Lithium Extraction and Purification from Geothermal Brine
(Technical Paper)

The Metaverse as a Technological Fix: An Analysis on the Quality of College Education
(STS Paper)

A Thesis Prospectus
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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

It is 9:05 am while the alarm clock screams in desperation to recover from failing to fulfill its purpose. Yet panic is far from sight, as the simple action of putting on a virtual reality headset transports an educator of STS 4500 into a virtual classroom to teach a class of 50 college students. Through the integration of the metaverse, a 3D virtual space where people can interact and communicate with each other through avatars, this scenario becomes reality (Hendaoui et al., 2008). While the metaverse provides an unmatched ability to create safe and unrestricted environments through the utilization of non-face-to-face services, there remains widespread uncertainty surrounding its implementation (Dahan, 2022). Leaders of Meta and Microsoft are currently partnering up to catalyze the construction of a strong network fueled through virtual spaces to increase both efficiency and user experience through the creation of an immersive environment in both the private and public sector (Upadhyay et al., 2022). Within the college education space in particular, the integration of the metaverse serves as a technological fix to structural problems in college education fueled by the transfer of power from college educators to tech giants.

On the same note of revolutionizing industries, electric vehicles (EV) hold an increasingly dominant role in dictating the future of the car industry as evidenced through increased sustainability efforts and the desire for net zero CO_2 emissions. The increased demand in the electrification of vehicles is driven by both rising fuel costs and growing environmental concerns while the supply of EV batteries fails to match demand. There is therefore a growing sense of urgency to find new sources of lithium hydroxide which is a key component in EV batteries. The final technical deliverable will involve the design of a downstream processing plant to achieve 90% recovery and 99.5% purity of lithium hydroxide (LiOH) from geothermal brines in Salton Sea, California.

There are two main projects in this portfolio: the technical project and the STS research paper. The goal of the technical project is to design a profitable plant that extracts and purifies lithium hydroxide from geothermal brines. Meanwhile, the STS research paper portion of this paper aims to analyze how the implementation of the metaverse will affect the quality of education through a technological fix and political lens. The portfolio will first discuss the technical project followed by the STS research portion, as the future of energy and education are explored in greater detail.

Process for Extraction and Purification of LiOH from Salton Sea Geothermal Brines

Rapid clean energy scale-up will generate increased demand for critical minerals; thus, new and diverse supply sources are necessary to counter supply strains (International Energy Agency, 2022, p. 14). These strains arise particularly from rapid scaling problems (Olivetti et al., 2017, p. 229), high geographic reserve location and refining capability concentration (Sun et al., 2021, p. 12180), mining asset exposure to climate risk (Delevingne et al., 2020, p. 2-5), and long project development time (International Energy Agency, 2022, p. 12). Lithium is classified as a critical mineral "hav[ing] a supply chain that is vulnerable to disruption and serv[ing] an essential function in the manufacturing of a product, the absence of which would have significant consequences for the economic or national security of the United States" (United States Geological Survey, 2022, p. 17). Current and pending mine projects have supply capability covering only half of projected 2030 lithium needs and "are not ready to support accelerated energy transitions" (International Energy Agency, 2022, p. 11). It is thus in the vested economic and security interests of the United States to jointly propel lithium extraction research and extraction process impact assessment (Hailes, 2022; Parker et al., 2022).

Primary lithium extraction pathways currently include extraction from hard rock pegmatites, extraction from sedimentary rock such as clays, or evaporation from arid basin brines (Blair et al., 2022, p. 4). Arid basin brine lithium sourcing faces particular criticism for its heavy water requirements within the internationally recognized wetlands of Chile, Argentina, and Bolivia; for its ecological disruption to migratory and native species; and for its exploitation of indigenous and local people's land (Blair et al., 2022, p. 4). Geothermal brine extraction has historically been hindered by severe scaling and equipment corrosion (Hoffmann, 1975, pp. 9-13); however, operations now produce electricity from the geothermal fluid heat (*Imperial Valley*

Geothermal Area). This work will further evolve research which aims to extract target minerals before stream reinjection back into their source geothermal reservoirs (Warren, 2021).

The project focuses on extracting and purifying a lithium product, lithium hydroxide (LiOH), following pretreatment from geothermal brines. Figure 1 displays a block flow diagram detailing the lithium extraction process beginning after solids have been removed from the raw brine and the power cycle has been run. A pH balancing and filtration step removes contaminants to avoid precipitation on equipment. The lithium loading and extraction processes use two reactors with opposite chemisorption directions that form a regenerative absorption network.

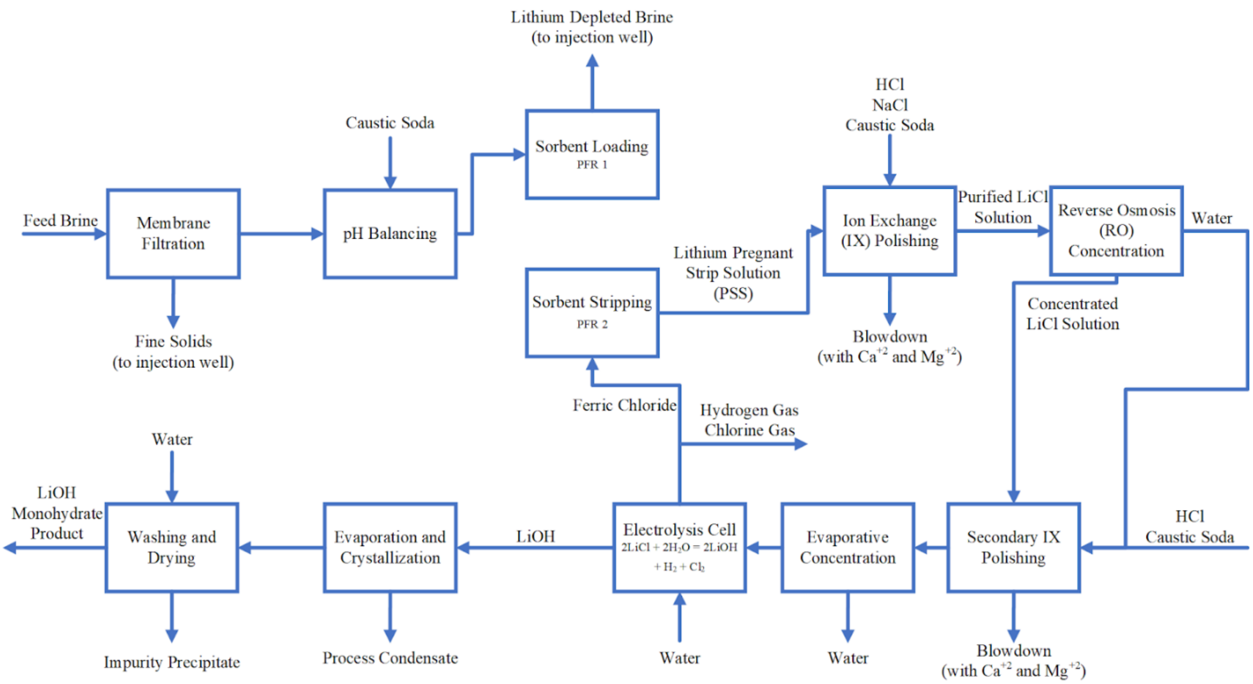

Figure 1: Block flow diagram of lithium extraction process

(Adapted from NORAM Engineering)

Two additional refining steps are executed to form a purer intermediate: Ion Exchange (IX) and Reverse Osmosis (RO). The IX process removes divalent ions such as calcium and magnesium. The reverse osmosis step pushes water through a membrane at high pressure to concentrate the mixture with the desired intermediate: lithium chloride (LiCl). The LiCl mixture then runs through secondary IX purification and evaporative concentration units to remove excess ions and water. The mixture is then processed in an electrochemical cell where lithium chloride is converted to lithium hydroxide. Once the LiOH is extracted from the cell, water is further evaporated and the LiOH is crystallized. Final processing steps include washing, drying, resizing, and packaging to meet the high purity standards for use in batteries and other applications.

The team of four students will produce a design for a plant to produce LiOH from geothermal brines which will be carried out over two semesters. The team plans to model most of the process using Aspen Plus, a process modeling tool that predicts performances of specified processes through an iterative method given a process design and thermodynamic models. For processes that are not modellable on Aspen like electrolysis, the team will utilize Excel spreadsheets and/or MATLAB software to compute the necessary calculations manually. Under the assumption that the brine has a lithium composition of 287 ppm, the feed enters the process at 110°C and at a pressure of 1 atm. Within the packed-bed reactor, an assumed lithium to sodium molar selectivity of 100 to 1 describes the catalyst efficacy. The additional data will be obtained through sponsors, Professors Giri, Koenig and Geise, as well as geothermal brine reports. The team will divide the work based around our 10+ process units by splitting the total number of process units in half and pairing up to work on the designated units. Regarding main operating units such as plug flow reactors and the electrolysis cell, the team will collaborate to perform the necessary calculations and seek aid from advisor, Eric Anderson, as necessary.

The Role of the Metaverse as a Technological Fix and Tool of Power

Recent advancements in the technology sector propelled the transformation of the physical world into a virtual world known as the metaverse. Apart from its direct translation of “meta” meaning transcendence and virtuality, and “universe” representing the world, the metaverse is more broadly defined as “a 3D-based virtual reality in which daily activities and economic life are conducted through avatars representing the real themselves” (Kye et al., 2021, p. 1). Users in the metaverse live and engage in social, economic, and cultural activities through the form of their own avatars. The introduction of this virtual world provides a creative opportunity to overcome spatial limitations; especially within the context of the COVID-19 pandemic, the applications of the metaverse in the E-learning space skyrocketed due to the rise in social distancing efforts (Dahan et al., 2022, p. 2). Tech giants are actively advocating for the use and implementation of the metaverse into all aspects of society, collaborating to build a strong network for the creation of a new virtual world. The implementation of the metaverse, however, results in a direct battle of interests and reallocation of power between tech giants whose interests fall largely in line with maximizing profit, and college students and professors who prioritize social interaction as they fear that becoming too technologically reliant decreases personal autonomy in receiving or delivering education, respectively. The utilization of the metaverse in college education, through the creation of virtual education systems and classrooms, requires the collaboration of college students and professors with the leaders of technology companies—primarily with Microsoft and Meta—to initially set the foundation for a new structure of education and minimize the resulting power imbalance.

An analytical framework used for analyzing the efficacy of creating technology to solve social problems is the technological fix. More specifically, a technological fix “describes the use of technology to respond to certain types of human social problems that are more traditionally addressed via political, legal, organizational, or other social processes” (Rosner, 2013). However, the main issue arises when technology serves to simply mask the underlying structural issues by failing to attack the root of these problems. Within the education space, the structural issues are the focus for professors and university leaders, as they seek to increase the quality of education for college students where quality is a function of both qualitative and quantitative assessments. To increase both the intelligence and overall educational experience, the metaverse serves as a technological fix as it fails to address the deeply rooted problems with the assessment structure and content delivery style. Professor Dane Scott from the University of Montana argues that technological fixes are "not alternative means for solving problems; science and technology are the only way to advance civilization," highlighting their use as temporary solutions. According to German philosopher Marx, the problems are primarily caused because of political, not scientific, means created by the man himself which emphasizes the need to employ disciplinary approaches to solve complex social problems (Scott, 2011).

The central idea that artifacts have politics is another analytical framework used for exploring the interaction between technology and society. Artifacts can be used as a means for exerting power, authority, or privilege where "the invention, design, or arrangement…becomes a way of settling an issue in a particular community," thereby possessing the ability to create a new power hierarchy (Winner, 1980, p. 123). The notion of using the metaverse to settle issues created within the college education system further transfers the power to tech giants, reversing the original power structure of education where professors exercised autonomy in the exchange of knowledge to college students. Critics of Winner, such as University of Notre Dame Professor Richard Donnelly, argue that there is a "denial of the primacy of the political" as politics under a capitalist society analysis are understood through deeper structural issues within capitalism rather than through the technology itself.

Considering the goal of implementing the metaverse within the next five years, it is becoming increasingly important to understand the effects of creating a virtual world in education, especially since the transfer of knowledge to the future leaders of the world largely dictates societal progress. The potential of the expansive reach of the metaverse warrants analysis regarding the overall net benefit—or lack thereof—to the college community in understanding its use as a technological fix through the reversion of the pre-existing hierarchy.

Research Methods

How does the integration of the metaverse serve as a technological fix to foundational issues in college education through the creation of a new power structure? Analyzing this question relies on utilizing documentary analysis and literature review using “metaverse”, “college education”, and “virtual worlds” as keywords. The analysis from journals of information systems education and internet information discussing the implementation of Second Life, a leading virtual world, will allow for the determination of the metaverse’s role as a technological fix in college education. In addition to journals, completed interviews from experts in the metaverse field, as well as college professors and students, will facilitate the understanding of the current power dynamic and future expected roles for these stakeholders. Available literature surrounding the challenges and benefits of utilizing the metaverse in the education sector further strengthens the analysis surrounding the metaverse’s function as a temporary solution to underlying power conflicts. The understanding of the role of the metaverse is enhanced through this combination of literature reviews and scholarly articles.

Conclusion

The team will extract and develop a downstream purification process for producing battery-grade lithium hydroxide monohydrate, $LiOH \cdot H_2O$, from a geothermal brine source in

Salton Sea, California. The team will also design a profitable plant that produces a 99%-pure product of $LiOH \cdot H_2O$ while minimizing operating costs. On the same note as revolutionizing industries, the widespread impact of the metaverse on the quality of college education creates an almost irreversible and new power structure with tech giants at its pinnacle. While the use of the metaverse eliminates several physical barriers that limit the access and quality of college education, the challenges it presents will far outweigh its benefits which solidifies its role as a technological fix. It is therefore essential to hinder the efforts proposed by Meta and Microsoft due to the resulting highly imbalanced transfer of power that solely masks the root of the problem.

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