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The Budding Botanist Paradox: Automating Human Inquiry with Immersive Technology

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Abstract: The way humans are using technology to augment our learning processes is evolving rapidly on a fundamental level. This evolution can be seen in the ways mobile computing has given us the ability to seek just-in-time information and have that information be customized and contextualized to fit our needs. Immersive technology is poised to exacerbate some of these trends and further supplement digital information to everything, everywhere. This study attempts to frame this progression in the automation of some of the most fundamental processes of human inquiry from mobile learning and the transition into immersive learning using tools like augmented and virtual reality. A hypothetical scenario of a learner of botany is presented and analyzed to explore continuing trends and concepts of these technologies and their use in learning contexts as they evolve. The budding botanist paradox is a thought experiment that attempts to reason that the more automated the learning process becomes, enhanced, and augmented with immersive technology, the more learners could be dependent on these automated systems for basic learning, more susceptible to second order influences in behavior, and the more vulnerable teachers and learners are if/when the automated systems have problems.

Keywords: Immersive Learning, Augmented Reality in Education, Metaverse Learning, Automation in Education

1. Setting the Stage

A great deal of opportunity for learning lies in the integration of technology into educational contexts. Teachers and students can both benefit from technology by being more efficient and effective, or perhaps in the case of immersive technologies, new viewpoints, and realities from which to understand our world (Eric Hawkinson, Mehran, and Alizadeh 2017). It is possible that in the coming years as these technologies come into ubiquity, we may be forced to rethink some decisions of how we introduce and maintain automated systems in education and other related fields, especially when immersive technology is applied. This trend is already making its way into educational contexts with the introduction of online and mobile learning. Now immersive technologies are being implemented in various ways, bringing with it a new level of possibilities for learning, but also unprecedented risks in privacy, data collection, and other second order effects in the automated processes that are built into our technologies (E. Hawkinson and Klaphake 2020).

1.1 The Paradox of Automation

Human beings will become less accomplished at less challenging or novel work as automation eliminates opportunity to do it. This is the concept of the paradox of automation, the more automated systems are introduced, the harder it is to understand and fix when things go wrong and the fewer the people who understand how to troubleshoot and fix the problem (Bainbridge 1983; Strauch 2018). A prime example is the idea of "Loss of control" due to over automation is the classification for Air France Flight 447 (AF447). Air France Flight 447 crashed with all lives lost over the Atlantic Ocean as it flew from Rio de Janeiro, Brazil, to Paris, France. On June 1st, 2009. After an investigation, it was found that the pilots stalled the plane when the autopilot malfunctioned, known as a 'loss of control' event to the Federal Aviation Association (FAA). Commercial aviation's greatest cause of casualties is a loss of control. From 2006 to 2015, nearly 1,400 people died in 15 fatal air accidents; between 2010 and 2014, there were 37 fatal air accidents and 1,242 deaths (Palmer 2013). There has been a decline in most types of aviation accidents, but incidents related to loss of control have stuck around. It is interesting to note that reducing accidents has also been credited to some of the same measures that have been attributed to loss of control - like sophisticated cockpit automation. In learning, automation is likely also to be a net positive, but AF447 shows us that we should at least be aware of how automation can take us to unintended places, and how we might design learning to avoid these pitfalls. It could be argued that AF447, and losses of control in general, represent extreme examples of failure of systems that function well within limits normally (Salmon, Walker, and Stanton 2016; Oliver, Calvard, and Potočnik 2017). It is my hope that more teachers and educational technologists grasp this paradox and its consequences for teaching and learning. The events leading to the loss of AF447 can be explained in part in lack of practice of manual control.

1.2 Relating Automation to Educational Contexts

There is a lot of work to be done in better understanding the role of automation in educational contexts such as plagiarism checkers, online testing, and massive open online courses, among others. It is a standard policy that student submissions should be carefully reviewed and graded by teachers to identify problems and provide feedback (Pappano 2012; Adedoyin and Soykan 2020). It is a huge amount of work to grade students' submissions once they are received that is being automated more and more. Examples in online education could be students who must give peer instruction or work together to answer an automated quiz instead or in addition to a weekly lecture. Grading can automated in such a way that students receive feedback in a timely manner through canned responses. This process is observed to be very similar to the aviation industry and autopilot leading up to AF447. There is an organizational need to scale and become more efficient, and systems are built to accommodate those needs, and the cycle continues. This cycle is poised to accelerate with the introduction of immersive technologies, as the amount of data to analyze and the ability to quickly make changes is increased simultaneously. For example, a virtual learning environment can take user biometric data taken from a VR headset and quickly make changes to all manner of aspects from detecting a learning disability to replacing content with user preferences (Cowan, Javornik, and Jiang 2021; Bekele et al. 2013).

2. Thought Experiment: The Budding Botanist Paradox

Frequently, universities automate important processes, such as grading programs, in order to deal with resource constraints (Hayes and Introna 2005; Savage 2004). As we observe possible training/learning failures in pilots when autopilot systems are introduced, there are perhaps lessons to be learned and applied to learning design and technology enhanced interventions. Perhaps forcing educators and policy makers to think beyond the obvious questions when looking to design and implement automated systems for teaching and learning. Cost and convenience are sometimes measured against risk, or whether the proposed automation supports or deters student learning. Automating instruction is a way to improve student achievement while reducing the demand on scarce resources for classroom instruction. But the paradox of automation, paired with the iterative cycle and mass scaling may bring into question some deeper questions and design decisions. To provide a better understanding of this concept in educational contexts, especially when paired with immersive technologies, I have created a thought experiment, a scenario from which to take a specific example of learning with automated systems and immersive technology to explore.

2.1 Learning Botany in Nature

Let us imagine someone learning botany and explore how automated systems contrast the learning of botany with and without automated and immersive technologies. As a budding botanist studying out in nature, there is a process, a method of inquiry that one must become skilled at to accurately identify the species of plants correctly. This process, perhaps most importantly, requires the learner to ask a series of questions about the environment, the time, the place, the season, and a host of other questions that would help inform perhaps other questions that lead to a category of plants and the process continues until one can name the individual species of plant with any sort of confidence.

By contrast, using online services or automated tools to identify plants or parts of plants that are becoming more common (White, Feiner, and Kopylec 2006). Our devices are increasingly collecting and curating information about where we are, what we do, what we say, who we are with, and much more. With this a pattern of behavior is formed and predictions can be made about what questions might need answering next. Smartphones have GPS and other radios that track our movements, and cameras, microphones and more that take in data to analyze a variety of things. This data can now be the foundation of automating the process of inquiry that traditionally happened for the budding botanist out in nature. Knowing information like our location, recent weather, climate trends, and the mountains of pictures, video, and other data generated by other users, the answers to the questions one would ask to come down on a plant species can be automated, and perhaps be prompted to us before we ask them. These systems have already been tried in botanical training in higher education to some success (Chien et al. 2019).

With immersive technologies, in this case augmented reality powered by computer vision and image recognition technologies, a picture, video, or 3D scan of the plant can be taken, uploaded, and compared with mountains of other similar pictures, videos, or scans. Paired with the other data, such as location, search history, weather, and other bits of information, an answer to the question, “What species of flower is this” is answered in an instant, along with the process and questions leading up to it. This could be analogous to modern-day equivalent to looking in the back of the book for the answers.

It is not clear if this is also a net plus for learners. It likely depends on the context of learning and the context of automating in practice, much like pilots and autopilot. In one case of young learners, a greater comprehension of plants studied was found by employing an AR app in the learning process (Chien et al. 2019). If one intends not to become a botanist, perhaps studying climate change having a tool to track plants to correlate to climate patterns might be a great learning boost to tangential learners to botany. But just as the paradox of automation suggests, we are outdating the underlying skills of inquiry. Thus, people are less able to cope with or replace failed or misleading automation systems. Learners of botany are now leaning on the automated system. If there are errors in this system, they may scale easily to many and harder to correct.

2.2 Contrast Learning about Plants with AR and without AR

It can be very helpful to learn about plants using AR. It appears that a general written query to Google will only provide us with a small amount of accuracy and a large amount of other relevant information. However, the situation can be reversed by using AR. In the search results, it can find exactly what you just imagined, so you will get a lot of accurate information and very little irrelevant information. This is due to the amount of data used in the curation of the response to a query. Augmented reality employs data from tools much later in the chain of telemetry, and therefore more robust in its ability to analyze a question, and by extension, more empathic.

3. 3 Stages in Automated Learning Systems

To better illustrate this trend in the automation of human inquiry towards immersive technology, let's examine three steps/stages in the most fundamental forms of the simple task of answering a question with the aid of technology. These three stages come in the form of three technology developments from the internet connected personal computer, to smartphones, and then to augmented reality enhanced smart glasses. Each of these technologies have popular methods for seeking information to answer simple questions. It is my hope that an examination of these stages will both illustrate the trend around automated learning systems and build context to the budding botanist paradox.

3.1 Personal Computers and Google Search

Internet search was a boon soon after the world wide web layer was developed and popularized in the 1990s. Google determines the order of its search results by using a ranking system called PageRank. Especially in its earliest iterations, Google search didn't use much more than a string of text for input data to give a very large set of data as results. This many times forced users to either reword or refine their search or to learn the syntax of Google to specify, exclude, or exclude specific criteria. This also gave the chance for the accidental discovery of pertinent tangential information along the way.
This could be considered analogous to the budding botanist in nature without the aid of technology. Giving incentive to the learner to ask different questions to find the answer needed, and in the process offering the chance of discovery, but also being presented with information to curtate and integrate on your own (Fisher, Smiley, and Grillo 2021).

3.2 Smartphones and Virtual Assistants

Users can now search for spoken words instead of typed ones by using a voice assistant like Siri (iOS) and Bixby (Samsung). The voice assistant also takes in audio data along with data from other sensors like GPS and motion, which is increasingly used to verify the user and their state of mind using a voiceprint. All this extra data allows algorithms to curate your question and give one answer, rather than to 100,000s of answers given in a text search from the previous stage. More data in, less data out, and less of a chance for an unexpected or nuanced finding without further inquiry from the user.

3.3 Smart Glasses and Computer Vision (CV)

Using computer vision (CV), the computer can acquire, process, analyze, and understand digital videos and images. It identifies an object by observing its appearance, location, and settings. This takes us to the third stage in this trend towards the budding botanist paradox.
A pair of smart glasses can overlay virtual objects on the real world using augmented reality (Polvi et al. 2016). This again ups the ante for collected data for the purpose of curating user queries. In addition to all the data in past stages, a larger amount of data is collected passively about a user's surroundings. In the smartphone and virtual assistant stage, we were starting to get prompted with information that was not requested, perhaps with automated notifications related to our past use of our devices. This is another component of taking the inquiry process

out of using these systems. Automation when combined with engagement algorithms, attempt to predict, curb, or nudge our behavior to revisit information, and perhaps to start anticipating our questions and feeding us the appropriate information. There is a possibility for immersive technology, with the aid of computer vision and a heads-up display to start exacerbating this trend (Amin and Govilkar 2015). The nature of this technology would now serve as a passive input device and allow for much more unprompted information in the form of virtual objects and other visual information displays. Because the camera and microphone are passively scanning and always on, the amount of data to be curated again jumps tremendously. In the budding botanist scenario, the heads-up display might start displaying the names of plants in view without asking after asking the device to identify some plants a couple of times. The automated system is now anticipating what questions might be coming up next and displaying them in our view. Other examples are pairing facial recognition to display people's names above their heads, helping us not to remember names just as we don't need to remember phone numbers.

In this stage of automation, the basic inquiry process has become again more dependent on the supporting algorithms that curate and prompt information, even before the user has formed a question.

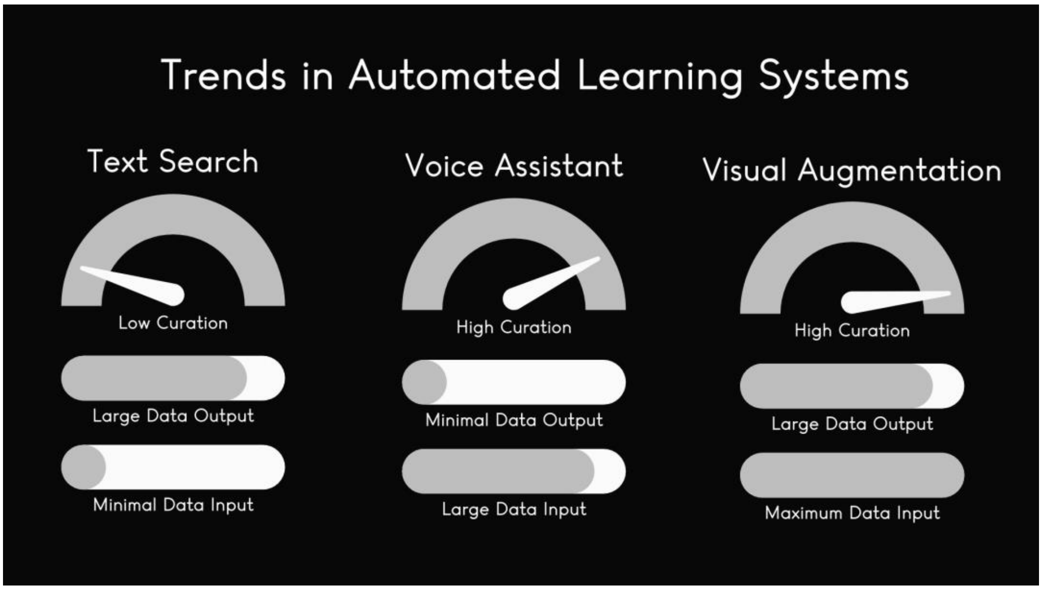

Figure 1. Comparing 3 Stages of Input Methods for Learning

4. Discussion

Covid-19 and the global pandemic accelerated distance learning and the need for developing digital competencies related to automation for teachers and students. To be effective in the classroom, technology must also be incorporated only when it is appropriate for the task at hand. There are some approaches that immersive technologies can offer in an educational context that other media cannot, such as highly accurate simulations of expensive or dangerous or novel environments. It takes an educator experienced in using these digital tools to best implement them. And in the absence of training, may rely more on the general automated or prescribed use and could contribute to the dark patterns and other designs that lie in the business models that shape the automation of many of these newer tools.

5. Conclusion

One driving force in the growth of automation in human inquiry is the evolution of human-computer interface and the move to more empathic computing. A precise and responsive input interface with just enough digital intervention to nudge behaviors. Glasses are challenging the smartphone as the dominant form factor. A simple, accurate interface is required for the augmentation domain. We will adopt new input methods like brainwaves, gaze detection, and muscle signals in the future.

The budding botanist paradox is a thought experiment to attempt to reason that the more automated the learning process becomes, enhanced, and augmented with immersive technology, the more learners could be dependent on these automated systems for basic learning, more susceptible to second order influences in behavior, and the more vulnerable teachers and learners are if/when the automated systems have problems.

References

Adedoyin, Olasile Babatunde, and Emrah Soykan. 2020. "Covid-19 Pandemic and Online Learning: The Challenges and Opportunities." Interactive Learning Environments, September, 1–13.

Amin, and Govilkar. 2015. "Comparative Study of Augmented Reality SDKs." International Journal of Computational Intelligence and Applications.

Bainbridge, L. 1983. "IRONIES OF AUTOMATION." In Analysis, Design and Evaluation of Man–Machine Systems, edited by G. Johannsen and J. E. Rijnsdorp, 129–35. Pergamon.

Bekele, Esubalew, Zhi Zheng, Amy Swanson, Julie Crittendon, Zachary Warren, and Nilanjan Sarkar. 2013. "Understanding How Adolescents with Autism Respond to Facial Expressions in Virtual Reality Environments." IEEE Transactions on Visualization and Computer Graphics 19 (4): 711–20.

Chien, Yu-Cheng, Yen-Ning Su, Ting-Ting Wu, and Yueh-Min Huang. 2019. "Enhancing Students' Botanical Learning by Using Augmented Reality." Universal Access in the Information Society 18 (2): 231–41.

Cowan, Kirsten, Ana Javornik, and Peilin Jiang. 2021. "Privacy Concerns When Using Augmented Reality Face Filters? Explaining Why and When Use Avoidance Occurs." Psychology & Marketing 38 (10): 1799–1813.

Fisher, Matthew, Adam H. Smiley, and Tito L. H. Grillo. 2021. "Information without Knowledge: The Effects of Internet Search on Learning." Memory , February, 1–13.

Hawkinson, E., and J. Klaphake. 2020. "Work-in-Progress—Legal and Ethical Issues in Immersive Education." In 2020 6th International Conference of the Immersive Learning Research Network (iLRN), 305–7.

Hawkinson, Eric, Parisa Mehran, and Mehrasa Alizadeh. 2017. "Using MAVR to Bring New Dimensions to the Classroom." LANGUAGE TEACHER 41: 31.

Hayes, Niall, and Lucas Introna. 2005. "Systems for the Production of Plagiarists? The Implications Arising from the Use of Plagiarism Detection Systems in UK Universities for Asian Learners." Journal of Academic Ethics 3 (1): 55–73.

Oliver, Nick, Thomas Calvard, and Kristina Potočnik. 2017. "Cognition, Technology, and Organizational Limits: Lessons from the Air France 447 Disaster." Organization Science 28 (4): 729–43.

Palmer, Bill. 2013. Understanding Air France 447. William Palmer.

Pappano. 2012. "The Year of the MOOC." The New York Times.

Polvi, Jarkko, Takafumi Taketomi, Goshiro Yamamoto, Arindam Dey, Christian Sandor, and Hirokazu Kato. 2016. "SlidAR: A 3D Positioning Method for SLAM-Based Handheld Augmented Reality." Computers & Graphics 55 (April): 33–43.

Salmon, Paul M., Guy H. Walker, and Neville A. Stanton. 2016. "Pilot Error versus Sociotechnical Systems Failure: A Distributed Situation Awareness Analysis of Air France 447." Theoretical Issues in Ergonomics Science 17 (1): 64–79.

Savage, S. 2004. "Staff and Student Responses to a Trial of Turnitin Plagiarism Detection Software." Proceedings of the Australian Universities Quality. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.187.5717

Shan, Caifeng. 2010. "Gesture Control for Consumer Electronics." In Multimedia Interaction and Intelligent User Interfaces: Principles, Methods and Applications, edited by Ling Shao, Caifeng Shan, Jiebo Luo, and Minoru Etoh, 107–28. London: Springer London.

Strauch, Barry. 2018. "Ironies of Automation: Still Unresolved After All These Years." IEEE Transactions on Human-Machine Systems 48 (5): 419–33.

Tan, Desney, and Anton Nijholt. 2010. "Brain-Computer Interfaces and Human-Computer Interaction." In Brain-Computer Interfaces: Applying Our Minds to Human-Computer Interaction, edited by Desney S. Tan and Anton Nijholt, 3–19. London: Springer London.

White, S., S. Feiner, and J. Kopylec. 2006. "Virtual Vouchers: Prototyping a Mobile Augmented Reality User Interface for Botanical Species Identification." In 3D User Interfaces (3DUI'06), 119–26. ieeexplore.ieee.org.