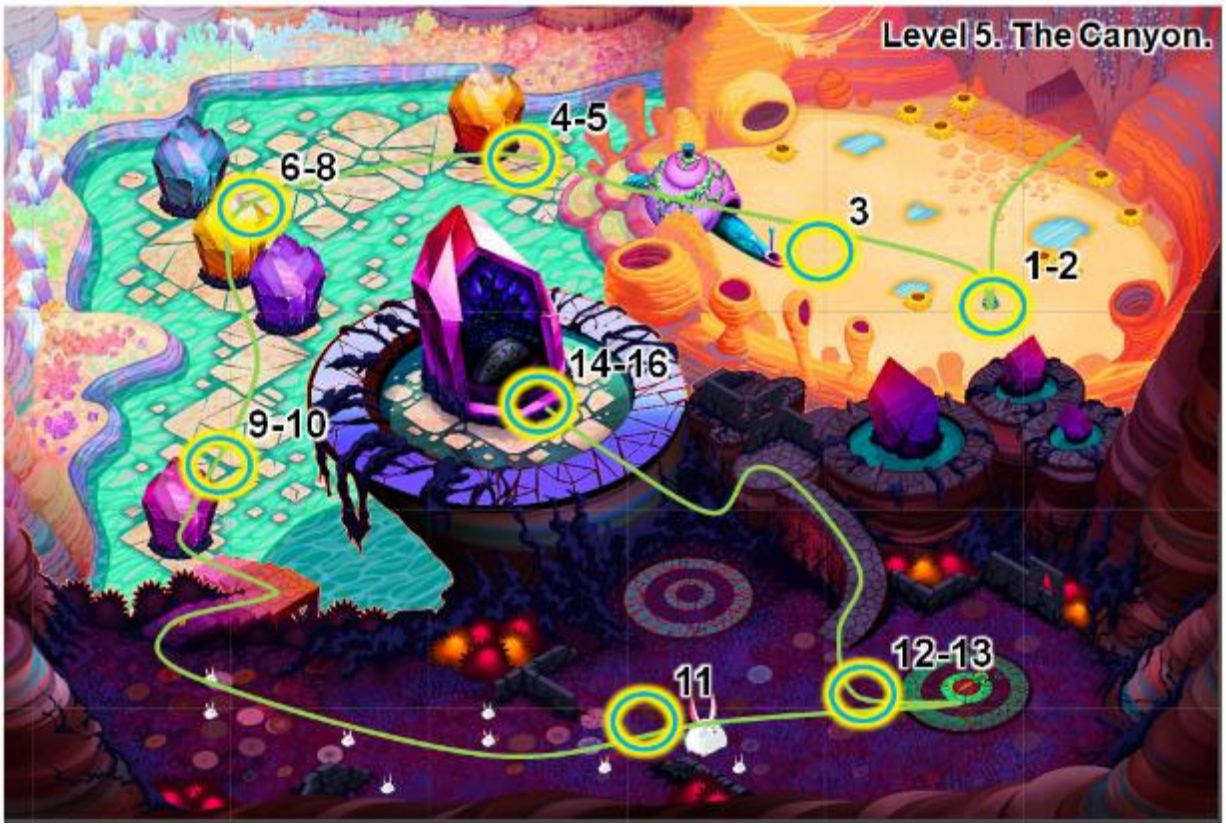
Notable interactions in this level are as follows:

1. Player discover the cowbell [go]
2. The cowbell can be activated by clicking on the icon, or pressing the “e” key on the keyboard. It makes a fan-shaped sound. [go]
3. Obstacles and walls block the sounds in this level, allowing the player to “see” using the cowbell [go]
4. Player discovers one of the keys needed to open the doors [go]
5. Player discovers one of the keys needed to open the doors [go]
6. Player opens the doors [go]
7. Player picks up the scroll needed that records the song used to summon the star bird in the final level, and exists the level [go]

Level Five: The Canyons

Emerging from the caverns the player finds themselves in canyons. Unfortunately their way is blocked by sleep snail kettle. Fortunately, a sound adapter ring can be found to help them

boost the sound amplitude and even change frequencies to break apart crystal formations blocking their way.



Notable interactions in this level are as follows:

1. As player enters the level, the see a sound tuner necklace [go]
2. Picking up the necklace they now have the ability to tune sounds. To activate the sound tuner, click the icon. [go]
3. To pass the snail, player needs to play a high amplitude sound [go]
4. Player needs to match the frequency color in the tuner to the color of the crystal [go]
5. By playing a loud sound at the orange (middle) frequency, player destroys the crystal [go]
6. Player destroys yellow (middle-left frequency) crystal [go]
7. Player destroys blue (left-most frequency) crystal (optional) [go]
8. Player destroys purple (right-most frequency) crystal [go]
9. Player selects correct frequency for the final, pink crystal [go]
10. Player destroys pink (middle-right frequency) crystal [go]

11. Player plays mid-to-low amplitude sound using the yellow (middle-left) frequency for the large bell bunny [go]
12. The large bell bunny follows player around [go]
13. Player lures bell bunny to carrot, which raises a platform [go]
14. Player approaches the monument [go]
15. Player assembles the instrument [go]
16. Player summons the star bird by playing the notes indicated on the scroll in order. If the strings are labeled A-E from left to right, then the correct sequence is: AECAB DEBCD [go]

Appendix of Screenshots

Level Two: The Forest

1

2


Hole digging is automatic. 2
39 dB

3


First instrument piece found. 3
<20 dB

4

5

6


Sound is dangerous..: 6
87 dB

7


Need to move away to rest ears, dig for multiple sessions: 7
66 dB

Level Three: The Swamp

1

2

3


Bells are dragged from inventory into... 3
<20 dB

4


... the stone monument. 4
<20 dB

5

6

7


Earmuff can be activated by clicking
on symbol or using the "q" key. 7
<20 dB

8


Dangerous sounds are... 8
<20 dB

9


... safe while wearing earmuffs. 9
74 dB

10


Second bell turtle. 10
59 dB

11

12

13

14

15

16

17

Level Four: The Caverns

1

2

3

4

5

6

7

Level 5: The Canyons

1

2

3


Need to play highest amplitude sound to scare snail kettle. 3
AMPLITUDE
FREQUENCY
67 dB

4


Need to match color of crystal with cowbell sound frequency. 4
AMPLITUDE
FREQUENCY
65 dB

5


Break orange crystal. 5
AMPLITUDE
FREQUENCY
65 dB

6


Break yellow crystal. 6
AMPLITUDE
FREQUENCY
65 dB

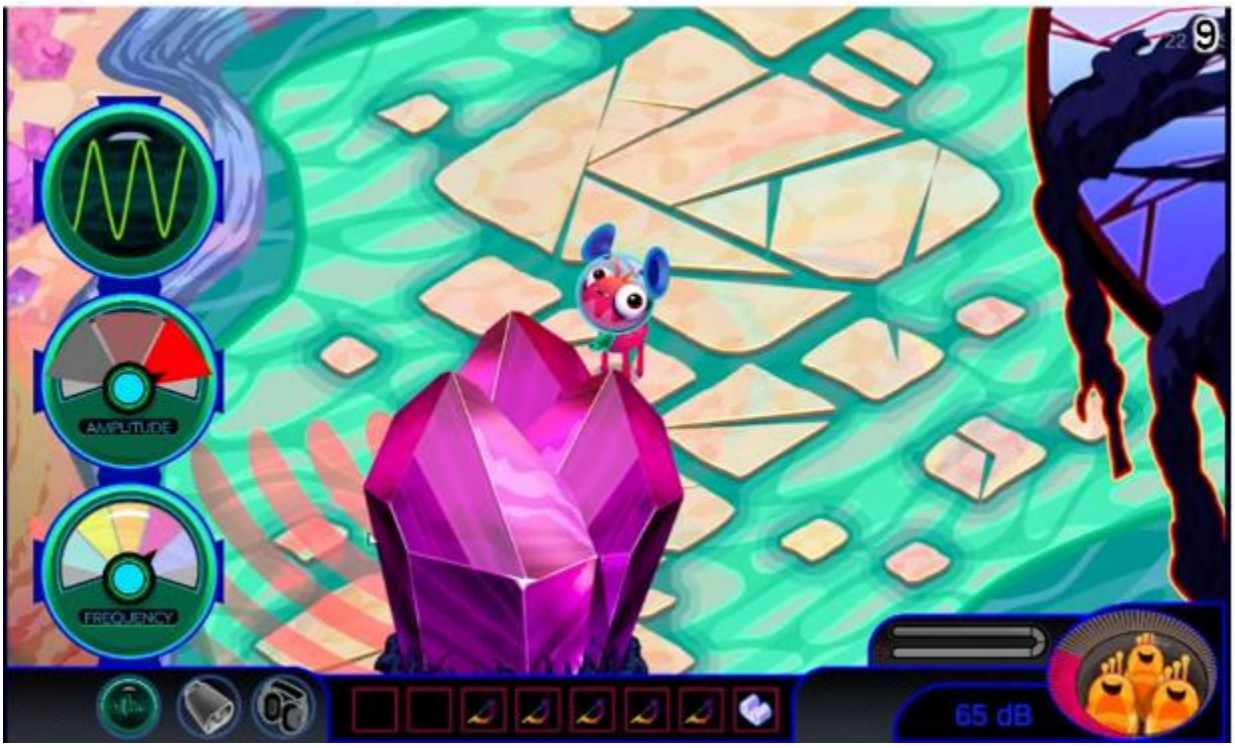
7


Break blue crystal (optional). 7
AMPLITUDE
FREQUENCY
67 dB

8


Break purple crystal. 8
AMPLITUDE
FREQUENCY
64 dB

9


9
AMPLITUDE
FREQUENCY
65 dB

10


Break pink crystal 10
AMPLITUDE
FREQUENCY
65 dB

11


Match color of bell bunny and... 11
AMPLITUDE
FREQUENCY
67 dB

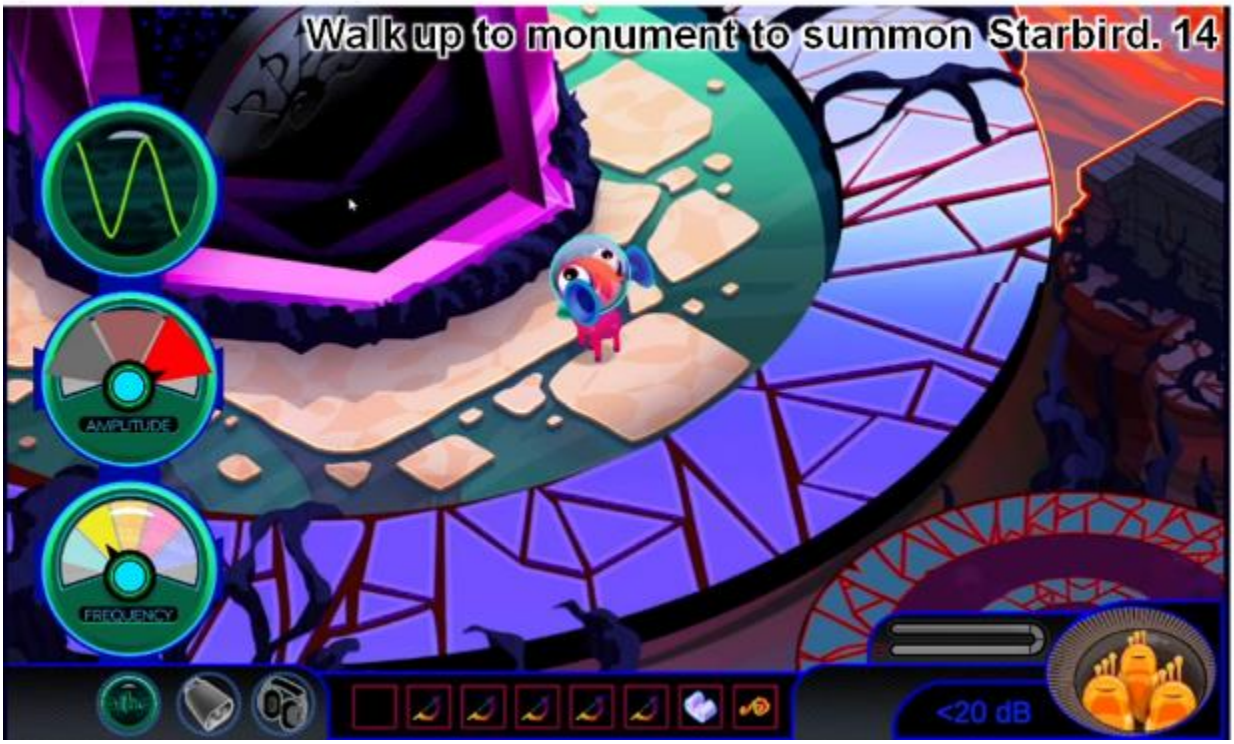
12


...big bell bunny will follow... 12
AMPLITUDE
FREQUENCY
<20 dB

13


... to the carrot, raising the platform. 13
AMPLITUDE
FREQUENCY
<20 dB

14


Walk up to monument to summon Starbird. 14
AMPLITUDE
FREQUENCY
<20 dB

15


Drag instrument pieces to monument. 15

16


Play each string, matching color shown on scroll
from left to right (B-Pu-O-B-Y-Pi-Pu-Y-O-Pi). 16

APPENDIX C

FLYER FOR TEACHERS

Have you heard?

Hearing screenings will be conducted for students in your school on the follow dates

Date(s): _____

You can help your students learn more about hearing and how they can preserve it!

A STEM game has been developed as an interactive way to help 4th-5th grade students learn about hearing health. The game can be accessed at school using the following link:

https://sotsb.crearecomputing.com/

Please share this link with students and parents. Students can even play the game at school on computers or tablets when/if time permits! Feel free to give it a try yourself, too.

APPENDIX D

FLYER FOR GAURDIAN(S)

Have you heard?

Your child passed their hearing screening today!

Hearing screenings are important because hearing loss can develop at any point in time and may not be noticeable immediately. Children can acquire hearing loss from listening to loud sounds for too long (music, machinery, etc.). Hearing loss can have many negative effects.

Your child can learn more about their hearing by playing a new computer game designed to teach youth about hearing health and hygiene.

Please visit **https://sotsb.crearecomputing.com/** to get them started on the road to better hearing health today!

An internet connection is needed to access the game.

APPENDIX E

SAMPLE EMAIL COMMUNICATION

TO GUARDIAN(S)

Dear [Parent and/or Guardian],

It was a pleasure to see you and your child at our clinic. Attached to this email communication are notes regarding the appointment as well as a link to a computer game that you and your child can play to learn more about hearing health.

Now is prime time for your child to learn about the ear, how we hear, and safe listening strategies. The game can provide a fun and entertaining learning experience for you and your child. Please take the time to play the game with your child and talk with them about the importance of keeping their hearing healthy. You may play the game as a guest.

https://sotsb.crearecomputing.com/

If you have any questions or concerns, feel free to contact our clinic.

Signed,

[Audiologist]

APPENDIX F

SAMPLE QR CODE/WI-FI FLYER

Want to play a fun, interactive digital game?

Scan the QR code below to play Song of the Starbird – a game that can teach you about hearing health!

1. Simply use the camera feature on your smartphone or tablet to scan the QR code
2. Tap the link that pops up on your phone.
3. Play as a guest.
4. Have fun!

<u>If you need Wi-Fi access:</u>

1. Enable Wi-Fi on your device.
2. Search for available networks.
3. Click: Clinic Wi-Fi
4. Enter the password: guest

APPENDIX G

AFTER SCHOOL PROGRAM FLYER

After School Program Activity

Join us after school to play a fun, interactive digital **game**! Come play

Song of the Starbird

a game that can teach you about hearing health!

Bring music back to planet Bumblethump by finding the pieces of an instrument to call the Starbird back to play its magical song! Learn about the anatomy of the ear, how we hear, and how you can protect your hearing.