2019

Bending Educational Reality

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BENDING EDUCATIONAL REALITY
Mariam Rafehi
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ACKNOWLEDGEMENTS

Before joining the MFA at Virginia Commonwealth University, I had a conversation with Rab McClure, Director of the MFA Program, to prepare me for what to expect. To reiterate his words, the MFA program would push me past my comfort zone to a point of growth and innovation. I would like to express my gratitude to him and the MFA faculty for making real what was promised. I would like to thank Diane Derr, my main advisor, for her elegant way of offering structure, creativity and inspiration. Thank you to Law Alsobrook and Sadia Mir for their readiness to offer support and honest feedback.

With the last two years pushing us to our limits, I am grateful to the time spent with my classmates and the new friends I made in them. Thank you Norah and my Doha family for the advice, guidance and many hugs. I would also like to thank my family for their love, stability, and support. Looking back at who I was at the beginning of the program and comparing it to the person I am now, I realize how much each of you have contributed to my change and I feel blessed. I can only hope that I was able to return some of the same guidance and inspiration that you have given me.
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ABSTRACT

Virtual reality (VR), an emergent technology, affords experiential content delivery in education by evoking emotive responses in users, which can be prohibitive via traditional media. This thesis explores VR for the development of grit – passion and perseverance, which are essential characteristics in education and long-term success. The research proposes design strategies to stimulate senses for emotional engagement and a physiological response. In the project, two interactive environments position the user in emotional states to build passion and perseverance. To develop passion, the virtual world is designed to engage in creativity using 3D-spatial audio and visual effects. In contrast, to build perseverance users are exposed to a challenging environment that requires them to overcome and positively associate frustration with growth. This thesis demonstrates the potential of design for higher sense-stimulation applied through VR in education.
1. TURN KNOB TO LOosen HEADSET
2. WEAR HEADSET AND TIGHTEN
3. STAND ON THE SPot MARKED BY "X"
INTRODUCTION

Ariadne walks through a dream created by the man with her – the dreamer, until she bends the road to fold on top of her and the dream becomes her creation, too: “I thought it was about how it looks, but actually it is more about how the dream feels,” she concludes.1 Ariadne is being interviewed for the job of a dreamer in this scene of the popular movie, Inception. Though classified as sci-fi, the film brings to the foreground a realistic concern as to whether the jobs of the future are beyond what can be imagined today.

Once logical and rational thinking have been outsourced to technology, creative thinking and innovative problem solving will become key hiring criteria.2 Over half of the jobs middle school students of today will be doing in the future do not yet exist.3 Therefore, rather than preparing students with career-specific skills they need character and intellectual skills to navigate uncertainty and succeed. The question then becomes: is education equipped for preparing today’s students for tomorrow’s careers? To build on this question, it may be even more important to consider: Do schools teach for tomorrow using the technologies of tomorrow?

Although this research explores various aspects of education and social psychology in character development, it is not meant to be a treatise within the social sciences. The content for tomorrow’s education is defined by emerging research in education, as well as neuroscience and social psychology. It is influenced by the work of Angela L. Duckworth, who founded the Character Lab to support educational development and formulate evidence-based ways to build character in kids.4 This concept grew from her research into “grit” with her colleagues Christopher Peterson, Michael D. Mathews and Dennis R. Kelly. Duckworth and her colleagues reframed the term grit to refer to perseverance and passion for long-term goals. Their research suggest that grit may be as essential as IQ to high achievement. The work of the Character Lab is founded on the notion that “intelligence plus character... is the goal of true education.”5

This thesis explores the delivery of tomorrow’s educational content through emerging technologies. In doing so it addresses fundamental shifts in information presentation by enabling people to experience media via multiple senses. Virtual Reality (VR) is said to contribute to “experiential media” consumption and will also “drive development of innovative use cases in education.”6 By exploring character-building interventions, specifically focused on grit in a VR context, I aim to create a response to the question of how education would be taught using tomorrow’s technology.
LITERATURE REVIEW

Virtual reality, in its most minimal sense, can be defined as a digital representation of a three-dimensional object or environment.\(^7\) Other than three-dimensionality, smooth temporal changes and interactivity are additional important features that distinguish virtual environments from common 3D digital technologies.\(^8\) However, both of these definitions fail to convey the excitement and opportunity that lie in the continuing development and innovation of VR. Medical students, for example, are able to train difficult surgical procedures in a virtual space before conducting a real-world procedure; flight attendants can run through realistic representations of fire drills to prepare for actual emergencies; and history students are able to visit ancient temples and other locations that no longer exist.

The State of Technology in Education Report shines a spotlight on VR stating that, while it has implications for all industries, for education the changes that come with it could be revolutionary, understanding that this affect is conditional to a wider adoption of the technology within schools and universities.\(^9\) That said, VR is believed to be one of the top ten technologies in education in the United Kingdom within the next five years.\(^10\) Globally, VR is primarily employed within higher education, and according to a 2017 review of VR in education, applications are largely skewed towards those for simulation and training, especially in general medicine and surgical education.\(^11\) This begs the question: are a number of opportunities missed in other subject areas, and if so, how can current features of VR be employed for pedagogical use?

As mentioned previously, one such development area, which may be exploited in VR is grit. When exploring grit as a factor across several disciplines, Duckworth and her colleagues found that “individual differences in grit [account] for significant incremental variance in success outcomes over and beyond that explained by IQ, to which it is not positively related.”\(^12\) Almost as interesting as its quality to predict a person achieving significant success, is the premise that an individual can develop or train to become gritty. Referred to as “follow-through” in the Personal Qualities Project, “evidence of purposeful, continuous commitment to certain types of activities versus sporadic efforts in diverse areas,” was the best predictor of, whether a student would achieve a leadership position in college.\(^13\) Students who showed follow-through or grit were involved for several years in at least two different extracurricular activities and showed significant advancement and achievement in each of them.

While these results offer an interesting outlook, it is difficult to draw a concrete conclusion of whether extracurricular activities build grit or gritty individuals display passion and perseverance in their leisure time as well. Nevertheless, there have been examples of in-classroom interventions to support the grit model. To begin, building perseverance is most possible once a student has a growth mindset, which allows him or her to tackle challenges with excitement. In Carol Dweck’s research, she explained to students how the brain creates connections when tasked to solve problems, thereby allowing it to grow.\(^14\) Lauren Eskreis-Winkler, built on this in her thesis by encouraging students to interpret feelings of “frustration and confusion as positive
signs that one is engaging in optimal practice activities.” Coupled with an introduction and exercises to teach the tenets of deliberate practice, this intervention improved math performance for fifth and sixth graders, thereby introducing a loop of optimism and further practice. Further driving this cycle of performance, Eskreis-Winkler uncovered that mentoring others in deliberate practice not only effected a protegees grit but also the mentor’s performance.

The second and equally important component of the grit model, is discovering and following a passion. In her book, *Grit: The Power of Passion and Perseverance*, Duckworth cautions that there is still a lot to be learned about the psychology of interest and describes a process of discovering an interest and repeated exposure until internalized and translated into a passion. Gerald Hüther, a neurobiologist, sheds further light on how a child’s brain could develop an interest in subjects and skills it may require for the future. Similar to Duckworth, he identifies playful discovery and solving problems as a breeding ground for interest development. However, what he considers a “magic potion” in child development, is shared and uninhibited singing. This activity simultaneously stimulates and connects several regions in the growing brain that offer character building benefits, for example self-reference is built through perception and correction of the singing voice.

David Hesmondhalgh, Professor of Media, Music and Culture at University of Leeds, supports the importance of music in human development by stating that “[m]usic imitates or represents emotions, …arouses them, and… expresses them” beyond cultural aesthetics. Due to music’s resemblance to human nonverbal expressive behavior, musical training has shown to enhance empathy. Engaging in singing, therefore, becomes not only a process of self-reflection and self-reference but also of building emotional intelligence and social resonance. In no other condition is a child as engaged, empathetic and creatively stimulated as when singing with a person to whom the child is emotionally connected. Music together with an ardent connection to the person, therefore, acts as a surrogate for emotional stimulation that help children retain information and learn.

This emotional reference to a person is, however, not the only vehicle for accessing a child’s memory and development. Emotional engagement is critical to building knowledge, as well as grit. In this regard, VR may present a unique opportunity to increase learning effectiveness. Hailed by some as the “Ultimate Empathy Machine,” VR is able to evoke emotions in users, which would be difficult to experience via traditional media. In their research *What are the learning affordances of 3-D virtual environments*, Barney Dalgarno and Mark J. W. Lee, professors at the School of Education, Charles Sturt University, have identified more of VR’s distinguishing features that translate into a “superior learning experience”. They have classified immersion or presence, increased representational fidelity and a higher level of active learner interaction in contributing to an increase in student engagement. Additionally, they have identified experiential, collaborative, and contextual learning – all of which result in increased understanding and knowledge retention. While not all-encompassing, they offer a starting point to inform educational design in VR beyond simulation and harness its potential for stimulating emotions.
Figure 1: A proposed model, by the author, of grit-development based on Angela L. Duckworth's research & with Gerald Hüther's theory of developing passion.
PRECEDENT STUDY

The following VR and real-world applications are intended to develop character and expand a user’s mental ability. VR affordances identified here are considered with the objective to complement and expand on the learning benefits identified by Dalgarno and Lee as outlined previously. Their model of Learning in 3-D Virtual Learning Environments (VLE’s) is further elaborated on in the investigations section. Precedents in VR considered in this section, however, are all outside the education sector. Exploring VR features used in psychology and the arts, enabled me to identify use cases for mental development that may inform a pedagogical application.

Montessori Method of Education

What may be considered evidence of a real life version of the virtual learning environment described previously, is the Montessori Method of Education, which nurtures experiential, collaborative and contextual learning. A Montessori classroom is mixed-age and designed to offer a supportive and thoughtfully prepared learning environment. Students have a choice of activity within a range of options, freedom of movement, long blocks of time, and a process of discovery. The system is intended to not only teach children subject content but, in fact, develop physically, socially, emotionally and cognitively. It is interesting to note that this method of education is intended to build character as well as knowledge and resembles the process through which Hüther believes humans develop passion. As noted previously, he argues that playful discovery and learning concepts by solving problems in a supportive environment may lead to developing passion. This is further conditioned on repeated exposure to the subject or triggering stimulus, as well as a role-model passionate about the same. The Montessori Method of Education recognizes the importance of curiosity-based learning environments and tries to support this through its teaching methodology and classroom setup. For example, recognizing height limitations and a need for ease of accessibility for children, the classrooms and subject content are organized in such a way as to invite a child to discover.

Figure 2: Montessori
Virtual Reality is for Artists

The impact of curiosity and an environment that forces one to think in 3D is evident in a small performance curated by Time Magazine. Seven artists were tasked with and recorded creating art in a three-dimensional virtual space. Using the Google Tilt Brush to paint and HTC Vive headset and controllers to enter a virtual space, illustrator Barry Blitt was surprised that strokes he thought were creating a 3D object, actually laid flat in space. Moving away from a 2D plane, such as a canvas, to 3D painting appeared challenging for most of the seven artists but allowed them to walk through and around their creation. Once they took off the headset, the drawing was left in the virtual world. Their steps and swift movement of their wrists resulted not only in splashes of colors and shapes but also a performance, which made the experience not only richer for the artist but for the observer as well. This embodied action that resulted in a manipulation of the virtual space has also been identified by Dagarno and Lee as one of the unique learning affordances of VR. However, while they primarily compare VR to traditional media, this project demonstrates the potential of VR to surpass analog methods of experience.

Figure 3: Quote by Tim O’Brien, Artist in VR Performance by Time Magazine
Figure 4: Virtual Reality is for Artists Performance by Time Magazine

“WHEN I TOOK THE HEADSET OFF THE DRAWING WAS GONE WHICH IS THE FREAKIEST THING.”

-TIM O’BRIEN
Machine to be Another

Another project that uses embodiment is the Machine to be Another. Created by a Spanish design collective Be Another Lab, the project is intended to build empathy in its participants and allow for an investigation into concepts such as sexism, gender identity and bias. In this regard, it places a person into the body of someone of different race and/or gender.

One contributor explains: “In the project, two participants stand in front of one another, and put on their headsets which allow them to effectively see out of one another’s eyes. When they look at each other, they see themselves. When they speak, they hear the other person’s voice.” The users are encouraged to sync their movements as well. This experience, the users report, increases their awareness of the other person’s social condition. The designers argue that through this more visceral approach, participants achieve greater understanding compared to experiments using virtual avatars. Coupling the virtual experience with performance, this piece blends reality and the virtual to achieve greater empathy in its users.
Sensations of Sound: On Deafness and Music

As part of another Time VR project, deaf scholar Rachel Kolb shares her experience of hearing music for the first time after receiving a cochlear implant. Based on her experience of feeling music’s vibration before ever hearing it, she urges her audience to change the question from “what does music sound like?” to “what does music feel like?”

While her video gives interesting insight into how differently she experiences the world, 3D audio is also used to explore music and sounds in an unexpected way. The project investigates methods of stimulating the users’ visual and auditory senses simultaneously for narrative engagement.

AWElectric: That Gave Me Goosebumps, Did You Feel It Too?

The AWElectric project seems to almost answer the question of what music feels like by creating an audio-tactile fabric to induce a feeling of awe in a person and transmitting the accompanying goosebumps to another individual. Understanding that the feeling of awe can improve mental well-being and social function, the AWElectric is designed to make this sensation something that can be physically communicated. By appropriating an audio’s physical properties, the project uses sound to stimulate additional senses and thereby amplifying the experience and emotional engagement. This project is an example for triggering a physiological response to evoke an emotional one.
Dalgarno and Lee incorporate VR’s unique characteristics and corresponding learning benefits in their model of *Learning in 3D VLE’s*. Their model, which identifies five VR learning affordances, serves as a starting point for the investigations conducted in this research.

Throughout the investigations, the intention is to experiment with and expand on three broad learning affordances outlined in the diagram – experiential learning, engagement, and contextual learning. Two of the five learning affordances, spatial knowledge and collaborative learning, are not addressed, as they relate to specific educational objectives, which are outside the scope of this research. Spatial knowledge references a learner’s intimate familiarity with a location or space and is achieved through a 3D representation of the same. Collaborative learning in VR refers here to embodied human interactions, which are superior to communication in 2D technology.

In their research, Dalgarno and Lee credit engagement in VR to game and narrative-based approaches among other things. This coincides with Hüther’s theory on neurobiological growth in children. However, Hüther emphasizes emotional stimulation as potent in learning and development.

Therefore, investigation no. 1, *Empathy for The Impossible*, explores a game and narrative-based approach. Investigation no. 2, *Emotive 3D Audio*, considers sound for emotional stimulation. Investigation no. 3 addresses experiential learning, engagement, and contextual learning in VR within a primary school curriculum for history of Qatar.
Congratulations!
You have found the lamp
a wish is granted to you

Take the lamp if you would
like to leave this grave!

The lamp can be stored in
the museum and controlled
through a game controller.
Investigation No. 1: Empathy for The Impossible

The project *Machine to be Another* mentioned previously, uses embodiment techniques with performance to draw a correlation between identity and empathy. It uses VR to create a cognitive, intellectual reaction that allows the user to understand the other person’s perspective. The *Interpersonal Reactivity Index*, designed by Mark H. Davis, Professor of Psychology at Eckerd College, measures both cognitive perspective-taking and emotional reactivity as dimensions of empathy and it includes a section dedicated to fantasy. In his research, Davis shows that readers or movie-goers are able to have a visceral reaction for a fictional character. Moreover, a narrative-based approach in VR contributes to a user’s engagement leading them to become psychologically immersed. The opportunity in VR lies in using a narrative approach to build cognitive empathy for a character, whose experiences the user does not have access to in the real world.

In this investigation, the user embodies the fictional character Aladdin in order to develop cognitive empathy through a narrative-based approach in VR. In this role, the user is faced with the task to enter the cave of wonders, after being warned of its dangers, in order to retrieve a lamp. As Aladdin enters a tomb, the walls begin to move, closing the way out. In addition to the closing walls, there are traps that could kill the character, such as spikes in the floor. Just as in the tale of *1001 Nights*, there is a magic carpet to help the user pass without harm and escape the tomb. Once out in the open desert landscape, the user can experience a sense of freedom and reward riding the magic carpet, after having retrieved the lamp.

Initially, the design of the magic carpet experience in HTC Vive left users feeling vulnerable and exposed, as they had to stretch out both arms to direct the carpet upward and out of the tomb. In order to alleviate feelings of vulnerability and achieve feelings of empowerment and freedom, the mechanism to fly was amended so that the magic carpet could be directed with only one hand. Though not a planned outcome of this investigation, the experience of working with users in 6 dimensions-of-freedom showed the empathy required by the designer for the user. By designing the way a user moves in real-space to interact with virtual space, I as the designer, am choreographing the user’s body movement, which allows him or her to feel either empowered or vulnerable. The investigation further showed that the user’s emotional state can either distract or support cognitive empathy and engagement with the virtual narrative.
Investigation No. 2: Emotive 3D Audio

Beyond the visual aspect of immersion, 3D audio is an additional and substantial characteristic of a 3D virtual learning environment. Martin Rieger, a sound engineer, who specializes in 360° sound production, argues that sound is the most effective way to subtly direct a viewer’s attention. Since, unlike visual cues that can easily be missed in a 3D space, sound elements are pervasive. This investigation aims to understand the potential impact of directional audio shifts on emotional engagement.

The peak of emotional stimulation is potentially a feeling of awe. The AWElectic project described previously, explains awe as a powerful, visceral sensation that is a mix of fear and wonder. Awe is often felt in the presence of extraordinary experiences. John A. Sloboda, professor of music psychology at Keele University, associates classical music with peak emotional experiences causing a physical reaction. He, specifically, relates these emotional experiences with sudden changes in dynamics and texture of harmony. The accompanying “physical responses ... are part of the innate autonomic response system of all human beings.”

David Huron, author of Sweet Anticipation: Music and the Psychology of Expectation, offers an explanation for this phenomenon. He argues that in our evolutionary past, sudden, unexpected auditory changes usually signaled danger. Therefore, when music elicits a physical response, it turns an ancient fear response into a source of pleasure.

To test this hypothesis, two scenes were created from 360° video footage of a classical music concert by the Qatar Philharmonic Orchestra. In the first scene, serving as a control, the participant stands on a stage encircled by musicians and hears a previously recorded performance in stereo audio. The second scene consists of the same view, however, invisible speakers surrounding the participant place emphasis on different parts of the melody, thereby providing a change in audio direction. To assess the impact of this manipulation, participants’ galvanic skin response was tracked and compared to an individual baseline, which consisted of a 1-minute average taken before the start of the VR experience. A total of ten individuals were randomly exposed to either scene 1 (control) or scene 2 (audio manipulation). Participants then filled out a questionnaire to gauge musical pleasure and awareness of audio direction.

When asked if they felt involved with the musical piece, participants, on average rated their experience higher when exposed to the audio manipulation. The bio-feedback results also showed a difference between the control group and the audio manipulation group, in which the control group presented almost no change or reduced skin conductance levels (SCL) when comparing baseline and VR experience. On the other hand, participants in the audio manipulation group showed heightened SCL’s with scores ranging from 22% to 74% increase compared to their baseline. The change in 3D audio direction, therefore, triggered an SCL response that indicated a physiological response and self-reported higher involvement with the musical piece.
Investigation No. 3: Rediscovering Pearl Diving in Qatar

Pearl diving was one of Qatar’s main industries prior to the discovery of oil and the introduction of Japanese cultured pearls in the 1930’s. The high value of pearls made diving for them a profitable and dangerous profession. The history of pearl diving in Qatar is currently taught in Qatar’s primary school curriculum as a lost tradition. VR provides an opportunity to “stimulate deeper learning as students are able to explore, immerse, and infer their own meaning from their experiences.”

Scott Curtis, author of The Shape of Spectatorship: Art, Science, and Early Cinema in Germany, describes ways in which educators adopted film as a new technology to enhance their pedagogical philosophy. In a personal interview, he identified ease-of-use and content relevancy in supporting learning objectives as two important criteria when adopting new technologies in a classroom environment.

The intent of this investigation was to build a VR application that simulates pearl diving and integrates into a curriculum. In the VR Pearl Diver application, students undertake an experiential learning task that would be impractical in the real world, yet relevant to the learning objectives. For ease-of-use, the application can be downloaded onto a regular smartphone and viewed in Google Cardboard VR. In the application, the diver must descend to depths of over 30 meters on a single breath to find enough pearl oysters. After the diver has ascended and is back on board of the boat, the next task is to open the oysters. When users click on an oyster holding a pearl, depending on the size, the specific local name, such as Dana for the largest pearl, appears in the virtual educational environment. The VR Pearl Diver app also shows a score based on the number of pearl oysters collected, which adds an element of gamification.

The VR application was designed as bilingual in order to fit the requirements of primary schools in Qatar. The English user-interface is accompanied by an Arabic voice-over providing instructions. While the Arabic verbal guidance was intended to overcome software limitations in presenting Arabic characters together with English, users found it easier to listen to a voice than read text. To enhance adoption of VR in the classroom, the VR application and Google Cardboard VR also included a handout outlining instructions and learning objectives of the experience. As an outcome of this investigation, it became clear that designing for ease-of-use needs to consider both user-experience of the student and equipment set-up conducted by the educator.
PASSION & PERSEVERANCE IN VR

The objective of this thesis is to facilitate grit-building in VR by employing learning affordances established in the literature together with opportunities identified in my investigations. Dalgarno and Lee classified experiential learning, engagement and contextual learning as pedagogical benefits resulting from the distinguishing characteristics of 3D VLE’s. They identified a narrative-based approach as a vehicle for engagement. In my investigations, however, designing for an emotive state proved to be powerful, as it could encourage or disrupt a user’s engagement. In this regard, directional shifts in 3D audio facilitated a physiological response and higher involvement with the content. The investigations further showed audio to be a preferred method of receiving instructions.

The content of a 3D VLE is bound by established learning objectives within a curriculum. As stated previously, schools that teach with the Montessori method of education focus on both character and knowledge building. Therefore, a VR application developing grit could potentially integrate well within a Montessori school rather than a traditional primary school curriculum.

The thesis outcome is a VR application for building grit, or passion and perseverance, that incorporates findings from the literature and investigations. When entering the virtual world to develop grit, the user is first transported to the top of a mountain with a view that stretches into the horizon. The intent of this environment is to instill a sense of freedom and possibility. It attempts to provoke the thought: *if I called into the distance or screamed, would anyone hear it?* With no intent to answer this question, a quiet voice surrounds the user like an echo and an invitation “sing with me.” The voice begins singing a melody and then fades until the user responds or 5 seconds pass. As the user sings to the mountains and with the bodiless voice in VR, the sky illuminates with colored patterns resembling the Aurora Borealis (northern lights). There is a sundial on the mountain that initially appears to serve no purpose. However, after singing, a portal to another dimension opens through the sundial. The same melody sung by the user, now played by an orchestra, escapes the portal and the user has a choice to enter or spend more time on the mountain.

Stepping through the portal, the user is transported to a concert hall, onto a stage in VR. The audience, seated and scattered around the hall, is looking at the stage. They show only somber expressions to the silence or singing of the user. After two minutes, the orchestral melody fades and, through the portal, the voice calls the user to return to the previous environment. Having faced the crowd for the full amount of time and sung, the user is rewarded with a star shining in the sky. If the user returns early, the voice offers an explanation of how frustration and confusion are positive signs that one engages in optimal practice. The two contrasting scenes – a mountain top and a concert hall, were designed to function in tandem and to nurture passion and build perseverance.
Passion Scene

Nurturing passion is an intricate process that begins with developing an interest. As stated previously, the ideal conditions to facilitate interest building, according to Hüther, are also associated with positive emotions. The climax of emotional engagement is a feeling of awe, which is a powerful, visceral sensation resulting in a physical response. While there is a certain awe associated with entering the virtual realm, the environment the user is immersed in the passion scene was designed to further evoke this feeling. At the top of a mountain the view towards the horizon is breathtaking. It positions the user closer to the sky and a display that resembles the Aurora Borealis. One person described seeing the northern lights for the first time, as follows:

“[I] ran outside, to see the bright green lights that were slowly making their way in different shapes and formations across the sky. If I wasn’t already in awe at this moment, the progression of the display had me absolutely dumb-founded. Suddenly, the movement of the lights became faster, spreading across the sky in various ways. Then came the red swirls amongst the green, as they danced in beautiful patterns – the sight was so incredible that I, embarrassingly, cried!”

Witnessing the northern lights is a rare event. By painting streaks of light in various hues when the user sings, the virtual environment is intended to inspire awe. The voice giving instructions in this scene, both guides and surrounds the user. Therefore, auditory feedback and the melody appear to come from different directions with the intention of 3D audio inducing a physiological response. VR is most useful, according to Dalgarno and Lee, when it introduces the user to concepts that are normally not accessible to the senses. The scene is designed to stimulate several senses simultaneously and induce a strong emotive response in the user.

Hüther, in Was wir sind und was wir sein könnten: Ein neurobiologischer Mutmacher, states that high emotional engagement can inspire a child to become interested in a specific activity. While passion, in regard to grit-building, could be directed at any activity that evokes interest, musical training offers significant benefits in character development. Prompting the user to sing is intended to raise emotional intelligence and social resonance in support of developing grit. The scene, therefore, facilitates experiential learning to grow a user’s passion for musical training and cultivate character strengths.
To build perseverance, users are exposed to an uncomfortable situation and be rewarded for the amount of time spent. The intent is to cause mild stress, as the person is standing and performing on stage before a group of strangers. As social animals, acceptance or rejection of the group, in evolutionary history was important for survival and today often translates into stage fright. The stress caused by performing for an audience needs to then be associated with positive emotions that signal progress, thereby facilitating a growth mindset. In this virtual world progress is signaled with the addition of a star decorating the sky over the mountains. As the user spends more time building perseverance in the stage scene, more stars will appear in the passion scene. This cycle of effort and reward is intended to lead to optimistic self-talk and consequently perseverance.

Unlike the passion scene, which embodies concepts the user cannot access in the real world, the stage scene resembles reality as closely as possible in order to facilitate contextual learning. Dalgarno and Lee argue that “there will be more effective real-world application of newly acquired knowledge and skills if the learning environment is modelled on the context.” The intention of the stage scene, therefore, is to facilitate the transfer of a growth mindset and perseverance to real situations in which the user is faced with self-doubt before an audience.

The method of moving between the two scenes – passion and perseverance, is teleportation. Like a window in space, users are able to see where they teleport. Similar to waking from a dream, they switch between the two scenes. This method is the most comfortable and likely to avoid simulation sickness. It visually connects the two separate spaces which are logically built on each other – a virtual space to practice singing and a stage to perform.
CONCLUSION

The acceleration of technological change brings with it both an uncertainty of future necessary job skills and the opportunity for technology-enhanced learning. In this thesis, I explored the emergent technology, VR, as it affords experiential content delivery in education. Through design strategies, VR's distinguishing characteristics were investigated in order to evoke emotive responses in users, which can be prohibitive via traditional media.

This thesis specifically considered VR in the development of grit – passion and perseverance—which are essential character strengths and are associated with high achievement. The literature review provided an understanding of the conditions that facilitate grit development, such as high emotional engagement for growing passion. The research also created a baseline for pedagogical affordances in VR. The precedent study and investigations expanded on this baseline by exploring and experimenting with VR's distinguishing characteristics. Identifying an overlap with the conditions that contribute to grit, the research then proposes design strategies to stimulate senses for emotional engagement and a physiological response.

Two interactive virtual environments were developed, which seek to position the user in emotional states to build passion and perseverance. To develop passion, the virtual world is designed to engage in creativity using spatial audio and visual effects. In contrast, to build perseverance users are exposed to a challenging environment that requires them to overcome and positively associate frustration with growth.

In addressing the question of how current features in VR
can be employed for pedagogical applications, this thesis demonstrates the potential of design for higher sense-stimulation applied through VR in education.

**FUTURE DIRECTION**

This thesis explores VR for the development of grit and demonstrates the potential of VR design for higher sense-stimulation in education. However, to determine long-term impact on grit and to understand successful integration within a curriculum, it would be beneficial to test the project over periods of three months and one year in an actual school setting. In this regard, the project’s objectives are aligned with a Montessori curriculum, which integrates both character and knowledge development. However, Montessori schools structure learning differently from traditional primary schools in longer blocks of time, therefore it would be beneficial to test the VR application within this specific learning environment.

Duckworth’s Character Lab develops research-based playbooks that integrate into a learning environment to build character strengths. Beyond grit, building character is categorized into three separate skills: interpersonal, intrapersonal, and intellectual. Music and empathy relate to the interpersonal category, grit development to the intrapersonal and creativity is considered an intellectual ability. While research in musicology is clear on the benefits of musical training has on building empathy, whether this project is able to contribute to other character strengths is subject to further research.
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Fig. 2. Montessori. Cathedral Hill Montessori School. http://chmschool.org/montessori/


Fig. 4. Virtual Reality is for Artists. Time. 2018. http://time.com/4282786/how-we-immersed-7-artists-inside-virtual-reality/

Fig. 5. Perspective of Users. Machine To Be Another. Be Another Lab. 2014. http://www.themachinetobeanother.org/?page_id=33

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