The Sum Assessment System
(Technical Paper)

The Effects of Augmented Reality Technology and its Impact on Healthcare
(STS Paper)

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Introduction

Pokémon Go was a vastly widespread game phenomenon that spurred millions of people to go outside in search of cute little creatures through their phone's camera lenses. Augmented reality (AR) is the technology that can be largely attributed to the game's initial marketing success. More specifically, AR is a human-machine interaction which projects an overlay of virtual images and components onto the physical world (Dini, 2015). The concept of AR can be dated back to the 1960s when Ivan Sutherland surmised the idea of immersive displays, but the term "augmented reality" was not coined until 1992 (Schmalstieg, 2016). The use of AR can affect everyday activities by providing users with useful information in a conspicuous way that does not heavily intervene the user. While the implementation of AR in Pokémon Go was not the main reason for its continued success, the additional walking by individuals playing the game was a positive health outcome (Rapp, 2018). Due to rising levels of obesity in the United States, along with other existing health problems, AR presented itself as a candidate within technology that could potentially impact individuals' health in a positive way. The idea that Pokémon Go's AR marketing could impact health on a global level motivated me to research how AR could be used in other ways within technology to combat health issues. Similarly, the work within my capstone team can be related to disabilities and health concerns through their implementation of demographically scored questions. The technical research of my capstone group is The Sum Assessment system. It is a data analysis form that takes individuals' responses to a set of questions to determine how they think and uses the data to perform guided consultation to individuals. Parts of the assessment are determined based on demographic sections pertaining to users' disabilities, which motivates me to research how the assessment evaluates those

individuals' perspectives in relation to the general populace. The general goal of my research is to investigate the effects of AR in technology to explore how it impacts healthcare practices.

Technical Topic

The Sum, led by Elliott Cisneros, is a Charlottesville, Virginia non-profit partnered with the Heather Heyer Foundation which promotes personal growth, skill development, and diversity. The goal of The Sum is to stand in solidarity with all people, no matter their background. The Sum offers a Power of Difference Assessment (PDA). The PDA gathers participants' demographics and asks a series of demographic-based questions. After taking the PDA, a report with results is generated and emailed to the participant. The results are categorized across demographics, areas of strength, and areas of growth. The results help reveal people's demographic biases. Those that take the PDA can meet with a consultant from The Sum to learn about their biases and how to communicate better across demographics. There are paid, free, and organizational versions of the PDA with the only difference being the length of the consultation received ("The Sum", n.d.).

The Sum already has an online PDA system in place. The current system allows users to take the PDA and schedule a consultation. However, the system is error-prone. The system improperly categorizes results and it requires someone at The Sum to manually generate reports and email them to users. As part of report generation, categorizations are manually checked and corrected. This makes report generation time consuming and prone to human error. Although manually generating a report only takes a few minutes, the time from PDA completion to reports being emailed to users varies based upon availability at The Sum and can take up to 24 hours. This methodology is not scalable and cannot support the upcoming UVA Department of

Psychology study of 1,000 PDA takers. In addition to this, the current system does not detect a difference between assessment versions. It is also insecure and allows for URL manipulation.

The goal of this capstone project is to make a new PDA system. The new system should include all the features of the current system. The new system should correctly categorize results, generate reports, email reports to users, and detect which version of the PDA is being taken. For organizational and paid versions of the PDA, the new system should handle organizational access and payments correctly. The new system should also have security checks in place to prevent revisiting previously answered questions and URL manipulation.

In order to make the new system, requirements had to be gathered from The Sum. Requirements determine what features should be part of the new system and which features should be prioritized. Feature prioritization impacts the development timeline. Requirements help track development progress. Separating the work into requirements allows the team to determine who works on which features. Most importantly, requirements establish clarity between the capstone project team and The Sum for what is to be built.

Minimum requirements are to make a system where users can sign up with a valid email address, undergo email verification, select which version of the assessment to take, fill out user demographics, answer each question of the PDA, only view one question at a time, only answer questions in order, and have access to the separate consultant scheduling system. Users cannot change responses to previously answered questions. For the minimum requirements, assessment versions do not have to differ and The Sum should have administrator access to the system so they can view results, generate reports, and email reports to users.

Desired requirements include having the system correctly categorize results, generate reports, and email the reports to users and The Sum. Desired requirements also include implementing the paid and organizational versions of the PDA, moving the system to the cloud for scalability, and enhancing the systems administrator experience for The Sum.

Optional requirements include integrating the consultant scheduling system with the PDA system, supporting mobile devices, supporting changing the PDA questions, letting The Sum give consultants permissions to view specific user's results within the system, and allows organizations to view the results for their members who have taken the PDA.

STS Topic

AR serves as a blend of virtual elements with real world environments to create overlaying visualizations. The problem that AR faces is the lack of widespread technological experimentation within healthcare. However, within the medical field in particular, AR can allow researchers to test different uses of AR to determine the impact that it has on patients with particular problems. The use of AR can allow for much easier access to rehabilitative methods since people would only need access to a computer with current technology (Jia-Kuan, 2011). Studying the benefits that AR can bring to the medical field greatly impacts how healthcare services are performed in regards to effects on individuals' health. As AR can span many platforms of technology, it can be used in web and mobile based apps with more room for scalability and adaptability in the future in terms of development (Qiao, 2019). It is worthy to note the potential AR technology has for impacting healthcare. Health has always been an important concern, and AR has the ability to reshape medical practices.

One STS theory that engages the research topic presented is social constructivism. It is the claim that scientific knowledge is determined by social forces that are independent of other methods (Detel, 2001). One of the main approaches of social constructivism is that the development and content of scientific theories are all based on social factors and mutual communication (Detel, 2001). Concerns related to the use of social constructivism stem from the fact that there are problems with the objectivity of knowledge, raising doubt on the reliability of knowledge that is socially constructed (Anttonen, 1999). There is a risk of having biased or false information taught in education, leading to the obstruction of true knowledge (Anttonen, 1999). However, as AR can be used for educational purposes, AR apps allow students to demonstrate new learning outcomes by exploring educational content in new ways (Del, 2019). With further integration of AR in education and other fields, new cognitive functions within social interactions will assimilate new knowledge. The medical field is one that has also begun to incorporate the use of AR technology to change the social outlook on AR's role within technology. In one study, a survey based on a theoretical research model ascertained that patients saw a positive response from interactions with AR technology in rehabilitative use (Parisis, 2019). People are guided by their interactions with environmental stimuli, and AR plays an active role in cognitive development and the assimilation of new knowledge by users.

Another STS theory that can be applied to my research topic is Actor Network Theory (ANT). ANT is based on the core assumption that society is always in the making, with science and technology being a large factor that configures how society is shaped as time moves forward (Callon, 2001). It also does not believe that social relations are independent of the material world and that everything is instead connected within a large network with varying levels of importance (Whittle, 2008). While ANT is used in organizational studies to develop critical

theories, it cannot provide a good account for organization in the process of empirical analysis (Whittle, 2008). ANT has also been criticized to not account for preexisting structures of power within its network, claiming that they are a result of the actions of other actors within the network where similar interests align (Sheldon, 2010). The impact of Pokémon Go on society can be attributed to ANT as the Pokémon series has been shaped by society to become a popular brand. The advertising ploy used by the app to incorporate AR with a real-world Pokémon experience works in tandem as it created a larger socio-technical impact despite AR being a failure in the actual success of the app (Rapp, 2018). Within the scope of the network involving healthcare, AR is not currently a prominent actor. Some research studies, such as one investigating the effects of AR in preventing the physical effects of Type 2 diabetes, places more importance on AR as an actor within the network due to its larger presence (Neira-Tovar, 2018). By conducting additional research with AR technology in healthcare, the network AR is in will continue to expand to create a larger network that can connect AR with other existing health related issues.

Research Question and Methods

The question that I wish to research is to know how the implementation of AR in technology can improve peoples' health, whether it be physical or mental health. I can employ documentary research methods and historical case studies to gather evidence. Documentary research methods align with my question, for it helps me to verify that the evidence I analyzed is capable of supporting my interpretations of data. With historical case studies, I can look at past artifacts or published accounts from researchers that have studied queries related to my question, which I can use to gain a deeper understanding of how the case relates to my topic.

Through documentary research methods, certain technology can be introduced as evidence that support AR's integration into the medical field. Structural health monitoring refers to damage detection implementation where technology is used to for impact detection (De Marchi, 2016). While it is typically performed using various sensors, an eyepiece integrated with AR can allow people to see the estimated impact position (De Marchi, 2016). Since AR can be used to detect impacts within structural health monitoring, there is the potential for it to be integrated into other healthcare systems to improve people's wellbeing. Similarly, a case study performed to improve surgical simulation using AR helps to shape healthcare artifacts in order to build newly designed solutions (Viglialoro, 2019). The published account details the long-term development of hybrid simulators that used real and virtual components for laparoscopic cholecystectomy, with AR visualization results demonstrating that the simulator can be used for training in recording surgical errors (Viglialoro, 2019). The results of the study support the interpretation that AR visualization can be seen as an effective tool for medical purposes, which supports my research into the effects of AR in technology on peoples' health.

Conclusion

The technical deliverable is The Sum's assessment system used for gathering participants' data from their responses, and the improvement of The Sum website. The anticipated outcome of the project is a revamped version of the original website with scheduling integration for consultation and limited use access codes for assessment entry. The STS deliverable is to research how AR technology's impact in healthcare can combat various medical problems. After analyzing current studies and examples of AR implementation in technology with regards to healthcare, the beneficial aspects of AR can be seen from present developments in select medical fields. With future innovation, AR can become more prominent in aiding

individuals with better methods of healthcare. AR is a relatively new technology in terms of healthcare capabilities in comparison to to other modern advances in medical fields. By researching current implementations of AR technology, new methods of integration can be incorporated within healthcare, although the expected outcome will potentially be restricted by limitations of time and quantity of data based on existing research. Allowing for more studies related to AR to be conducted in the future will help to reinforce the outcomes of the research presented here, with the anticipation that AR technology helps the medical field to advance towards better healthcare services for society.

References

Anttonen, S. (1999). The trouble of social constructivism. http://www.leeds.ac.uk/educol/documents/00001349.htm

Callon, M. (2001). Actor Network Theory. In N. J. Smelser & P. B. Baltes (Eds.), *International Encyclopedia of the Social & Behavioral Sciences* (pp. 62–66). https://doi.org/10.1016/B0-08-043076-7/03168-5

Del, S. (2019). Seeing Is Believing: Using Virtual and Augmented Reality to Enhance Student Learning. *Gifted Child Today*, *42*(1), 46–52. https://doi.org/10.1177/1076217518804854

De Marchi, L., Ceruti, A., Testoni, N., Marzani, A., & Liverani, A. (2016). Augmented Reality Tools for Structural Health Monitoring Applications. In A. De Gloria (Ed.), *Applications in Electronics Pervading Industry, Environment and Society: APPLEPIES 2014* (pp. 115–121). https://doi.org/10.1007/978-3-319-20227-3_15

Detel, W. (2001). Social Constructivism. In N. J. Smelser & P. B. Baltes (Eds.), *International Encyclopedia of the Social & Behavioral Sciences* (pp. 14264–14267). https://doi.org/10.1016/B0-08-043076-7/01086-X

Dini, G., & Mura, M. D. (2015). Application of Augmented Reality Techniques in Through-life Engineering Services. *Procedia CIRP*, *38*, 14–23. https://doi.org/10.1016/j.procir.2015.07.044

Jia-Kuan Lin, Cheng, P., Yen Su, Jer-Junn Luh, Shao-Yu Wang, Hsiang-Wen Lin, … Mei-Ju Su. (2011). Augmented reality serious game framework for rehabilitation with personal health

records. *2011 IEEE 13th International Conference on E-Health Networking, Applications and Services*, 197–200. https://doi.org/10.1109/HEALTH.2011.6026743

Neira-Tovar, L., & Castilla Rodriguez, I. (2018). The Use of Virtual and Augmented Reality to Prevent the Physical Effects Caused by Diabetes Melitus Type 2: An Integrative Review | SpringerLink. https://link.springer.com/chapter/10.1007%2F978-3-319-91584-5_11

Parisis, G., Joseph, L., Charalabos, G., Aggelos, M. E., & John, M. (2019). Measuring the Intention of Using Augmented Reality Technology in the Health Domain. *Studies in Health Technology and Informatics*, 1664–1665. https://doi.org/10.3233/SHTI190586

Qiao, X., Ren, P., Dustdar, S., Liu, L., Ma, H., & Chen, J. (2019). Web AR: A Promising Future for Mobile Augmented Reality—State of the Art, Challenges, and Insights. *Proceedings of the IEEE*, *107*(4), 651–666. https://doi.org/10.1109/JPROC.2019.2895105

Rapp, D., Niebling, F., & Latoschik, M. E. (2018). The Impact of Pokémon Go and Why It's Not about Augmented Reality—Results from a Qualitative Survey. *2018 10th International Conference on Virtual Worlds and Games for Serious Applications (VS-Games)*, 1–2. https://doi.org/10.1109/VS-Games.2018.8493442

Schmalstieg, D., & Höllerer, T. (2016). *Augmented Reality: Principles and Practice*. Retrieved from http://proquest.safaribooksonline.com/9780133153217

Sheldon, B. (2010). Criticism of Actor-Network Theory. https://island94.org/2010/01/Criticism-of-Actor-Network-Theory.html

The Sum. (n.d.). http://thesum.org/.

Viglialoro, R. M., Esposito, N., Condino, S., Cutolo, F., Guadagni, S., Gesi, M., … Ferrari, V. (2019). Augmented Reality to Improve Surgical Simulation: Lessons Learned Towards the Design of a Hybrid Laparoscopic Simulator for Cholecystectomy. *IEEE Transactions on Biomedical Engineering*, *66*(7), 2091–2104. https://doi.org/10.1109/TBME.2018.2883816

Whittle, A., & Spicer, A. (2008). Is Actor Network Theory Critique? *Organization Studies*, *29*(4), 611–629. https://doi.org/10.1177/0170840607082223