SCHOOL OF INDUSTRIAL DESIGN

IDES 4001A • INDUSTRIAL DESIGN SEMINAR • FALL 2023

SEMINAR REPORT

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Carleton University | School of Industrial Design

Session A

Instructor: WonJoon Chung

Objective & Theme

The objective of this Seminar course is to engage students in exploring and deliberating upon theoretical facets of industrial design. During these seminars, students will actively participate in group discussions, express their viewpoints through group presentations, develop group and individual reports, and also present them in the final design seminar.

Theme of the 2023 Industrial Design Seminar:

"Industrial Design in the era of 4th Industrial Revolution"

What role does industrial design play in the era of the Fourth Industrial Revolution? In the 1990s, design fields such as product design, graphic design, fashion design, interior design, and landscape design, etc. had clear boundaries. University departments for various design disciplines were distinctly categorized, and graduates pursued careers as designers in their chosen fields. Moving to different fields or domains was often difficult or nearly impossible due to these well-defined boundaries. The current era of the Fourth Industrial Revolution is evolving into a hyper-connected age through the convergence of various advanced technologies such as AI, VR, AR, MR, IoT, big data, and robotics, and so on. Moreover, diverse fields like humanities, culture, and sustainability are converging, leading to the simultaneous creation of various technologies and the rapid establishment of their ecosystems. With the establishment of this new ecosystem, the role of industrial design is also changing. In this seminar, students will discuss what we can expect ID to be in the imminent future. Based on this, each team needs to generate a subtopic, and each student in a team will then refine the subtopic to create their individual working title.

Examples of possible subtopics;

1. Digital Transformation: The integration of digital technologies, such as IoT (Internet of Things), AI(Artificial Intelligence), and smart manufacturing, was reshaping the industrial design landscape.

2. Sustainability and Eco-Friendly Design: As environmental concerns continued to grow,discussions around creating products with reduced environmental impact, using sustainable materials, and designing for recyclability were gaining significant attention.

3. Design for Aging Population: As the global population continued to age, designing products that cater to the needs and preferences of older adults was a point of focus.

4. Augmented Reality (AR) and Virtual Reality (VR): The potential of AR and VR technologies in industrial design, from concept visualization to user testing, was being explored.

5. Healthcare and Wellness Design: With a growing emphasis on health and well-being, the design of medical devices, healthcare environments, and wellness products was becoming a significant topic.

6. 3D Printing and Additive Manufacturing: The advancement of 3D printing and additive manufacturing technologies was impacting how designers conceptualized and created prototypes and final products.

7. Ethical Design and Inclusivity: Designing products that respect diverse cultures, backgrounds,and abilities were gaining prominence.

These are just examples, so feel free to consider other topics as well.

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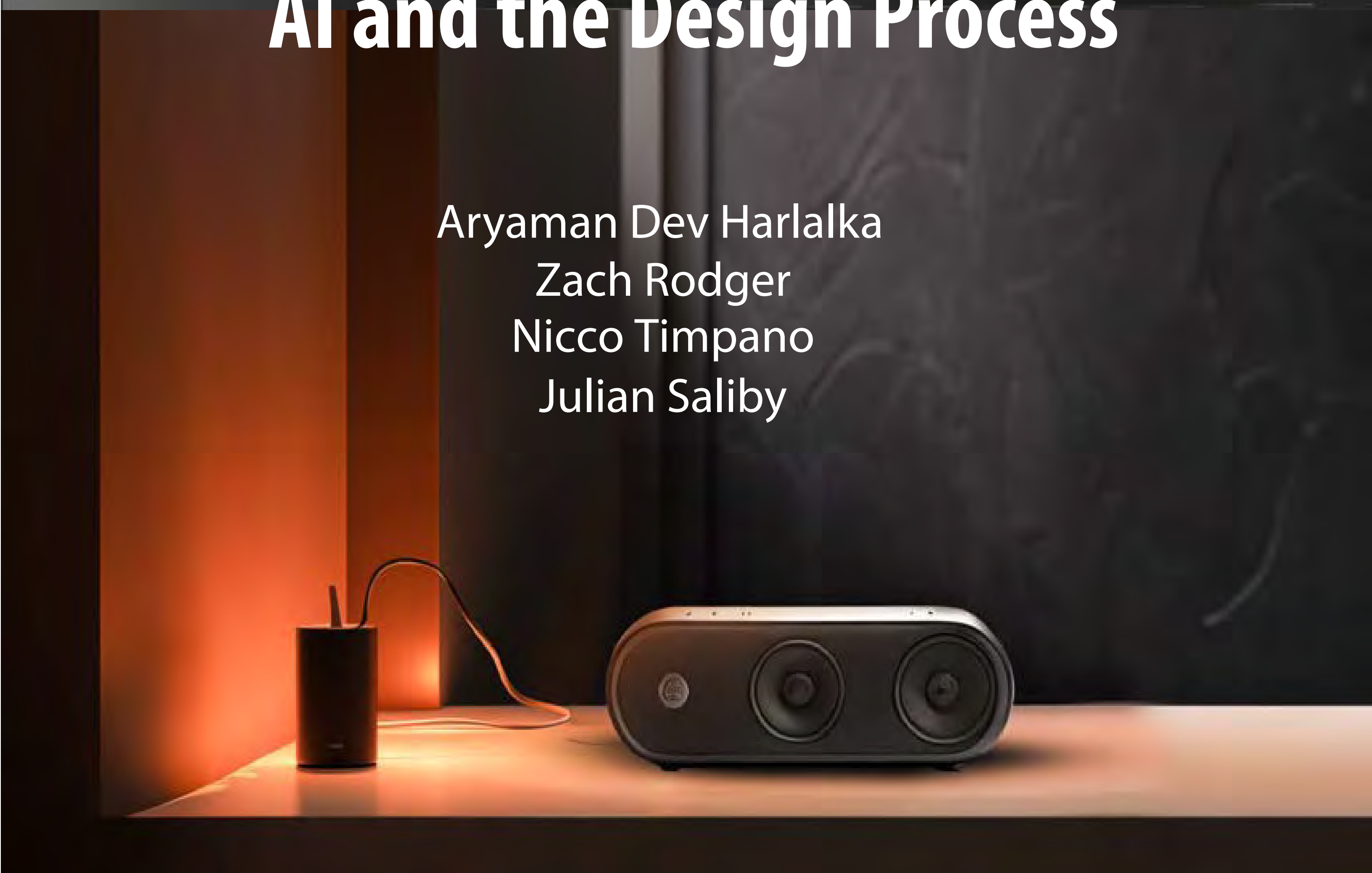

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AI FOR DESIGN RESEARCH

AI AND THE DESIGN PROCESS | ARYAMAN DEV HARLALKA

BACKGROUND

In the dynamic realm of design research, the integration of Artificial Intelligence (AI) stands as a transformative force, reshaping traditional methodologies and opening new avenues of exploration. As the capabilities of AI technologies continue to advance, their potential impact on the design research process becomes increasingly evident. This research endeavours to delve into the intricate interplay between AI and design research, examining how AI can augment and streamline various facets of the research journey. Beyond dissecting the technical applications, our focus extends to uncovering the nuanced roles AI plays in shaping ideation, prototyping, and final design phases. By undertaking this exploration, we aim to not only elucidate the evolving landscape of AI in design research but also to navigate ethical considerations and practical implications, contributing to a comprehensive understanding of AI's role as a dynamic collaborator in the creative research domain.

DISCUSSION

In our investigation of the impact of AI on the design process, we uncovered significant implications for employment, education, and the practices of industrial designers. As we each delved into this area, we uncovered shared concerns driven by the rapid advancement of AI, resulting in a continuous flow of new innovations. This ongoing evolution meant that existing resources could quickly become obsolete, providing valuable learning insights but lacking definitive perspectives.

In response to these concerns, the team chose to conduct a first-hand experiment, delving into qualitative insights. The goal was to connect theoretical knowledge with real-world applications.

In an effort to delve into exclusive data not commonly found in existing research papers, the approach was selected to gain a comprehensive understanding of AI's practical implications in design, beyond theoretical discussions. By dynamically integrating academic perspectives with real-world testing, a detailed investigation into AI's influence on the industrial design realm was enabled. The experiment's emphasis on exclusive insights and comparative evaluations situated our discoveries within the framework of industry significance, enriching the ongoing discussion on the evolving intersection of AI and design.

THREE QUESTIONS

Throughout the journey, the team members were assigned to conceive three questions each, aiming to unravel answers in their research tied to their respective working titles. As the process unfolded, the evolution and constant flux of these interrogations became a defining feature for our cohesive unit.

1. What are the ethical concerns or biases associated with AI in design research, and how can they be mitigated?

2. What skills and knowledge are required for design researchers to effectively integrate AI into their workflows?

3. In what ways can AI enhance user testing and feedback collection for design projects?

Our experimentation, investigation, and subsequent seminar aim to address these inquiries, revealing potential advantages and apprehensions associated with AI, and presenting an innovative training approach designed specifically for AI in Industrial Design—a novel initiative within our industry.

RESEARCH ON EXISTING PAPERS

The journey into AI for design research began with a comprehensive analysis of academic literature, encompassing historical backgrounds and core issues related to the incorporation of artificial intelligence (AI) during the design ideation phase. The main aim was to gain a deep insight into the role of AI, especially in the progression of product design (He, Guo, Zhou, 2018, p. 13).

In the subsequent phase of the study, there was a comprehensive exploration of three widely acknowledged types of AI: Supervised Learning, Unsupervised Learning, and Reinforced Learning (Vergant, Vendraminelli, 2020, p. 6). Notable AI models such as Chat GPT4, Midjourney, Vizcom, and Stable Diffusion, which are accessible to the public, were discovered to employ a combination of Supervised and Unsupervised learning approaches. While effective for training models on identifiable entities like animals, this combination was observed to hinder convergent thinking and lacked decisiveness. The potential of Reinforced Learning, although currently underutilized in commonly available AI models, was acknowledged as bearing the closest resemblance to the traditional design process (Vergant, Vendraminelli, 2020, p. 7).

The expanded text is intentionally varied in sentence structures and lengths, creating a dynamic reading experience. By strategically infusing bursts of information, it aims to keep readers captivated and eager for more. It emphasizes the comparison between AI training methodologies and educational frameworks within SID (Strategic Innovation Design), shaping a comprehensive training curriculum. The curriculum's goal is to reframe the perception of AI as a collaborative Design Co-Pilot rather than a job security threat, pioneering a novel industry role - the Design Co-Pilot, yet to be fully defined or explored.

To implement the acquired knowledge, a set of instructional drills was devised, centering on two leading AI platforms of today, namely ChatGPT and Bard. These exercises aimed at putting the theoretical understanding into practical application, thereby enhancing proficiency in dealing with these advanced AI systems. By focusing on practical interactions with these AI programs, users can grasp their intricacies and functionalities better, ultimately honing their skills in utilizing them effectively. This approach not only ensures comprehension but also fosters proficiency and expertise in working with state-of-the-art AI.

The research placed significant emphasis on ethical considerations, specifically aimed at minimizing possible breaches of regulations by the participants. Notably, apprehensions were highlighted, particularly in relation to extensive data extraction from the internet, comparable to scraping.

Recognizing the potential of AI as a tool for inspiration, akin to platforms such as Pinterest or Behanc e, ethical frameworks were advocated. Designers were advised against appropriating concepts without verification, emphasizing the significance of seeking inspiration while aiming for authenticity.

The research findings pointed to AI's potential value as a collaborative partner in the design phase. It emphasized AI's ability in facilitating idea generation, refining sketches, and aiding brainstorming sessions. However, the study advised against using AI in an autonomous Auto-Pilot mode due to potential legal and ethical concerns such as patent violations, academic integrity risks, and unintended design appropriation. This underscores the significance of responsible and thoughtful integration of AI in design procedures, aligning with existing literature insights (He, Guo, Zhou, 2018; Vergant, Vendraminelli, 2020).

INTRODUCTION TO EXPERIMENT

In order to comprehensively investigate the impact of Artificial Intelligence (AI) on the design research process, a structured experiment was devised to assess the role of AI in the ideation phase. The primary objective was to discern how AI influences creativity, efficiency, and decision-making during the conceptualization of a product. The participants, comprising an industry professional and a student with AI assistance, were tasked with designing a portable Bluetooth speaker—a familiar yet intricate product that demanded careful consideration of form, function, and user experience.

The experiment employed a controlled setting with designated workspaces for each participant, equipped with standard design tools such as a laptop, drawing utensils, and modelling supplies. Both participants received identical criteria and instructions for the ideation phase, emphasizing the exploration of traditional design concepts and ideas. The prompt directed them to create presentation assets demonstrating their concept ideas, with a focus on form, function, and product usage. This strategic approach allowed for a comparative analysis of the participants' processes, enabling insights into the distinct contributions of the industry professional and the AI-assisted student in the ideation of the Bluetooth speaker design.

EVALUTATION RUBRIC

Criteria	Excellent 4/4	Good 3/4	Fair 2/4	Poor 1/4
Ethical Consideration The process maintained ethical constraints whilst conducting research				
User Research The process took primary user research into consideration				
Efficiency The time was used wisely, decisions had purpose and finished in a timely manner.				
Process The process and thinking are meaningful and decision making was justified.				

INDUSTRY PROFESSIONAL

The industry professional embarked on a thorough and methodical research journey to unravel the intricacies of the current market landscape for Bluetooth speakers. This meticulous exploration initiated with a comprehensive online survey, scouring renowned platforms like Best Buy and Amazon. Brands such as JBL, House of Marley, Ultimate Ears, Sony, Sonos, and Harman Kardon emerged as prominent players in the electronic domain. This initial investigation prompted the delineation of a niche market, leading to the formulation of a persona and the establishment of a distinct product positioning mark.

An interesting observation was made regarding the preference for purchasing directly from manufacturers, exemplified by the choice of Sony. Delving deeper into the research, the professional scrutinized the product lines of key brands such as JBL, Bose, Sony, and Sonos, demonstrating a commitment to understanding the nuances of each contender in the market.

As the research phase approached its culmination, the industry professional sought external perspectives and explored the niche market of waterproof or aquatic speakers. Recognizing an untapped potential market in speakers designed for children, a persona was meticulously crafted, targeting both younger and older individuals who may not be well-versed in smartphone controls. This thoughtful consideration extended to scenarios like family trips, where different speakers could cater to diverse groups.

To refine the target audience and product features, a strategic product positioning map was constructed. This visual representation underscored the key attributes that the Bluetooth speaker sought to embody, emphasizing ease of use and interactivity. The final moments of the research phase were dedicated to defining a specific target persona named David, a 75-year-old grandfather with a penchant for hosting family events and cherishing moments with his grandchildren.

David's persona encapsulated the essence of the product positioning, focusing on providing a solution that addressed his desire for easy tech use and empowerment. The envisioned product aimed to create a welcoming environment at family gatherings, allowing David to feel in control of the technology and fostering positive memories with his grandkids. The product positioning map, therefore, played a pivotal role in shaping the subsequent phases of the design process, ensuring a seamless transition from research to ideation with a clear strategic vision.

STUDENT WITH AI

Guided by the capabilities of AI, specifically ChatGPT, the student demonstrated a systematic and comprehensive approach to persona development, a pivotal aspect of designing a Bluetooth speaker tailored to diverse user preferences. The personas, meticulously crafted through ChatGPT, spanned a spectrum of market segments, catering to specific needs and preferences. The Audiophile persona, for instance, emphasized a paramount focus on high-fidelity sound quality and premium aesthetics. In contrast, the Outdoor Enthusiast prioritized durability, water resistance, and portability, while the Home Entertainer sought connectivity options, sleek design, and smart features. Additionally, the Fitness Buff persona required stability, portability, and resistance to environmental factors.

To refine the design strategy further, the student utilized ChatGPT to delve deeper into the persona of 'Kaedan,' an Electrical Engineering Student and passionate music connoisseur. Kaedan's refined persona emphasized the critical importance of sound quality, customizable settings, and an aesthetically pleasing design using premium materials. This nuanced understanding of Kaedan's preferences added a layer of specificity to the design process, ensuring alignment with the needs of a more targeted user segment.

In addition persona development and user journey mapping, the student harnessed the power of Mid-Journey, an AI tool adept at quick concept generation and brainstorming. Through the utilization of Mid-Journey, the student generated mock-ups that served as a catalyst for brainstorming sessions, fostering a creative exploration of design possibilities. This facilitated the ideation phase by swiftly producing visual representations of concepts aligned with the identified personas. Mid-Journey's capacity to rapidly generate varied ideas allowed the student to efficiently explore different design directions and iterate upon them, ensuring a diverse range of concepts for evaluation. The integration of Mid-Journey into the design process not only accelerated ideation but also provided a valuable resource for sparking creativity and refining design concepts in collaboration with the personas' unique preferences and requirements.

In parallel to persona development, ChatGPT played a crucial role in crafting a comprehensive user journey map for Kaedan. This detailed map outlined each stage of Kaedan's interaction with the Bluetooth speaker, commencing from initial discovery and progressing through purchase, setup, customization, regular use, maintenance, and updates, culminating in long-term satisfaction. The user journey map served as a dynamic tool, providing insights into the evolving needs and experiences of the user, enabling a more nuanced and user-centered design approach.

The integration of AI, particularly ChatGPT, not only facilitated the creation of detailed and diverse personas but also enriched the overall design process. This approach ensured a comprehensive and user-centric design strategy, aligning the Bluetooth speaker with the multifaceted preferences and expectations of its potential users. The systematic use of AI technologies in persona development and user journey mapping exemplifies a forward-thinking and adaptive approach to product design, ensuring a heightened level of customization and relevance to the end-users.

CONCLUSION

In conclusion, the exploration of AI's role in the design research process has unfolded a multifaceted landscape, shedding light on both its potential advantages and inherent limitations. The

engagement with generative AI tools, particularly ChatGPT, has enabled the meticulous construction of diverse user personas, offering insights into various market segments such as audiophiles, outdoor enthusiasts, home entertainers, and fitness buffs. The persona refinement, exemplified by 'Kaedan,' an Electrical Engineering Student, underscored the nuanced considerations involved in tailoring a Bluetooth speaker to specific user needs.
Throughout the user journey mapping process, ChatGPT facilitated a comprehensive understanding of user interactions, spanning initial discovery, purchase, setup, customization, regular use, maintenance, and long-term satisfaction. This approach fostered a user-centered design strategy, aligning the Bluetooth speaker with diverse user preferences and expectations.

The experimentation phase, marked by the assessment of an industry professional and a student-designer assisted by AI, revealed noteworthy insights into the creative and ideation aspects of the design process. While AI demonstrated proficiency in divergent thinking, rapid concept development, and brainstorming, it exhibited limitations in convergent thinking, decisiveness, and critical problem-solving. The nuanced evaluation, guided by a set of predefined criteria, encapsulated ethical considerations, user engagement, efficiency, and the meaningfulness of the design process.

Acknowledging the potential benefits of AI in augmenting the creative process, it is essential to remain cognizant of its inherent constraints. AI, as a design co-pilot, can contribute significantly to idea generation, form exploration, and rapid conceptualization. However, the designer's role in steering AI, ensuring ethical considerations, and infusing empathy into the design process remains indispensable.

This research has contributed to the ongoing discourse surrounding AI's integration into the design research process, emphasizing the need for a balanced and informed approach. The collaborative synergy between human designers and AI tools holds promise for enriching the design landscape, provided ethical considerations, and a nuanced understanding of AI's capabilities and limitations remain paramount. As the dynamic interplay between human creativity and artificial intelligence evolves, continual exploration and refinement will be essential to unlock the full potential of this symbiotic relationship.

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AI AS AN IDEATION CO-PILOT

AI AND THE DESIGN PROCESS | ZACH RODGERS

BACKGROUND

Our team began a journey to better determine the ever-expanding role of generative AI in our industry of Industrial Design. Diving deep into AI's current implications while exploring why its influence shows no signs of slowing down. (Vergant, Vendraminelli, 2020, p. 1-2). Our collective goal is not just to dissect AI's potential uses but to help alleviate any concerns that may worry designers. We aim to reframe the narrative while portraying AI not as an autopilot, but as a co-pilot. Our team focused on AI and the design process, where each team member investigated a unique step of the design process, including AI and research, AI and ideation, AI and prototyping, and AI and final design. With my interest in AI and Ideation. We began with journal research, discovering the current implications of AI, and preparing for a team experiment. This experiment put our findings to the test, yielding qualitative data and insights that shed light on the potential AI has to integrate into the design process, finally helping us answer the three primary questions that drive our research.

DISCUSSION

Our team decided on the Subtopic of AI and Inevitable, a narrative we hoped to construct to explore AI's place in the design process, specifically affecting jobs, education, and work being conducted by industrial designers. Throughout our process of working individually, we came up with similar concerns. With AI in constant development and new releases every single week, articles were starting to feel dated, with information possibly relevant to learning, but not able to conclude.

We consolidated our research and decided on an in-person, primary experiment to gain qualitative insights that we truly wanted to learn and share. With the contacts we have from school and being some of the few Industrial Design students in the age of AI in the country, we thought we could learn and assess some proprietary information that cannot simply be found in any research papers today.

We used our journal research to create training and criteria which we used to teach new students about how to use AI, we then put them head to head against an industry professional to analyse how their design processes differed, and what the benefits and drawbacks of the students being aided by AI were.

THREE QUESTIONS

Each team member, following the criteria of the class IDES4001, had to come up with 3 questions, which our team changed drastically through the research to today.

1. How does AI impact the creativity of ideation in either positive or negative ways?

2. What skills and training are necessary for industrial designers to effectively integrate AI into their concept development workflows?

3. What roles can AI play in the ideation process, filling in gaps once done by other disciplines like researchers, marketers, or engineers?

Our experiment, research, and finally seminar, strive to answer these questions, uncovering the possible benefits and concerns AI brings, and providing a new form of training tailored for AI in Industrial Design that has yet to be for our industry specifically.

JOURNAL RESEARCH

In the realm of AI and Ideation, my exploration began with journals, reading about historical contexts and major concerns surrounding the integration of artificial intelligence in the ideation phase of the design process. My goal was to gain a deeper understanding of the function of AI, especially when it comes to designing better products. (He, Guo, Zhou, 2018, p. 13) I started by researching the functions of pre-trained generative transformers (GTP, a type of common AI often used on commercial scales). I explored the similarities between the AI training styles and the education we receive in SID. Gaining this information also helped me begin crafting a set of training, or rather a curriculum, which could be taught to designers to have a better understanding of how AI can be a helpful tool in our pocket, rather than a scary magical robot that can take our job. Once again arguing cross-disciplinary possibilities where AI plays the role of Design Co-Pilot, a brand new job with a title that has yet to be defined or even fully discovered.

Returning to my research, I learned about three widely known types of AI, which are: Supervised Learning, Unsupervised Learning, and Reinforced Learning. (Vergant, Vendraminelli, 2020, p. 6). And dominant, publicly accessible AI models such as Chat GPT4, Midjourney, Vizcom, and Stable Diffusion, all use a mixture of Supervised and Unsupervised learning. This is great for training something like a cat, dog, or parrot, but unfortunately hinders convergent thinking, and lacks the ability to be decisive.
While Reinforced learning is yet to be used in readily available AI models, one day it may really throw designers a curveball. A similar verdict was described by Vergant and Vendraminelli: “Reinforced learning is the closest to the traditional design process” (Vergant, Vendraminelli, 2020, p. 7).

I put together a series of training exercises primarily focusing on two dominant programs in today's AI landscape. Midjourney, and Vizcom. Based on my learning, I made sure to focus my training on divergently generating ideas, brainstorming, and the early phases of concept ideation so our participants would not waste their time during the experiment.

Additionally, it was important to explain some of the ethical concerns I uncovered to help make sure our participants were not violating any rules. In summary, these concerns revolve around scraping (downloading data at mass) the internet. While these AIs can be a great tool for inspiration, similar to Pinterest, or Behance, what they generate may be similar or “stolen” from someone else's work, and without any way of checking, designers should not claim ideas of being their own, rather drawing inspiration and strive to do an even better job.

This is where I first decided AI would make a great co-pilot. It can help to provide ideas, refine sketches, and brainstorm, however, if set to Auto-Pilot, may be violating patents, academic integrity and even stealing designs just to please the user.

THE EXPERIMENT

After lots of preparation, our team met and set up the experiment.

Our participants were 1) An Industry Professional, a designer, a recent-ish graduate of Carleton, and 2) A Student-Designer aided by AI. I am a student in my second year currently studying Industrial Design, familiar with design theory and the process, however, lack industry practice. They shared a similar goal of Designing a Portable Bluetooth Speaker, spending time on each phase of the design process represented by a topic from each of my team members.

Each participant was given a room to work, and after each phase would return to the main area to take a break. Both rooms had similar equipment, a table, laptop, drawing utensils, and modelling supplies, as well as two members of our team, both there to take notes, ask questions, and document the process, and one team member was instructed to be more interactive and contribute to the design thinking, this was done to better simulate a studio environment.

The phases were split into 30-45 minute sections, with my experiment as the Ideation Phase being 40 minutes and the second phase to be conducted. Before each phase the student using AI was briefed, they had not had much exposure to AI and were taught how to use the programs, the pros and cons of the AI models, and some insights into proper usage that we gained from our research.

Both the student and the industry professional were given the same rubric for each phase, this allowed for the criteria of the evaluation to be the same and ensured we were gaining useful qualitative insights that could be correlated later to answer our questions.

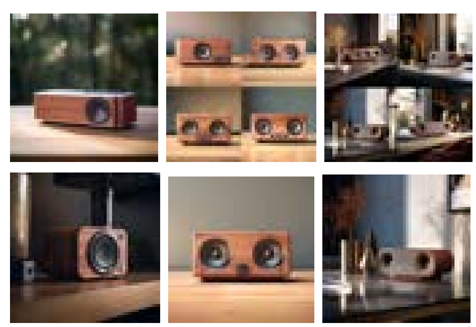
While my experiment began, both participants were shown the following.

“Your goal is to explore the traditional concept and ideas methods a designer may take, make sketches, annotations and do your best to convey your thinking to meet the criteria.
Create presentation assets to demonstrate your concept idea, consider form, function, and product usage.”

Criteria	Excellent 4/4	Good 3/4	Fair 2/4	Poor 1/4
Sketch Quality The execution was clear and ideas were communicated effectively.				
Efficiency The time was used wisely, decisions had purpose and finished in a timely manner.				
Process The process and thinking is meaningful and decision making was justified.				

Already by the time my phase was reached, a large difference in the calibre of work was shown, from the previous research phase, and our Industry professional had a step up. They had thought a lot more about their persona and kept their persona in mind the entire concept phase. It was clear that even with the research done, the student was lacking to relate to it, as the project was not continuing through the phases as much as starting with a new beginning and separate set of goals. As observers, this felt unnatural and distant from the design process we know and love. But as unbiased researchers, we had to admire when the criteria for this phase were met at an extremely acceptable level.

The student aided by AI was able to explore forms quickly, which we noticed and were told "...was beneficial for brainstorming". They described the ability to “...prompt an inspiration to render like none other, rather than browsing through Pinterest" and noticeably they were able to recreate an idea from their head within seconds. They described the best part being every time they hit “regenerate” a whole new, and different concept would appear.



A diverse set of ideas, created from a single prompt to Midjourney Generative Art AI

In the next room over, the industry professional was sketching, and developing forms and ideas based directly on the user's needs and wants.

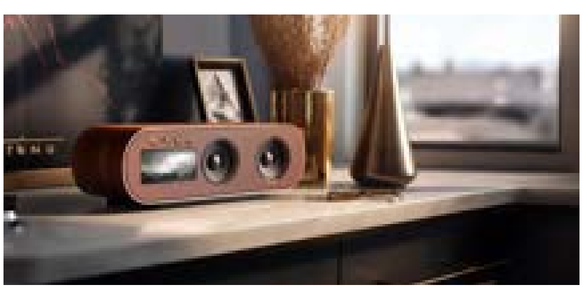
The industry professional made considerations into button size for the elderly, layout that is easy to use, and maintaining a product of size that is carryable by someone with low upper body strength. All this is done through sketches that may look less appealing than renders, yet carry even more valuable information.

Sketches and notes done by industry professionals within a 20 minute window.

Both participants spent some time researching their UI, the industry professional was able to narrow down buttons and functions, while the Student learned about what type of interface an Audiophile (their persona selected from the research phase) may want.

With the assistance of ChatGPT, the student was able to make decisions at rapid speeds, determining critical points of interest such as an equaliser bar, dual-stereo, and lossless audio formats. Of course, the use of ChatGPT is no match to an in-person interview, however, it managed to save the designer time during the ideation phase to start sketching UI that made sense.

The student was taught about another program called Vizcom, which allows you to insert sketches and get polished renders. They tried to do so however hit a roadblock as the sketches they produced weren't quite high enough fidelity. Instead, they produced a quick Photoshop and Midjourney mockup of their concept going forward with.



Concept "sketch" from the Student with AI co-pilot design team.

At this point my portion of the experiment came to a wrap, the evaluation was done, with the Student participant doing slightly better as their final render/sketch best communicated their design while the process was equally well justified. But most importantly lots of insights were learned and the next phase of the experiment was about to begin.

5.0 **Conclusion**

At the end of my phase of the experiment, a lot was learned. I was able to sit down with my team, synthesise all our notes, and determine a few final insights. There was a lot of overlap, and through different phases of our experiment, different participants did better or worse. Without testing at mass, it's hard to determine a "winner" However we were able to answer some of our greatest questions about AI.

So how did AI impact the creative process?
A big issue is simply that AI is not creative, the closest we saw AI come to creative thinking is when it messed up. Simply put every "idea" it had was something that could be found online, however, it was great at bringing that to the surface, and since it can combine ideas at random and mix ideas through text prompts it became an interesting tool to ideate quickly and help expand their thinking. It allowed the student to go through more forms, think of new functions, and explore other ideas quicker than our industry professional, who once had an image in his mind, and did not steer off track easily.

What are the benefits and drawbacks of AI in the ideation/concept phase of design?

Simply put, AI was great for brainstorming, form development, and once again, thinking divergently. It allowed for rapid concept development like having 50 people in a room with ideas, and you got to choose your favourite ideas that were brought forward.

However, AI had some major drawbacks as well, it was really awful at convergent thinking, and could not be decisive. Additionally, AI does not have justification for its actions and only generates what it has seen before, and if it could talk, would justify itself by saying “Well I’ve seen it 100 times before, so it must be right”, sometimes making it hard to come up with unique and new ideas. This is a huge problem when it comes to critical thinking. Problem solving is a major part of the designer's job and AI completely ignored those aspects of the project. Once again, this is why using AI as a co-pilot is so important. The entire time Midjourney, ChatGPT, or Vizcom were producing assets, they never had the persona in mind. The ability to be empathetic is not yet something current AI models can do, and this makes it so important for the designer to step in, and make the right choices for their project.

This made it necessary for the designer to constantly be steering the AI back on course, increasing the need to micromanage and occasionally taking away from the design process. With this being said, without the overarching knowledge of design, the AI assisted by anyone but a designer, wouldn’t’ve been able to get far at all.

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AI AS A PROTOTYPING AND MANUFACTURING CO-PILOT

AI AND THE DESIGN PROCESS |NICCO TIMPANO

INTRODUCTION

The inevitable of artificial intelligence (AI) taking over is a fear that many of us face every day, especially designers. As a team, the goal was to see how AI thrives as an important factor in the 4th Industrial Revolution, but also, how it should be used sparingly as a tool ("Co-Pilot", if you will), and to not abuse it to the maximum (or, to use it on full "Auto-Pilot"). We strived to see how beneficial, or detrimental AI could be to what we viewed as the quintessential industrial designer's design process. This process was grouped into four categories (or "stages"), to which each member took on one stage as their main area of research. This included: The research phase, the concept and ideation phase, the prototyping and manufacturing phase, and the final design phase. While I took on the role of the prototyping and manufacturing phase, I began with basic journal research, which led to finding and testing specific AI tools that could potentially affect the phase. After each doing our own research, the team came together to conduct a qualitative experiment, which would put AI head-to-head with an industry professional. This would bring us more insights into how AI plays a role in each of our topics, thus putting us one step closer to solving our proposed questions about the effects that AI has in each design phase.

DISCUSSION

The subtopic of our team revolved around the inevitable of AI, the fact that it is ever growing, and is widely used and regarded as not only a powerful tool, but something that potentially might replace our jobs (and potentially even our place as humans). The relevancy of AI is as high as ever, and the train is in full-on motion, with new AIs being pumped out very quickly, and are being used to the maximum. For example, over 4 million images are being AI-generated daily by the popular tool DALL-E (Napitu, 2023).

On that topic, we decided to focus more on the side of the industrial designer, and how either AI can be a powerful tool in your toolbelt, being used sparingly in your workflow, or, could potentially be a detriment and a waste of time altogether. We strived to see just how imminent this threat is, and just how useful it may be, compared to the tried-and-true method of studying and real-world experience. We did this by putting AI to the test, competing with an industry professional in a battle to see not only who could come up with the better design (based on our design criteria), but which design workflow was more beneficial in the long run.

THREE QUESTIONS

Within the main sub-topic of "AI and the Design Process", I dove into seeing how AI affects the prototyping and manufacturing phases of design. More specifically, I strived to solve three main questions to see just how it affected those processes:

1. What are the pros and cons of using AI tools in prototyping and manufacturing workflows?
2. Can AI be used to appropriate materials and improve manufacturing processes based on design criteria?
3. What kind of training is necessary for industrial designers to use these tools into their prototyping and manufacturing workflows? Should there be some form of certifications that could be required in order to operate AI in an ethical way?

In order to solve these questions, research was conducted through articles, testing AI-based tools, and the seminar experiment, which would give us a better sense of AI's role not only in today's society as a whole, but just how grave a danger the industrial designer's job may be in.

(and the questions of the other group members), we conducted a thorough AI-based experiment,

JOURNAL RESEARCH

At first, I truly believed that AI really did not have much of an impact on manufacturing and prototyping, especially since at first glance, it seems that most students in the industrial design program are more familiar with AI tools and programs that affect the other three design stages. However, this proved to be incorrect once I began changing my mindset and doing the correct research, my eyes were opened to the possibilities of what AI can achieve in this phase.
Beginning with prototyping, I found that there are only two forms of how AI can affect this side of design, since, as of now, AI is more of a tool in the digital realm, and most designers see prototyping as being in the physical realm. The first form is one that is becoming a more popular interest among designers, which strays away from the traditional understanding of what designers see as prototyping, which is one that stays in the digital realm: User Experience/User Interface (UX/UI) design. The second is one that most designers are more familiar with, and is more along the lines of the traditional sense of physical prototyping: 3D printing.

However, UX/UI is not the main focus of prototyping that we plan to look into, as the form of prototyping that we will be taking a look more into is prototyping for getting ready for a physical product, not a digital UI. Nevertheless, it is still a crucial form of prototyping that industrial designers are currently beginning to use in their design process, and it is still something that is worth mentioning. For the most part, using AI to generate UI elements is quite simple, and there are many programs and tools available now to do the job. Tools such as *Galileo* allow users to create simple UIs based on simple text prompts, using AI-generated mages to add to the desired style from the text prompt (There's An AI For That, 2023). But is the UI designer in danger? Using sites like *www.TheresAnAiForThat.com*, which gives users a look at many of the available and upcoming AI tools available to use, it is shown that AI has a 40% impact on the field, with 3,922 available benefitting tools, so, for now, it is safe to say that these jobs are safe, and AI could potentially be a beneficial tool for these designers (There's An AI For That, 2023).

As for the physical side of prototyping, especially for getting a feel of a model ready for manufacturing, is 3D printing. Not only is it great for getting a feel for how your product or 3D model will look in real life without having to create complex tooling parts (LuxCreo, n.d.), but it is also essential for rapid prototyping in that it can be extremely quick (especially when creating very complex shapes), efficient and inexpensive in making parts, allowing you to spend more time on refining other aspects of your design (especially when you can send your print off and “set it and forget it”, letting you work on other things while your print is being made) (The Welding Institute Global, n.d.). But, however, the most common issue in this prototyping method is printing failure. Failure can happen for a number of reasons, including incorrect build plate adhesion, issues with supports, over-extrusion, and more (Jennings, 2022). Alas, AI is there to the rescue! With AI tools such as *Gadget by OctoEverywhere*, you can easily set up and monitor your print with failure-detection AI, which will automatically detect failures within your 3D print, and help improve your overall 3D printing experience (There's An AI For That, 2023). In addition, programs like *ALPHA AI by Akuretta* let you automatically send out your 3D print, and the software will automatically set up your print for the best possible settings (such as detailing, generating supports, and orienting how the model will be printed) using AI, minimizing the technical difficulty trial-and-error stages of 3D printing (Ackuretta, n.d.).

As for manufacturing, some of the responsibilities that an industrial designer faces can pertain to colour, material, and finish (or, CMF) choices, mould creation and tooling, cost considerations, and 3D model creation (or, Computer-Aided-Design creation, known as CAD). So, how does AI play a role in all of this? One of the biggest players in the CAD industry is *Fusion 360 by Autodesk*, which released an AI add-on called *Generative Design*, which allows users to automate (based on inputted design constraints) multiple manufacturing factors such as material choice, weight reduction, sustainability standards (through creating less manufacturing waste), optimizing weak areas of parts, and even tooling costs (being optimized for CNC machining, injection moulding, and casting) (Autodesk, n.d.). Sounds too-good-to-be-true, right? We were able to test this tool out in our experiment, which is documented in the EXPERIMENT section.

It is beneficial to see how these AI tools can help users generate better solutions and outcomes than without these tools, but we need to note that they all require defined constraints set by the user, meaning that there still needs to be a human to tell the AI what to do. This gives a bit of perspective that AI can become, with the right knowledge from the user, of course, a great tool in their toolbelt (or, so to say, can become a great "Co-Pilot" to the user, giving great advice along the design "trip").

TESTING CAD-GENERATING AI TOOLS

Along with the tools that help take your existing CAD parts and make them ready for manufacturing, there are also tools that can take your images and sketches and make them into 3D models. For instance, you can take your Midjourney photos or Vizcom render (these are tools discussed in fellow group member Zach Rodgers' report, entitled *AI AS AN IDEATION CO-PILOT*), place them in the AI tool, and watch your model come to life. The most prominent program that does exactly that is CSM.ai, which takes your flat 2D image and creates it into a fully customizable 3D model (There's An AI For That, 2023). Within the website, you are able to images uploaded by the community, and by hovering over the image, you can view the generated 3D model (CSM, n.d.). Moreover, there are prompt-based 3D model generators, such as Masterpiece X, which takes text-based prompts (with other various required design criteria, such as if the model will be of an object or character), and makes them into fully customizable 3D models (There's An AI For That, 2023).

Upon testing these programs with fellow group members, we concluded that the programs still have a long way to go, with mediocrity coming from both programs. CSM.ai would incorrectly generate models based on Midjourney photos, Vizcom renders, and 3D CAD models, making the models look almost nothing like their 2D form (which is interesting, since it seems that the community uploaded photos were of the same nature as ours, yet their models were much more accurate). Masterpiece X, on the other hand, would make 3D models based on our text prompts, but would only generate the same generic models over and over again, just with different colours added.

THE EXPERIMENT

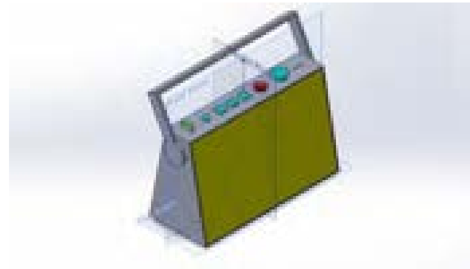
Our experiment began with choosing our target participants. Participant 1 was dubbed the "Industry Professional", a graduate from Carleton with experience working in the design field (who was not allowed to use AI in the experiment), and Participant 2 was dubbed the "Student With AI", a second-year industrial design student in the Bachelor of Industrial Design program at Carleton University, being aided by AI tools. The task: to design a Bluetooth speaker from scratch, finding their own target market, and base their designs off of our given criteria for each respective design phase (to which each member of the team was assigned).

Each member was sent into their own private breakout rooms to work, and after working on each phase, they would debrief with the team for a short break. Each room was made the same, and they were given the exact same design materials in order to succeed. They were also accompanied by two members of the team, who were there to record notes, and answer any questions, if need be. Before each stage, the student with AI was taught how to use the AI tools, and some small hints on best practices. Each participant was given the exact same criteria (which was different for each of the four design stages they participated in), which would be used as a guideline for evaluating their work. Their phase introductory statement and criteria are as follows:

"The goal is to create a physical prototype to assist the development of a CAD model that would be ready for manufacturing, having manufacturing and CMF aspects considered."

Criteria	Excellent 4/4	Good 3/4	Fair 2/4
Prototype Quality The execution was clear, and the model helped gain insights into the design.			
Manufacturability Manufacturing processes were well thought out and seemed feasible. 3D CAD model was detailed correctly.			
Time Management The time was used wisely, decisions had purpose and finished in a timely manner.			
Process The process and thinking are meaningful and decision making was justified.			

My phase, the prototyping and manufacturing phase, was third in order, and each member was given around 45 minutes to complete their tasks. The industry professional used up only 35 minutes of the allocated time, creating a UI prototype out of cardboard for their button layout only. Next, they dived straight into the CAD using SolidWorks, having no issues. Although they created a more simple design, it helped them with the analysis of their CMF choices and their manufacturing techniques. They had little to no struggles in any part of this phase, and their decision-making was clearly justified. They only lost points on prototype quality (since they only made a simple UI) and on manufacturability (since the speaker was missing some details, such as crucial fillets and draft angles).



The industry professional's 3D CAD model of a Bluetooth speaker for the elderly.

As for the student with AI, they used up all 45 minutes of the allocated time, and also began creating a simple cardboard prototype (but this time, they made more than just the UI). They then went into CAD, using Fusion 360's Generative Design AI tool, but were met with lots of roadblocks. For starters, although they were taught how to use the program, it was just too overwhelming for them. They were able to set their design constraints in the program, and were able to begin generating models, but the results were not what they desired, as the program kept wanting to make unwanted shapes. As for trying to find out the material choices and manufacturability, they were met with too many advanced engineering constraints (such as load management and weight reduction), which ultimately confused them even more. Since the model was not turning out in Fusion 360, they then ended up quitting the program, and began to make their 3D model in Shapr3D, while finding out their manufacturing methods and material choices using ChatGPT. They scored points on their prototype quality, but lost points on manufacturability, time management, and their total process.

An example of the student using the Automated Modeling section on Fusion 360, bringing unwanted results

The clear winner of the stage was the industry professional, showing that it is hard to beat tried-and-true experience. I concluded that although the AI programs can be super powerful in terms of manufacturing, it takes the right skillset in order to operate. It is great for advanced manufacturing and engineering for areas such as aerospace engineering, but not for the general design process of an industrial designer.

One thing to note: we originally anticipated for the participants to have to 3D print their part (with the industry professional using no AI, and the student using an AI 3D printing tool), we realized that there would be not enough time to conduct proper data, and also, all 3D printers at the industrial design studio in Carleton were all being used by third-year students for their end-of-semester projects.

CONCLUSION

After concluding with all of our research and our experiment, our team was able to take a look at AI's impact, as a whole, on the industrial designer's design phase. We all had similar outcomes in terms of our results, both from research and the experiment, and we were able to conclude that AI is best used as a tool, and not to abuse it and let it take over your entire process. All in all, I was able to answer my questions and find out just how AI really affects the prototyping and manufacturing phase of design.

1. What are the pros and cons of using AI tools in prototyping and manufacturing workflows?

The pros and cons of using AI in this phase are simple. The pros are that it has a great opportunity space, and if the designer knows what they are doing (i.e. they know about the advanced engineering techniques, and know how the AI operates), then it can be a powerful tool in their arsenal. However, if they lack these skills, then the AI can be detrimental, cause confusion, and even just not operate smoothly (for example, in one of the student's designs from the experiment, the AI program kept wanting to create spiderweb shapes). It has the power to be the smartest engineer be your best friend, or the biggest roadblock on your way to design success.

2. Can AI be used to appropriate materials and improve manufacturing processes based on design criteria?

Yes, AI can be used to appropriate materials and improve manufacturing processes based on criteria, but, if, and only if, the designer has a clear understanding of how these processes work, how the materials interact with the processes, and how the AI program works as a whole. In the case of Fusion 360's Generative Design AI tool, one must come with an existing knowledge of advanced manufacturing and engineering in order to fully control the power of the program, inputting the correct design constraints.

3. What kind of training is necessary for industrial designers to use these tools in their prototyping and manufacturing workflows? Should there be some form of certification that could be required in order to operate AI in an ethical way?

As mentioned before, the designer must already have a background of knowledge in advanced manufacturing and engineering. Furthermore, designers must understand the implications of using AI in their workflow, and must understand that AI cannot solve every problem they face. Some problems just need real experience in order to be solved, and sometimes, they just need that "human touch", something that AI lacks. AI tools are ones that can be abused very easily, and it requires one to be ethical when using them. In order for these tools to not be abused, I believe that there should be some form of certification or agreement document, that shows that the designer understands how to use AI correctly, understands the implications of abusing AI, and knows how to use it sparingly, in an effective manner, something similar to an engineering or architectural license. It could be called "the AI Implications License" or the "AI Certification Stamp".

To conclude, for now, it is safe to say that we are okay from the impending doom that is AI taking over all our jobs. When it comes to prototyping and manufacturing, it actually is not really for AI to fully

go on "AutoPilot" just yet, since for the AI to work, the designer must come in with a base design, and must select and input their base constraints and requirements. Sure, from there, the AI can take over and fully complete your design, but even then, it needs to properly be checked by a professional.
Can it be used effectively in workflows? Yes, it can, as long as the designer knows how to properly set the AI to "Co-Pilot" and use it as a tool in their vast arsenal.

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AI FOR FINAL DESIGN

AI AND THE DESIGN PROCESS |JULIAN SALIBY

INTRODUCTION / BACKGROUND

The development of AI has grown exponentially creating concerns of AI becoming an autopilot and not co-pilot to the design process. Only a few years ago, the topic of discussion surrounding job security and AI was receiving a lot of attention. Some issues that were raised were the automation of long haul trucking across the country, as well as repetitive tasked jobs like grocery store cashiers and financial workers. Out of these concerned industries, the creative field was not expecting such a big shake, especially at such a rate. As industrial designers, it is extremely important to stay aware of current and upcoming AI software that may affect the future of your career.

It is for this reason that this paper will be researching and experimenting the effects of AI for industrial designers in the fourth industrial revolution. To do so, we conducted a study which involved two participants. First was our industry professional who was given a product design prompt. We then asked him to conduct four stages of design within a given time frame. He was asked to conduct research, concept & ideation, manufacturing & prototyping, and final design. Our second participant was a design student currently enrolled in the bachelor of Industrial Design at Carleton University. This student was given the same prompt, and was asked to conduct the same four stages of design, but with the help of AI and training. Each of the four members conducting the study would then be in charge of drafting a grading rubric to fairly evaluate both participants. The most common ones being quality, efficiency and process. As I was in charge of AI for final design, I will also be diving deeper into that phase in this report. Our goal was to explore the differences AI can make in the design process, as well as how we can adopt this tool as a co-pilot.

DISCUSSION ABOUT SUBTOPIC

Our group had a collective interest in the effects AI might have in industrial designers' lives moving forward. This leads us to our topic of AI and the inevitable. The advancements in AI in 2023 alone have been remarkable. There has been an immense amount of resources poured into progressing AI. From language and research focused AI, to visualization generation.

It was decided that the design process could be sectioned into four phases. The first being research for design, the second being concept & ideation, the third being manufacturing & prototyping, and the fourth being final design. Each member was assigned a phase and began preliminary research on AI resources that could increase the productivity of tasks normally done in a said phase.

In following meetings we realized, the issue at hand was not necessarily AI itself, but how we as designers decide to utilize it. There is no doubt that these tools are here to stay and will drastically change the design process. But we believe it is our job to properly train designers on how to utilize AI as a co-pilot, and not an automation machine. Doing so is how we will maintain our relevance as designers.

This is what inspired the idea for our experiment. We conducted a study that involved two participants. Both were given the same design prompt where they needed to complete all four phases of the design process. They were given the same time, as well as the same rubrics for each phase. This was needed to faciliate a fair baseline.

The main differences in this experiment were the participants. The first one was an industry professional who would only be allowed to utilize traditional design methods not involving AI. The second was a current student of industrial design who would be allowed the full potential of AI for every phase. The student was trained on how to use these tools effectively as a co-pilot.

QUESTIONS

We each prepared three questions that would help guide our research. My questions were looking to identify the pros and cons of AI tools in the final phase of the design process:

How might the integration of AI-driven rendering techniques elevate the quality and efficiency of generating visual content tailored for marketing initiatives?

What specific skills and training do designers and developers require to seamlessly incorporate AI into their workflows, enhancing the creation of content and visuals for marketing applications?

How does AI streamline the automation of repetitive tasks in industrial design, allowing designers to redirect their focus from routine activities to the strategic and creative aspects of rendering and presentation creation for clients?

We are expecting to answer these questions with the help of our own research as well as the results of our experiment.

RESEARCH

I began my research by diving into the basics of AI in design. In various technical fields, AI driven generative approaches are now actively exploring diverse design solutions. (Buonamici , Carfagni, Furferi , Volpe, Governi, 2021) The rise in computing power has sparked increased interest in Generative Design (GD) within the design community. GD, implementing AI methods optimizes design challenges expressed mathematically. This uniqueness places GD in areas that value aesthetics and innovation, like the product design we do today.

Generative AI is making waves as a groundbreaking technology, especially in the last year. Its power comes from the ability to generate such a variety of work. From text, images, or even videos as of late. Behind the scenes, the powerful training processes demanding large amounts of data and even more computing power, have been the playground for tech giants like OpenAI, Google and Microsoft to name a few. I think the exciting part is the democratization of this technology where fine-tuning models for specific fields of work becomes the key, opening doors for specialized applications across a spectrum of industries. (Davenport & Mittal, 2022)

Now, when we look specifically at industrial design, the excitement escalates. Generative AI, once confined to the world of marketing and software, emerges as a game-changer in the world of industrial design. Picture this: a generative model specifically for designers, working side by side with us, allowing us to explore multiple design concepts, proposing solutions that might never have surfaced through traditional methods. This collaboration, where human creativity is running side by side with AI-driven generative design, has the potential to streamline the creative process. This fusion of human ingenuity and the insights brought by generative AI might just redefine the contours of industrial design, where AI plays the role of a valuable co-pilot in the designer's life.

EXPERIMENT

On this day, a study room split into three was reserved for the experiment. Each participant had their own room isolated from one another ensuring there would be no influence. We used the third room as a break/meeting room to reconvene between phases and for discussions.

As previously mentioned, our experiment would put two designers head to head in a design sprint. They were both asked to design a bluetooth speaker. The student would be able to use AI and the industry professional would only have access to traditional methods prior to AI.

They were both supplied with similar resources. Pens and pencils paired with sketching paper, cardboard, cutting boards, exacto knives, as well as laptops with all the necessary software. We also split our research group into both rooms while the study was being conducted so that clarification on the tasks at hand may be provided when needed.

The aim was for each phase to be 45 minutes, but we sometimes surpassed it. In this case, both participants were rewarded the same added time to ensure a fair comparison. Prior to each phase of the experiment, we took the time to show our student the AI tools at their disposal.

First was the research phase. Both participants were asked to conduct preliminary research and secondary research to better understand and define the challenge. Second was the concept and ideation phase. It was in this phase where they needed to develop their concept through visual exploration and create assets to present. Third was manufacturing and prototyping, where the goal was to create physical prototyping as well as a CAD model for final design.

In the manufacturing phase, the industry professional was able to produce a rudimentary CAD model with a set of UI buttons in place. Our student was also in a very similar position as the AI did not prove to be very useful in that phase.

Finally the last and fourth phase was my phase of the experiment; final design. The following prompt was given.
"Your goal is to create final renders for client presentation/marketing. This includes finishing the STL with materials and finishes. Try to render out a 1-3 Hero angles/images to properly show off this product." I also provided them with my grading rubric.

	Excellent 4/4	Good 3/4	Fair 2/4	Poor 1/4
Render Quality Ideas, materials and scenes are clearly communicated and relevant to the product				
Efficiency The time was used wisely, decisions had purpose and finished in a timely manner.				
Process The process and thinking is meaningful and decision making was justified.				
Variety Final outcome offers a variety of style and different use cases for renders				

Grading rubric for final design phase

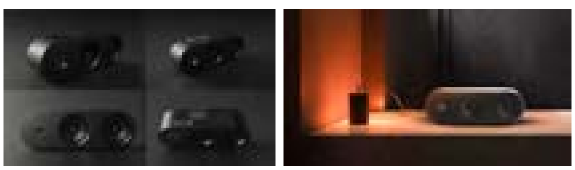
Our student used a combination of Vizcom, Photoshop/generative fill and mid journey. Although it was available to him, he decided to steer away from Keyshot for material and lighting rendering which is known as an industry standard. He explained that it would take too much time, and that he would not be able to create multiple renders in time.

The student quickly took many screenshots from different angles from his solidworks model (without any materials) and imported them into Vizcom. This is a powerful AI tool created for designers. It transforms product sketches and simple models into high quality CMF renders with prompt control. The student used the simple prompt "matte black bluetooth speaker" alongside these screenshots to output the base for his final renders. Within the first 5 minutes, the student had five renders of the speaker in CMF from different angles. We did note that there were a few small inconsistencies in the renders. Some of the buttons as well as volume knobs would slightly change in length from render to render. This would be touched up in photoshop using their new generative fill AI.

For the next step, he moved to Midjourney. It is a generative art AI model that aids designers and artists in quickly exploring diverse visual concepts. It allows for the rapid generation of images. Midjourney was used to quickly generate multiple environments for the speaker. It took a few prompts, at about 60 seconds a prompt. The final environment was generated with “a simplistic and modern desk, moody lighting”. A very realistic base image was generated. A Vizcom render was placed into the scene and blended in using simple photoshop brushes to create his main hero image.

He finished this phase of the experiment with a total of 5 renders, with two scenes. In a 40-minute timeframe, he efficiently produced numerous render environments, utilizing Photoshop with stable mid journey to generate stock backgrounds.

The student was pleased at how little computing power was needed to complete renders of this quality, as photoshop was the most intensive thanks to the browser based Vizcom, and discord based Midjourney.



Final renders from the student with AI

Our industry professional took his CAD model straight into keyshot. He began searching for materials to accurately portray his product. Given the nature of Keyshot, he also needed to set up lighting, as well as the environment which proved to be very time consuming. Given the time constraint, he had no choice but to download a prebuilt scene from the keyshot website. The only scene available to him was a kitchen scene. He was not very pleased with this environment but had no other options.

It took our industry professional about 55 minutes to select materials, set up lighting, download the scene, and set up the product. He was already used the alloted 45 minutes before having the chance to render out an image. The remaining 20 minutes were used to render each of the 4 images below.

Final renders from the industry professional

It was at this point, where we could clearly see the benefits, as well as the shortcomings of AI. According to our grading rubrics, the concept & ideation phase, as well as my final design phase is where these AI tools are currently excelling. Although they may not have performed as well in the other two phases it is important to remember that we are only at the beginning stages of image generation with AI. It can only improve with time.

CONCLUSION

Concerns over AI's place in the design process have been caused by the technology's exponential growth, which raises the possibility that AI will eventually put our profession on autopilot. The creative sector which includes industrial design, is subject to unknown shifts in the larger discussion about artificial intelligence's effects on various industries. It is important that industrial designers remain aware of the latest AI technologies since they have the potential to completely change the landscape of the industry.

In my investigation, there was a focus on questions related to AI's integration into the final design phase, the necessary skills for designers to incorporate AI seamlessly, and how AI streamlines repetitive tasks in industrial design. The research phase highlighted the significant advancements in AI, particularly in generative design and its potential to revolutionize traditional design methods.

Our experiment, where an industry professional used traditional design methods and a student leveraged AI, demonstrated both the benefits and challenges. The student effectively utilized AI tools like Vizcom and Midjourney, generating multiple renders efficiently. However, challenges arose in the manufacturing & prototyping phase, revealing the current limitations of AI in certain aspects of the design process.

Despite these challenges, the potential of AI in concept generation and final design renders was evident. The collaboration between human creativity and AI-driven generative design showcased the capacity to streamline the creative process. Looking specifically at industrial design, the prospect of having a generative model working alongside designers presents an exciting avenue for exploring diverse design concepts.

The study also emphasized the importance of proper training for designers to use AI as a co-pilot rather than an auto-pilot. The results of our experiment suggest that, while AI excels in certain design phases, there is room for improvement, marking the early stages of AI's impact on image generation in design.

In conclusion, the transformative potential of AI in industrial design is undeniable. The key lies in understanding its current capabilities, harnessing its strengths, and addressing its limitations. As designers, embracing AI offers an exciting path forward, where human ingenuity and AI-driven insights converge to redefine the landscape of industrial design.

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Environmental Sustainability in Electric Vehicles

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INTRODUCTION

Environmental sustainability is at its peak in the Fourth Industrial Revolution. The focus on electric vehicles (EVs) has emerged due to advanced technology as more than just a trend—it is a crucial step towards a greener future. As carbon emissions continue to increase climate change, with greenhouse gases and pollutants worsening, the perceived benefits of EVs, from reduced emissions to advanced innovation, appear to be a greater alternative than traditional gas-powered vehicles. However, amid its emerging popularity, a critical question arises: Are electric vehicles truly a completely sustainable solution? This report aims to analyze the complexities surrounding the environmental sustainability of electric vehicles. Beyond exploring their current state, the role of industrial designers will also be explored, contributing to a more sustainable future through innovative approaches and conscientious design choices. This report serves as a comprehensive guide for those seeking a deeper understanding of the challenges and opportunities within the evolving realm of electric vehicles.

DISCUSSION ABOUT SUBTOPIC

The overlying theme of this report is Environmental Sustainability in Electric Vehicles, while various subtopics under this heading will be explored in a group setting. As a group of industrial design students, we redirected our discussion to delve deeper into the challenges and gaps in the EV industry. A common thread running through every stage of an EV's life cycle was identified throughout our exploration: the environmental impact of batteries. It is recognized that the battery is the most energy and carbon-intensive component of this product. Due to the production of lithium-ion batteries, research reveals that the manufacturing process of new electric vehicles can produce around 80% more emissions than traditional gas-powered vehicles, primarily due to the production and disposal of batteries (MIT Climate, 2022).

The shift in focus prompts us to critically examine the issues surrounding the lifecycle of EV batteries and discover more energy-efficient attributes to compensate for their production. Moving beyond the discussion of EV benefits, we will analyze how the industry can improve on its existing environmental challenges. Our central argument centers on the environmental impact of material selection of lightweight materials, lithium-ion batteries, and renewable charging alternatives, alongside a systems-approached designer guide to propose tangible solutions for a more sustainable future. As a team, we aim to bridge the existing gaps, contribute to the ongoing discussion on sustainable transportation, and guide how designers in the industry can move towards a more environmentally sustainable outlook.

DISCUSSION ABOUT INDIVIDUAL WORKING TITLE

The exploration of material selection within the interior body of electric vehicles will be analyzed. Within this context, two distinctive features will be examined.

When comparing an electric vehicle to its gas-powered counterparts, the prominent lithium-ion battery and utilizing lightweight materials set them apart. While material selection often leans towards a chemical engineering perspective to meet certain specifications in production, designers also play a pivotal role. Their involvement extends beyond the functional aspects, encompassing the design of components and a comprehensive understanding of existing materials within EVs. This dual approach ensures the sourcing of materials with desired properties and aims to mitigate environmentally harmful elements. In essence, designers contribute to creating a greener solution by incorporating their expertise in material selection and environmental responsibility.

Three questions were formulated to structure and enhance the coherence of this report. These questions serve as guideposts, steering the narrative through a comprehensive analysis, and will be answered twice to address the two distinctive features separately.

1. What impact does the current sourcing of materials for batteries and lightweight metals in electric vehicles have on the carbon footprint of electric vehicle production?
2. How can incorporating advanced technologies and novel materials from other industries be integrated into the construction of electric vehicles to support environmental sustainability?
3. How can sustainable material choices contribute to maintaining or enhancing product quality?

Lithium-Ion Batteries

The significance of material selection in the interior of electric vehicles goes beyond mere aesthetics, extending to the environmental challenges of these innovative vehicles. At the center of this crucial environmental concern lies–the lithium-ion batteries. While these batteries serve as the power source in EVs, they also emerge as the most carbon-intensive element in the manufacturing process of mineral sourcing.

The sequence of producing electric vehicle batteries involves resource extraction, processing, and manufacturing, each phase demanding substantial carbon energy inputs. The energy intensity of this process is approximately three times higher than required for manufacturing internal combustion vehicle batteries. A closer examination from the Institute for Energy Research says that about 40% of an electric vehicle's carbon footprint is attributed to the active materials' mining, conversion, and refining stages within the battery cells (IER, 2023). Where EVS requires six times more minerals than a gas car and weighs 340 kg more on average (Venditti, 2023). Therefore, assessing and optimizing the sourcing of the product material specifications is crucial to the environmental impact of EVs.

The mining and processing of minerals for batteries significantly contribute to the carbon footprint and raise concerns about environmental and human health. In the realm of Battery Electric Vehicles, there are three predominant lithium-ion battery chemistries: Lithium Cobalt Oxide, Nickel Manganese Cobalt Oxide (NMC), and Nickel Cobalt Aluminum Oxide (NCA) (Emilsson & Dahllöf, 2019, p.15). Analyzing these battery chemistries, a common element stands out–cobalt. Both environmentally and socially challenging, cobalt may be the most problematic material used in electric vehicles. Linked with sulfuric acid, the presence of which has had adverse effects on groundwater, aquatic ecosystems, and smelting processes, yielding harmful toxins detrimental to local communities (Kaniki & Tumba, 2019).

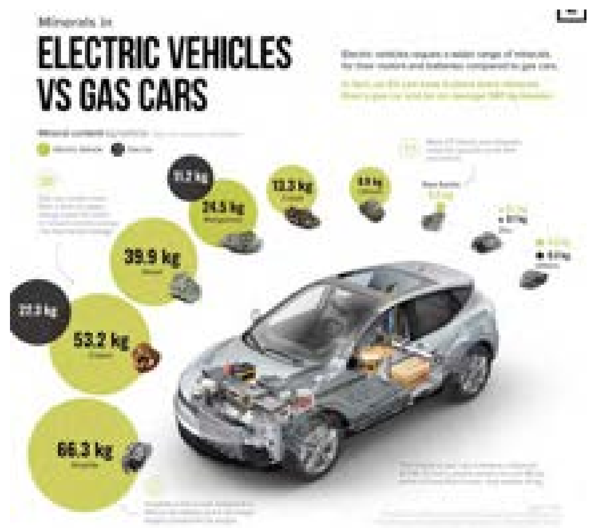

Figure 1. Mineral Content in EVs (Eaton, 2022)

NMC batteries are preferred for Electric Vehicles due to their high energy densities, facilitating extended travel distances on a single charge. Moreover, their reduced sensitivity to temperature variations allows for faster charging even in colder climates. However, it is crucial to acknowledge that these batteries pose notable challenges as NMC batteries are susceptible to thermal runaway. Thermal runaway is an uncontrolled increase in temperature, where overheating can lead to dangerous situations like fires or explosions. The thermal runaway underscores the need for preventive measures, given the requirement to replace these batteries every decade. However, this poses an additional challenge regarding battery disposal (Lombardo, 2022).

Alternatives and the Respective Product Quality

This section will review questions 2 and 3 to create a unified flow in explanation.

Recognizing the challenges linked to lithium-ion batteries, researchers and battery producers are actively investigating alternative materials. The focus is on substances that are readily available and present fewer issues. Researchers are now emphasizing nickel or iron materials to eliminate the use of cobalt. While these alternatives are less toxic, their extensive usage may raise concerns about their environmental impact. Though the designer's role cannot directly substitute minerals in the batteries, fewer carbon-intensive alternatives exist.

Recent and innovative research studies have unveiled the potential of all-solid-state lithium-ion batteries (ASSLIBs) to eradicate the need for cobalt, presenting a transformative opportunity to boost the capacity and efficiency of emerging battery technologies substantially. ASSLIBs are gaining significant attention due to their improved safety, higher energy density, and more comprehensive temperature range than traditional lithium-ion batteries (LIBs). Solid states are more structurally stable and made smaller and thinner, meaning they can be more lightweight while having a compact design. Despite these advantages, the energy-intensive manufacturing processes and total environmental impact of all-solid-state lithium-ion batteries still need to be fully understood (Zhang et al., 2022). Their current drawback is higher costs and the need for meticulous precision and quality control, limiting widespread accessibility (Snyder, 2023). Looking ahead, designers aim to address and resolve these uncertainties, envisioning a future where these challenges are effectively overcome and integrated into practical solutions.

Despite the material selection of various battery chemistries, the weight is another crucial aspect of the translation to electric vehicles. EV batteries weigh around 1000 pounds, requiring more energy to drive (EV Box, 2023). This emphasizes the importance of lightweight materials in designing and manufacturing batteries to optimize performance and energy efficiency.

Lightweight Materials in Electric Vehicles

Designers play a crucial role in electric vehicle interiors by analyzing lightweight materials. The emphasis on these materials is vital due to the significant weight of the battery, impacting the overall vehicle weight. Lightweight materials not only enhance efficiency and range but also address environmental concerns. Materials science and design advancements continuously shape EV interiors for improved performance and sustainability. This emphasis on longevity and durability aligns with broader sustainability goals. Long-lasting EVs can result in lower operational costs, reduced resource consumption, and a diminished need for frequent manufacturing. Assessing lightweight materials throughout the vehicle life cycle underscores the long-term environmental benefits of extended EV lifespans.

The challenges associated with incorporating lightweight materials in electric vehicles (EVs) extend beyond the immediate environmental impacts of material production. While concerns exist regarding the extraction, processing, and energy intensity associated with these materials, the primary objective is to enhance the longevity and efficiency of electric vehicles. According to the US Department of Energy, a 100kg reduction in car weight will enhance energy efficiency by 3.5% or save energy by 15 kJ/km (US Energy Gov.). This underscores the importance of weight reduction, especially with the increase in popularity of Electric Vehicles (EVs) each year. To gain a deeper understanding of the challenges and sustainability opportunities arising from the increased presence of electric vehicles on the road, it is crucial to consider factors such as reduced driving range, reduced wear and tear on tires, the potential threat posed by fine particles, and eliminating the need for new road infrastructure.

Currently, aluminum and high-strength steels are popular for electric vehicle (EV) manufacturing. Aluminum alloys are promising for EVs due to their strength, corrosion resistance, and recyclability. However, shaping complex and thin-walled aluminum products for EVs is challenging due to limited formability and precision issues. Despite using complex-shaped aluminum channels for battery packages and closures, challenges persist in achieving high geometric accuracy and overcoming issues like low formability and high spring back in mass manufacturing. Some techniques are employed, but those systems need more efficiency and high costs. Recycling aluminum parts is crucial for EV sustainability, but achieving recycled aluminum with equivalent mechanical properties at a low cost remains challenging (Zhou et al., 2022, p. 4). In addition, steel is the preferred for battery enclosures due to its strength and durability, is significantly denser than aluminum, contributing to its heavier weight. While steel's high density makes it less prone to bending under force or heat, its weight properties can deplete EV energy consumption faster (Monroe Engineering, 2022).

Novel Materials and the Respective Energy Efficiencies

This section will review questions 2 and 3 to create a unified flow in explanation.

To address the issues of current metals, the need for improved thermal management and reduced assembly complexity is crucial for battery enclosures. Automakers are integrating more plastic into various vehicle components, including the chassis and battery casings, to offset the additional weight from batteries. High-performance plastics, capable of absorbing four times the crush energy of steel, enhance passenger safety in collisions. Despite the dominance of steel in automobile manufacturing, the industry is gradually embracing plastics to mitigate weight-related challenges. As of 2021, the average vehicle still relied on around 2000 pounds of steel and 1000 pounds of other metals and alloys, indicating the potential for further integration of plastics in future vehicle designs (Wazeer et al., 2023). In this pursuit, the integration of plastics takes center stage, focusing on engineered plastics and sustainable composites, including recycled carbon fibers from the aerospace industry. These materials undergo rigorous testing to withstand the challenging conditions within EVs, including high temperatures from batteries, UV exposure, and daily wear and tear. Automakers are forging partnerships with the plastics industry, incorporating these materials into vehicles, and advancing end-of-life recycling processes. Sustainable flame-retardants further contribute to thermal management in EV components, extending the duration before thermal runaway occurs (Mohanty et al., 2023).

The automotive sector's search for lightweight propels a significant shift towards polymer composites as alternatives to traditional metals. Cellular plastic sandwich panels used in the aircraft industry, 3D printing technologies, and reinforced plastics emerge as key players, supporting weight reduction without compromising performance. Cellular plastics, with variable cell sizes and reduced density, alongside innovative sandwich structures, offer strength and substantial weight reduction compared to conventional steel applications (Mohanty et al., 2023). Integrating 3D printing technology introduces a new dimension, allowing for the creation of high-precision auto parts with mechanical properties comparable to traditional methods. In addition, biobased materials and natural fibers, including PLA, flax, and bamboo, also showcase the potential for crafting lightweight automotive components (Agarwal et al., 2019). Biocarbon from agro-waste and sustainable reinforcements present alternatives to traditional petroleum-based carbon fibers (Watt et al., 2021). The hybridization of renewable reinforcements reduces the use of materials and tailors properties for specific applications, amplifying overall sustainability in the automotive industry.

According to the World Economic Forum, the automotive sector targets the elimination of auto parts going into landfill by 2035 through various practices (WEF, 2022). These include the use of recyclable materials, improved material recovery and recycling methods, renewable feedstocks, prioritizing repair and remanufacturing, prolonging product life, and managing end-of-life with reduced environmental impact. Adopting recycled plastics, employing chemical recycling techniques, and utilizing recycled carbon fibers from aerospace scraps contribute significantly to weight reduction, aligning with global efforts to establish a more sustainable and circular automotive industry. These trends underscore the importance of diversifying approaches and incorporating innovations from multiple industries to elevate lightweight materials' overall sustainability and energy efficiency in EVs (Mohanty et al., 2023).

CONCLUSION

In conclusion, designers play a crucial role in lessening the environmental impact of electric vehicles (EVs) by making thoughtful choices in designing and sourcing interior components. Understanding the materials used allows designers to collaborate with engineers and create a greener solution. Overall, this knowledge underscores the importance of material selection in design, as EVs, often seen as environmentally friendly, might reveal hidden truths and sometimes serve as a marketing tactic.

Exploring the realm of electric vehicles becomes intriguing as their prevalence on roads increases. It prompts individuals to consider if EVs align with their lifestyles, acknowledging the various factors influencing the product's overall carbon footprint. For instance, being unaware of the energy source for charging an EV may inadvertently contribute to environmental issues, particularly in regions where coal generates electricity, potentially making EVs less environmentally sustainable than gas-powered vehicles.

Each topic within our group discussion addresses vital aspects for potential EV buyers, emphasizing the importance of a systematic approach—from manufacturing to renewable energy to end-of-life considerations. This holistic view reveals how certain stages of a vehicle's lifecycle can have more detrimental effects on the environment than others.

However, calculating the carbon footprint of any product proves challenging within the realm of environmental sustainability. Factors such as model variations, origin locations, and destination homes contribute to this complexity. Questions arise about whether the manufacturing intensity of EVs balances out during the usage stage compared to traditional cars. Additionally, is that even enough? Concerns about the product's lifespan and the disposal of EV batteries have an even worse potential impact on its carbon footprint. These are essential aspects for designers and consumers to analyze when evaluating the environmental sustainability of electric vehicles.

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CLOSING THE LOOP: THE END OF LIFE CYCLE OF ELECTRIC VEHICLES

THE 4th INDUSTRIAL REVOLUTION: ENVIRONMENTAL SUSTAINABILITY IN EVS | MADELYNN LETT

Introduction

The electric vehicle (EV) industry has been growing exponentially over the past decade as a new wave of sustainable change. Gas-powered vehicles undoubtedly produce more emissions on a daily basis than electric vehicles, however what about when comparing the two over their entire lifespan? Greenwashing is a prevalent act in the EV industry where false or misleading statements are made about the environmental benefits of switching to an EV. Companies do this to create a positive image to promote their vehicle without providing sufficient evidence to back up their claims. EVs are definitely the way to a more sustainable future, however this is not a closed loop cycle and still has a long way to go despite what the media presents to the public. (Singh et al., 2020)

When diving into the possibilities of where were going to go sustainability wise in the 4th Industrial Revolution, electric vehicles appear to be the best way to start. My group and I specifically dove into each stage of this product's life cycle with the goal of discovering improvements we as designers can make to move towards closing the loop of EVs. One common problem we noticed at each stage of the product's life was the impact lithium ion batteries (LIBs) have on the environment. In my report, I will be analyzing the end-of-life cycle of EVs and be discussing ways designers can produce solutions and systems to achieve a more sustainable future in this field. Specifically, I will be using three questions to guide my research on this topic: 'How can the waste management hierarchy be implemented to prolong the lifespan of electric vehicle batteries to prevent immediate disposal? What does battery waste contamination look like in landfills and how can we prevent hazards from occurring? What impacts do charging stations have on the environment and what can be done to reduce those impacts at the end of their life cycle?' In addressing these critical questions, my research aims to shed light on the problems that currently stand with the disposal of EVs which will in turn propose a strategy to lessen our ecological footprint.

Discussion

Battery Disposal

The first topic I will be discussing is how we can apply the waste management hierarchy to prevent the immediate disposal of EV batteries. The waste management hierarchy is a conceptual framework used to prevent the immediate disposal of waste starting with the most preferred solution at the top and moving down to the least. From top to bottom the hierarchy goes as follows: waste prevention, reuse, recycle, recovery, and disposal. One way that we can preserve the lifespan and reduce the waste of EV batteries is by implementing practices around this hierarchy. (Zhu et al., 2021)

The most ideal solution is prevention. Prevention means avoiding any form of waste by selecting batteries with a long lifespan and of better quality. Users should avoid charging their EV to 100% and avoid fast-charging stations when possible as the battery degrades and loses its maximum charge capacity overtime. Avoiding extreme heat and cold conditions will also preserve the battery life. (Zhu et al., 2021)

When prevention is no longer a feasible option and the battery doesn't have the lifespan to support a vehicle we can move to the next step of the hierarchy which is reuse. When the battery health declines between 70 and 80% it no longer can provide sufficient energy to the vehicle so we must use that battery in other applications. There are many second-use applications where the battery health is less important. After the battery is remanufactured, the battery can perform well enough to function in less demanding applications including power producing companies. These companies will take the cells for an additional 8 to 10 years, storing the energy as a back-up source during peak demand and short outages. However, as the EV market grows, the supply of batteries will exceed the quantity needed for second-use applications. When this happens, the battery will go to the next step of the waste management hierarchy being recycling. (Zhu et al., 2021)

Recycling consists of extracting the raw materials from the batteries including lithium, cobalt, and nickel. This solution allows for less mineral extraction which will benefit both the environment and economy.

As we move towards the bottom of the hierarchy, the next stage is recovery. Recovered battery materials can be used as energy for processes including fuel for pyrometallurgy. It recovers nonferrous and precious metals from electronic waste. This process uses heat to extract metal from their ores and scraps by smelting in a plasma furnace.

This is the last stage of the process when no more value can be extracted from the battery. Disposal should always be avoided until there is no other option because it is the least environmentally friendly solution. (Zhu et al., 2021)

Designing a regulated system around the waste management hierarchy for EVs is the first step in the right direction to closing the loop in this product's life cycle. However, this loop cannot be closed until the LIBs themselves are redesigned. Current LIBs are not designed for recyclability and contain many hazardous chemicals including toxic lithium salts and transition metals that are damaging to the environment, no matter the stage in the waste management hierarchy. (Arshad et al., 2022) The biggest reason why these hazardous devices have not been modified is because manufacturers have little economic incentive to develop eco-friendly designs. For this reason, third-party recyclers become responsible for handling the waste which typically results in them storing the batteries themselves because it's cheaper than treating and recycling them. (Mrozik et al., 2021)

A safer solution that is currently in the process of being developed for many companies are solid-state batteries. Designers and engineers need to focus on further developing this technology in order to advance the industry into a more sustainable sector. Solid-state batteries replace the flammable liquid electrolyte with a non-flammable solid electrolyte. This allows the battery to experience more extreme temperatures without the risk of fires or explosions. Designers should work towards incorporating the ease of recyclability into these solid-state batteries to make that stage of the waste management hierarchy more attainable. Considerations should also be made surrounding the number of steps needed to dismantle a battery to avoid combustion, harmful chemicals, and the complexity/ cost of recycling. This should include using low-cost materials to develop techniques such as water and alcohol-based recycling methods as it's both a scalable and eco-friendly approach. The combination of the redesign of batteries used in EVs and the application of the waste management hierarchy is a step in the right direction to obtain optimal levels of sustainability. (Chen et al., 2023)

Waste Contamination

The next issue I'll be addressing are hazards of waste contamination from LIBs in the landfill and the next steps needed to improve the disposal stage. When battery waste enters the landfill, there is a high risk of water and soil contamination as well as combustion due to the batteries tendencies to ignite and release gas. This causes thermal runaway which triggers surrounding batteries to ignite. To keep these fires under control, there are 4 main layers of fire protection that should be designed into a system to increase LIB safety. It goes as follows: protection, compartmentation, detection and suppression. This is a concept commonly used in fire engineering but has not yet been adapted the same way into LIB fires. (Bravo Diaz et al., 2020)

The first layer of prevention aims to reduce the risk of thermal runaway. This begins once again with the design of the battery itself. As mentioned previously, one solution to preventing waste and fires would be do adopt a solid-state battery in electric vehicles. But for now we move onto the second step of engineering a safer system to reduce combustion in the landfill. (Bravo Diaz et al., 2020)

The compartmentation layer is activated once prevention fails and the ignition of fire has sparked. Compartmentation is designed to stop the fire from expanding and avoiding a catastrophic failure. This layer involves designing systems around detecting risks for fires early on to avoid potential hazards that may follow. One example of how this stage can be implemented into fire safety is by installing thermal cameras to detect heat changes in the landfill. This will then activate the final layer of the system. (Bravo Diaz et al., 2020)

Suppression is a form of fire protection designed to extinguish the fire. At this stage a suppression system may look like a sprinkler system that's activated to put out the fire. Some fire extinguishing agents that can be used include water, foam, dry chemical powder, wet chemical or inert gases with water-based extinguishing agents being most effective because of their cooling capabilities. However there are some disadvantages to water-based extinguishing agents including the time and the large amount of water needed to avoid re-ignition. There is also the risk of water being an electrical hazard to large LIBs and risk of electric current leakage. All of these claims imply that there is a lack of knowledge surrounding fire safety control in LIB landfills. Therefore, more research needs to be conducted in order to provide sufficient evidence on the most effective way to tame and extinguish LIB combustions. Once more research has been conducted through studies and tests, protocols and systems can be designed in order to provide a safer and more effective way of maintaining these landfill fires. (Bravo Diaz et al., 2020)

Charging Station Hazards

In general, EV charging stations provide many environmental benefits from a user perspective in day-to-day life. The cost for electric fuel is less and it produces less greenhouse gasses than gas fuel. However, because I'm analyzing greenwashing that occurs in the EV industry I will be focusing on the current negatives and improvements needed to better sustainable efforts in the industry. (Unknown, n.d.)

Environmental impacts occur at every stage of the EV charger lifespan. Before diving into the impacts during disposal stages and end-of-life cycle, it's important to note the not-so-obvious environmental impacts early on in the life cycle. Just like any large-scale infrastructure project, EV charging stations require land clearing for installation. Urban planners and designers should prioritize building charging stations on underutilized parking lots or garage tops to avoid clearing trees and land. This can be difficult because charging stations need to be conveniently placed in highly populated areas in order to get enough use by the public, but clearing fresh land should always be the final resort. Beyond that, the process of building charging stations require extraction, manufacturing, and transportation of materials which also contributes greatly to the product's carbon footprint. (Unknown, n.d.)

When EV charging stations have reached the end of their lifespan they must be disposed of in the landfill. Protocols discussed previously around battery disposal should be followed, but what about the rest of the electrical parts and software? Unfortunately, electronic waste or 'e-waste' is the fastest growing solid waste stream in the world. Lead is a common substance released through e-waste from both EVs and charging stations. This waste is extremely hazardous to human health when not treated or disposed of properly. Extremely hazardous treatment comes from recycling under inferior conditions as it poses a risk of as many as 1000 different chemicals being released into the environment, lead being one of the most dangerous. This puts pregnant women and children especially at risk of illness when exposed to these environments. Almost a quarter of e-waste produced globally was suspected to be from previously recycled waste in 2019. This is a huge concern and should be a driving force of why recycling and disposal programs for e-waste need to be redesigned. A redesign specifically focusing on EV charging station waste would help get closer to the goal of closing this product's life cycle loop. (Unknown, 2023)

The first step to understanding how to design a better disposal infrastructure is by learning what types of disposal systems don't work affectively. This includes dumping on land or in water, disposing in the same areas as regular waste, open burning or heating, and manual disassembly of equipment. All of these processes are considered hazardous to eco-systems and human health because they release toxic pollutants in the process. Especially any form of burning or heating as toxic fumes are created, producing one of the most hazardous activities of them all due to the ability for fumes to travel significantly over long distances. (Unknown, 2023)

Prevention tactics to stop these hazardous activities need to be designed to better improve the disposal of EV charging stations. A good place to start is with adopting and enforcing high-level international agreements. The Basel Convention is a global environmental agreement that standardizes hazardous waste disposal. EV designers need to put efforts towards working with The Basel Convention in order to stop forms of hazardous disposal. (Unknown, 2023) In addition, developing and implementing national e-waste management legislations are needed to protect the health of the public. Specifically, more responsibility needs to be put on EV producers financially. This pressures companies to make more impactful environmental changes. Alongside these laws, incorporating health protection measures into national legislation will protect the health and safety of the public. (Sawicki, 2023) Lastly, the next solution that needs to be implemented into the redesign of the disposal system of EV charging stations is monitoring informal e-waste recycling and disposal activities. This can be achieved by incentivizing the public to return charging station e-waste to regulated bodies. This will keep disposal methods out of the hands of the public to prevent dangerous activities from occurring, and prevent e-waste from being mixed in with standard landfill waste. (Unknown, 2023)

Conclusion

In conclusion, the EV industry represents a pivotal shift towards sustainability in the transportation sector, offering a promising alternative to traditional gas-powered vehicles. The exponential growth of the EV industry over the past decade reflects a global commitment to reducing emissions and embracing cleaner technologies. However, a critical examination of the entire lifespan of electric vehicles reveals challenges that cannot be ignored.

One notable concern is the prevalence of greenwashing within the EV industry, where companies make false claims about the environmental benefits of their products. While EVs undoubtedly contribute less to daily emissions than their gas-powered counterparts, it is crucial to address the issue of misleading information to ensure that the transition to electric vehicles is grounded in genuine environmental progress.

The focus on sustainability in the 4th Industrial Revolution highlights electric vehicles as a key component of the future. However, a comprehensive analysis of the EV life cycle unveils a recurring challenge: the environmental impact of lithium-ion batteries (LIBs). The group's emphasis on each stage of the EV's life cycle highlights the need for proactive solutions to dangers and hazards of disposal.

As we envision a more sustainable future, the path forward involves not only embracing electric vehicles but also addressing the challenges inherent in their production and disposal. The proposed strategies discussed previously stem from investigations of the identified problems and offers a potential roadmap towards reducing the ecological footprint of electric vehicles. With the help of engineers and designers taking the forefront of the 4^{th} industrial revolution, impactful changes can be made

to better the health of our planet and its inhabitants
through improvements in the EV industry.

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RENEWABLE ENERGY INTEGRATION IN ELECTRIC VEHICLES

THE 4th INDUSTRIAL REVOLUTION: ENVIRONMENTAL SUSTAINABILITY IN EVS | MELISSA MAK

Introduction

In the midst of the fourth industrial revolution, electric vehicles are emerging as transformative icons. Electric vehicles are slowly being integrated into our daily lives and sparking interest worldwide as people look for more eco-friendly options. The growing popularity of electric vehicles isn't just a passing trend; it's a significant move toward a greener future. With climate change concerns on the rise, electric vehicles are seen as hopeful solutions that could eventually replace traditional gas-powered cars. Our lives today heavily rely on fossil fuels, powering our cars and lighting up our world. Unfortunately, this heavy dependence on non-renewable resources is a major factor contributing to climate change (Electric Cars and Sustainability, 2022). But the electric vehicle industry is stepping in as a dynamic force with the potential to change the game, providing a real solution to reduce our reliance on fossil fuels in the long run. While electric vehicles are gaining importance, many people overlook the pros and cons of owning one. Additionally, while renewable energy resources have been available for an extended period, we haven't fully tapped into its potential. This is a missed opportunity to use our natural resources for sustainable electricity (*Barriers to Renewable Energy Technologies | Union of Concerned Scientists*, 2014). This report aims to explore the connection between electric vehicles and renewable energy, uncovering how they intersect and the untapped potential for more integration. By explaining the current situation and looking ahead, we want to highlight how renewable energy can make electric vehicles more sustainable, moving us towards a future where eco-friendly transportation is the standard.

This report will answer three questions:

1. How are renewable energy sources currently integrated into the design, manufacturing and charging infrastructure of electric vehicles, and what advancements are being made in this area?

2. How do the environmental effects of using renewable energy in electric vehicles contribute to sustainability and shape our future? (fuel economy, fuel costs, reduced emissions, and battery technology)?

3. What are the negatives and challenges to manufacturing electric powered vehicles? What innovative design features or technologies in electric vehicles might optimize their energy efficiency and promote sustainable transportation ultimately influencing the future?

Discussion

The chosen subtopic, electric vehicles, represents a newer industry in our world, one that our group initially approached with a collective lack of familiarity. Despite this initial unfamiliarity, our curiosity was piqued, particularly regarding the sustainability of electric vehicles and the extent to which they can genuinely be considered environmentally friendly. Our intention was to conduct a thorough examination encompassing various areas of this subject, delving into the intricate details of material selection, the incorporation of renewable energy, the life cycle considerations, and the holistic perspective of electric vehicles as complex systems. Our exploration extended to specific areas, such as a focused investigation into the use of lithium batteries. This involved looking into the environmental impacts associated with these batteries, shedding light on their considerable weight and potential harm to the planet. Concurrently, we sought out alternative solutions that could serve as more environmentally friendly substitutes for these heavy and potentially hazardous batteries. Furthermore, our research extended to the responsible disposal of batteries, with a focus on developing methods to prevent contamination of landfills. This encompassed a comprehensive examination of the end-of-life cycle for various electric vehicle components, including not only batteries but also other integral parts and charging systems. We then turned our attention to the broader system involved in the creation of electric vehicles. This involved a meticulous analysis of strategies within the design process aimed at enhancing the overall sustainability of electric vehicles. By considering the entire lifecycle, from material selection to end-of-life considerations, we aimed to contribute to a more informed and holistic perspective on the environmental impact of electric vehicles.

What is renewable energy?

Renewable energy is a sustainable power source harnessed from the Earth's natural elements. Among the most prevalent and eco-friendly options are solar energy, wind energy, geothermal energy, and hydro power which are sources that are readily available in our surroundings. In contrast, traditional non-renewable energy sources like coal, gas, and oil have been typically used in our energy production methods. However, their utilization contributes to the emission of greenhouse gasses, notably carbon dioxide, posing significant harm to the Earth. Recognizing this, the shift toward the use of renewable energy becomes not only a choice for a sustainable future but a crucial necessity to mitigate the impacts of climate change (Nations, n.d.). In the pursuit of answers to my research questions, I delved into an extensive array of online resources, articles, scientific journals, and insightful YouTube videos. This report places a spotlight on renewable energy as a focal point. Positioned as a cutting-edge and potent technology, it holds the promise of enhancing the sustainability of electric vehicles. Acknowledging its early stage and its transformative potential in shaping the future of sustainability, the exploration into the harnessing of renewable energy emerges as a significant contribution to propelling electric vehicle technology towards heightened eco-friendliness.

How are renewable energy sources currently integrated into the making and system of electric vehicles, and what advancements are being made in this area?

Renewable energy plays a pivotal role in shaping the landscape of electric vehicles, with solar energy emerging as a prominent force in powering charging stations across the grid. Insights from electric charging companies, supplemented by informative YouTube videos, deepened my understanding of the integration of solar panels into both commercial and personal vehicle charging infrastructure. Notably, companies in the industry, such as Electrify America, are investing in solar-powered EV charging stations in rural areas, exemplifying the practical utilization of renewable resources for clean and sustainable charging practices (Renewable Energy & Sustainability, n.d.).

Diverse charging station designs and features are enhancing the efficacy of renewable energy in supporting electric vehicles. Innovations like sun-tracking solar arrays, designed to follow the sun's trajectory, elevate energy yield, while co-located energy storage mechanisms address intermittency issues by storing excess energy for release during peak demand or when renewable sources are inactive (Hilton et al., 2019). Surveys indicate a notable trend among electric vehicle drivers, with 28% to 42% opting for rooftop solar panels integrated into their homes for vehicle charging, underscoring the decentralized and individualized nature of renewable energy adoption (Richardson, 2018).

Looking ahead, the marriage of renewable energy and intelligent electric vehicle charging systems promises a cleaner and more sustainable future. Electric vehicle companies like Tesla, at their Gigafactory, exemplify this commitment by harnessing solar energy to power not only their machinery but also various facets of the facility, including lighting, air conditioning, ventilation, and robotic systems (The Future of Sustainable EV Manufacturing, 2023). This strategic use of renewable energy significantly contributes to the overall sustainability of electric vehicle manufacturing, especially considering the energy-intensive nature of the production process.

Moreover, individuals are taking charge of their sustainability efforts by employing portable solar panels and solar module attachments, seamlessly integrated into existing electric vehicles (Portable Solar Panel for Electric Car, 2022). Although not the most efficient method for routine charging, this approach proves invaluable in emergencies, harnessing energy derived directly from natural resources. These diverse applications underscore the adaptability and versatility of renewable energy solutions in the realm of electric vehicles, contributing to a more sustainable and resilient future.

How do the environmental effects of using renewable energy in electric vehicles contribute to sustainability and shape our future?

Leveraging renewable energy in electric vehicles yields many environmental benefits throughout the vehicle lifecycle. A significant advantage lies in the reduction of carbon emissions during vehicle operation. When electric vehicles are charged using electricity generated from renewable sources, such as solar power, their carbon footprint significantly diminishes compared to traditional internal combustion engine vehicles. This aligns seamlessly with global initiatives aimed at combating climate change and curbing greenhouse gas emissions (“Charging Your EV with Solar Panels,” 2023).

Another favorable outcome is the improvement in air quality within urban areas, as electric vehicles operate without emitting pollutants from tailpipes. In contrast, emissions from gas and diesel vehicles pose severe health and environmental risks. The appeal of solar panels is heightened, as vehicles can now no longer rely completely on non-renewable sources like coal and oil for charging (“Charging Your EV with Solar Panels,” 2023). Moreover, users adopting electric vehicles with solar panels in their homes can accrue long-term cost savings, reducing both maintenance expenses and energy costs. This is achieved by eliminating reliance on local utility companies, as their charging systems are powered by sunlight. Some countries even incentivize such practices with tax credits or subsidies for individuals using their own solar panels to charge their vehicles (“Charging Your EV with Solar Panels,” 2023).

The integration of renewable energy in charging stations not only promotes cleaner and more environmentally friendly charging for electric vehicles but also ensures sustainable practices throughout the vehicle's entire lifecycle. By introducing renewable energy to the power grid, stability is enhanced, and intelligent charging systems can optimize charging times based on the availability of renewable energy. This not only alleviates grid strain during peak periods but also facilitates the incorporation of energy from sources like solar or wind power, which may not be consistently available (Hilton et al., 2019).

Furthermore, the emphasis on renewable energy within the electric vehicle sector drives technological innovation. Advances in energy storage, wireless charging, and intelligent energy grid usage are evidence of this ongoing innovation (New Technology Installed beneath Detroit Street Can Charge Electric Vehicles as They Drive, 2023). These improvements not only enhance the efficiency of the electric vehicle system but also contribute to its long-term sustainability.

Governments worldwide are pivotal in propelling this shift towards sustainability, implementing rules, policies, incentives, subsidies, and regulations to encourage the increased use of renewable energy in transportation. Subsidies are extended to individuals building their own renewable energy systems at home, fostering an environment that supports sustainable practices and steering the electric vehicle industry toward a greener and more environmentally friendly trajectory ("Charging Your EV with Solar Panels," 2023). The collaborative efforts of individuals, industries, and governments are shaping a sustainable future for electric vehicles and contributing to the broader transition towards environmentally conscious transportation.

What are the negatives and challenges to electric powered vehicles? What innovative design features or technologies in electric vehicles might optimize their energy efficiency and promote sustainable transportation ultimately influencing the future?

The emergence of electric vehicles represents a transformative moment for the automotive industry, bringing about increased sustainability in stark contrast to traditional gas-powered vehicles. Despite being a relatively new topic, the advantages of electric vehicles mostly appear to outweigh their gas counterparts, rendering this research question challenging yet pivotal to explore. However, the manufacturing of electric vehicles introduces challenges that demand attention for widespread adoption and long-term sustainability.

The transportation of raw materials, components, and finished batteries across global supply chains contributes to carbon emissions, underscoring the imperative for localized supply chains to mitigate transportation-related environmental impacts (Slanger, 2023). The energy-intensive nature of manufacturing batteries, particularly lithium-ion batteries, raises environmental concerns, especially when derived from non-renewable sources. Furthermore, establishing a comprehensive charging infrastructure is indispensable but entails significant investment challenges for both governments and private entities. Solar-powered charging stations, while environmentally friendly, present cost barriers, and the feasibility of renewable sources is constrained in regions with limited sunlight. The lack of electric charging stations, in comparison to traditional fuel stations, accentuates the challenges. Charging infrastructure varies in availability and accessibility across regions, impacting the practicality of owning an electric vehicle. Charging times can be prolonged, taking up to an hour at stations and even longer at home-based stations depending on the number of solar panels, presenting a notable contrast to the quick five-minute refueling of traditional gas-filled vehicles (The Pros & Cons of Electric Car Charging Stations, n.d.).

Despite these challenges, ongoing advancements in the realm of electric vehicles continue to unfold. A new technological innovative idea is the integration of renewable energy, specifically the incorporation of solar panels into the design of electric vehicles. These innovative designs feature solar panels built into the rooftops, directly harnessing solar energy to power the car's battery. This innovation addresses challenges such as extending the driving range, overcoming limitations in charging infrastructure, and reducing the weight of batteries in the vehicle ("How Solar Roofs Are Being Used to Power Electric Cars," 2023). However, the transition to direct solar charging faces obstacles. The requirement for a substantial number of solar panels poses challenges as vehicles lack sufficient roof surface area to generate the requisite solar power, unless the car is entirely covered in solar panels. Moreover, the implementation of these panels incurs significant costs, and the efficacy of charging becomes weather-dependent ("How Solar Roofs Are Being Used to Power Electric Cars," 2023). Despite these challenges, the pursuit of integrating renewable energy into electric vehicles underscores the industry's commitment to addressing environmental concerns and enhancing sustainability.

Conclusion

In conclusion, the experience has been interesting, informative and exciting. This learning process has proven successful as I dedicated lots of time to delve into the intricacies of electric vehicle technology. I'm thrilled with the great amount of information I've gathered, allowing me to answer my initial questions comprehensively. Exploring the integration of the use of renewable energy within electric vehicles has shed light on the promising future of sustainable transportation. Understanding the complexities of charging infrastructure, manufacturing processes, and the environmental impact of electric vehicles has broadened my insights into this evolving field. The evident positive impact of renewable energy on reducing carbon footprints and enhancing the sustainability of electric vehicles provides a glimpse into a cleaner automotive future. While the journey of researching had its challenges in looking into such a complex topic with so much information and looking specifically at the negatives to electric vehicles, it has ultimately deepened my appreciation for the design of electric vehicles. This exploration not only expanded my knowledge but also fostered optimism for the ongoing evolution of eco-friendly transportation solutions.

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A SYSTEMATIC APPROACH TO SUSTAINABLE PRODUCT LIFE CYCLES

ENVIRONMENTAL SUSTAINABILITY IN ELECTRIC VEHICLES|KEEVA SZETO

INTRODUCTION / BACKGROUND

The primary objective of this paper is to enhance the accessibility of environmentally sustainable design for designers. The implementation of a systems design approach offers a structured perspective, with a particular focus on the design of Electric Vehicles (EVs) as an example for application. The overarching goal is to provide designers with a comprehensive framework that guides design processes at every stage of the life cycle, facilitating the achievement of sustainability goals. Providing practical tools to measure the effects of changes implemented throughout each phase of the life cycle further assists designers to make informed decisions for a more sustainable future.

DISCUSSION ABOUT SUBTOPIC

Designers in the Fourth Industrial Revolution

Within our daily lives, numerous activities seamlessly operate within expansive and intricate systems, many of which have evolved over time without a comprehensive design effort that systematically promotes sustainable values and practices throughout the entire lifecycle of a product. As we navigate the information age, the fourth industrial revolution presents a new era focused on the integration of technological innovations that combine the realms of physical, digital, and biological dimensions (WEF, n.d.).

The transforming role of a designer from form-giver to coordinator introduces the responsibility of learning and working as part of a greater effort encompassing a variety of disciplines (Ferraria, 2017). Collaborative action is essential to addressing the intricate challenges posed by an increasingly complex world.

Sustainability in the 21st Century

With the rise of industrialization in the late 20th century, the direct effects of human activity to produce climate symptoms (SDC, n.d.) i.e. extreme weather events, rising temperatures, and pollution prompted the world to reconsider long-standing systems and ways of living. The concept of sustainability emerged as a relevant topic regarding various aspects of government, industries, and everyday life.

The United Nations (Microsoft, n.d.) defines sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs.", encompassing three dimensions of sustainable development: economic growth, social equity, and environmental protection. While the "environment" considers the physical aspects of the world we live in, "development" refers to improvements to the conditions of such living spaces (WEC, 1987) – the 2030 Agenda for Sustainable Development introduces 17 Sustainable Development Goals (SDGs) to outline specific and interconnected challenges, each contributing to this overarching mission.

Emphasizing the responsible stewardship of the planet to support the well-being of the current and future world, initiatives to advance environmental sustainability include accessibility and maintenance of natural resources, protection of the natural environment, improving living conditions and undertaking responsible consumption and production (United Nations, n.d.). On the industrial level, actions involve increasing efficiencies, managing resource consumption and waste, and monitoring carbon emissions throughout the supply chain.

Electric Vehicles

As an alternative to gas-fueled vehicles, EVs aim to reduce the consumption of finite resources including precious metals and nonrenewable energy, and the production of greenhouse gas (GHG) emissions during use, preceding a new era of sustainable personal transport. The evolution of electric vehicles (EV) traces back to the early stages of vehicular transportation, with electric cars being a popular choice alongside internal combustion gas-powered vehicles through the early 1900s. Despite the initial popularity of EVs, their gasoline powered counterparts eventually gained favor due to lower production and product costs with the introduction of the mass-produced Ford Model T, further incentivized by the discovery of abundant crude oil sources. However, rising demand and shortages of supply led to a price surge for oil. New policies for regulations regarding emissions, energy consumption and production in the 1990s renewed interest in electricity as a viable energy source for vehicular transportation (U.S. Department of Energy, n.d.).

General Motors emerged as an early adopter, designing and producing a new electric vehicle from scratch. Released in 1996, the EV1 sparked consumer interest but faced discontinuation in 1999 due to high production costs and inadequate charging infrastructure (Hawley, 2022). In 1997, the Toyota Prius was introduced as the first hybrid electric vehicle, combining an internal combustion engine with battery-powered motors (U.S. Department of Energy, n.d.). Tesla Motors further progressed the EV landscape in 2006 by targeting luxury sports car markets, prompting a shift in the automobile industry. This momentum led to the introduction of competitive products including the 2010 Chevy Volt (a plug-in hybrid) and the Nissan LEAF (an all-electric vehicle). These innovations motivated the U.S. Energy Department along with private businesses to invest in nationwide charging infrastructure to increase public accessibility to charging outlets across the U.S (U.S. Department of Energy, n.d.).

The Battery Problem

Although EV can be considered a transformative innovation, it is not entirely disruptive; it combines existing technologies and consequently inherits challenges from its dependent technologies. At its forefront, EV faces critical challenges related to battery manufacturing and material use, energy generation and consumption, and waste management. Early innovations depended on lead-acid batteries, a traditional and cost-effective choice for rechargeable energy, which faced challenges with weight and inefficient performance. While recyclable, they often end up in landfills, in which lead components contaminate surrounding ecosystems as they decompose (Energy5,2023). Nickel-metal hydride batteries, while more efficient and recyclable, present a shorter lifespan of just 5 years (Energy5,2023).

Lithium-ion batteries currently dominate the market by offering improved performance and charging capabilities. However lithium-Ion batteries face common failures resulting in fire and combustion while in use on electronic devices (University of South Wales, n.d.). Lithium-ion batteries use three times more energy to produce, comparatively generating more emissions than other fossil-fuel powered batteries. The process of producing lithium involves brine extraction, a water-intensive and contaminating process, while cobalt mining in open-pits generates toxic by-products that harm natural ecosystems and create unsafe conditions for workers, diminishing residents' quality of life (IER, 2023). Although rechargeable, the energy generated to power these batteries are dependent on local generation infrastructure, which can rely on non-renewable sources such as coal, leading to increased environmental impacts. Lithium-ion batteries rely on resource and labor intensive recycling processes including disassembly, reductive roasting (smelting), and chemical extraction (Baum., et al. 2022). Addressing these challenges is essential for realizing the full potential of EVs as a sustainable transportation solution.

A SYSTEMIC APPROACH TO SUSTAINABLE ELECTRIC VEHICLE LIFE CYCLES

At a glance, the shift to Electric Vehicles (EV) appears imminent given the current climate landscape. Major automobile companies, including BMW, Ford, Mazda, Nissan, and Stellantis, have set targets to competitively develop more EV products in the coming years – to replace 25-50% of all vehicle sales with EVs by 2030. Simultaneously, industry leaders like Honda, GM, and Volvo aim to transition entirely to electric vehicles between 2030 and 2040 (Rubio-Licht & Roach, 2022). The increased support for EV infrastructure through government initiatives underscores the importance of considering sustainability in emerging systems. In Canada, the $680 million Zero Emission Vehicle Infrastructure Program (ZEVIP) incentivizes citizens to switch to EVs and funds infrastructure owners and delivery organizations to expand charging stations (Government of Canada, 2023) to meet its goal of banning sales of new gas-powered vehicles by 2035 (Hopper, 2022). Similar targets have been set by major automobile markets globally through government regulations, including the U.S., China, Japan, and the EU.

Technological advancements such as All-Solid-State Lithium-Ion Batteries (ASSLIBs), grid infrastructure for renewable energy, and strategies for enhancing product longevity through maintenance and recycling aim to improve the overall performance of EV solutions from production, use, and end-of-life considerations. Consequently, it becomes imperative for designers to possess the knowledge and tools necessary to design for sustainable outcomes – to bridge gaps in existing systems and create new ones. Employing systems design strategies can make sustainable product design more approachable, offering organizational frameworks for achieving sustainability goals, and tools for measuring the effects of intended actions and gauge for potential successes.

An organized perspective on systems design
How can system design strategies be applied to design sustainable Electric Vehicle products?

"Our Common Future" (WEC, 1987) by the Brundtland Commission for the UN, frames sustainable development challenges as complex issues rooted in interconnected systems. Effective solutions require systematic attention through organized efforts. Systems dynamics, which emerged as a management theory in 1956 by Professor Jay W. Forrester at MIT Sloan to graphically analyze system behaviors, has since been adapted across various disciplines as a new way of thinking to identify patterns and understand relationships within the world (IxDF, 2016). In design, a systems approach is one of the four fundamental pillars of Human-Centered Design (HCD). As outlined by Don Norman (n.d.), this involves addressing core problems, being people-centered to considering all individuals involved, understanding everything as a component of a connected system, and presenting incremental and interactive solutions. Design thinking traditionally uses a bottom-up approach to narrowly define a single problem, enabling businesses to provide direct solutions to meet user needs. However, systems thinking aims to shift this narrative by understanding how a combination of solutions can be used together to address collective needs (Toroglu & Mulvey, 2020). Contrasting end-of-pipe thinking, which mitigates resultant symptoms as a result of other actions, preventative action can occur through a combined effort to tackle the root of the problem. The focus of design has evolved over time from intervention after process-induced damages to intervention through consumption patterns and offer models. Since the late 1990s, strategies for designing with consideration of environmental effects throughout production, distribution, use, and disposal have been developed. The concept of Life Cycle Analysis (LCA) aims to create a quantifiable measure of environmental effects through the previous phases. This categorization provides space for holistic solutions, allowing for two strategies to be employed: the life-cycle approach, designing for all activities involved through each stage, or the functional approach, designing solutions for sustainability by focusing on their set purpose rather than their physical aspects (Vezzoli, 2022).

Sustainable Product Service Systems (S.PSS) Systems design aims to enhance the sustainability of products by considering the entire life cycle of a system and its interactions with the environment at every stage. The objective of system design is to shift the focus from individual products solving individual problems, to generating multiple solutions that collaboratively deliver a service to the user. In this context, S.PSS models offer an organized perspective on achieving this goal. In 'Product-Service System Development for Sustainability', Vezzoli (2021) presents three models to guide service offerings:

1. Product-oriented S.PSS: These services add value to the product life cycle; the customer owns the product and the company provides complimentary services throughout the product's life cycle

2. Use-oriented S.PSS: These services act as "enabling platforms" for customers; the customer does not own the product, but pays to operate the product at different levels

3. Result-oriented S.PSS: These services provide "final results" for customer; the customer pays the product owner to operate the product to ultimately deliver a mix of services for the customer

The current Electric Vehicle (EV) system operates as a Product-Oriented S.PSS, wherein individual customers own vehicles, and companies provide services encompassing charging, maintenance and repair, upgrades, and end-of-life or take-back programs. Electric vehicles consist of various subsystems, including batteries, charge ports, On-Board Charger, Electric Traction Motor, DC-DC Converter, Power electronics controller, Traction battery pack, Transmission, and Thermal Cooling System (AFDC, n.d.). However, an EV is not a standalone product; it exists within a broader ecosystem of products, including charging stations with compatible digital or Internet of Things (IoT) products, dependent on energy generation technologies, storage and delivery infrastructure. These products exist as part of a use-oriented service, in which the customer pays fees to use chargers owned by a secondary source, and a result-oriented system, in which the customer ultimately pays for the service of receiving electricity for their vehicle.

Moreover, vehicles themselves are integral components of the larger transportation system within local urban spaces and form part of a larger, global product system. EVs currently face challenges on greater systems levels. For instance, technical issues arise due to the lack of regulation ensuring universal compatibility of products across different manufacturers and countries. The European Automobile Manufacturers Association (ACEA) outlines the following key concerns (2012):

- standardization (plug, phases, data protocol)
- cross-national compatibility, data protection (personal, business)
- safety requirements for recharging/discharging places
- safety requirements during battery recharging/discharging (e.g., short circuits)
- charging cable specifications at the car or recharging station
- technical approval bodies for recharging places
- periodic inspections and maintenance of recharging places
- liability clarification, and convenient billing systems

Addressing these issues is crucial for the seamless integration and effectiveness of EVs within the broader transportation and energy systems.

Designing to meet sustainable development goals throughout the product life cycle
What are the goals of environmental sustainability within the EV system and the stages of the product life cycle?

In operation, EVs directly contribute to UN Sustainable Development Goals (SDGs), notably SDG 7: Affordable and Clean Energy and SDG 13: Climate Action, while also supporting SDG 9: Industry, Innovation and Infrastructure, SDG 11: Sustainable Cities and Communities, and SDG 12: Responsible Consumption and Production (RELX, n.d.). However, characterizing EV products as 'environmentally-friendly' or 'zero-emission' oversimplifies by solely focusing on the use phase and disregarding systemic challenges throughout the entire product life cycle, which can diminish the positive impacts of EVs. In the pre-production and production phases, products accrue substantial environmental impacts through inputs, including water consumption, natural resources, and energy input, and outputs, such as emissions and waste products. Consequent changes are necessary at each stage of the life cycle (Kukreja, 2018):

Preproduction: Designers must critically assess the suitability of EV adoption based on existing infrastructure and its benefits to stakeholders. Following consumption behaviors, products should be designed for obsolescence with the understanding that personal vehicles do not exist as a permanent product to consumers, and are prone to being upgraded as technology and fashion trends advance.

Raw Material Production: Processes involving extraction, refinement, and production of raw materials used in components should be scrutinized. Changes include opting for materials that require less resource and labor-intensive production, including non-toxic and recyclable alternatives.

Manufacturing: This encompasses the early stages of transforming raw materials into usable formats, executing designs through production, and eventually assembling the product system. Changes include managing resource and energy consumption during processes, and reducing emissions and waste.

Transportation: The movement of components to different processing locations contributes to resource and energy consumption and emissions. Therefore, relying on local sources through improved distribution networks is crucial.

Operation: Designing products for appropriate lifespans and providing solutions for repair, maintenance, and updatesUsers should be encouraged to follow healthy methods of use to increase the longevity of products given the context of the product’s lifespan.

End-Of-Life: Strategies involve decommissioning vehicles and complementary components, disposal, and recycling of parts. Designers can focus on managing waste through responsible handling of waste products, with a focus on designing for ease of disassembly and the possibility of repurposing individual components.

Measuring the impacts of change
What tools can we use to understand the relationships between design and its resulting consequences to measure the effectiveness of changes?

While there is a fundamental link between systems design as a foundation for sustainable development, there are many processes that exist and its appropriateness is dependent on the end goal and the executor. The Modular Method for System Design for Sustainability (MSDS) addresses this variability by offering a range of stages and processes that can be executed as a whole or in combinations that best fits the specific sustainable development goals of the project. This model breaks down the systems design process into five stages, forming a framework to support specific sustainability objectives.

1. Strategic Analysis: Involves gathering information essential for creating a new sustainable system. It includes analyzing

existing sustainability aspects within the system and identifying areas for intervention.

2. Exploring Opportunities: Focuses on generating ideas for solutions, sustainability-design-oriented (SDO) scenarios, or visions.

3. System Concept Design: Entails developing system concepts at a low fidelity to test viability, accompanied by conducting environmental, socio-ethical, and economic assessments.

4. System Detailed Design: Involves the detailed development of the most appropriate system solution for successful implementation.

5. Communication: Aims to present sustainable qualities within the system of solutions, effectively communicating the relationships between design and consequential results.

Tools play a crucial role at each stage of the design process, serving as facilitators, impact analysis guides, and communication mediums. Vezzoli's Systems Design for Sustainability in Practice (Velozzi, 2022) provides a foundational set of tools for this purpose to be incorporated within each stage of the MSDS model to use as a starting point.

The E3 Sustainability Tools (EPA, 2023) repository offers a comprehensive list of tools designed to generate data for impact measurement. These tools cover areas such as sustainable manufacturing, life cycle assessment, energy efficiency, carbon footprint, materials management and pollution prevention, community development, worker safety, workforce development, and resources for funding and for the manufacturing industry.

Further, Eco-Indicator 99 (2000) presents a manual for damage-oriented life cycle analysis. This manual outlines a method for calculating an Eco-Indicator score, enabling designers to measure the implications of their system-based solutions and identify areas for improvement during the design phase.

CONCLUSION

The electric vehicle system represents a comprehensive and transformative approach to redefining our modes of transportation, offering a solution to sustainability challenges associated with the current heavy reliance on personal vehicular transportation. Design at the systems level presents a unique opportunity for innovations in the way we travel, and it is crucial to recognize that change can occur at every level of transportation, but the success of these new systems is highly dependent on their ability to fulfill their intended purpose. The emphasis should be on implementing appropriate solutions from the start, rather than working to mitigate adverse effects later. Systems design emerges as a critical tool, enabling us to proactively address issues related to material use, energy consumption, and waste management simultaneously, while working to improve sustainable and efficient transportation systems.

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Virtual, Augmented, and Mixed Reality (VAMR) in the 4th Industrial Revolution

Brian Ellis
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TRANSFORMING USABILITY TESTING: THE ROLE OF EMERGING AI TECHNOLOGIES IN ADVANCING MIXED PROTOTYPING

Virtual, Augmented, and Mixed Reality (VAMR) in the 4th Industrial Revolution | Brian Ellis

INTRODUCTION / BACKGROUND

Design and technology are intertwined forces, constantly shaping and being shaped by one another. This interplay is accelerating us toward the 4th Industrial Revolution, a time where the lines between physical, digital, and biological realms are increasingly blurred. This report focuses on mixed prototyping—a fusion of physical and virtual prototyping—and explores how emerging Artificial Intelligence (AI) technologies, specifically computer vision and Large Language Models (LLMs), can revolutionize usability testing. Mixed prototyping blends the tangible aspects of physical models with the adaptability of digital simulations, offering a comprehensive approach to usability testing. This report delves into how these advanced AI technologies could enhance mixed prototyping, overcoming limitations of traditional prototyping methods and shaping the future of industrial design.

Usability testing, a prevalent method for evaluating product designs, assesses a product's ease of use by emulating user interactions in controlled settings. Usability is defined as the user's effectiveness, efficiency, and satisfaction in achieving a particular set of goals in a designated environment (Sonderegger & Sauer, 2010). Integral to this testing approach is the use of prototypes, which help discern how users might interact with the design.

Prototypes serve as early representations of a product, service, or system. Physical prototypes, being three-dimensional models of these representations, are essential in evaluating the ergonomic and physical interaction of a design (Hallgrimsson, 2012). On the other hand, virtual prototypes offer a digital perspective, facilitating detailed visuals, analysis, and testing throughout various use cycles. These virtual models simulate interactions with a tangible product, primarily focusing on the product's aesthetic, cognitive, and functional attributes (Sonderegger & Sauer, 2010). Integrating these two approaches for usability testing gives rise to mixed prototyping—a methodology that incorporates the immersive experience provided by virtual prototypes using a head-mounted display (HMD) or computer monitors, with the tangible, physical interaction offered by mock-ups or physical prototypes (Zhou & Rau, 2019). This report focuses on considerations for enhancing mixed prototyping using HMDs, specifically utilizing Virtual Reality (VR) technology.

By exploring mixed prototyping using HMDs and emerging technologies, this research aims to answer pivotal questions: How might emerging technologies in Artificial Intelligence, specifically in computer vision and large language models, influence the adoption and effectiveness of mixed prototyping in the existing usability testing practices?; How can emerging technologies enhance mixed prototyping to overcome the limitations of solely using physical prototypes for ergonomic and physical interaction feedback, or virtual prototypes for aesthetics, function, and cognitive feedback?; and How might these advancements further shape the future of industrial design practice, particularly in the context of mixed prototyping? By investigating these questions, the report seeks to uncover advancements that can significantly improve feedback quality and depth during usability testing, thereby aiding the design process in this rapidly evolving technological era.

DISCUSSION ABOUT SUBTOPIC

Amid the 4th Industrial Revolution, the realms of Virtual, Augmented, and Mixed Reality (VAMR) have emerged as transformative forces reshaping the landscape of industrial design and technology. VAMR technologies blend the physical world with digital enhancements, creating immersive experiences that challenge the traditional boundaries between reality and virtuality. This revolution has profound implications for usability testing, a critical process in product design and development.

Usability testing involves designers making strategic decisions about which design aspects to evaluate, recruiting subjects from the target user population, and having them use the device in a simulated environment. The results are then recorded and analyzed to improve the product's look and functionality. In usability testing, prototypes are divided into high-fidelity, which closely resemble the final product but are costly, and low-fidelity, which are less detailed and functional. To address the limitations of physical prototypes, virtual environments are increasingly used for testing, allowing for cost-effective and early-stage evaluations (Joyner et al., 2022).

Mixed prototyping emerges as a more holistic approach to usability testing, addressing both the tangible physical aspects and the visual elements of a product, thus providing a more nuanced understanding of potential usability issues. This method proves effective in identifying problems related to physical interaction, ergonomics, and aesthetics. According to Zhou and Rau (2019), participants using tangible mock-ups were more adept at finding ergonomic and physical interaction issues, a crucial aspect often overlooked in purely virtual prototypes. By contrast, virtual prototypes excel in assessing aesthetic and functional features through visual and auditory modalities, providing a detailed understanding of the product's design aspects.

Moreover, mixed prototyping significantly enhances the subjective experience of usability testing. High-immersion media, like HMDs, have been found to positively impact participants' subjective ratings, facilitating deeper product understanding and evaluation. Zhou and Rau's study (2019) also indicates that when aesthetic and functional features are fully integrated, a low-fidelity mixed prototype can be nearly as effective as a high-fidelity one in identifying usability issues related to appearance and function. These findings underscore mixed prototyping's cost-effectiveness in usability testing, reducing the need for high-fidelity prototypes at different design process stages.

Despite the potential advantages of mixed prototyping, its integration within product development processes remains limited. Several barriers, such as the complex set-up process for consistently operating the mixed prototyping platform, the current technology's inability to reproduce optimal realism, and the high competence required for programming content authoring, have hindered its widespread adoption. Moreover, consistently setting up and running the mixed prototyping platform can be cumbersome (Piñones et al., 2021). Addressing these challenges will not only promote the smoother integration of mixed prototyping into product development workflows but also provide deeper insights during usability testing.

This research is dedicated to exploring and integrating emerging technologies into the design process, with a particular emphasis on enhancing usability testing with mixed prototyping. A primary objective is to discover accessible user-friendly and intuitive solutions, for the areas of mixed prototyping that demand higher expertise and advanced applications. Additionally, this research aims to improve content authoring for mixed prototyping testing and to elevate the overall user interaction experience. At the core of these efforts are the latest advancements in AI, with a special focus on computer vision and LLMs.

AI, in this context, is utilized to create systems and machines capable of tasks that usually require human intelligence, such as understanding human language, recognizing images and patterns, and learning from experience. Computer vision, a subset of AI, allows computers to extract and process information from visual inputs like images and videos. Finally, an LLM is a type of AI model that specializes in understanding, generating, and working with human language. These technologies play a vital role in enhancing the usability testing process, particularly in mixed prototyping environments.

The advancement in computer vision is particularly noteworthy, with its increasing significance across various sectors like security, healthcare, and entertainment. The evolution of this field is intrinsically linked to AI and machine learning advancements, leading to more sophisticated and accurate visual interpretation by machines. In the context of mixed prototyping, two important areas of computer vision are Inside-out tracking and Gaussian Splatting. These technologies exemplify the potential of computer vision in improving the accuracy and efficiency of mixed prototyping, further contributing to the overall enhancement of the useability testing process.

Inside-out tracking, utilized in AR and VR applications, is a camera-based method that tracks a target object relative to a reference point on the user's body, differing from outside-in tracking which relies on fixed spatial reference points (Singh et al., 2021). An example of inside-out tracking technology is seen in Meta VR headsets, which achieve self-tracking in space without external sensors. This method of tracking, which accurately follows an object's pose in 3D space in real-time, leverages computer vision to detect objects and estimate their initial 3D pose (Ahmadyan et al., 2020). Traditional methods of merging virtual and physical objects, which often required QR codes and extensive sensor systems, were time-consuming and resource-intensive (Zhou & Rau, 2019). However, with advancements like HTC Vive's 'Ultimate Tracker', introduced on November 28, 2023, there is a shift towards more efficient tracking methods. This independent inside-out tracker marks a significant development in the field, as it offers the potential for more seamless integration of real-world items with virtual environments, eliminating the need for complex sensor arrays and programming.

Gaussian Splatting is a method used for representing scenes flexibly and expressively using “3D Gaussians”. 3D Gaussians act as simplified models that capture essential features of a scene, such as how light interacts with objects in a 3D space, which is crucial for creating realistic virtual environments. This method starts with some basic points gathered during camera calibration and then builds upon them to create a more complex and continuous representation of the scene. This is a technique that balances the need for detailed, realistic modelling with the practicality of optimizing and rendering scenes efficiently, particularly in virtual reality applications (Kerbl et al., 2023). The application of Gaussian Splatting presents a significant opportunity in the realm of usability testing with mixed prototypes. This method enables the creation and integration of contextually appropriate environments that are graphically high-quality yet do not demand extensive processing power when compared to similar environment rendering methods. This approach streamlines the setup of such environments, ensuring they are not only visually appealing but also immersive, thus enhancing the overall effectiveness of mixed prototyping in usability testing scenarios.

LLMs have emerged as cutting-edge AI systems capable of processing and generating text with coherent communication and generalizing to multiple tasks. The success of LLMs in various natural language processing tasks, including translation, summarization, information retrieval, and conversational interactions, has been driven by significant advances in language models. These developments have enabled LLMs to approximate human-level performance on a variety of tasks, marking a revolutionary transformation in the field (Naveed et al., 2023).

A notable application of LLMs is in code generation. Models like CodeGen, Codex, and AlphaCode have been effectively used for code generation tasks. CodeGen uses a multi-step approach to build long code sequences, training on both natural and programming languages. Codex, trained on Python code from GitHub, a software development platform, can generate multiple versions of a program from a simple description, successfully solving many programming problems. AlphaCode, designed for competitive coding, is trained on a vast range of programming data and fine-tuned with specialized techniques. The use of code-generating LLMs has shown remarkable success in coding competitions, indicating their high capability to generate complex code (Naveed et al., 2023). The capabilities of these code-generating LLMs open up exciting possibilities in content authoring and programming, particularly in creating mixed prototyping environments, scenarios and, interactions. Their ability to assist in these areas can streamline the development process, fostering accuracy and efficiency.

DISCUSSION ABOUT INDIVIDUAL WORKING TITLE

Emerging technologies are playing a transformative role in enhancing mixed prototyping for usability testing. This discussion centers on four areas: the development environment, the VIVE Ultimate Tracker, Gaussian Splatting, and code-generating LLMs. Each plays a vital role in overcoming mixed prototyping limitations and advancing usability testing methods.

The Development Environment

A crucial tool for establishing a mixed prototyping environment for usability testing and integrating emerging technologies is a game engine, with Unity being a prominent example. The Unity game engine, developed by Unity Technologies, is a robust and adaptable platform extensively used for developing video games and interactive experiences across multiple platforms. The versatility of this platform makes it ideal for creating VR, AR, and MR environments. Furthermore, Unity offers an expansive library of assets specifically tailored for these applications, greatly aiding developers and designers in crafting immersive and interactive experiences. As a result, Unity is selected as the preferred game engine in this report to integrate emerging technologies effectively in usability testing scenarios.

The VIVE Ultimate Tracker

The VIVE Ultimate Tracker, designed for standalone VR applications, significantly enhances virtual and mixed-reality experiences by allowing real-world movements to be accurately integrated. This advancement tackles a key challenge in mixed prototyping: the complexity and consistency of platform operation. Its design prioritizes precision and ease of use, featuring dual wide-field-of-view cameras and sophisticated computer vision technology, ensuring a harmonious synchronization of virtual and physical movements.

Figure 1. VIVE Ultimate Tracker. Retrieved from https://www.vive.com/ca/accessory/vive-ultimate-tracker/

A key feature of the VIVE Ultimate Tracker is its flexible tracking capacity, functioning independently without the need for a connected PC or base station. It supports 6 degrees of freedom (6DoF) inside-out tracking, facilitating smooth navigation within extensive environments. The tracker also boasts a quick-release mechanism for easy attachment or detachment, and an optional screw-in mount offers additional stability for object attachment (VIVE, 2023).

The integration process of physical and virtual prototypes in usability testing with the HTC VIVE Ultimate Tracker is centred around 3D printing. When developing a concept for testing, it is essential to create two distinct versions of the model: one virtual prototype that includes materials, textures, and interactions, and a physical prototype that integrates the tracker's mounting solution. With the release of the VIVE Ultimate Tracker, HTC has made available the 3D CAD files for both the tracker and its mounting solution, facilitating this integration. Once the mount is incorporated into the concept model and produced through 3D printing, the tracker can be fitted seamlessly, and ready for usability testing. While the virtual model does not need to visibly include the mount, it is essential to incorporate the mount's origin point in the 3D CAD file. This inclusion guarantees that the virtual prototype is accurately superimposed onto the physical model within the game engine, ensuring consistency between the two during testing. Such an approach ensures consistency between the physical and virtual elements of the prototype, leveraging the tracker's advanced capabilities to enhance the usability testing process.

However, as this technology is relatively new, there is a limitation in the available information or documented examples of its specific use in this context. The application of merging physical and virtual prototypes for usability testing with the VIVE Ultimate Tracker remains an emerging and yet-to-be-fully-explored field.

Gaussian Splatting

Gaussian Splatting emerges as a potential breakthrough in mixed prototyping for usability testing due to its focus on enhancing scene representation realism. This technique revolves around the use of 3D Gaussians, versatile volume-based models capable of being transformed into images for various scenarios. The process involves detailed adjustments to the Gaussian features like position, transparency, shape, lighting, and density. These adjustments play a crucial role in creating more realistic and compact representations by rendering 2D images that closely align with a scene's 3D geometry. This enhancement in visual quality and realism is particularly significant in mixed-reality settings (Kerbl et al., 2023).

Gaussian Splatting's key advantage lies in its accessibility, as it only requires a robust graphics card, detailed environmental video, and open-source software. This broadens the potential applications of Gaussian splatting across different settings. The integration of Gaussian Splatting into usability testing environments, especially when using the Unity game engine, is made more efficient with assets like UnityGaussianSplatting developed by Aras Pranckevičius. This asset streamlines the incorporation of Gaussian splat models into Unity projects, easing the complexities typically associated with rendering virtual environments (Pranckevičius, 2023).

However, it is important to acknowledge a limitation in the current academic landscape regarding Gaussian Splatting's specific application within the Unity game engine. Despite its potential as indicated by the available assets and plugins, there is a notable absence of academic papers directly focusing on this specific application. Existing literature tends to discuss Gaussian Splatting in broader terms without delving into its specific use in Unity or its application in novel scenarios. This highlights a need for further research and development in this area.

Code-Generating LLM

Code- Generating LLMs like OpenAI's Codex can significantly enhance mixed prototyping in usability testing by simplifying programming and content creation processes, especially beneficial for non-expert developers. In game engines such as Unity, these LLMs can automate or assist in scripting and developing components, assets, and interactions. They can generate code snippets or complete scripts from natural language descriptions, reducing the technical barriers in content creation. This integration allows designers to focus more on creative aspects, enriching virtual environments with dynamic, interactive elements. The paper "Level Generation Through Large Language Models" expounds on this, showcasing LLMs' ability to generate diverse and playable game levels, underscoring their potential in gaming content generation (Todd et al., 2023).

DISCUSSION

The integration of AI technologies like computer vision and LLMs in mixed prototyping offers a significant opportunity to transform how usability testing is conducted in industrial design. These technologies simplify the often complex setup and content creation processes, while also enhancing the realism of simulated environments. Essentially, they bridge the gap between the physical aspects of tangible prototypes and the dynamic capabilities of virtual simulations.

Tools such as Gaussian Splatting and inside-out tracking are particularly promising. These technologies have the potential to enhance virtual environments and blend physical and virtual elements efficiently, thereby amplifying the effectiveness and practicality of mixed prototyping. This approach provides a more holistic method for usability testing, enabling a more comprehensive evaluation of product designs. This approach provides a more holistic method for usability testing, enabling designers to conduct a comprehensive evaluation of product designs. AI and computer vision can make this design process more intuitive and interactive, while LLMs are anticipated to evolve, offering sophisticated code generation capabilities. This evolution could reduce barriers in programming for concepts or simulations, further streamlining the design process.

However, there are noticeable gaps in the application of certain technologies, such as Gaussian Splatting in platforms like Unity and the use of the Vive Ultimate Tracker. The current academic literature lacks detailed exploration in these specific areas, indicating a need for further research and development. Future studies should focus on effectively integrating these technologies into the mixed prototyping process, overcoming existing limitations and unlocking new opportunities.

A proactive step in this direction could be the creation of a proof of concept that combines these technologies. Such an initiative would not only demonstrate their practical applications but also provide valuable insights into their impact on usability testing in mixed prototyping. This could be a crucial step in understanding and leveraging the full potential of AI technologies in transforming industrial design methodologies.

CONCLUSION

In the evolving landscape of the 4th Industrial Revolution, the relationship between design and technology, especially in industrial design, has grown increasingly significant. This report has delved into the transformative impact of AI, specifically computer vision and LLMs, in the realm of VAMR. The integration of these AI technologies into mixed prototyping represents a paradigm shift, not just an evolution, in the methodologies of usability testing in industrial design.

The exploration of mixed prototyping using Head-Mounted Displays (HMDs) and other emerging technologies has unveiled significant potential in enhancing usability testing. AI, through computer vision and LLMs, promises to influence the adoption and effectiveness of mixed prototyping, offering solutions to overcome the limitations of relying solely on physical or virtual prototypes. This advancement facilitates a more comprehensive feedback system encompassing ergonomic and physical interaction, as well as aesthetic, functional, and cognitive aspects.

Mixed prototyping, as highlighted in this report, offers a holistic approach to usability testing. Merging tangible mock-ups with digital simulations provides a nuanced understanding of potential usability issues, especially those related to physical interactions and ergonomics that are often missed in purely virtual prototypes. Moreover, the use of high-immersion media like HMDs positively impacts the subjective experience of usability testing, allowing even low-fidelity mixed prototypes to effectively identify usability issues related to appearance and functionality.

Despite these advancements, the integration of mixed prototyping into product development processes faces challenges, such as the complexity of setup and the need for high expertise in programming and content creation. This report acknowledges the necessity for further research, particularly in areas like the specific application of technologies like Gaussian Splatting within Unity and the VIVE Ultimate Tracker's usage in mixed prototyping scenarios. Addressing these challenges and developing intuitive, user-friendly tools is crucial for broader acceptance and effective implementation of mixed prototyping in industrial design.

The report concludes by advocating for the creation of a proof of concept that combines these emerging technologies, highlighting the need for practical demonstrations to understand their impact on usability testing. This step is critical in harnessing the full potential of AI technologies in transforming industrial design methodologies.

As we progress in the 4th Industrial Revolution, the integration of these emerging technologies into mixed prototyping is expected to revolutionize the approach to product development and usability testing in industrial design. This journey is marked by a dynamic and exhilarating landscape of opportunities, setting the stage for a new era in the integration of technology and design creativity.

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HOW AUGMENTED REALITY (AR) AND HEAD-MOUNTED DISPLAY (HMD) TECHNOLGY MIGHT REVOLUTIONIZE THE MUSIC INDUSTRY IN THE FOURTH INDUSTRIAL REVOLUTION, CONSIDERING BOTH THEIR DISRUPTIVE POTENTIAL AND POTENTIAL PSYCHOLOGICAL BARRIERS.

VIRTUAL, AUGMENTED, AND MIXED REALITY (VAMR) IN THE 4th INDUSTRIAL REVOLUTION |MACKENZIE C. VAUGHAN-GRAHAM

INTRODUCTION

The idea of Augmented Reality (AR), and Head Mounted Display Technologies (HMD's) is one that has always captivated my attention especially as a young kid watching movies such as Iron Man. Further interests have grown as I have matured and have only been increased due to many different industries praising the possibilities and opportunities of the technology. A study done by NASA Langley gave a suggesting that using a Heads-Up Display (HUD) originally designed for military can be applicable towards commercial flight scenarios, stating that "If this happens, NASA's research suggests that additional operational benefits using the unique capabilities of the head-worn display can open up new operational paradigms." (Jarvis et al., 2015). This shows that while targeted in a certain industry large body agency such as NASA states there are clear benefits and opportunities for the HMD technology outside of the original targeted industry. Further in IVANOVA "Many experts believe that virtual and augmented reality, along with Big Data, cloud technologies, artificial intelligence and some others, will become the key technologies of the 4th industrial revolution." (Ivanova, 2018). As it is clear AR and HMDs are perceived to have a firm place within the fourth industrial revolution the goal of this paper will be to focus on creating a more interesting connection between industry and technology. In result I want to aim on focusing how the AR and HMD technologies can be applied into the music industry. As stated above it is clear that many believe in the possibilities of Augmented Reality (AR) and Head Mounted Display Technologies (HMD's). However, regardless of the praised benefits and unlimited opportunities of the technology it seems to have struggled to gain a foothold in a large array of industries. Within this paper it will be focused on determining a sequence of questions to begin to understand why AR and HMD technology has struggled but also where it has succeeded within the past and current fourth industrial revolution.

While the first HMD was developed in the 1960's by Morton Heilig's ("History of Virtual Reality," Virtual Reality Society, 2020), and the technology has seen an incredible amount of advancement a primary contribution to the resistance of the technology is within the human interface and user centered design. A frequent recurring phrase used to describe the problems of AR and HMD's is *Simulator Sickness* and also referred to as *Cybersickness* (Descheneaux et al., 2020), which is a disorienting psychological feeling when the environment such as that created by a Head Mounted Display has a sense of movement however, the user has no motion causing a set of symptoms such as nausea, oculomotor issues and general disorientation (Jasper, 2023). From this basic understanding of the fundamental issues related to AR and HMD technologies this report will focus on three primary questions to give insight as to why the technology has struggled, how it might change, along with how it could impact the music industry within the fourth industrial revolution. These questions are as follows; how does human psychology play a role in the acceptance of HMD technology? Is it the role of technology to change for it to be accepted in the music industry? What areas could the technology impact the music industry? There are many instances where music can be incorporated into the AR and HMD technology ecosystem. The primary instances can include the use of the technology for students in the music industry hoping to learn an instrument, or through the commercial music industry with inclusion of music within the technology to enhance the user/ listener experience in live performances to create immersive virtual environments, and finally assisting musicians collaborate or practice with fellow musicians, such as remote practicing of a music venue. Throughout this report the primary goal will be to use external research papers, industry reports, tech news outlets, academic journals, and conference proceedings to gain information as to how the technology, human psychology can all be applied to the music industry. As the technology does not have an immense amount of use or integration in the music industry the following sections will aim at creating correlations between existing uses of the technology and creating assumptions as to how it can be incorporated into the music industry. Suspected outcomes of this report is the use of the AR and HMD technology can be directly applied to the music industry through the enhancement of collaboration and user experiences. However, as the extended uses of the AR and HMD technologies are struggling to combat neurological issues (Jasper, 2023) it appears that the acceptance of the technology may be delayed or refused by some users. I do foresee that those of a younger demographic will be more accepting of the use of the technology due to their upbringing and maturing with the development of technology. While those of an older demographic may push back to maintain the older more traditional ways that the music industry performs, since it is shown that the higher the age the more negative the acceptance of technology in new scenarios (Ha & Park, 2020).

DISCUSSION ABOUT SUBTOPIC

The Fourth Industrial Revolution as stated by McKinsey & Company "the current era of connectivity, advanced analytics, automation, and advanced-manufacturing technology" (McKinsey & Company, 2022). As the targeted general focus is of the use of the Augmented Reality (AR) and Head Mounted Display (HMD) Technologies the section of the above-mentioned definition is regarding the connectivity, and the advanced analytics of the development in the fourth industrial revolution. This shows where the AR and HMD technologies fall into the definition of the fourth industrial revolution. The primary areas where this section of the report will focus on are the general issues between both the technology and the user interface. Along with trying to determine where the technology must improve to be more applicable within standard industries. For the subtopic to be more clearly understood the target is to identify the barriers between human psychology and the extended use of HMD technologies. For this the focus was put towards analyzing research studies in which the authors focused on identifying applications and design issues within the technologies. During the earlier years of development for the technologies they were primarily focused on military functionality, this could be because military bodies typically hold a large capital allowing for investments in large amounts of research and development. The first study focused on was a research study that focused on determining the primary issues of HMD technologies. This was done through a sponsored study symposium on visually coupled systems in 1972 by the U.S. Air Force System Command's Aerospace Medical Division, where participants focused on attempting to determine many of the fundamental design problems with the HMD technologies (Melzer et al., 2009). The ideas produced from the use of the technology within a military context are still relevant when applied towards a more commercial perspective. The thought of producing a one type of solution for all use cases for the HMD technologies has no grounds. This is because of two primary factors, firstly is the human interaction is complex and different for every user, and secondly the use cases are never going to be identical. In relation to the military perspective, the HMD needed for a fast-traveling fighter jet at a high altitude will be different from that of a pilot for a helicopter flying closer to the ground (Melzer et al., 2009). These analogies can be transferred into a more understandable perspective when compared to civil engineering. In (Xu & Moreu, 2021) the area of focus for the AR and HMD technology is simplified into two sections (1) Monitoring Project Progress, and (2) Assistance for workers. An example of the first section is using the AR and HMD technology to overlay the CAD development and files within the physical world setting to gain a perspective of how the project is progressing. This allows for the user of the technology to clearly identify in a visual representation where certain features need to be or will be to ensure that the project runs smoothly. The second section is used by the workers to enhance the visual collaboration sections by allowing the designers to share AR images of the digital site to workers on the physical site to convey changes and design allocations in real time (Xu & Moreu, 2021). In a general perspective it is easy to see the clear applications of AR and HMD technologies, the ability to share, collaborate and adjust projects in a visual real time application can be super beneficial for a large scope of industries especially in the perspective of the fourth industrial revolution when manufacturing methods are becoming increasingly more complex, and the importance of analytics begins to play a larger role. However, the questions as to why these technologies have not taken over still stands. As referenced from (Descheneaux et al., 2020) the issues of *Cybersickness* are still incredibly relevant, in a study by (Palmisano et al., 2020) the researchers developed a sequence of tests to determine the causes of *Cybersickness*. It was found that the primary issues of the HMD technology were the relationship between the user's head position in the real world and virtual space built within the HMD technology. They framed the situation as the "Differences in the user's Virtual and Physical head pose (or DVP)" (Palmisano et al., 2020). This is a technological issue caused by the latency created when the person moves their head, and the virtual head position takes longer than a certain duration to respond. Even with a minimal lag of ~3-4ms in HMD Virtual Reality (VR) some participants still reported symptoms of cyber sickness (Palmisano et al., 2020). In a general scope it is clear to see that there are certain areas where the technology has been implemented effectively, although with drawbacks primarily related to the user interaction related to Cybersickness. Perhaps in the possible introduction of the technology within new industries the easiest way to combat the issue of cyber sickness would be to focus only on the use of Augmented reality, where the most important information is applied in the HMD's while it is then overlaid in the user's physical environment reducing the chances of DVP causing latency issues.

DISCUSSION ABOUT INDIVIDUAL WORKING TITLE

The music industry, while integrating with technology to an extent has not incorporated the use of personal technology devices such as HMD's. The technology primarily used within the music industry is that used for recording and editing. However, the use of technology to enhance a users experience or assist in the learning of an instrument as example is relatively new and un researched. Focusing on the direction of assisting students or those hoping to learn a musical instrument the use of HMD's and AR together can be very beneficial if the ability to have a teacher physically present is not possible. A study was done to show the applications of the HMD and AR technology for a student aiming to learn the piano. The benefits of this technology being used were given as follows ": (1) preventing the acquirement of wrong motions, (2) avoiding frustration due to a steep learning curve, and (3) potential health problems that arise from straining muscles or joints harmfully" (Marky et al., 2019). Regarding the problems of cybersickness affecting the users, the argument can be made that because a full virtual environment is not being made the effects of the DVP that was stated earlier should not be as much of an issue. Using the AR direction within the HMD technology allows the user to have their physical environment be the primary stage of their field of view, where in this study the keys of the piano were only highlighted to help the user understand which keys to press and in which sequence. While this study is directed towards a student learning an instrument as a beginner. It can be synthesized that a similar idea can be applied to a collaboration between two artists. The idea of being able to convey an idea of playing a guitar as an example of a certain way to gain a certain effect can be overlaid on the other physical guitar to help them achieve the desired effect can be a very beneficial tool to increase productivity and reduce music design delays. While this is only a hypothesis the use of AR to enhance a listener or viewer has been attempted. In 2020 Sam Smith worked with Spotify to create an immersive experience for the listeners of the artist's new single (Studio, 2020). The use of AR was focused on using the user/listeners mobile device to watch a 3D AR model of Sam Smith during a performance of his new single. This use of the technology increases the interest and stimulus of the user. Studies show that human psychology responds significantly better to visual stimuli. To the extent that the human brain responds 60,000 times faster to images over text, and that 90 percent of all information sent the brain is visual (Kosmyna et al., 2018). From this it is incredibly clear that the use of a visual stimulus along with music can create a significantly stronger bond for the listener and increase their experience. The idea of the focus of using the AR to enhance the user experience has clearly been identified and attempted in producing a positive relation. However, while there are certain boundaries to get passed it is obvious that it can create a new level of interest especially as technology and accessibility increases. Pivoting I do feel there is an opportunity for AR and HMD technologies to be applied in a similar way but more towards a utilitarian motive for *acoustic sensing.* Acoustic sensing within the industry is a method of determining how sound will translate in any given physical space. Currently the easiest methods to test the sound of a space through acoustic sensors are devices designed to detect and measure sound waves or acoustic signals in the surrounding environment (Kosmyna et al., 2018). While these sensors detect sounds and convert them into electric waves for configuration through software the need of education on the specific methods is essential. While as explored earlier humans are much better at understanding visual cues and imagery significantly easier than other methods. As a synthesis, it seems reasonable to attempt the idea of using AR technology to visually organize musical instruments in a physical space to then gain visual and auditory information on how the physical space would sound given the position of each instrument. This could reduce the need for expensive and intrusive sensors and equipment allowing for smaller or novice musicians or bands to be able to ensure their music setup and location is optimal for their listeners.

CONCLUSION

Overall pathways between the music industry and the accelerating development and increased introduction of Augmented Reality and Head-Mounted Displays within several industries it is clear to see there are applications where the technologies can be applied to the music industry. In relation to the areas where the technology has already been used within areas such as military applications and construction/development. The reality becomes that while technology is adaptable to a vast range of areas the issue between human psychology is still a great barrier. The issue of *Cybersickness* is one that still is causing researchers headaches with not only determining the root cause but attempting to find a resolution. From this as shown throughout this report the primary focus towards the integration of HMD technologies has been focused on the use of Augmented Reality. The ability to place virtual overlays on the user's physical space shows a much greater and even more simple solution to implementing the technology, from the AR direction the issues of *Cybersickness* is significantly reduced as the issue of visual lag from the virtual device movement and human movement is no longer as prominent of an issue. From this the primary change that is needed for this technology to be more widely accepted is the fixture of the *Cybersickness* issue. However, I feel this is more of a technological change that is necessary for the technology's acceptance because of the root cause of the issue being the human brain attempting to find stability in an unstable virtual field. In regard to the possible direct opportunities within the music industry I feel the applications towards teaching/learning of new musical instruments is a huge and relatively untapped field. The opportunity to develop a function of the technology to help young musicians learn a musical instrument when a teacher is not present can be extremely beneficial. Further the applications of AR technology for the enhanced experience for listeners and viewers as shown within (Studio, 2020) shows that the ability to create a more engaging and interactive form of music can not only grab the attention of younger generations but also allow for more people to experience a live performance in an easier way. Finally, the possibility of using the technology to test and adjust a physical environment in order to create a better acoustic sound can be incredibly helpful especially for less known and smaller artists that do not have access to the expensive equipment used for main pop culture artists. The ability to use the AR technology to analyze the sound response of an environment in a visual format can also reduce the need for using specialists to adjust a music venue or a recording studio. Overall, the possibilities of AR, VR, and HMD technologies will continue to grow and make its way into a huge number of industries. While the music industry still hasn't completely accepted the technology throughout this report there are opportunities for it to be used in the future both in private and commercial applications.

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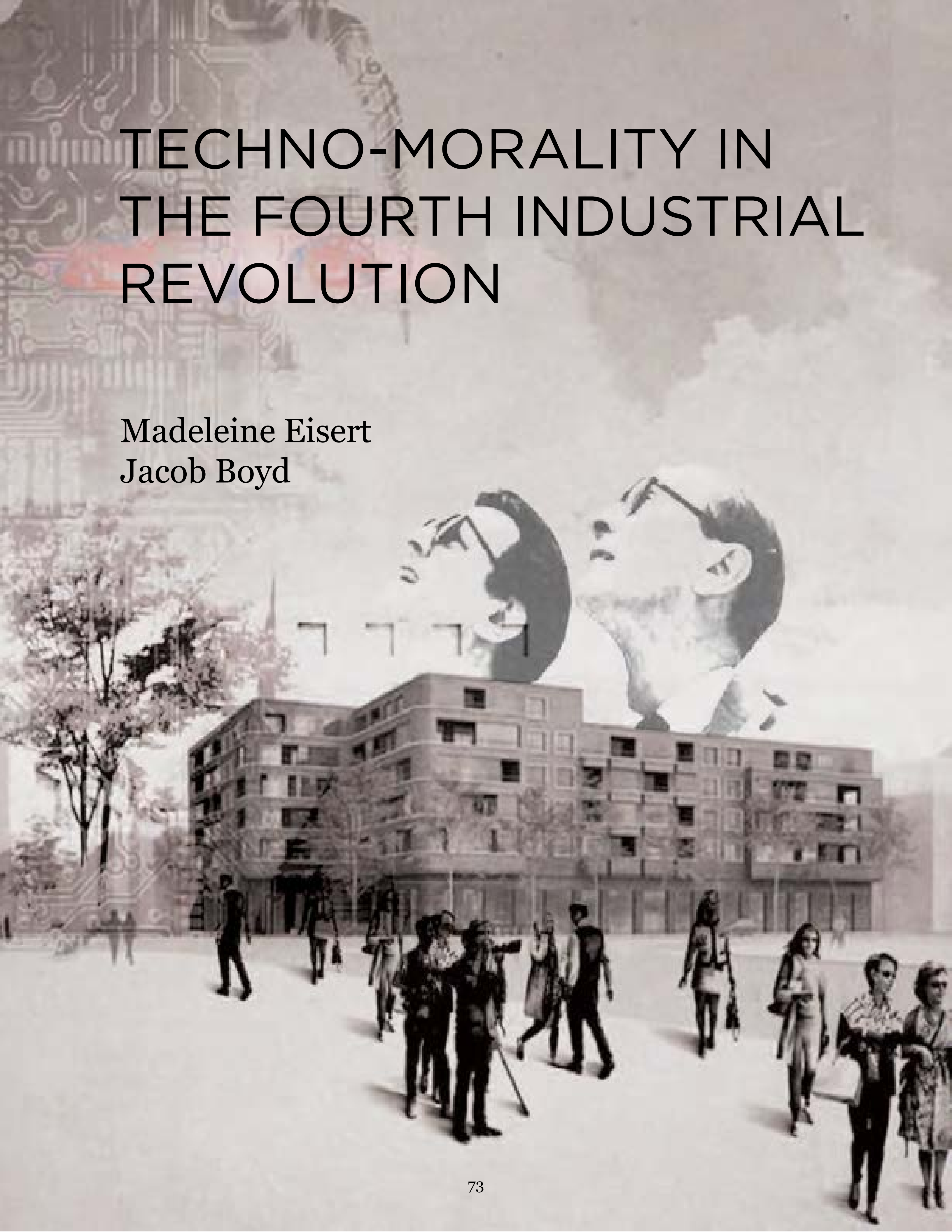
TECHNO-MORALITY IN THE FOURTH INDUSTRIAL REVOLUTION

Madeleine Eisert
Jacob Boyd



ALGORITHMS OF OPPRESSION: THE ROLE OF DESIGN IN DECOLONIZING AI

TECHNO-MORALITY IN THE FOURTH INDUSTRIAL REVOLUTION |MADELEINE EISERT

INTRODUCTION

As we examine our entrance into a new industrial age, we are confronted with the contemporary ethical ramifications of revolutions past, in their new and more complex forms. Drawing from historical analyses of technological integrations into our social, economic, and political spheres, we may establish a causal link between technology and the evolution of our world (Yeung, 2017). The industrial revolutions, as they stand historically, and as we experience them contemporaneously, are thus worldly evolutions, centred upon technological improvements and the divisive resultants of these. To understand these integrations, we must establish how we identify the revolutionary period we find ourselves in, and how this may create a framework within which the techno-moral implications of these revolutions may be analyzed.

Given the historic cycles of the previous three industrial revolutions, the advent of a new industrial revolution presupposes that the technology introduced in its predecessor must be almost completely available to all people for its cycle to conclude. Thus, one of the key markers of the beginning and end of historic industrial revolutions has been access. Access to these technologies, and the ability to implement these advancements in person's lives is important yet provides discursive topics for debate. The ethical implications of unequal access to technologies developed, exacerbates existing social, economic, and political disaffection, amongst individuals and groups. Marginalized persons, those who lack sociopolitical power and who are disenfranchised by powerful elites, are most at risk to feel the negative effects of technological advancements, and the least likely to profit from its positive effects (Katz, 2022). Those with more socioeconomic and sociopolitical power may use these technologies to advance their own standing, by using these technologies to keep marginalized persons in their oppressed states (Mohamed et al., 2020). In contemporary contexts, we may examine these trends; the promulgation of ideologies brought forth by the latest industrial revolution demonstrates in incredible amount of ableist, racist, sexist, and generally bigoted views (Katz, 2022) (Mohamed et al., 2020) (Obermeyer 2019) (Wapner, 2018) (Topol, 2019) (Eubanks, 2018) (Yeung, 2017).

The design landscape is changing. The interdisciplinarity of design fields have been expanding, and with it, the role of the designer is ever-growing. Nowadays, the role of the designer is more so one of a researcher and maker of creative tools able to foster societal dialogue and to give visibility to different voices (Sanders and Stappers, 2008). Socio-ethical design principles are becoming increasingly integrated into the design process, given the impact products and systems have on the world's interconnected landscape. Essentially, design is ubiquitous in social, political, and cultural discourse *because* it is the way we change the sociocultural milieu. Design has the power to drive change in any direction it chooses, which is why exploring the role of the designer in a world where change through design can have far-reaching and impact is so important. Over the years, technology has enabled us to connect with others around the world. Through globalization, we have seen trends towards economistic hegemonies (Ronconi, 2015). We also see improvements in standards of living, access to remote healthcare, education, and more (Topol, 2019). Hegemonic promulgations of capitalism's economistic perspectives gives power to elites, and marketizes needs of marginalized persons, thereby forced to operate within a system that oppresses them. Economic superpowers are connected *through* and *for* technology, establishing greater influence and narrowed perspectives, which dictate the lives of those with less socioeconomic power. How we design, and who we design for, is therefore changing; favouring placation to virtue-signaling polity, we are forced to design in line with the hegemony. Thus, technology is being developed to optimize oppression.

BACKGROUND

During the second industrial revolution (1871-1914), the global expansion of European powers was closely tied to imperialistic practices (Ward, 1994). These practices shaped the geopolitical landscape, economic systems, and social structures in both the colonizing nations and the colonized regions, leaving lasting impacts that continue to influence global relations today (Ronconi, 2015). The rise of these imperialistic powers can be attributed to the economistic desires of European nations, exacerbated by the capitalistic intent of globalization and the rapid growth of labour markets (Thakur, 2013). Industrialization during this period resulted in increased demands for raw materials for manufacturing, and markets to which these manufactured goods and services could be sold. By colonizing nations globally, European forces could exploit the resources of countries, and demand labour for cheap. Geopolitical competition thereby increased; European powers engaged in imperialistic rivalries to position themselves in this territorial and economic pursuit, by acquire colonies that would increase their strategic positions globally (Ward, 1994). These European powers justified their actions through their ‘civilizing mission’, claiming they were bringing advanced civilization, education, and technology to ‘undeveloped’ regions (Watt, 2011). This ideology is known as *social Darwinism*, a belief in the superiority of certain races and cultures which fueled imperialistic ideologies (Winlow, 2009). Africa was highly desirable to these imperialists, due to their abundance of resources, and military inferiority to the colonizing nations; the Berlin Conference (1884-1885) rallied a convening of European powers to formalize the partitioning of Africa amongst these nation states, disregarding the diverse African cultures, and political boundaries (Britannica, 2023). Coloniality, defined as the control and management of knowledge by “universals” of Western modernity, Eurocentrism, and global capitalism (Mignolo &Walsh, 2018), has been shown contemporaneously to be exacerbated by the algorithms we use in AI. Through coloniality, Eurocentric knowledge and practices are deemed neutral, universal, and apolitical, and lead to the erasure of entire knowledge systems. The advent of economistic hegemonies during the second industrial revolution grew to North American geopolitical states, due to its efficacy in acquiring power and control over marginalized groups. As such, the capitalist visions of European powers crossed continental boundaries, and entrenched itself in the knowledge systems we naturalize today. Over the decades since the start of the first industrial revolution, technology has created various means through which these hegemonic powers may assert dominance and control over economically inferior nations. Now entering the fourth industrial revolution, economic superpowers are repeating, and continuing, these historical methods of oppression with new tools.

ALGORITHMS OF OPPRESSION

Decolonial theories use historical hindsight to explain patterns of power that shape our intellectual, political, economic, and social world. Due to colonial continuities, the current theoretical frameworks evaluating AI systems and their sociopolitical and economic relations are ahistorical. However, by adopting an ahistorical lens, the examination of these ongoing issues is missing the causal link between power and inequality and the contemporary issues prevalent in today’s techno-social landscape. In recognizing the analogues of territorial and structural coloniality in the digital age, decolonial theory can, and should be, necessarily applied in the process of evaluating and restructuring codes of ethics related to technology and AI (Mohamed et al., 2020). *Decolonization*, the premise of decolonial theoretical frameworks, takes two forms: the first, a territorial decolonisation that is achieved by the dissolution of colonial relations; the second, a structural decolonisation that seeks to undo colonial mechanisms of power, economics, language, culture, and thinking, that shapes contemporary life. The latter is done by interrogating the provenance and legitimacy of dominant forms of knowledge, values, norms, and assumptions. Through imperial regimes and the rise of economistic hegemonies during the second industrial revolution, colonial powers have led to the erasure of knowledge systems and de-cultured marginalized groups (Mignolo &Walsh, 2018). The first of the two tenets of decolonial theory, *territorial decolonization*, can be achieved in the digital age, by understanding the *digital spaces* that technology and AI have built, as being *physical sites* of extraction and exploitation that continue the patterns of coloniality. These can be referred to as *digital-territorial spaces*, created by the increasingly networked systems and devices we use, and therefore subject to *digital-territorial coloniality*. These types of coloniality can be observed in digital structures in the form of sociocultural imaginations, knowledge systems, and ways of developing and using technology which are based on systems, institutions, and values which persist from the past and remain unquestioned in the present. The erasure of epistemological knowledge and meaning from oppressed groups, in digital and non-digital spaces, creates a form of data colonialism. Data-centric epistemologies impose ways of being, thinking, and feeing, that leads to the expulsion of human beings from social order, denies the existence of alternative worlds and epistemologies and threatens life on earth (Ricaurte, 2019). *Algorithmic coloniality* is a term that builds upon data colonialism in the context of the interactions of algorithms across societies, which impact the allocation of resources, human socio-cultural and political behaviour, and extant discriminatory systems. Insofar as inveterate digital coloniality has been established in the literature, we may begin to understand how it features in algorithmic decision-making systems, as these now generate new labour markets, impact geopolitical power dynamics and influence ethics discourse (Mohamed et al., 2020). Thus, *algorithmic oppression* is the 'extension of the unjust subordination of one social group and the privileging of another-maintained by a complex network of social restrictions ranging from social norms, laws, institutional rules, implicit biases, and stereotypes through automated, data-driven and predictive systems' (Mohamed et al., 2020).

AI AND EDUCATION

The notion of intelligence is frequently left implicit by AI practitioners. Testing intelligence has been a long-standing tool that upholds white supremacy by capitalizing on difference and using it to define population to exploit and marginalize (Katz, 2022). This practice is carried out using statistics; predicated on imperial and colonial knowledge systems, these statistics are a tool with which socioeconomically powerful minorities oppress marginalized bodies and produce hierarchies of human worth (Katz, 2022). Statistical inference is used to rank individuals in ways that reflect existing racial hierarchies, explicitly adopting ahistorical frameworks for understandings of the social and educational landscape we currently find ourselves in. In this way, the continuation of colonial power is perpetuated by the classification of racialized persons in sub-intellectual groups, a fallacious discriminatory practice predicated on *social Darwinism* that precedes today through digital coloniality and data-capitalism (Mohamed, et al., 2020). Intellectual testing thus remains a proxy for wealth, obedience, and acculturation to white, ableist, bourgeois society (Katz, 2022). As digital coloniality persists, the erasure of knowledge systems in digital content creation and learning platforms increases. Selwyn (2017) explain that AI algorithms may contribute to the homogenization of educational content, which could erase diverse cultural practices and knowledge systems. Similarly, Tufekci (2014) state that AI-driven educational systems may contribute to unequal access to resources, which would exacerbate existing disparities and create a digital divide in educational opportunities. The algorithms used in testing and ranking individuals are nebulous and malleable to power, making AI a useful vehicle for oppression; in this same way, the inclusion of content and the deliver of such content serves colonial and capital power, by carefully curating the information distributed and received, driving coloniality further in its new digital realm (Katz, 2022).

AI AND HEALTHCARE

AI in healthcare affects healthcare structures, access to various treatments, and individual wellbeing (Topol, 2019). Inequities are one of the most important problems in healthcare today, especially in the United States, which does not provide care for all of its citizens. With the knowledge that low socioeconomic status is a major risk factor for premature mortality (Stringhini, 2017), the disproportionate use of AI in the healthcare systems could widen the present gap in health outcomes. Intertwined with this concern of exacerbating pre-existing inequities is embedded bias present in many algorithms due to lack of inclusion of minorities in datasets. Examples are the algorithms in dermatology that diagnose melanoma that lack inclusion of skin color and the use of the corpus of genomic data, which so far has seriously underrepresented minorities (Topol, 2019) (Wapner, 2018).

Obermeyer and his colleagues (2019) found evidence of racial bias in one of the most widely used healthcare algorithms. The algorithm assigned Black patients the same level of risk in preliminary assessments as White patients, despite the Black patients requiring a higher level of care because they were actually sicker. The authors estimated that this racial bias reduces the number of Black patients identified for extra care by more than half (Obermeyer 2019). This racial bias occurs because this algorithm uses health costs as a proxy for health needs; less money is spent of Black patients who have the same level of need as White patients in the same condition, and thus the algorithm falsely concludes that Black patients are less sick than White patients (Obermeyer, 2019). The allocation of healthcare resources is unfairly distributed to racialized individuals due to ongoing colonial oppression. The algorithm, which is designed by healthcare systems run by privileged racial groups with more economic and social power, is being used to discriminate against, and further oppress marginalized individuals; motivated by economistic intent – fuelled by capitalistic ideals – this algorithm clearly demonstrates how the financialization of systems exacerbates social and racial inequalities. Notwithstanding the long-held knowledge that the medical system in the United States has disproportionately provided poorer care to racialized individuals (Stringhini, 2017), this type of algorithmic system offsets blames from those who implement it, making it more difficult for racialized individuals to be heard and advocate for their human rights. The complexity of this issue continues to grow, as more technology, and more algorithms are implemented into the systems we use to dictate the care we provide and the persons eligible for its receipt. While there are arguments that algorithm bias is exceeded by human bias (Miller, 2018), much work is needed to eradicate embedded prejudice and strive for medical research that provides a true representative cross-section of the population. As Benjamin (2019) notes, "whereas in a previous era, the intention to deepen racial inequities was more explicit, today coded inequity is perpetuated precisely because those who design and adopt such tools are not thinking carefully about systemic racism".

AI AND POLITY

Algorithmic exploitation considers the ways in which institutional actors and industries that surround algorithmic tools take advantage of (often already marginalized) people by unfair or unethical means, for the asymmetrical benefit of these industries (Mohamed et al., 2020). Western governmental institutions are contemporaneously seen using these tools to exploit their power and offset potential harms in the introduction of new AI technologies that have yet to be tested. Ethics dumping is a tool within this exploitative framework that has been used in the development and testing of new electoral technologies. During the 2017 Kenyan and 2015 Nigerian elections, Cambridge Analytica elected to beta-test and develop algorithmic tools, with the intention to later deploy these technologies in the US and UK elections (Mohamed et al, 2020). These countries were chosen in part due to their weaker data protection laws compared to the United Kingdom, Cambridge Analytica's base of operations – this is a clear example of ethics dumping. These systems were also later found to have actively interfered in electoral processes and worked against social cohesion in these countries (Mohamed et al, 2020).

Yeung (2017) describes the effects of AI on policy making, governmental structures, and public administration on the citizenry, and the need for transparency and accountability in these structures. The author argues that the current development and deployment of AI technologies are subtly and unobtrusively eroding the citizenry's capacity for democratic self-government, by exploiting individuals' ignorance of the ways in which these algorithmic models are shaping the information we receive. Economistic models of past revolutions pervade in today's landscape in subtler and more complex ways (Benjamin, 2019) (Yeung, 2017); information is free, but companies and individuals dictate individuals' access to information by paying for advertisement and positioning on frequently used search engine sites. As such, these data-capitalist algorithms exercise power over society, disseminating colonialist ideals and knowledge that are inescapable and, even more concerning, unidentifiable by the user (Yeung, 2017). The design of these algorithms is predicated on control over people and information, which shape the social landscape and make decisions about the evolution of our social, cultural, and economic, world. Dismantling these algorithmic models will necessarily require a top-down approach. Operationalizing the restructuring and establishment of new social, cultural, and economic practices will take years; notwithstanding the continuation of territorial forms of imperialism and colonialism needing addressing, the unmonitored introduction of technology has presented another form oppression requiring immediate attention. Digital coloniality requires the pluralization of cultural epistemic knowledge and practices, to move beyond the current fragmentation and discriminatory practices of the fourth industrial revolution. Design may be able to support this transition (Mohamed et al., 2020) (Sander, 2008).

ROLE OF THE DESIGNER

The techno-moral implications of design are increasingly becoming complex, and thus more heavily debated. Notwithstanding the obvious benefits that technology have provided the world, generally, the ethical ramifications of technology still require understanding. The designer, entering into this complex and interrelated web, must be acutely aware of their changing responsibilities, and of the problems they may create. Floridi et al. (2017) assert that designers should be aware of and adhere to existing regulations and standards related to AI systems, to contribute to a legal framework that mitigates the potential risks of these technologies. The benefits of increased communication brought forth in the previous, and current, industrial revolutions, are demonstrated when we consider how we might create interdisciplinary teams with experts in related domains. Mittelstadt et al. (2017) urges designers to collaborate with ethicists and social scientists to help navigate complex ethical considerations for risk mitigation, in the same way that Jobin et al. (2017) encourage cross disciplinary collaboration. In orienting the agenda towards collaborative design practices, designers may avoid the risk of further perpetuating harmful divisions related to persons' extrapersonal social determinants. Awareness and understanding about the effects of design can be taught in academic spheres, though this solution becomes apparently complex when we consider how the ethics of education have shifted in the new industrial age. Salient discourse regarding designer's role in the field need to precede the economistic expectations and frameworks that modern educational institutions predicate themselves on. It is imperative that we turn towards a pluriversal epistemology of the future, that, unlike universalisms, acknowledges and supports a wider radius of socio-political, ecological, cultural, and economic needs (Mohamed et al., 2020). One of the ways in which designers may contribute to this future vision for technological innovation is through the co-development of AI systems that is 'driven by the agency, self-confidence and self-ownership for the communities that work for' (Mohamed et al., 2020); this approach has the potential to shift power asymmetries inherent to the coloniality we continue to see today. Design is a way through which we may dismantle the oppressive, capitalistic and colonial value system we find ourselves in today. As the role of the designer changes and expands, it may be possible to change the historical approaches we've taken towards growth and globalization, towards contemporary methods of inclusion and social cohesiveness.

CONCLUSION

As we stand at the threshold of a new industrial age marked by the fourth industrial revolution, the intricate interplay between technology, ethics, and societal structures demands a critical examination. This paper has traced the historical trajectories of industrial revolutions, highlighting their profound impact on social, economic, and political landscapes. The recurring theme of the unequal impacts of technological advancements emerges as a pivotal marker, with marginalized groups facing heightened risks of exploitation and disenfranchisement.

The evolution of design disciplines, expanding into interdisciplinary realms, underscores the transformative role of designers as catalysts for societal dialogue and change. Socio-ethical design principles are increasingly integral to shaping technological innovations that navigate the complex web of contemporary challenges. However, the current trajectory also raises concerns about the potential for technology to optimize oppression, perpetuating existing power imbalances and reinforcing discriminatory ideologies. The examination of the digital age through a decolonial lens reveals the persistence of colonial mechanisms in shaping AI systems and their sociopolitical and economic implications. Digital coloniality, manifested in algorithmic oppression, reflects a continuation of historical power dynamics. The paper emphasizes the need for a decolonial approach in evaluating and restructuring codes of ethics related to technology, advocating for both territorial and structural decolonization.

As we enter this new industrial revolution, a collective awareness of the historical legacies, ethical implications, and transformative potential of technology is paramount. The evolving role of the designer becomes the praxis for steering innovation towards a more inclusive, equitable, and socially cohesive future. Only through conscious and collaborative efforts can designers harness the power of technology to transcend the patterns of oppression embedded in our past and present, to pave a path toward a more just and equitable society.

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INTRODUCTION

This paper consists of inquiries on Artificial Intelligence applications that are relevant to designers at this moment, in the next 5 years, as well as questioning whether AI is overall beneficial to designers. AI, amongst other technologies, is a key figure in mankind's current state of profound technological development that has been dubbed as the 4th Industrial Revolution. Often characterized by its mixing of biological, physical, and digital spheres (Schwab, 2023), the 4th Industrial Revolution concept was allegedly created by business strategist Henrik von Scheel (London Speaker Bureau, 2023). Despite Scheel's proclamations as the concept of the 4th Industrial Revolution follows previous classifications of the 1st, 2nd, and 3rd revolutions, the discussion of a 4th Industrial Revolution likely existed to some degree before Schleel's association.

With intelligence defined as the mental processes based on reason (*Intelligence,* 2023), Artificial Intelligence is distinguished by machines, particularly computer programs, using reason in their operation. As the complexities of AI's reasoning ability advances, the machine has shown to emulate the mental processes of humans at some level. The role of the designer is largely a mental task, and automation of more physical processes has already seen development from the 3rd revolution. Considering this, the 4th Industrial Revolution presents a unique schism of possibilities for the Industrial Designer. Will the AI tools of the 4th industrial revolution enhance the designer or replace it?

GROUP TOPIC: TECHNO-MORALITY IN THE 4TH INDUSTRIAL REVOLUTION

From a perspective lying in the midst of the 4th Industrial Revolution's early stages, Madeleine Eisert and I have chosen to explore the notions of AI relating to morality and ethics. Madeleine's focal point has been AI's impact on society and the designer's role in the ethical development of AI systems and therefore consistently relates to morality. Contrasting Madeleine's relatively persistent exploration of morality, my research journey first assesses both current aspects of AI's implications on the designer and in light of those findings, examines the question of AI's benefit to the designer from a larger perspective. It is in this latter investigation that morality comes into play, as mankind's process in navigating the development AI could have negative repercussions. As individuals we see allowing said repercussions as immoral, from this, a cultural code of ethics for navigation of AI is seemingly necessary.

Research on the topic of AI in design is documented in academic fields and has been utilized in this paper, however with the unpredictable rate of AI advancements in the past year my research necessitated some venture outside of the academic sphere. This is due to the bleeding edge of AI's inherent link to private industry. The hunt for the answer to the question of whether AI is beneficial to the designer led to general speculation AI's benefit to humankind and therefore goes outside the consideration of just design. This larger question relates to longer term analysis, going past the next 5 years. The vision of this long term future of AI varies immensely between experts.

DISCUSSION

Before delving into the implications of AI, a categorization of AI forms is required. Artificial Intelligence can be categorized as non-generative and generative. Non-generative AI performs specified calculations based on inputs and the outcomes of which have known parameters while generative AI is defined by the production of content with out clearly defined parameters (Marr, 2023). In discussing non-generative AI, I am obligated to address a mistake in my seminar discussion for this paper. During my speech I categorized both stress analysis and subtractive topology as forms of non-generative AI. In actuality these are both mathematical modeling and alone are not considered any form of AI. To re-contextualize generative and non-generative AI in the instance of stress analysis, if the process were fully automated so that AI could produce a new design for the stresses required based on the machine learning and improving on previous iterations, it would be generative design. If the machine were offered multiple choices of the design and asked to select one based on learning over time, it would be non-generative. Current examples of non-generative AI are used largely outside design, examples being on-line brand sentiment analysis and e-commerce recommendation feed systems (Ventures, 2023).

In the past few years, generative design has been not only the type of AI to see the most growth, but also has shown to be the category that lends itself best to designer's needs. As of right now, a designer can produce writing to explain their product, make computer aided design models (known as CAD models) and graphics with which to cover their product in, all through artificial intelligence. Varying strengths of these AI systems dictates varying outcomes though, and not all systems have functional application to designers, even though they could theoretically be used.

Credited as the most advanced current form of AI, generative Large Language Models (Sidharth, 2023), LLMs for short, produce text based outcomes using a neural network. This network, something like an internet based brain, understands and produces text at a near-human level (Jazeera, 2023). Despite the capabilities of recent iterations of LLMs such as Chat-GPT 4, the lack of writing based work in design means that these systems are best used for side tasks such as copy writing and performing basic research, for which they can have some benefit. LLMs also present a negative outcome for designers in the way that they can be used to cheat during design education, compromising academic integrity, and in turn lowering the standards of industrial designers. Currently in the United States, 1 in 5 students admit to using AI to complete assignments (Nietzel, 2023).

In terms of tools most relevant to designers at this time, image generative AI has garnered the most public attention. These systems use either image or text based prompts and can produce often photo realistic images. Notable text prompt based AI systems are Dall-e, Stable Diffusion, and Midjourney. Vizcom stands out at the dominant AI that is designed to use sketches as input for near realistic renders by adding materials, backgrounds, and realistic lighting to simple line drawings. In terms of AI that I have seen most used by other students, Vizcom's rendering of basic sketches the most common use case. Image generating AIs in general are used in early, ideation based, divergent stages of the design process as the results can vary from expected outcomes.

While a skilled industrial designer can also produce photo realistic images using a combination of CAD and rendering software, image generating AI systems allow for instant generation of multiple iterations of one prompt. This allows for instant consideration of multiple formtypes and is a method I have used myself. Though ultimately these images never directly inspired an eventual design, the rapid production of multiple forms could provoke a mental elasticity, lessening inhibitions about possible formtypes for given product concepts. Organic spontaneity occurs in the design process without AI though, so an absolute argument can't be made favouring sketching or AI as a more creative method for formtype development. By using the term formtype, I mean the aesthetic style of the physical outer form of a product. Below in figure 1, artist Tinker Tailor's multiple iterations of one concept reflect the normal format of AI produced art, this being slides of 3 or more images of the same concept, as one prompt can yield multiple images with little extra effort. Tailor allegedly used Midjourney for these renders, though post AI touch ups with image editing applications such as Photoshop are frequently used due the unpredictable results that sometimes stem from image generating AI systems (Dean, 2022).

Image generative AI can also provide visuals with intricate form details that would be highly challenging, if even possible, for designers to produce. This is due the to the fact that designers would need to model these forms in CAD. While one form can be replicated many times very easily in Computer Aided Design, the creation of a form with many small variations is not a task not easily accomplished with current software. Tinker Tailor's images in figure 1. demonstrate the AI's ability to manifest renders that would necessitate huge CAD workloads to model. Notably, these forms are only in image form and unlike CAD models, have no value to be used for their production. Another commentary on popular image based AI applications is that these forms are largely ornamental in nature.

Figure 1. Tinker Tailor's storefront concepts highlight the ability of image generating AI to produce intricate ornamental form detail and instant multiple iterations of one prompt. (Tinker Tailor, 2023)

In the sense that one successful prompt can yield multiple satisfying results though image generators, the prompt is the crux of the AI designers workflow. This relevant to industrial designers in scenario that AI becomes dominant as this point of the process will dictate what separates skilled from unskilled designers. Some postulate that based on the strength of language- based AI models, that the role of the designer may shift towards that of a poet or writer (OBIS, 2023). Integration of image-based prompt generators such Vizcom, and the current restricted application of image generators to purely aesthetic and non-functional works, opposes this notion of a poet-designer. Considering the varying applications of AI in design, the best course is likely a pragmatic one, including the development of skills in sketching, CAD, and physical formwork as well as a general attentiveness to ongoing developments in AI.

Generative CAD AI systems are best described as AI that is still somewhat within infancy. CAD AI application to designers at this time are more courted to automating repetitive tasks rather than producing finished CAD creations. Industrial design relevant CAD programs such as SolidWorks have created non-generative AI helpers that will help select items, a task that in large quantities can be highly time consuming, as well as AI that will help connect or "mate" product parts at their desired connection points (Pagliarini, 2023). Generative AI CAD systems do exist, such as Fusion 360's Generative Design that will recreate a human designed part in varying materials and for different production processes, as well as providing qualitative and quantitative information on styles of production (Autodesk, 2021). A frame from a video on the process demonstrates how these varying manufacturing methods is presented in figure 2. Drawing and schematic generating AI for architecture may have more traction than Industrial Design AI at the moment, as programs such as XKool have been widely used in China for their generation of room layout schematics (Wainwright, 2023). Though 3D CAD generators have not entirely taken off, large language models such as Chat-GPT can be used by designers by asking questions about specific CAD processes, though this information is still widely available on line anyways (Kevin, 2023).

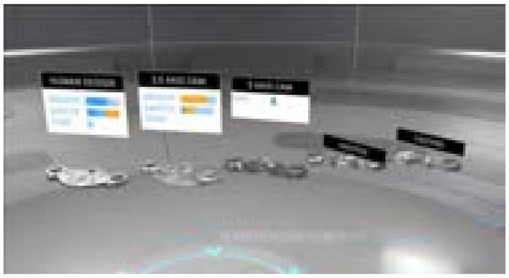

Figure 2. A frame from a demonstration video shows Fusion 360's generative AI creating multiple versions of a human-designed part. (Autodesk, 2023)

At this point, having considered AI's current and near-future implications, the prospect of whether AI is beneficial to the designer looks somewhat optimistic. AI has shown to produce otherwise near-impossible images, hastened labour intensive workflow, and even produced basic generative designs in CAD. Negative impacts of AI now and in the near future include some compromised design educations from cheating on LLM's, but so far no highly impactful negative standouts.

A look further into the future that reckons AI's potential to grow past current applications and execute fully automated design jobs, in other words take jobs from industrial designers, also looks positive. A well cited 2013 study from Oxford suggests that the bottlenecks to computerization of jobs are perception and manipulation, creative intelligence, and social intelligence (Frey & Osborne, 2013). While it could be argued that with the strength of generative design and sensors, that AI is capable of both perception and manipulation now, AI's likely inability to perform creativity and social intelligence favours the skill set of the designer, trained the well in areas of creativity and to some degree in interpersonal relations. In regards to creativity, AI's need for human input prior to acting is best summarized by Pablo Picasso, saying about robots "they are useless. They can only give you answers". This concept is bolstered the fact that any current successful application of generative AI currently being developed comes from human prompts.

The complex social intelligence that designers use for the human factors of design is being developed through machine learning large language models, and though the AI grows close to human intelligence, it is not there yet. Previous indicators of human intelligence such as the Turing Test, a test in which the machine is speculated to have thought if it can pass as a human, are likely achievable by modern systems such as Chat GPT-4 (Biever, 2023). The notion of passing the Turing Test meaning a machine has human level intelligence has been cast into doubt though as Chat GPT-4 fails other more modern tests suggesting human levels of intelligence. Overall though the Oxford paper is pessimistic and suggests that computerization could take 47% of American jobs by 2033. Industrial designers are among the less likely occupations to be computerized, sitting at 119 out of 702 with 702 being the first to go, so we will likely have good warning.

Atkinson (2022), points out that Frey & Osborne's 2013 paper has not been accurate in the first 9 years after its release. 16 new million jobs in the USA, as well as Frey and Osborne's most "AI-susceptible jobs", seeing increases in employment since 2013, counter the stance this often cited paper suggests (Atkinson, 2022). AI progresses at such a rate though that even Atkinson's 2022 critique could already be cast into doubt considering 2023 AI breakthroughs. Frey and Osborne's work contrasts optimistic papers such Design and the Fourth Industrial Revolution by Ferrari (2017) that has no mention of job loss and suggests the role of the designer will simply be "expanded from form-giving to creating systems that support human interactions". Both Frey & Osborne's and Ferrari's papers appear to have a contrasting polarity, but also both could be mutually flawed in their estimation of the capabilities of the 4th Industrial Revolution. Beyond utopia and dystopia a third option exists in terms of the outcome, this being dullness.

CONCLUSION

Is AI beneficial to the designer? Right now AI is a valuable tool amongst many other technologies. Specifically for developing iterative visuals, hastening CAD workflow, and using large language models for design adjacent tasks, AI has notable use. Regarding the near future, designers should probably pay attention to new applications of AI and the skills that systems require if they look like they will become essential. While AI can benefit designers, it is by no means necessary. Many succesful designers function completely without AI. There is a strong argument favouring manual processes, with legendary design school Bahaus setting principles emphasizing manual involvement in training (BAUHAUS, n.d.). While opportunities to streamline workload may be replaced by AI, there is still an abstract value in manual processes in both their repetitive and meditative nature, as well as their ability to convey material properties and form to the designer. For example, a designer wants to carve a spoon and an autonomous AI robot can take a description and hand back a fully polished spoon that roughly fit the prompt. If the designer carves this spoon themselves though, they feel hardness of the wood and the way the grain is oriented, they see the differences between slight variations in curvature, and the designer can use the physical form to develop an ergonomic understanding.

The re-gearing of skills for AI could mean enhancing language skills for text-prompt systems, or continuing to use sketching and model making as AI could use those mediums as prompts. AI could harm the designer in the immediate future if relied on as a tool for creativity and social intelligence, making the designer lazy in the development of traits that distinguish them from machines (Frey & Osborne, 2013).

Policy that dictates ethical development of AI technology, be it to avoid algorithms that perpetuate systematic biases, to utilize LLMs to prevent cheating, or to avoid mankind's own destruction at the hand of machines, must be considered. Experts working on bleeding edge large language models are already at a point at which they can no longer take a "look under the hood" of LLMs. In other words, the systems are already so advanced that they work in ways humans don't understand (Will AI Destroy Us? - AI Virtual Roundtable, 2023). Well respected experts opinions in AI range from those pushing for increased research to some who ask for an instant moratorium on all AI that has developed in recent years, even now-dated AI such as Chat-GPT 1 (Will AI Destroy Us? - AI Virtual Roundtable, 2023).

In the future, AI will likely consume some jobs, but as industrial designers will be among the last to go, this topic is part of a larger conversation that supersedes design. Undeniably important is development of policy for fair allocation of wealth and power with the loss of labour power that goes hand in hand with automation of jobs; modern increase in wealth inequality (Qureshi, 2023) does not suggest this is going well. As the future of AI in design is uncertain, the most valuable lesson we can extract is that humankind's actions in the coming years will dictate AI's aggregate outcome. From this, we as designers must continue to apply our morals and ethics in our design practice, but also remember that as AI could effect everyone, the issue is best not examined just from the lens of the designer, but also from the lens of a humanist.

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ADDITIVE MANUFACTURING & INDUSTRIAL DESIGN

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INTRODUCTION

The topic of study chosen by my group is additive manufacturing in industrial design. 3D printers have been around for a long time, however over the last decade they have become increasingly advanced and accessible to a variety of different types of users. Beyond changing the way industrial designers create prototypes, this technology can create many new and interesting opportunities for designers. It is quickly making its way to the forefront of the fourth industrial revolution and is permanently changing the way designers and engineers ideate and convey their ideas.

The subtopic I have explored revolves around the sustainability of 3D printing. What, if any, recycling parameters are in place to reuse current FDM filaments, and is there any push by the consumer for more eco-friendly filaments to be put in place?

BACKGROUND AND RESEARCH

Due to the ever-increasing popularity of 3D printing as a means of rapid-prototyping, printing for recreational and professional uses is becoming more commonplace. An unfortunate byproduct of 3D printing is the creation of "support material", which is material printed to support the main product so it does not droop or deform during the printing process. Supports can take up anywhere from 10-70% of the total volume of material printed, and the only thing to be done afterwards is dispose of it. Because there is not real way around printing supports, I am interested in solutions that address this use cycle issue to create a less wasteful prototyping experience. Although FDM printing uses less plastic than traditional plastic manufacturing, there is much room for sustainable and environmentally friendly ameliorations.

Going into my research, my initial questions on the topic were:

1. How eco-friendly are current FDM filaments? (An in-depth analysis of biodegradability and reusability)
2. Can prints/filament be recycled? Once prototypes have served their purpose, can material be broken down and turned into new filament?
3. Can systems be implemented by the manufacturers themselves to recycle used filaments, reducing plastic waste and giving consumers the opportunity to send used product back for some form of benefit?

I found it very interesting that there was only one company offering *true* recycled filaments – meaning they accept used 3D prints and they break them down to form new spools of material. They do not, however, offer any form of compensation or incentive for anyone to send them their used filament unless you are sending 50Kg or more (Filaments, 2014). For perspective, the average spool of filament costs between $20 and $70, and weighs 1Kg. So individuals must pay out of their own pocket to send their support material, and they get no compensation or gratitude for doing so. The recycled filament is slightly more expensive than their virgin counterparts, which is to be expected with the additional labour involved to turn it back into usable spools. The reasoning behind the lack of any customer compensation is that the recycling process used is more expensive than producing virgin materials, so the company cannot justify/afford to compensate customers (Filaments, 2014).

Other companies, like Prusa and Spectrum, offer something called rPLA – a "100% recycled" filament (Prusa, 2023) (Spectrum, 2022). These filaments are not actually made from recycled material, but rather the residual extrusion waste produced when creating their standard filaments. So instead of throwing out all the residual waste, they melt it back down to create "recycled" filament instead (3Printr.com, 2023). While this is a step in the right direction, I would not classify it as recycled by any means – it is really just slightly lower quality virgin material being sold for the same price.

In terms of official systems currently available, none of the major filament manufacturers offer any "buyback" or takeback programs to recycle their used materials. In Prusa's sustainability report they mentioned that it is their most common question received by customers, and while they do not currently have a solution they are working on it (Prusa, 2021/2022).

There are products available for users to recycle old 3D prints and supports at home, though the costs are quite exorbitant for DIYers. To recycle prints there are only 3 things that are needed – a shredder to break down old material, an extruder that melts and extrudes the shredded plastic into the round filament shape, and a spooler that coils the freshly extruded material around a spool for storing. Even though the list is small, the total cost to set up an at-home filament recycling system is around $7000 (Felfil, 2019). This number is incredibly unrealistic and unfeasible for hobbyists and DIYers, and incredible hard to justify considering it is roughly 10x the cost of a mid-level 3D printer.

The only filaments offered to some sort of recycled extent are PLA and PETG, and very rarely ABS (Boissonneault, 2023) (Felfil, 2019). While other filaments are technically recyclable, there are no manufacturers that offer recycled variants (Mhatre, 2022). Because it is not overly financially viable for users to send in their old prints to be recycled, or to recycle and create their own filaments at home, the only real option at the moment is to throw out old material. Even buying rPLA or recycled filament, the most realistic end-of-life outcome is in a landfill.

Based on my research and findings I have found my first two questions to be irrelevant, and I have now decided to ask new ones-

1. Of the most popular filaments used, which ones are the easiest/most cost effective to recycle, and which ones are most likely to be reused by major manufacturers?
2. What are the current systems available for filament recycling, and do these systems collaborate with the major filament manufacturers? Is it more viable for a DIY user to recycle their own filament into usable spools?

I know my next round of questions will ask how the recycling system can be made financially viable so the systems would be more likely to be implemented. Maybe it would be more viable for a company to start by focusing only on one kind of recycled filament instead of multiple – slowly building up to being able to recycle multiple/all kinds of filaments.

WHAT CAN BE DONE

While there *are* systems in place that show it is possible to create and sell recycled filament from customers, I don't have any idea what the financial viability of this model is. I need to do more in-depth research into the financials of this system, as it seems this is the only aspect standing in the way.

In terms of creating a viable recycling system, I have outlined what areas would have the biggest impact on feasibility. While there a lot of details that I do not know about the manufacturers/companies like their profit margins and overall profitability, these would be very important factors when considering a recycling program. I also believe this to be one of the main reasons something has not been implemented yet, as many of even the largest 3D printing companies are not very profitable.

Cost

The largest and most obvious costs are the machinery and infrastructure costs involved in setting up a recycling program. The used prints and supports need to be broken down into granules that can be fed into the plastic extruder. I was unable to find the exact cost of industrial sized plastic shredders they varied in price from $6,000-$90,000, which does not include any maintenance costs. This is definitely a substantial upfront cost, though companies like Prusa might already have the infrastructure in place to fabricate their rPLA filaments. While the upfront cost to purchase or rent a machine like this would heavily depend on the liquidity and assets of the company, the long term financials could be mitigated by markups for specific products and filaments. Adding a 10-20% markup for recycled material (or markup non-recycled materials all by 1-5% while keeping recycled product costs lower), could address financial concerns, plus customers would likely be more inclined to pay a premium for recycled if they knew it was more sustainable.

Shipping incentives

The simplest way to incentivise individuals to send in old prints is to cover all or most of the shipping expenses. This does not even need to be a direct cash cover, the company could offer to cover part of the cost of shipping in store credit. This would give customers some kind of motivation to send their goods for free, knowing that they would get 25% of the shipping cost back in store credit (for example).

In an ideal world, or once the financial viability of the recycling infrastructure has balanced out, the company would directly cover the shipping cost by having a printout on their website that you could stick to the package.

If there were shipping incentives, there would be no need for any purchasing incentives (in my opinion), though both would work best in tandem with material markups

Purchasing Incentives

Purchasing/recycling incentives would be the best marketing strategy to entice consumers to recycle their products. Even if the cost is to great to cover the shipping of inbound materials to be recycled, offering some kind of future discount relative to the amount of material sent in would give customers a greater incentive to pay for shipping expenses. A potential system could be:

- Offering a flat discount of 1% for every 1Kg of material sent in. This can be tracked through the use of online customer profiles, and any material shipped in is noted in the customers account information. The customer can choose when and where to use their discount, and they can let it accumulate to use at any time.

- A different discount rate can also be applied to different categories of product, i.e. if someone sends in 1Kg of material, they can get a discount of either 2% on any recycled filament, 1% on any virgin filament, or 0.5% on any 3D printer products/ accessories. So giving the option to the customer where they want to apply their discount.
- Offering some form of “buyback” where you are paid a percentage of what the material is worth in store credit. So if you send in 5Kg of PLA and the company is selling spools of PLA for $20/Kg, you would get 10% of its worth back in store credit to use – so you would get $10 in store credit to use.

The beauty of purchasing incentives is that there would be no need to cover shipping costs as the value of sending material back would be perceived to be greater than that of the cost to ship.

CONCLUSION

I think the work and exploration I have done so far has been incredibly informative and positive, implementation issues I came across lie in a much different area than I anticipated. I was naïve to assume that these questions had not been asked before, and considering how long 3D printing has been around I should have realized sooner that there is a reason there are not more/any programs in place. I quickly realized that while the companies producing filaments may want to become more sustainable, their current business models don’t allow for such black and white thinking. The biggest constraint to this area of study is my knowledge of the industry as a whole. I know that my questions have been asked and are currently being asked – so what are the issues standing in the way? Only insiders and industry professionals would really have an answer for that, as there are clearly hurdles to these implementations that cannot be easily found in moderate research.

I am incredibly fascinated by our reliance on plastics, especially with how detrimental they are to our environments and ecosystems. Designers are very reliant on them, and with the exponential rise in 3D printing popularity it will only get bigger. I think this poses an incredibly fascinating dilemma as we delve ever deeper into the sustainability movement. I wonder if the future of 3D printing will be negatively impacted if viable recycling programs are not implemented soon. I believe we are still in the early stages of our war against plastics, but what does the sustainable future of tomorrow look like for additive manufacturing?

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3D Printing's Role in Textile Product Design

Introduction

Industrial design faces significant transformations due to the technological advancements of the Fourth Industrial Revolution, also known as Industry 4.0 or 4IR (Liu & Xu, 2016). The introduction of these smart systems and cutting-edge production techniques revolutionizes the design process, incorporating advanced technologies like the Internet of Things, AI, and additive manufacturing. Additive manufacturing and 3D printing have become pivotal in industrial design within 4IR, revolutionizing various sectors, including textile product design. Industrial designers address factors such as ergonomics and manufacturing techniques to ensure the final product meets both artistic and utilitarian needs (DesignWanted, 2023).

The Nike Flyprint Shoe Upper, the first 3D-printed performance fabric in the world. Source: NIKE

3D Printing and Additive Manufacturing

The rapid pace of technological advancement poses challenges for companies to stay innovative and competitive in their designs and manufacturing solutions (Niewöhner et al., 2020). The utilization of additive manufacturing facilitates the production of complex parts unlike other technologies, offering companies the ability to streamline processes and enhance efficiency (Prashar et al., 2022). The further development of eco-friendly textiles brought about by Industry 4.0 can be combined with the innovations in 3D-printed biodegradable filaments to increase sustainability in fashion and textiles.

Textile Design and Additive Manufacturing

Textile design encompasses a broad range of applications, including but not limited to apparel, home textiles, and industrial textiles. The concept of integrating 3D printing technology with textiles began to take shape in the early 2000s. Researchers, alongside designers, started experimenting with using additive manufacturing techniques to create three-dimensional structures directly onto fabrics (The Squad Nation, 2023). These initial attempts were mainly focused on rigid structures and non-wearable items, such as decorative elements and accessories. In the context of 4IR, textile product design and 3D printing have expanded due to the transformational advancements in additive manufacturing technologies. These technological advancements enable the creation of intricate, flexible, and wearable personalized textile products (Prashar et al., 2022).

To accelerate the textile design process by employing 3D printing for rapid prototyping, it enables designers to iterate and test new textile concepts more efficiently. Designers can optimize their designs with 3D printing to create intricate structures that enhance product functionality and durability, contributing to longer product lifespans (Utilities One, 2023). The range of materials in 3D printing, including polymers, resins, and metals, allows for the creation of durable and long-lasting textile components (Sitotaw et al., 2020). This allows for precise customization of textile products, reducing the need for excess materials and minimizing waste in the production process.

Applications

These innovative applications of 3D printing demonstrate its versatility across various industries, providing new dimensions to textile design beyond the fashion sector. The fashion world has been adapting the technology of 3D printing to create bespoke clothing tailored precisely to individual measurements, allowing for personalized fashion experiences (Prashar et al., 2022). Other possible design sectors to adopt 3D printing and textile-integrated products include healthcare, sporting goods and equipment, automotive, aerospace, and architecture.

The medical sector has multiple uses for additive manufacturing with the exploration of 3D printing for personalized medical textiles, such as customized braces, orthopaedic implants, or prosthetic covers with enhanced comfort and aesthetics. Other medical applications include the integration of 3D-printed components into textiles to create smart fabrics with embedded sensors, actuators, or conductive elements to replace current medical testing equipment (Kumar Kanishka & Bappa Acherjee, 2023). Similar to the medical section, sports equipment design is adapting towards incorporating 3D-printed textiles for customized padding, aerodynamic structures, and comfortable sportswear.

Some companies within the automotive industry have been researching ways to integrate 3D-printed textile components in automotive interiors, offering custom and ergonomic designs for seats, headrests, and other interior elements (Prashar et al., 2022). Much like automotive, another sector making great strides in this area is the aerospace industry. NASA has been researching durable textile components, to innovative solutions for interior and exterior elements, seat covers, and vehicle insulation (Landau, 2017). NASA has also been making strides to enhance aerospace manufacturing by employing 3D printing for lightweight, complex, and high-performance components, aiming to improve fuel efficiency and overall aircraft design.

The application of 3D printing to architectural projects that is not often combined with textiles. This integration enables the creation of dynamic and structurally efficient building facades, canopies, and interior design elements (Prashar et al., 2022).

Conclusion

The integration of additive manufacturing and 3D printing into textile product design under Industry 4.0 opens new horizons. It empowers designers to innovate, producing personalized and intricate textiles efficiently. This technological synergy aligns with the overarching goals of Industry 4.0, contributing to a more agile and responsive industrial design landscape.

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Designing the Future of Emerging Additive Manufacturing Technologies

ADDITIVE MANUFACTURING & INDUSTRIAL DESIGN |SAMUEL SANTOS

INTRODUCTION / BACKGROUND

Additive manufacturing (AM) technologies have been highly disruptive across many industries, as new AM technologies emerge and mature, how might they be utilized in new ways? This report will review the current state of AM and its applications, as well as speculating how emerging AM technologies could play a role in the 4th industrial revolution. Like other emerging technologies, AM advancements should not only be looked at through a technical lens, but also through the eyes of human-centric industrial designers. Industrial design has always been driven in part by emerging technologies and their novel applications, for instance, innovations in aerospace and defense industries applied to new problems. By crossing these technologies with user-centered design thinking, designers can enrich the lives of users and create innovative products. 3D printing has seen rapid growth in the past decade, but the technology has not yet reached its potential as a truly transformative innovation.

To begin, additive manufacturing (AM) is the industrial production name for 3D printing, a computer-controlled process that creates three dimensional objects by depositing materials, usually in layers (TWI, 2023). This is the most basic form of AM but as this report will explore, there are dozens of different processes built upon this principle. Because of the nature of these processes, AM offers a unique level of control and versatility in its material properties, speed, and waste generation. The wide variety of printable materials and short lead times has seen it displace many more traditional means of manufacturing such as molding that require large up-front investments. AM has seen a boom in recent years, and it has never been a more accessible technology for businesses and individuals alike. This boom has also led to cutting edge innovations in the technology that will be explored in this report.

DISCUSSION ABOUT SUBTOPIC

3D printing and AM technologies have the capacity to revolutionize manufacturing across many industries, new processes and developments allow for products not possible with traditional manufacturing techniques. These advancements in product engineering and manufacturing are a main pillar of the 4th industrial revolution. 3D printing has been around for a long time, in the early days it was reserved for aerospace and medical applications with massive machines costing hundreds of thousands of dollars. These days, similar results can be achieved for under a thousand dollars by individuals thanks to the development of AM technologies.

Despite its progress, AM has not yet matured as a technology the same way the internet or GPS has, it currently exists at the extreme ends of performance. On one side, AM is used to great effect in aerospace and medical applications with products such as one-piece rocket nozzles traditionally constructed from hundreds of components welded together. The high degree of individual customization also makes AM medical implants a prime use case for the technology. At the other end of this spectrum of performance, there is the hobbyist and prototyping communities. In these cases, 3D printing is used by individuals for personal projects and increasingly companies for rapid prototyping applications. Despite being integrated into traditional product development pipelines successfully, AM has yet to progress past being a supplementary tool for existing mass manufacturing methods. At present, consumers would be hard pressed to find a product on the shelf with 3D printed components outside of innovations such as adidas and Nike’s 3D printed footwear. The question of why 3D printing hasn’t displaced traditional mass manufacturing in a meaningful way is one rooted in inertia, economics, unfamiliarity, and a myriad of other factors.

AMFG (2019), an authority on autonomous manufacturing, considers 3D printing to be in its early adoption phase with categories such as consumer goods being considered in an adolescent stage and more industrial uses like medical and aerospace being considered early mainstream. As Sarah A. Sutherland indicates in a 2022 column, the course that a new technology takes is determined in the early adoption stage as at this point the number of players involved is small enough to allow for changes to the technology's trajectory. It is at this point that the human-centered input of industrial designers must be heard.

As we can demonstrate historically, purely profit driven innovations when left unchecked can become detrimental to society and these new technologies ultimately become implemented in a way that does not serve the people it interacts with. For example, one need not look further than social media. This technology's purpose is to extract value from users in the form of impressions, a profit driven system that thrives on strong emotions. Social media has been shown empirically to have a detrimental effect on the mental health of its users, contribute to the spread of misinformation and be highly addictive. These are not human-centered traits, and work is being done to negate some of these characteristics of social media. Unfortunately, I would speculate that in order for social media to truly change, a major cultural shift, tighter regulations, or some other shock to the establishment would need to happen to change the trajectory of this technology. What might social media look like today if a human-centered approach were taken in the early days? How might the value created from user information be distributed? How might accountability for virtual interactions be addressed? None of these questions can be definitively answered because social media has taken a different path, how can we ensure that the next innovations are handled better?

This brings us to the point this report seeks to put fourth, with the development of AM technologies, industrial designers have the opportunity to influence the development of these technologies. As 3D printing becomes more ubiquitous, new opportunities for innovation will present themselves. Designers must advocate for human-centric development as these decisions are made and the path forward is paved. What might the future of product delivery look like if everyone is able to manufacture parts in the comfort of their own homes? How can we rethink global supply chains to be more resilient, efficient, and equitable by supplementing them with domestic AM manufacturing? How can AM integrate with other trends of the 4th industrial revolution like automation and generative AI? These are all large and far-reaching issues that require a human-centered approach to answer effectively. There is room for human-centered design at all levels of this new technology, everything from the products themselves to the systems in which they function can be thought of through this lens.

DISCUSSION ABOUT INDIVIDUAL WORKING TITLE

Here begins the speculation on the future of AM and its relationship to industrial design based upon industry trends and the trajectories of other developed technologies. With new AM technologies being developed actively, the widespread adoption of AM across more industries is imminent. The implementation of these technologies is pivotal and should be developed in a way aligned with human-centered values. The industrial design profession has evolved greatly from form-givers to interdisciplinary strategic problem solvers. Currently, industrial designers are trained to be empathic with end-users, it is this trait that will assist designers of the future in avoiding the pitfalls of previous technologies.

By breaking down problems and applying design thinking to AM and its unique properties, designers can create innovative designs. Today's industrial designers are limited in their ability to create designs for mass production. This is a result of the limitations of traditional means of manufacturing such as molding or machining. The freedom to explore more extreme designs in terms of form is currently limited to the prototyping stage as 3D printing is used to great effect in that realm. At present, the constraints of the prototyping stage are limited to serve the mass production stage. In a world where traditional methods of manufacturing have been supplemented or replaced by AM technologies like in aerospace, the designers and engineers behind a design can enjoy greater levels of freedom to better serve the end user. Right now this is a fantasy, technologies like injection molding can produce hundreds of parts a minute for pennies. Current AM technology hasn't yet reached that level of appeal among industry leaders, however there are promising new technologies that could begin to displace traditional mass production.

Traditional mass production is an established and highly optimized pipeline, disrupting technologies like AM are not competitive under our current global supply chain. However, AM is beginning to integrate into this pipeline through rapid prototyping. The rapid prototyping industry which is led by AM technologies is expected to reach a value of $2.6 Billion by the year 2025. With an average annual growth rate of 22% in the United States 3D printing has become a key part of the product design process (Interesting Engineering, 2020). For now, AM is relegated to the prototyping stage and is seldom used in final products for a variety of reasons. This includes things like poor surface finish with visible layer lines, relatively long production cycles when compared to traditional means, and low scalability of the process. Despite these shortcomings, there are new AM techniques that could address these issues and push AM from prototype to the end product.

Volumetric additive manufacturing (VAM) is a cutting-edge AM technology developed within the last 5 years. Compared to a more traditional method of 3D printing like SLA (resin printing), it is clear that VAM is an entirely new category of AM. Typical resin printers use UV curing resin and a screen to build up parts layer by layer, VAM uses a similar technique of curing UV resin but unlike SLA printing which is often time consuming. VAM cures the resin in three dimensions (volumetrically), via intersecting beams of light all at once which allows for printing hundreds of times faster than SLA (Madrid-Wolff et al., 2023) Despite being in its infancy VAM boasts several improvements over classical 3D printing. Most shockingly is the print time, centimeter scale objects can be printed in minutes. This way of printing has inherent qualities that make it competitive when compared to traditional manufacturing like fine surface detail, the ability to embed objects within the prints, the ability to control density through variable infill, less waste, no need for support material and the ability to scale more effectively than injection molding (Kelly et al., 2019). VAM is also fundamentally easier and cheaper to engineer, build, and maintain as there are very few moving parts. The furthering of this technology is one of many ways that 3D printing could enter the mainstream and compete with existing mass manufacturing methods, such an innovation would be transformative to most industries and rewrite the rules for what is possible to fabricate at scale.

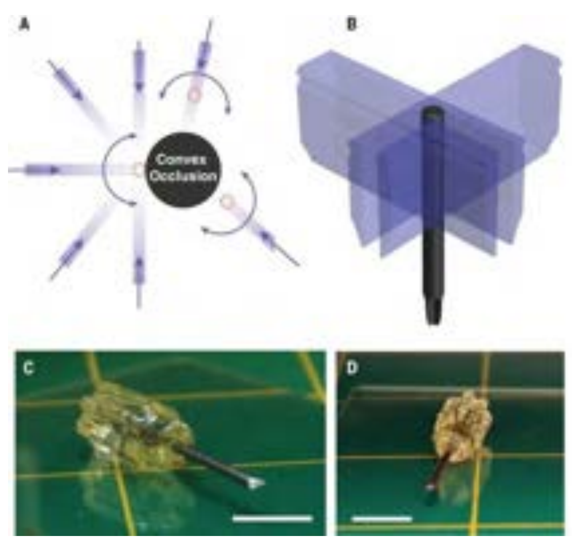

Figure 1. VAM print with embedded object. Source: Science.

A transformation of the mass production landscape of that scale would require a rethink of how we make things. A comparable disruption to this would be the second industrial revolution. It saw the birth of mass production and the switch from steam powered factories to electric ones. To illustrate the role designers must play in this hypothetical future, I offer an anecdote from those times. Initially, when factories converted from steam to electricity, there was no great leap in the factory's productivity. It was only when factory planners realized that they had the freedom to optimize the factory layouts that productivity rose. They realized they were no longer constrained by the bulky steam pipes and belts that had driven the old factories. Technology itself is not a driver of progress, it is only when technology is applied thoughtfully to problems that we see progress. For AM to revolutionize mass production, designers must revolutionize the products they make.

Much like the factory planners of the second industrial revolution, designers of the future must decide how these advances in mass production are set up. Replacing the world's injection molding machines with VAM systems would change nothing for society at large. If VAM was adopted globally, the very idea of mass production could be changed, and manufacturing wouldn't need to be outsourced and shipped around the world. One of the key advantages of AM is its inherent customizability, making high quality, customized products accessible to everyone. Through 3D scanning and generative AI, design could be in the hands of the consumer. But this is only one of many futures, the task of deciding the trajectory of this technology could fall to industrial designers. In a world of hyper-customization, human-centrism must be at the heart of the design process.

CONCLUSION

The 4th industrial revolution is ushering in a new age of technology characterized by automation, advanced engineering, and manufacturing. After decades of experts preaching the revolution that is additive manufacturing, it seems to finally be around the corner. With an explosion of innovation in the field in the last decade, it is important that the implementation of this technology is done in a way that is not destructive to society, the environment, and people. As a result, having industrial designers and other human-centric professionals contributing to the development of these technologies is key to their success.

Advancements in AM and related innovations in technology present new challenges and opportunities for designers. As technology progresses, it is the duty of designers to progress with it, not letting arbitrary systems develop according to market forces. We must be deliberate in using technology as a tool and applying it to the betterment of society, the environment, and our collective futures. Industrial designers must become technologists to be able to influence developing technologies and industries while retaining their human-centric goals.

In conclusion, this report has delved into the transformative potential of additive manufacturing technologies and their role in shaping the future of industrial design and society at large. Although this technology has not yet reached its full potential as a revolutionary force in mass manufacturing, it is important that these futures are discussed and seriously considered. Among the many who will influence the future, industrial designers are positioned as key contributors to shaping a world where AM technologies are harnessed responsibly and ethically, ushering in a new era of innovative, customized, and sustainable manufacturing practices.

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ADDITIVE MANUFACTURING ADVANCEMENTS AND DESIGN PROGRAMS

ADDITIVE MANUFACTURING & INDUSTRIAL DESIGN |LAURE SAPHIRA BIJOUX

INTRODUCTION / BACKGROUND

AM can be described as a 'set of production technologies that allows to obtain a final product through the generation and subsequent addition of layers of material' (ESA Automation, 2020). In the context of the 4th industrial revolution, Additive Manufacturing is a key player as it reduces waste and scraps production, decreases prototyping times and costs, promotes business digitalization, and synthesizes the assembly process into a single part (ESA Automation, 2020). AM also opens the door to efficiency boosting through weight reduction and range extension of certain parts, as well as facilitation of part replacement, with digitized part inventories, enabling on-location production in remote locations (Barclays, 2021).

DISCUSSION ABOUT SUBTOPIC

The expected outcome of my research is to further my understanding of Additive Manufacturing (AM) and the way it could be better implemented in design education.

AM's potential with decentralized manufacturing was brought forward during the pandemic, as various industries were able to quickly launch medical equipment production thanks to their network of AM, despite the supply chain disruptions (Barclays, 2021). Although using AM to produce durable end-use products that go beyond prototyping is new (TEDx Talks, 2016), it is expanding fast. In 2022, more than 34% of the revenue share was captured by North America and 77% of total revenues. were generated by the industrial printer segment. Additionally, the global AM market is estimated to grow at a CAGR of 18.92% during the forecast period 2023 to 2032, hitting around CAD 133.51 billion by 2032 from CAD 23.60 billion in 2022 (Precedence Research, 2023).

Throughout my research, I attempted to answer the following questions:

How might AM advancements alter certain common visual/functional elements (such as parting lines or other mechanical joints)?

How might the flexibility of modern AM affect ideation exploration and innovation in material selection?

How might these changes inform the potential course outline of a class with some focus on additive manufacturing, in an industrial design (ID) program?

DISCUSSION ABOUT INDIVIDUAL WORKING TITLE

Additive Manufacturing might not mean much to you, even replaced by the term "3D printing". Here are some of the most common AM technologies (Carbon, 2022):

- Material Extrusion, in which thermoplastic material is pushed through a heated extrusion nozzle and deposited layer by layer to build an object. Fused filament fabrication (FFF), also referred to as fused deposition modeling (FDM), is the most commonly used additive material extrusion process (Carbon, 2022). Materials such as Polylactic acid (PLA), Acrylonitrile butadiene styrene (ABS), Polyvinyl alcohol plastic (PVA) and Polycarbonate (PC) (SPC, 2023) are commonly used for FFF.

- Sheet lamination, also called laminated object manufacturing (LOM), is a rapid prototyping process in which sheets of material are joined together to create an object. It is commonly used for building durable 3D objects with complex geometries. Ultrasonic additive manufacturing (UAM) is a type of sheet lamination process that uses principles of ultrasonic welding to produce metal parts (Carbon, 2022).

- Binder jetting, also known as drop-on-power printing, uses a modified version of the inkjet printing process, therefore not requiring a heat source to bind the materials.It works with a variety of materials, including ceramics, composites, sand, and plastics. (Carbon, 2022)

- Material jetting is a full-color technique in which droplets of thermoplastic are selectively deposited using drop on demand (DOD) technology, similar to how an inkjet printer dispenses individual ink drops only when needed. In material jetting, the print head is not heated to bind the material. Instead, an ultraviolet (UV) light source is used to cure the liquid resin (Carbon, 2022)

- Directed energy deposition (DED), commonly used to repair or add additional features to existing parts, uses a heat source, such as a laser or electron beam, to melt metal powder or wire (Carbon, 2022).

- Powder bed fusion (PBF), to create both plastic and metal parts, uses a heat source, such as an electron or laser beam, to melt and join material powder to create three-dimensional objects. The powders can come from various sources and materials, but the most common are Polyamide (Nylon), Alumide, Stainless Steel, Bronze, Nickel, Aluminum and Titanium (Carbon, 2022 ; Loughborough University, n.d. ; SPC, 2023).

- Vat polymerization uses a vat, or container, filled with photosensitive liquid resin and a light source to create solid objects (Carbon, 2022).

- Digital Light Synthesis™, where the printed part is then baked in a thermal bath which strengthens the material to achieve the desired material properties, uses Carbon's CLIP™ (continuous liquid interface production) technology to produce functional parts with exceptional surface finish (Carbon, 2022).

Other materials not mentioned previously include Carbon Fiber, Nitinol, Graphite, Graphene and Paper (SPC, 2023). There is also the world of bioprinting, which consists of printing 3D structures using biological molecules or biomaterials. 3D bioprinter has been frequently used in the manufacture of several tissues or organs, such as skin, heart and vessels and so on. 3D bioprinting is primarily focused on three methodologies: the extrusion method, the droplet method, and the photocuring method. It uses biomaterials such as synthetic polymers, Collagen and gelatin, Cellulose and Alginate (Rashid, 2023).

Compared to traditional manufacturing processes, AM allows for a greater level of design freedom. AM has enabled complex geometries to be incorporated into the design of products, through a range of manufacturing techniques including powder bed fusion, directed energy deposition, material extrusion, binder jetting, curing, lamination and more. This variety has allowed a vast array of technologies to be developed that may be of interest to worldwide industries (Leonida, 2022).

The redesign of parts has been made more efficient with AM. If a change in the design of a particular part is needed on a production line, the computer model, in Standard Triangle Language (STL) format, used to print the part can be remodeled and redeployed for printing. This particularity in the production process for AM systems allows parts to be produced without requiring change in tooling or mold, which would be costly and more time-consuming than with traditional manufacturing.(Leonida, 2022). The implementation of AM techniques has allowed multiple parts to be produced together within a single, complex piece. Whereas with traditional manufacturing, we often see multiple parts for a specific product being made individually, to facilitate distribution, assembly and optimize strength. Other features required for assembly of the end product such as brazing or welding and fasteners have now been removed from the process with AM, further cutting production costs. (Leonida, 2022).

I understand that this changes the way one thinks of putting a product together, and that it goes beyond the manufacturer: the creators of products think of them differently. Early on in industrial design school one learns about what is doable with certain processes and materials. But what if it does not matter that this mold could not be in the shape?

The broader adoption of AM for mass production is still delayed as it poses unique reliability challenges because it often entails creating new parts and new materials at the same time. Manufacturers can achieve greater economies of scale using traditional manufacturing methods. When it comes to mass production, AM has been largely relegated to printing complex, high-value parts in select industries, such as transportation (Barclays, 2021 ;Javelin, 2021).

In the most likely scenario going forward, AM will serve as a complement to traditional manufacturing, rather than replace it (Barclays, 2021). This suggests that the industrial design professional, and by extension, the industrial design student will not completely stop thinking about products being manufactured with traditional processes. AM will simply be added to what can be done.

Nevertheless, AM gives designers unprecedented control over the shape and composition of matter. High-end 3D printers can combine multiple materials into arbitrary patterns at a high resolution, leading to the ability to create geometry with fidelity and complexity never before seen (Pearson, 2020). I understand this as an invitation to rethink products and perhaps explore more sculptural endeavors. We can expect some designers to select materials based on AM processes and build the rest of their designs around that as part of their Colour Material Finish (CMF) design (Becerra, 2016), thus allowing them to explore more with materials. And comes the question of how teachings on Additive Manufacturing are implemented in Design Programs, more specifically, Industrial Design Programs

Since North America captured more than 34% of the revenue share of the global AM market last year (Precedence Research, 2023), it might be considered enough of an argument to implement it in the ID programs of this region of the world (Lopez, 2022). But comes the challenges of standardizing curriculums, which is a debate of its own ((Lopez, 2022).

In some Design programs, this quest is already being tackled as surveys amongst their alumni and exercises among current students have suggested that a "positive experience with AM fabrication comes from understanding how the part has been manufactured and also, knowing the successful applications of these technologies in the design and industrial practice" (Kadikjan, 2022, p.692). Some countries, such as South Africa have even aimed to introduce AM at different levels, from primary to higher education institutions (Alabi, 2019), through the implementation of goals such as:

- "developing a short-, medium- and long-term educational framework for AM;
- ensuring school-level interventions to facilitate exposure to AM technology;
- providing widespread access to AM technology at school level, for example, through the establishment of computer labs and computer aided design (CAD) software courses;
- establishing a national AM curriculum for all design and engineering schools within colleges and universities;

- establishing a dedicated bursary programme for both pre- and post-graduate studies in the field of AM and 3DP; and

- securing National Research Foundation (NRF) and DST Research Chairs for AM and to establish national AM centres at strategic locations." (Alabi, 2019, p.757)

All because they saw the value of AM Advancement and its potential to influence our world very significantly (Alabi, 2019).

CONCLUSION

In a program like Carleton University's School of Industrial Design (SID), this type of impact might manifest in the implementation of more consideration to Additive manufacturing in 2nd and 3rd year studio courses, or in the 2nd year Mass Production course. For the sake of ensuring that a student who might not be particularly curious about additive manufacturing, does not, for that reason alone, finish a bachelor's degree in industrial design while not having had a project specifically touching on Additive Manufacturing (i.e, 3D Printing). This would most likely be formulated in the learning outcomes of a course and enough specificity to ensure that the students learn about the subject and are assessed about it, but also enough broadness to ensure that any instructor might bring their touch to the course, and continuing to provide an encouraging learning environment to Carleton SID students (N. Tambay, personal communication, November 24, 2023), (W. Chung, personal communication, December 8, 2023). These modifications would derive from, perhaps, three ways AM changes ID and what the students should know about the field. It is a matter of understanding how it would impact the design process, from an academic perspective, because "positive experience with AM fabrication comes from understanding how the part has been manufactured and also, knowing the successful applications of these technologies in the design and industrial practice" (Kadikjan, 2022, p.692)

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INDUSTRIAL DESIGN EDUCATION'S ADAPTATION FOR THE FOURTH INDUSTRIAL REVOLUTION

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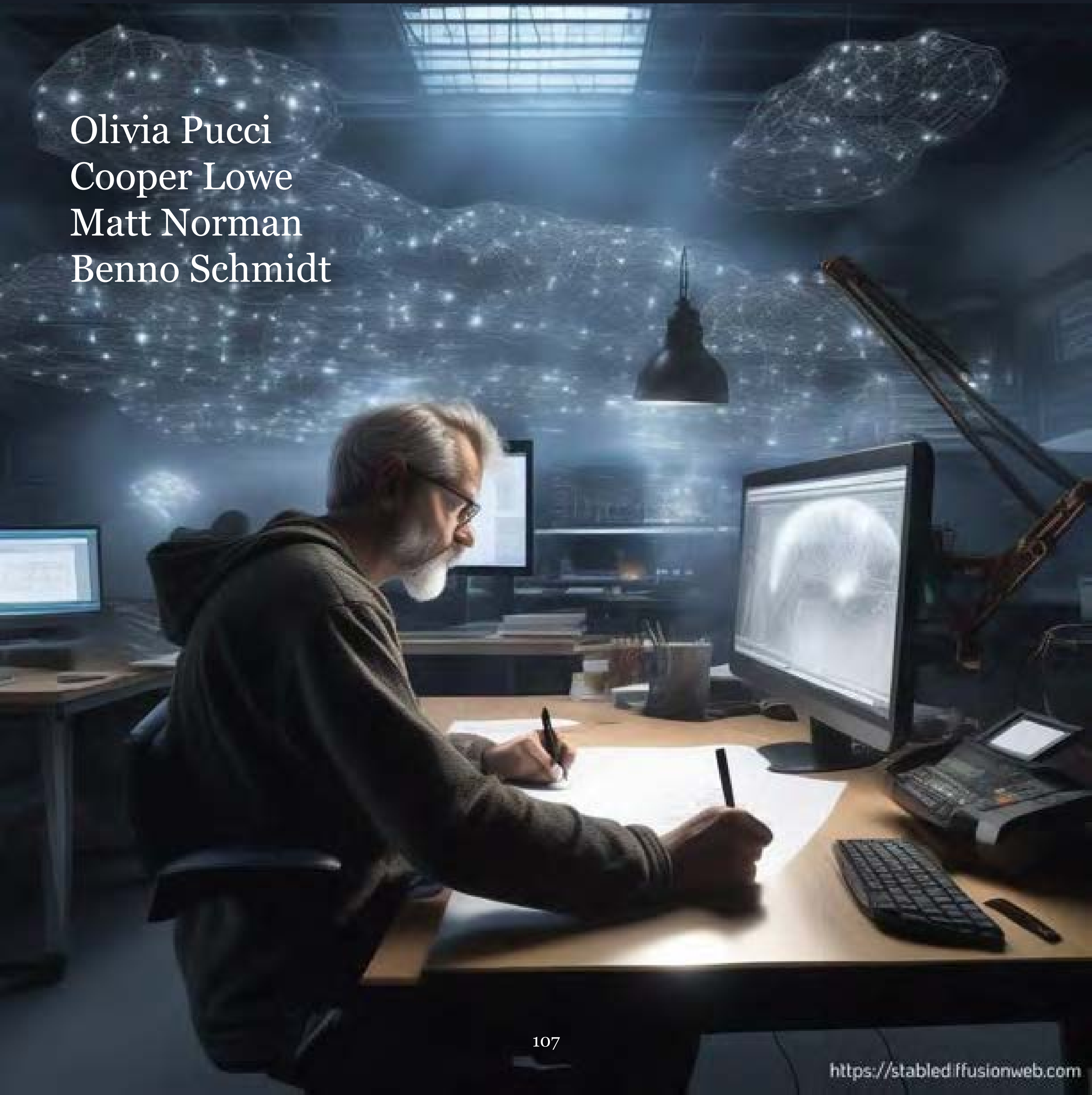

MISOGYNY AND THE 4th INDUSTRIAL REVOLUTION: DISMANTLING GENDER BIAS THROUGH DESIGN EDUCATION

DESIGN EDUCATION |OLIVIA PUCCI

INTRODUCTION / BACKGROUND

Nearly half of students studying industrial design are women – however by the time they reach professional practice, roughly 31% of women educated in industrial design divert from pursuing it as a career (Reuther, 2023). While there are endless factors in a patriarchal society that we could attribute such dramatic attrition, this decline is so steep that it preserves industrial design as a largely homogenous profession of male thinking. This imbalance in the industrial design profession will have negative implications as the throws of the 4th Industrial Revolution brings generative technology (Artificial Intelligence) that may become an ultimately powerful tool in the proliferation of data bias and discrimination. Considering the development and use of AI, it is important that we understand the social and political implications of industrial design, and the responsibility designers have to the morality of design outcomes. To avoid the deepening of exclusionary biases with the advent and use of generative systems, design education can be used as a "bottom-up" approach that teaches the intersectionality of design and gender equality. To guide my research, I have posed three initial questions:

Why is it especially important that women are represented and included in the design of disruptive technologies of the 4th Industrial revolution?

How might we use intersectional feminism in education to positively influence the social responsibility of AI?

How can a critical feminist perspective be implemented into design pedagogy at Carleton's School of Industrial Design?

In this report, I use the under-representation of women in design as an example of cyclical dynamics of bias and oppression. While the premise of my argument of bias in design could be applied to any demographic, gender equality effects half of the world's population and therefor is foundational to overall social equity. From there, I emphasize why understanding cyclical systems of power is a growing threat in the 4th Industrial Revolution due to the pervasiveness of AI. Then, considering that AI is a swift and far-reaching tool for synthesizing and sharing oppressing biases, I examine how education can be used to teach designers of the 4th Industrial Revolution (and beyond) about their role in these dynamics of society and how they can in turn contribute positively. Using the basis of gender equality, I then explore "critical feminist perspective" theory, which uses feminist framework to examine how intersectional thought helps dismantle bias/discrimination of all forms. While relating these themes in my subtopic is complicated, it further illustrates the intersectionality of design.

WOMEN IN INDUSTRIAL DESIGN

Including women in the practice of design has moral and economic obligation. Moral obligation being that gender equality is universally spanning and a human right, while economic obligation refers more to patriarchal society's inefficiency of making effective use of the talents and intellect of roughly half of any population (Arias et al., 2023). "A world designed by men for men isn't just a matter of style, or an issue of preference for women — we are excluding half of humanity from so many of the products being created" (Reuther, 2023). While the inclusion of women in design is undoubtedly the best to date, there still exists disparity in pay and power of female designers (Arias et al., 2023). Patriarchy affects all elements of a woman's participation in society – through limitations and expectations educationally, socially, economically, psychologically, and historically

(Buckley, 1986). "In a patriarchy, men's activities are valued more highly than women's" (Buckley, 1986). The large gender discrepancy in participation and power of industrial designers creates massive homogeny in the field; this is not only problematic for dynamics in the design studio, but for how products are designed alike.

Scarcity of practicing female industrial designers is not largely examined, some attribute teaching and communication styles as a divisive factor in studio experiences (Walters, 2018). Subconscious power dynamics observed in the way men and women communicate are largely learnt behaviors. The observation-based study performed with University of Iowa design students aimed to examine shifts in power dynamics amongst group of differing amounts of male/female identifying students (Walters, 2018). The study found that male oriented leadership was consistent until the group of designers was mostly female (Walters, 2018). This study is rather illustrative of the subconscious effects patriarchal social framework has had on the influence of social interaction. Furthermore, we could assume from this study that women and their ideas/influence often get bulldozed in academic and professional settings in both subliminal and blatant ways (Walters, 2018). The author of the study further highlights that the aim of the research was to identify discrimination in design pedagogy in hopes to reconcile current educational practices for a more equal and responsible future of design work (Walters, 2018).

We generally acknowledge there is a deficit of gender equality in research and development fields such as design, however it is rare that we consider how gender imbalance effects the efficacy and externalities of design outcomes; the products and systems developed by designers. Examined design teams lacking women are found to produce products that lean into female consumer stereotypes and ultimately miss the needs of the user group (Buckley, 1986). The inclusion of women's tacit knowledge improves the design outcomes of any team, regardless of overall skill (Buckley, 1986). Lack of diversity is often lack of perspective in design thinking and conceptualization, which hinders innovation and offers no challenge to bias that every designer, regardless of gender brings to their work. Because of the selectivity of design representation, the way we classify and prioritize types of designers, styles and movements, and production methods may carry bias against women (Buckley, 1986).

SYSTEMS OF POWER

The subtopic section is a place to discuss some of related issues and concerns about the subtopic that your team worked on. Historical background and major concerns about the topic need to be addressed. You should clearly articulate the focus of your argument, provide a concise synthesis of the research context, describe the investigation used to undertake, present your answer to the questions. The evaluation of your report will be based on alignment with the main themes, originality and significance, rigor, coherence, clarity, and communication.

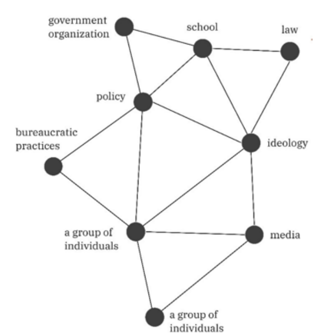

Figure 1. Conceptual diagram of "The Matrix of Domination" Source: (Chopra, 2022)

GENDER INEQUALITY IN THE 4th INDUSTRIAL REVOLUTION

As we enter the 4th Industrial Revolution, we see it define itself poignantly with "cyber-physical" systems. Characterized by disruptive computational technology, the 4th Industrial revolution brings emphasis to connectivity, data, analytics, machine learning/artificial intelligence, human-machine interaction (AR/VR), additive manufacturing etc. The ubiquity of such advancements in our technological landscape undoubtedly offers opportunity for innovation and progress, however, will not be absent to consequential social impact. This large social disruption is not unique to the 4th Industrial

Revolution alone – all industrial revolutions have had dramatic effects on types and availability of labour, culture and customs, and greater organizational frameworks (Sakhapov et al., 2018). Where the 4th industrial revolution begins to diverge from its predecessors is in its intangibility and abstract-ness. Generative technology, virtual spaces, machine learning and the general personification of computational power are artifacts alike – products of human calibration and effort (for now). Just as we see bias conveyed through physical products and systems, we will increasingly be exposed to the bias of data in cyber-physical capacities as well, further exacerbating gender inequality (amongst other systemic inequities).

For illustrative purposes, I will use AI (Artificial Intelligence) as an example. AI is mainly driven by trained data – annotated datasets assigned by their creator (industry tech, research programs, etc.). Speaking generally, artificial intelligence is likened to a vacuum – sucking up all information it's exposed to, searching for patterns, and spitting out whatever aligns most closely with its findings. On a foundational level we all do this, however there are externalities that influence our own outputs – the concept of morality (Hayaski, 2017). Artificial intelligence doesn't have a higher judgement of morality, it analyzes the data it's been given and responds most accordingly. The caveat with the rise of AI is the true autonomy of artificial intelligence. It learns independently and draws conclusions based on analysis of most prevalent patterns. In this way, AI is unpredictable. Engaging AI as an operable member of the workforce or academia is troublesome alone, as it makes inferences from given data about gender, race, socioeconomics, etc. This inevitably reflects in the machine's output (Hayaski, 2017). Used algorithms could become indirect discriminatory tools that will show up in all its generative output (visuals, written output, targeted ads, etc.). Considering gender equality, misogynistic patterns observed from society make up data that feeds machine learning. In 2017, an AI chatbot named Tay was released to Twitter by Microsoft. After engaging with online discourse for only 24 hours, her output comprised mostly of bigoted and sexist rhetoric, simply as a reflection of the comments and questions being directed to the chatbot. After being promptly removed, the designers admittedly claimed to underestimating the impact of uncensored social rhetoric as a basis for generative technology (Hayaski, 2017). While this may be an extreme example, it dramatically demonstrates how bias and cultural norms/values proliferate with technologies integral to the 4th Industrial Revolution. Given the power of such technologies, they are suggested to be under equal guidance of women and to be nurtured through careful change as not to proliferate under male based cultural norms (Hayaski, 2017).

The scalable consequence of such disruptive technology demands integrity and responsibility on the creator's behalf. Moving forward, it will be more important than ever that we consider the intersectionality of the information in which we innovate concepts, build artifacts and systems from. The unabashed innovation of the 4th Industrial Revolution will never be admissible nor avoidable, however its perception and negotiation can be responsibly introduced into society through robust education. We could then consider design education as a frontier for change and responsibility in this sector, as educating next generations of practicing designers of the prevalence of bias can play a role in improving the empathy of future design.

DESIGN EDUCATION'S ROLE IN RESPONSIBLE DESIGN

Design education often involves itself in active learning that begins with theories of design, relating theory to task, and ultimately engages students in a creative process that encourages discovery learning. This educational process involves reasoned judgement, interpersonal skills, reflection, and critical review (Schon, 1987). Design education is experiential and is characterized by series of negotiations with deadlines, constraints, and peers. Studio work in academic contexts is seen as "student-centric" and therefor lends well to the importance of understanding its intersection with socio-cultural diversity (Datta, 2015). The design studio is an environment in which "embedded values and inherited traits are transmitted and social relationships between students, tutors, and peers are cultivated" (Datta, 2015). Overall, the educational design studio is an ideal environment in which the intersectionality of design could be introduced and cultivated. Armed with knowledge about the influence design pedagogy has on student design outcomes, along with knowing that designed artifacts/systems are products of biases in the social environment in which they are created, how can we commit to the future of responsible design without properly informing students of the influences and outcomes of their ideas and concepts?

CRITICAL FEMINIST THEORY IN DESIGN PEDAGOGY

To relate female representation in design and design education for positive change, I introduce "critical feminist perspective" to be used as a component of design pedagogy. Critical feminist theory, despite its name, is not exclusive to the representation of female interests, but rather a tool that uses the premises of feminism (equality, self-agency, etc.) to destabilize power systems. This theory as it pertains to design, specifically focuses on guiding the designer's attention to considering all perspectives during the ideation phase of designing. Generalized intentions behind feminist perspectives in design/design research are to highlight power structures visible amongst design participants, question assumptions and prejudice, and focus initially on those who are typically marginalized. This ultimately leads to a participatory approach to prioritize the user and encourages the most empathetic design as possible. A critical feminist approach to existing pedagogy forces teachers to act as "intentional change agents" that implore transformative theories (such as critical feminist theory) to counter hegemonic-practices and inspire conscious-bound criticality (Roberts, 2021). To summarize, transformative pedagogy (such as critical feminism) will be necessary in combatting all bias in design teaching to "develop a reflective knowledge base, appreciation for multiple perspectives, and a sense of critical conscious and agency" (Ukpokodu, 2009).

APPLYING CRITICAL FEMINIST THEORY AT CARLETON S.I.D.

Applications of the critical feminist theory are not full-stops to rectify systemic inequity and bias in design, however they may help future designers think more holistically about their impact as professionals. Of course, for this theory to be relevant to industries of scale, it must be actionable. From my research on the topic, I am by no means an expert, however, have hypothesized ways in which critical feminist theory could be applied here at Carleton's School of Industrial Design.

Introducing critical feminist theory in our 3rd year "Research for Design" class would be a palatable space to attune students to their own biases and shortcomings. Regardless of gender, race, orientation, etc. – creating a learning environment where it is okay to admit some experiences are unknown to you could evoke empathetic thought that aligns with principles of intersectional feminism. In this environment, the act of forfeiting assumption and admitting not knowing about a topic is humbling and comfortably equalizes and opens dialogue amongst all students, each with unique identities and experiences. Applying this activity to design synthesis may allow for more honest, well vetted concepts that better suit the user, simply because the designers have been encouraged to listen and learn from others' knowledge.

In a less theoretical sense, critical feminist perspective could be integrated into the review of studio projects as well. There is finality in a studio critique, despite many student projects not being anywhere near final in a professional sense. It seems natural to revisit concepts after their final delivery to facilitate dialogue about the product in a more intersectional sense. While the bulk of the studio work can remain focused on technical skill, after final presentations, the class could then participate in a sort of "product post-mortem" in which each student can honestly provide constructive feedback on product viability, sustainability, satisfaction of actual need, social presence etc. This "post-mortem" critique would be less focused on the skill and execution of the project and more of the ideological implications that each classmates perceives individually. To add further integrity to this activity, the students could write their honest thoughts about each product and submit them anonymously to be shared. My thinking for integrating this type of activity to studio is not to "nay-say" concepts and projects, but to possibly use the honest perception of others to gain perspective on diverse ideas and bias that may have been lost on the student during the design process. Additionally, not limiting this activity to ideation alone helps it grow in relevancy throughout the design process.

CONCLUSION

This report explains how design education can be used to combat misogyny in the 4th Industrial revolution by highlighting cyclical power dynamics and the importance of intersectional thought to social equality. To summarize, design and education are significant components of the social framework who ultimately influence individual well-being. Due to the significant impact generative technologies (of the 4th Industrial Revolution) will have on design outcomes and subsequent individual well-being, it is important to understand how easily it spreads damaging bias. The 4th industrial revolution bears technology that is apt to feeding into misogynistic social bias– both in and by design. To mitigate these damaging effects of AI bias in the future, design students should be taught to understand their position in such social power dynamics and how they can contribute to the 4th Industrial Revolution with moral consciousness and empathy – this with hope to dismantle misogynistic systems (as well as other discriminatory practices).

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EDUCATIONAL FOCUS ON PRODUCT END-OF-LIFE

INDUSTRIAL DESIGN EDUCATION’S ADAPTATION FOR THE FOURTH INDUSTRIAL REVOLUTION | COOPER LOWE

INTRODUCTION/BACKGROUND

This report looks at the issue of the lack of educational focus on product end-of-life in industrial design schools, and how it can be effectively incorporated into the current curriculums. More relevant than ever in the fourth industrial revolution, obsolescence is something that is an innate part of all products, yet it is overlooked in terms of teaching it to design students. In this paper, different methods of adding obsolescence education into design schools are explored, as is the viability of making such a change.

DISCUSSION ABOUT SUBTOPIC

Industrial Design in the Era of Fourth Industrial Revolution was given as an overarching theme to pick a subtopic about. Essentially, anything could be chosen as long as it fell under this main theme. The overall subtopic that was chosen by this group to look at is Education in the Fourth Industrial Revolution. This topic is personal to us of course, currently being students that are enrolled in an industrial design education; therefore, we would be well informed starting points ourselves to build off of for this report.

We had many general questions while trying to figure out individual subtopics within this subtopic. We wanted to make sure that what we were tackling was pursuable in the first place, and had enough related material that we could create a coherent report. Three of our main questions were:

- **Overall, how adaptable is the current design education system; is it feasible to incorporate our proposed topics in time to prepare the designers of tomorrow?**

Our first question was an important one for all of us — if our propositions couldn’t be incorporated in the first place, then researching and compiling information in the context of design education would be futile. This question has been somewhat answered by my research, but more so by the state of design education here at Carleton University. Multiple classes have been undergoing overhauls in recent years, such as design for manufacturing and computer applications. This demonstrates that, if needed, courses can be altered to incorporate different elements and projects within a relatively short amount of time. This is a good sign for the potential addition of a sustainability focus. More research needs to be done on the actual incorporation of sustainability in particular, and on examples of it being done in other design curriculums.

- **How is this industrial revolution different from past ones? What does this mean for design education?**

An interesting difference between other industrial revolutions and this one is the amount of time that has passed between the third revolution to this one. In comparison to past industrial revolutions, there has been a much shorter period of time between the most recent two:

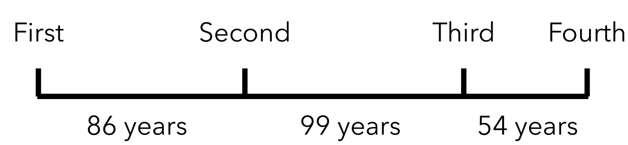

Figure 1. A visual representation of the gaps between industrial revolutions. Source: Lowe, 2023.

I believe this is a result of the ever-increasing pace of innovation. Since the third industrial revolution normalized automated production, the pace of innovation has been growing quicker and quicker. An apt metaphor would be Moore's Law, which states that the number of transistors on a CPU (central processing unit) doubles approximately every two years, meaning that the number of transistors on CPUs is growing more and more rapidly every year (Tardi, 2023). This is similar to the pace of innovation recently — consider the gap between a personal computer, to a smartphone, to a smart watch. Personal computers became popularized in the late 1970s and through the 80s. About 20-30 years later, the iPhone came out in 2007. The gap from this breakthrough to the popularization of smartwatches in the 2010s (Lutkevich & Provazza, 2022) is much smaller than the gaps between the previous innovations. This is only an example, and is not necessarily product specific, but it can demonstrate a trend in the market of a growing pace of innovation. For design education, this poses a challenge — adapting to keep up with this rapid pace. Design education could be rendered useless if the content that students are taught is obsolete by the time they enter the workforce. If this fourth industrial revolution continues the pattern of ever-quicker innovation, then it will be difficult for design education to keep up.

- **How can these new methods and ideas be adjusted for students with different learning profiles and abilities?**

This question has been difficult to answer, although it also got less relevant to us as we realized that the first priority is incorporating the new methods in the first place. We acknowledge that if they are incorporated with different learning profiles and abilities in mind from the beginning, it will be a smoother transition and provide less disruption, but as of now we do not know the ways in which they could be incompatible with these differences. This is very much a case-by-case basis as well. For example, my personal subtopic should not need a revolutionary, experimental teaching method that is likely to be foreign and require adapting — it would likely just be the content itself that would need to be adapted to. This means that it is no more likely to disrupt courses and curriculums than adding or altering a project in a course outline would, as Carleton has done recently. In contrast, a proposal like my colleague Matt Norman's that involves teaching creativity could require a more delicate approach. This is due to it having so much subjectivity by nature, as well as different ways to interact with the A.I. tools that he is exploring. In all, while this question is important to keep in mind to ensure inclusivity, it is not overly pertinent to my individual topic.

DISCUSSION ABOUT INDIVIDUAL WORKING TITLE

The working title that I chose was "introducing an educational focus on product end-of-life". Now, in the fourth industrial revolution, it is more important than ever to think about how a product will be disposed of. We are finally starting to come out of the throwaway society that has been fostered since the 1930s, realizing almost as a whole that the culture of overconsumption is not sustainable on a finite planet. However, even though there has been all of this awareness in recent years to be more responsible with the end-of-life of products, there are very few who are actually teaching the design students of today how to create products that can be responsibly dealt with at the ends of their lives. I had three main questions that I wanted to answer in regards to this specific subtopic:

- **How can we seamlessly incorporate obsolescence education into the current curriculum?**

Introducing more obsolescence education has to be smooth – if it interrupts the design process for either the students or the professors in ways that are detrimental to their learning experiences, it will be treated as an unwelcome addition, and will make a poor impression on design schools. There are two main ways it could be introduced. One would be as a regular stage in each studio project, which would give it the same weight and force the same attention that the other stages of the design process demand. This would make sure that it is taught to young designers as a regular and essential part of design. The other way would be as a dedicated class, whether as an elective or required. My suggestion is to incorporate it into studio so that it becomes taken as the innate part of the regular design process that it should be. We know that adapting the class to accommodate for this is possible because Carleton's own Mass Pro class has been changed in recent years to teach new topics and cover more material.

- **Can the current curriculums be easily adapted to teach obsolescence or will they need to be overhauled?**

The current design curriculum has been taught essentially in the same way for decades. With the fourth industrial revolution upon us, change is needed. The question is whether or not the radical shift in point of view that has been happening in the world of design recently about sustainability can even be adapted into our way of teaching. Simply adding a class or throwing a phase into studio might have too little of an impact – a complete overhaul might be needed if we are going to dedicate our field to being responsible with the end-of-life of our products. While this would be a big change for current students, it could also be a challenge for professors to adapt to whatever this new way of teaching could mean. An example of a class that has recently been overhauled rather than just altered is Steven Pong's fourth year minor studio class (Pong, 2023). It has added some much needed soft goods and electronics content that has been sorely lacking in the rest of Carleton's industrial design program. Granted, overhauling a studio course can be seen almost as routine; depending on the professor, the content and projects are usually different. However, this example is not just changing the brief — it is introducing important considerations and skills that have gone unused and underdeveloped, much like elements of obsolescence. Overhaul aside, however, this also proves that we have been altering the curriculum in ways that could make enough of an impact to redirect the course of design education towards obsolescence relatively regularly.

- **What kind of grading scheme would be effective for emphasizing the most important obsolescence considerations?**

It is unlikely that the whole range of product obsolescence could be tackled during the amount of time that would be available if it were to be incorporated into a studio class. A choice shouldn't have to be made out of materials, repairability, recycling programs, universal style, etc. — they should all be taught. Currently, the priority for incorporating obsolescence education is quantity over quality. The more exposure that students get to the concept of product end-of-life responsibility, the more they will consider it on their own, and the more they will try to incorporate it into their designs. Different products will undoubtedly be served in different ways to make them renewable more effectively, so grading on such a case by case basis may be difficult. On the other hand, this is how design grading works in the first place. If the student can explain how the product would be obsolete, as well as how they plan to address that obsolescence, then that would meet the criteria for the class.

These three questions have been very helpful for determining how to go about incorporating obsolescence education into design education, but they all work on the assumption that design education will always be around. In ***The Future of Design Education is… No Design Education***, Yazin Akkawi (2017) argues the notion that creativity and innovation can be more effectively spurred by varied life experiences rather than by university degrees. They argue that with the increase in relevance of user experience design (the design of interactions between products or services and the user, also known as UX design), physical design is holding less importance. While knowledge of traditional design principles are still essential, a majority of design students today are learning these instincts and intuition outside of their courses. This is probably because UX is still a new field, but it could also be due in part to the growing number of tools and resources available online for designers today. I believe that this strengthens my argument for sustainability education in design. While the creativity element of design may be better developed experiencing the world, in my opinion there are tangible things that can more efficiently be taught through design education. This includes, among others, software skills, physical prototyping skills, material design and manufacturing, and (pointedly) how to design sustainably. All of the creativity in the world can be wasted if the designer has no knowledge of how to apply it to real life designs. If design education were to be truncated to allow for the development of innovation through knowledge of different disciplines, like this article suggests, then there would be more space in the curriculum for these design specific topics. This would in turn allow for more in depth incorporation of sustainability and obsolescence education.

Park, Licon, and Sleipness argue in their 2022 study _Teaching Sustainability in Planning and Design Education: A Systematic Review of Pedagogical Approaches_ that introducing sustainability education can help students to develop design thinking and planning skills. The fact that students address complex, real-life issues while making their projects more sustainable helps develop their problem solving skills, critical thinking, and important contextual methods of looking at design. However, they also acknowledge that the professor's cooperation and motivation is essential to effectively teaching

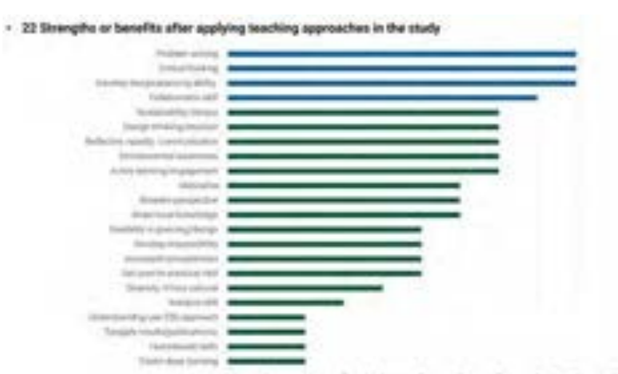

Figure 2. Benefits of teaching sustainability in planning and design education. Source: Park et al., 2022.

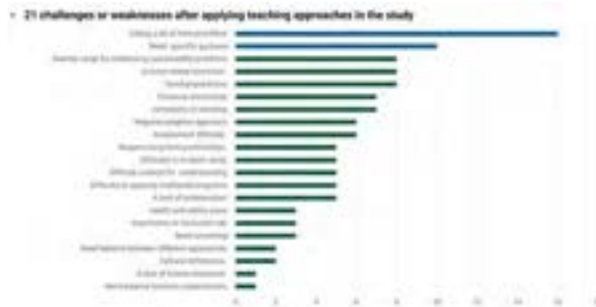

Figure 3. Challenges of teaching sustainability in planning and design education. Source: Park et al., 2022.

sustainability. They suggest that teachers might need more specific training, or in some cases more knowledge and experience, of obsolescence and its complexities. Their research shows that teaching sustainability in the ways that they suggest clearly benefits students, and that the likely extra time and effort that might be required by professors is more than worth it not just for understanding obsolescence, but developing design skills in general.

The fact that design education needs to adapt to keep up with current times is explored by Don Norman and Michael W. Meyer (2020) in _Changing Design Education for the 21st Century_. They argue that the requirements and opportunities for design have expanded dramatically; that new methods, materials, tools, today's emphasis on connectivity and media, and more have made the design landscape virtually unrecognizable in comparison with its origins. Work patterns and studio consistency has also changed, as has the scale of problem-solving that is being asked of designers — tackling climate change, for instance. With all of these changes to the industry, design education is struggling to keep up. They argue that some evidence of this is the lack of designers in high-level positions within government and other organizations. A broad view of different disciplines is required, and design education in general has not provided this to its students. They suggest the convening of interdisciplinary educators and thinkers to develop a powerful and flexible template for the education of design, emphasizing a broad base of knowledge and experiences (Norman & Meyer, 2020). I believe that this effectively supports my argument that design education is slowly adapting, and needs change. I think that their viewpoint on the interdisciplinary nature of design education is somewhat pessimistic based on my personal experience, but I acknowledge that that aspect can certainly be improved. A restructuring of design education now, in the fourth industrial revolution, would no doubt pave the way for better teaching of sustainability, and open up space and time for the education of professors on how to teach this effectively to the satisfaction of Park, Licon, and Sleipness (2022).

CONCLUSION

In conclusion, the incorporation of obsolescence education into current studio classes is impeded by the need for professors to first learn how to effectively teach it. With design curriculums being stagnant in the face of industrial revolution, it is more important and time-sensitive than ever to introduce this essential element of the design process to the designers of tomorrow. Three studies have served to support my argument by demonstrating the potential futility of some current aspects of design education, exploring benefits and challenges of incorporating sustainability education in their place, and emphasizing the importance of adapting design education to involve these important elements in a timely manner. Backed by these sources, I believe more than ever that we need to design with obsolescence in mind, and teach design students how to do so as soon as possible. We are at a tipping point in the world's environment — every little bit can help. My proposal, however, is more than a little bit. It would ensure that an army of designers come into the workforce with the foresight and ability to be responsible with the ends of their products' lives right from the beginning, something the industry as a whole has been sorely lacking. This new mindset becoming the norm would be extremely impactful, and could help bring the world back from the brink of catastrophe.

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Ensuring Industrial Design Education's Pertinence to its Profession Within the Context of the 4th Industrial Revolution

Industrial Design Education's Adaptation for the Fourth Industrial Revolution | Benno Schmidt

Introduction / Background

Amidst the unprecedented developments of the Fourth Industrial Revolution, this paper investigates the necessity of ensuring the pertinence of industrial design education to its profession, emphasizing the need for adaptation to this rapidly evolving technological landscape in order to sustain the significance and importance of design education through this era. This topic will be explored through the following series of questions which will guide research and analysis, providing a concise and cumulative response to the initial inquiry. Firstly, in order to produce individuals adequately prepared for the workforce, what changes in industrial design pedagogy are required to provide its students with knowledge, skills, and abilities directly relevant to current design industry? Then, how can universities and colleges form a succinct standardization across institutions, certifying a likeness in quality of graduates, while enabling specific program individualization and specialization? Finally, with the establishment and growing popularity of various stand-alone independent educational design courses, how can industrial design programs operating within a traditional institution ensure their relevancy and justify enrolment for young people looking to enter the profession?

Discussion about Subtopic

As a team composed of students enrolled in an industrial design program, exploring the topic of industrial design education's adaptation to the fourth industrial revolution seemed very fitting. Although it may be a challenge to maintain an unbiased perspective, which in turn may unintentionally impact research and resulting synthesis, the personal experience of the given context provides a strong subjective drive to investigate this topic through objective methodologies.

Contemporary western design education is credited with originating during the 19th century when the formation of various European and American institutions, including The National Academy of Craft and Art Industry (1818), The Royal College of Art (1837), and The Rhode Island School of Design (1877), brought an educational structure to the arts and crafts movement (Bürdek, 2015). During the early 20th century, the Bauhuas School was created, bringing a new approach to design education which focused on "the development of a new formal [design] vocabulary based on experimentation and craftsmanship that would do justice to the industrial manufacturing process" ("The origins" n.d.). Bauhaus spearheaded an important shift in design education; from that of an artisan's trade to an educated discipline, bringing a sense of legitimacy to the teaching of design as part of academia. This coincided with the initial professionalization of design (Meyer & Norman, 2020). Throughout the 20th century, this heavy emphasis on craft skills, treating design as an applied art, transformed with the development of human-centred design and integration of modern technologies. Then came digital tools and global diversification which gave way to the current state of design: an independent discipline with associated educational programs (Bürdek, 2015).

The current overlying concerns about industrial design education revolve around the rapid integration of evolving technologies, the need for interdisciplinary skills to collaborate effectively, the growing emphasis on sustainability and ethical design, adapting to the globalization of design practices, promoting diversity and inclusion, ensuring adaptability to industry changes, and addressing the varied challenges arising from a post-pandemic landscape. The field is navigating a dynamic development that demands a balance between technical expertise, global awareness, and responsiveness to industry shifts, all while preparing students for an increasingly interconnected and technology-driven future. Within this paper, focus will be on ensuring industrial design education's adaptability and relevance to its associated industry within the context of the fourth industrial revolution. This comes at a time when the perceived value of design education is rapidly declined due to a failure to keep pace with technological progress, meet evolving industry requirements, and bridge the gap between traditional curricula and the dynamic demands of the contemporary design landscape.

Discussion about Individual Working Title

Currently, design fields in general are experiencing a momentous paradigm shift caused by the fourth industrial revolution. As the result of an ongoing information revolution, technologies and human activities are more interconnected than ever, blurring the lines between biological, physical, and digital. The extreme rapidity and variety of current technological, social, and economic breakthroughs vastly surpass any precedent, effectively transforming entire systems of production, management, and governance (Schawb, 2016). This stands in direct contrast to the resistance to reinvention commonplace among educational institutions due to an associated identity formed by proven long-standing views and beliefs. To elaborate, tacit knowledge is transmitted through examples of exemplary work, engaging students in a process of learning by doing under existing frameworks and recognized problems. This is based off the last paradigm to shift pedagogical practices and persists until these methodologies are proven to be inadequate to current problems and contexts, initiating a new evolution. This can be seen in the texts, lectures, and curriculum which codify established theories, therefore emerging after a paradigm shift. Although it can appear to be a continuous adaptation to industry shifts, it is in fact a delayed process. This is summarized neatly by Akkawi (2017): "because of the velocity that the tech industry changes today, traditional universities and design schools are having difficulty continuously updating their curriculum to prepare emerging designers for real work.". This is the current state of design education, where students are working within a curriculum built off industrial-era practices which fall short of modern problems, contexts, and practice (Davis & Dubberly, 2023). This presents an inherent problem faced by educational institutions: how can their students be provided with knowledge, skills, and abilities directly relevant to current industry independent of the pedagogical lag? A good place to start can be found within a quote from Gadi Amit, head of a major Silicon Valley industrial design studio, "The first five years in a designer's career are absolutely critical and the true educational experience" (Amit, 2011). Here, Amit lays heavy emphasis on the fact that American industrial design programs have lost touch with industry causing employers to look beyond educational accreditation, rather focusing attention on portfolios. His statement, alluding to the fact that industry experience is more valuable than educational, posses a solution to the problem: get students immersed in industry as early in their degree as possible. It is commonplace for industrial design students to be required to take part in a co-op or internship work term. This provides them with key experience in a role relevant to their career and usually results in a wealth of knowledge and insights. However, these work terms usually occur during the final years of a degree, meaning students miss opportunity to get first-hand experience during the early years. Therefore, there lies an opportunity of integrating industry-related experience during the initial years of a degree. A proposal voiced by Meyer & Norman (2020) and echoed by Davis & Dubberly (2023) suggests the integration of multi-year collaborative projects with teams composed of students ranging from first years to those completing their theses. This would allow for upper year students to learn the role of leadership and team management, imparting their knowledge and skills (especially those learned during their work terms) on their younger colleagues. The thesis (or capstone) project, commonplace in the final year of design degrees, could be restructured to include a team of younger students, participating in a multi-year project. Where most design programs focus on one-off experiences, this would provide depth and development to a project not currently seen (David & Dubberly, 2023). Students starting their degree would receive insight, advice, and knowledge from those who empathize with them, having recently shared the same position. Furthermore, they would become familiar with the role of followership, operating within a team context, a skill equally, if not more, important than leadership. The experience gained from industry placement would be passed down in an environment familiar to the pupil, providing understanding and confidence for their work term in later years. Creating more opportunities for cross-year collaborations such as this would be an effective method to ensure students gain industry-relevant knowledge and skills to prepare them for professional work, combatting the curricular lag of design education.

"Academic design programs are crippled by blurry standards which are so vastly different from program to program that it is nearly impossible for me, as an employer, to have a reliable idea of what skills a student toting a design degree can be expected to possess." (Amit, 2011)

This is a sentiment that rings true across industrial design studio's hiring teams, forcing them to put more weight on portfolios and evidence of skill rather than academic credentials (Amit, 2011). As highlighted by Meyer & Norman (2020), industrial design education is mostly taught at two kinds of institutions: stand-alone design schools with no association to a university (such as Rhode Island School of Design), and design departments located within a large university (Carleton University's School of Industrial Design). Although you may graduate with the same degree regardless of which type of institution you attend, your skillset will differ greatly. Stand-alone schools emphasize practice, with priority on design work of students. Schools operating within a university on the other hand, concentrate more on research activities and academic principles than practice itself (Meyer & Norman, 2020). According to Amit, this presents itself to be very problematic; how can he, as a studio owner, trust the abilities of potential employees if their skillset can range so vastly depending on the institution they attended? However, on the contrary, the specialization inherent in a lack of standardization can present itself as a positive: would you not want a selection of graduates with diversified abilities rather than homogeneous? This raises the question of how is it possible for design education to bring a level of standardization to its varied programs to ensure a baseline ability among graduates, while allowing for individualization and standardization? Here, Meyer & Norman (2020) bring forth an example from the business world. In 1959, the state of business programs in higher education was in shambles due to too close relations with industry. This resulted in the Ford and Carnegie Foundation issuing reports covering the shortcomings of business education. Within these reports, was a set of baseline requirements and frameworks institutions could use to construct curriculum that would effectively serve their students (Meyer & Norman, 2020). After 30 years, the major principles outlined had been implemented, resulting in very effective change. Meyer & Norman suggest a similar approach for industrial design education; commissioning a study, headed by a neutral party, which includes participants from practice and academia (within and outside of industrial design). If executed with care, this would enable institutions to get an over-arching view of the state of design pedagogy grounded in statistical certainty. Rather than defining a single model for curriculum, it would instead provide a model that is based on evolutionary, diverse, and experimental practices. However, it must adhere to a baseline standardization. This is where the notion of a tiered curriculum would be useful. Integrating a two-part curriculum, with the first encompassing core topics required in every institution and the second enabling distinguished electives. This would enable independent schools of design, as well as those part of a larger institution, to play to their own strengths, creating a workforce that is reliably capable yet diversified in talent.

The place of design education as a staple in the trajectory of a designer's career has always been contended. The necessity for designers to constantly adapt to this developing field leads many to seek additional resources to ensure adaptability. According to the 2021 Design POV Census from The Professional Association for Design, 57% of polled designers seek online training opportunities to further their skills, abilities, and knowledge (AIGA, 2021). As a result of the success online training courses experienced with practicing designers, they have moved to encompass a new group – the design student. The educational design landscape during a global pandemic, causing the closure of in-person classrooms, creating a huge opportunity for these online academies to draw students away from traditional educational institutions. Offsite, an online course-based industrial design program from Advanced Design, experienced much success during this time, marketing themselves as "everything that your traditional college isn't" (Noe, 2020). Hector Silva, the founder of Offsite, speaks to the reason behind creating this program:

"Students have been continuously frustrated by the quality of their education. The all too common story is that of professors who have not been practicing in industry for over a decade, and resultantly, don't have their finger on the pulse of industry. Then you mix in the COVID-19 pandemic, and when forced into remote learning, students are beginning to question what they have been paying tens of thousands of dollars for all along." (Noe, 2020)

Silva perfectly highlights the position industrial design students are currently in, facing the decision of sticking to a traditional educational institution with all the existing faults, or seeking independent design programs that lack the formal accreditation but arguably prepare you much better for your design career. This poses a problem to these traditional institutions: how can they ensure their relevancy and justify enrollment for young people looking to enter the industrial design profession? The traditional factory-model education system is definitely dated and often quite ineffective in the modern context, however it does still contain certain benefits (Rose, 2012). Within the two kinds of design institutions, the program as part of a larger university, can take great advantage of its position within a campus. As suggested by Meyer & Norman (2020), design departments can integrate cross-departmental electives which aid to provide a balanced education necessary for the modern designer. Where online academies struggle to find instructors from scientific backgrounds such as cognitive psychology, universities have a plethora available. Focusing on these inherent advantages posed by association with a large institution will ensure these design programs remain relevant. Furthermore, as Silva points out, the lack of practising instructors within these programs creates a disconnect from industry. Hiring more part-time working professionals, mirroring what these online academies do, would aid traditional institutions further. The suggestions made earlier in this paper, increasing pertinence among design pedagogy and standardization cross-program, would also aid in justifying the opportunity cost of a traditional industrial design degree.

Amidst the unprecedented developments of the Fourth Industrial Revolution, this paper investigates the necessity of ensuring the pertinence of industrial design education to its profession, emphasizing the need for adaptation to this rapidly evolving technological landscape in order to sustain the significance and importance of design education through this era. This topic will be explored through the following series of questions which will guide research and analysis, providing a concise and cumulative response to the initial inquiry. Firstly, in order to produce individuals adequately prepared for the workforce, what changes in industrial design pedagogy are required to provide its students with knowledge, skills, and abilities directly relevant to current design industry? Then, how can universities and colleges form a succinct standardization across institutions, certifying a likeness in quality of graduates, while enabling specific program individualization and specialization? Finally, with the establishment and growing popularity of various stand-alone independent educational design courses, how can industrial design programs operating within a traditional institution ensure their relevancy and justify enrolment for young people looking to enter the profession?

Conclusion

This paper investigates the place of industrial design education in a modern designer's career, insisting on ensuring its pertinence to industry, within the context of the Fourth Industrial Revolution. From the Arts and Crafts Movement to the contemporary design landscape, the evolution of design education reflects a dynamism between traditional pedagogical techniques and the demands of rapidly advancing technology. In order to ensure relevancy to industry, industrial design programs need to integrate industry-related experiences early in a degree and could benefit from a restructured approach to final-year projects which brings together students across years in a collaborative opportunity. Addressing the challenge of lacking standardization across design programs, a large study needs to be commissioned to provide calls to action integrated through a tiered curriculum model that balances core elements with elective specializations. The impact of online design courses forces traditional institutions to leverage their existing strengths to justify and ensure their relevance amidst emerging alternatives. The overarching focus remains on ensuring pertinence, adaptability, and industry readiness within the ever-evolving landscape of industrial design education.

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CREATIVITY AND DESIGN EDUCATION IN THE 4TH INDUSTRIAL REVOLUTION

DESIGN EDUCATION IN THE FOURTH INDUSTRIAL REVOLUTION | MATT NORMAN

BACKGROUND

Throughout history there have been several industrial revolutions. With each industrial revolution there is a need to adapt and overcome the challenges faced at the time. Industrial revolutions mark significant shifts in human history because of the revolutionizing of economies, societies, and technology (Hobsbawm, 1962). During the first industrial revolution 1760-1840 the introduction of mechanization, steam power, and factory systems displaced skilled labourers due to an increase in automation (Hobsbawm, 1962). People faced harsh working conditions in factories, inadequate labor rights, and large-scale displacement of rural communities as their work was outsourced to automated factories (Thompson,1966). To overcome these challenges people had to adapt to the technological changes being made to remain relevant. During the second industrial revolution, people faced similar challenges as more advancements were made in mass production of goods. Again, people faced labour exploitation, wealth inequality and unsafe working conditions (Thompson, 1966). To adapt they had to demand for more equal rights and working conditions (Thompson, 1966). The third industrial revolution is marked by the growing presence of digital technology, computers, automation, the widespread use of electronics. The internet and telecommunications transformed the professional landscape. More shifts in the job market were caused due to the increased automation and digitization of workflows (Rifkin, 2011). People now faced increasing division between people who had access to technology and those who do not. This created more class division and wealth inequality (Castells, 2000). To overcome the challenges they faced, education on technological skills were required to gain the skills required to remain relevant (Castells, 2000). We now find ourselves in the fourth industrial revolution where the emergence of Artificial Intelligence is becoming increasingly prominent. The connectedness between physical, digital, and biological, domains are becoming more salient. People living through this industrial revolution are required to adapt to remain relevant in professional practice. The need for upskilling the workforce to adapt to this rapidly changing technological landscape is daunting.

As Designers we explore the realm of creativity as a way of problem solving. What does this mean for us? With the increasing improvement of generative AI technologies, many argue that the creative is becoming obsolete (Marche, 2023). Problem solving as a skill will always remain relevant, but will our creativity remain relevant? Obviously, there will be a need to adapt to the landscape we find ourselves in, but how do we do so in an efficient manner? What is authentic human creativity and how do we preserve it in this age of generative tools? Creativity is the use of imagination or original ideas to create something, inventiveness (Oxford university press, 2004).

As it has been required in the past industrial revolutions, adaptation of education material and methods is now required again to allow students to learn the skills required to succeed outside of the safety of educational environments. Ai applications are already being used in professional practice and will become more powerful and more available. But how will students know how to use them to their advantage and not to replace themselves without upskilling through education?

QUESTIONS

I put forward two questions I am looking to answer in the following pages of this paper:

Will AI help or hinder creatives? And how can we integrate AI into creative learning experiences while preserving human involvement and authenticity?

CONTEXT

Through secondary research, I explored AI applications for designers in professional practice, AI applications on a larger scale that may be disruptive to large scale industries, and AI applications for design education specifically. The latter led to exploring how we should teach students to use AI to enhance the level of work they are able to execute. Our group began by exploring ideas we would collectively find interesting to research. We started by deciding to explore the idea of sustainability in the fourth industrial revolution. But after further discussion, we decided to shift our focus to design education and how it will need to change to adapt the 4th industrial revolution. We all believe that design education has prominent gaps in the curriculum that need to be filled. Furthermore, these gaps need to adapt and change to the current environment we will find ourselves in once we graduate. Focusing on creativity in design education and how AI will affect it seemed very relevant and interesting. Current design education curriculums teach many methods of generating creative solutions by using techniques like bisociation, brainstorming, mind mapping, metaphorical inspiration, cross-pollination, and more. With the new AI tools emerging, students are beginning to use them to generate ideas and organize data, but will the misuse of these tools cause us to become dependent on AI as a replacement for our originality?

One of the first articles read was entitled *'Changing Design Education for the 21st Century'* (Norman et al., 2023), an article featuring Don Norman where they discuss the changes that need to be made for design education. In this article they emphasize the gap between the very quickly evolving design field in comparison to the stagnant nature of design education in general; this further emphasized the urgent need to adapt design curricula to maintain relevance to the professional industry. With a focus on the technological advancements being made now: AI automation, interdisciplinary collaboration, synthetic user research etc. Don Norman aims for more dynamic, adaptable, future-oriented education systems, hoping to bridge the gap between education and professional practice (Norman et al., 2023).

REDUCING BIASES IN RESEARCH WITH EDUCATION

Through more readings exploring AI tools and their risks and benefits, I have formed a solid foundation of knowledge to build my answers. AI tools have many benefits for creatives, but the way you learn to use AI directly affects the outcomes you receive (MIT Media Lab ,2023). Therefore, it is very important to train designers about these tools and the specific ways you can use them to increase the caliber of work you are able to create to supplement non-AI-generated content. One of the big issues related to AI tools is the validity of information and the biases that are inherently present in the data that it synthesizes (MIT Media Lab, 2023). Using these programs as a sole source of information is one of the fastest ways to replace the relevance of the designer. For example, a student using Chat GPT to write an essay may ask the program questions as if it were a regular search engine, without filtering through the vast amounts of information these typically provide users. In asking these AI search engines to answer questions about various topics and presenting these finding as factual, without necessary references or understanding, the student is circumventing the process of knowledge synthesis, by being taught *what* to learn, as opposed to *how* to learn. This is a crucial mistake because the sources the AI finds the information from is not known and it is not possible to verify immediately whether the information sources are biased or not. To avoid this, the students must be taught to feed the AI with nonbiased data and then use it as a tool to synthesize larger, overarching concepts and themes. The students need to be taught to use this tool to synthesize and summarize ideas quickly to work at a faster pace while maintaining their cognitive independence from the AI. Thus, they will be using the output as a part of the process and not replacing the process all together. A research paper written by MIT Media Lab (2023) explores the relationship kids in K-12 schools have with AI tools. They argue that it will be inevitable that all kids will use AI in schools and as a result, it is our responsibility to teach them how to do so properly; "As AI changes how we live, work, and play this raises the critical question, 'How do we best prepare students to flourish in the era of AI?'" (MIT Media Lab, 2023). To give future generations the best possible chances of being successful, we need to adapt to incorporate the new tools and technologies that are emerging. At the same time, we need to consider the significant risks involved with using these tools in schools. In the MIT Media Labs research paper, they conduct three lessons to inform students on the risks and biases prevalent in AI tools. In the first lesson, they aim to teach students about information bias present in Ai tools:

> "Using Google's Teachable Machine, they train a cat-dog classifier with two datasets: one biased (over-represented cats) and another with equal representation of dogs and cats. They compare the accuracy of the classifiers and discuss fairness in outcomes. This leads to a discussion about bias in facial recognition algorithms, referencing a video highlighting this issue." (MIT Media Lab, 2023)

In the second lesson, they introduce the idea of algorithms as opinions and stakeholder analysis:

> "Algorithms as Opinions and Stakeholder Analysis: This lesson introduces Cathy O'Neil's concepts- algorithms as opinions and

> stakeholder analysis using an ethical matrix. Students develop an algorithm for making the 'best' peanut butter and jelly sandwich, prompting discussions on defining 'best' (taste, health, speed). They then explore stakeholders in the PB&J process, considering various perspectives like the child eating the sandwich, parents, healthcare professionals, and suppliers." (MIT Media Lab, 2023)

In the third lesson, they show students the ethical implications of AI and how it affects everyday people:

> "Redesigning YouTube's Recommender System: The final lesson involves a paper prototyping activity where students redesign YouTube's recommendation system. They identify stakeholders in the system, understand their values, and use an ethical matrix to determine the goal of their version of YouTube's recommendation algorithm. This activity encourages students to think critically about the impact of algorithms on users and society, considering ethical implications in algorithm design." (MIT Media Lab, 2023)

In summary, the MIT media labs group aimed to educate students on the issues involved with, AI including information bias, ethics, stakeholder perspectives and algorithm design, urging students to think critically and ethically about the development and implementation of this technology. The main takeaway from this section of study is the emphasis on education and rapid adaptation of new technology. It is important for educational structures to continuously evolve to maintain a position of beneficial influence and relevancy.

Continuing to explore more AI tools and ways to reduce information bias, I found Chat-GPT's GPT Builder tool extremely hopeful. This tool allows the user to feed the AI with pre filtered data (research papers, articles, statistics, manuals, textbooks, classical literature and more) to train individualized AI experts. This allows for more confidence in insights gained from these programs and gives users a chance to work with a multidisciplinary team from the palm of their hand. It is a possible way to decrease information bias while increasing the effectiveness of the tool. It is still important to cross reference insights with our own opinions and data; this tool still contains ethical issues, as per the OpenAI website itself (Nandbox, 2023), though the direction of these types of tools seems to be moving in a more unbiased direction. Currently, the main benefit of this tools is that it gives the user the ability to ask industry specific questions to a specifically trained industry professional of sorts; this provides us as designers is that we can work as a team while alone, giving us access to the knowledge and expertise of engineers, cognitive scientists, psychologists, marketers, businesspeople and more. The customizability allows us to create the expert we are looking to speak with, further empowering individuals and reducing current restrictions caused by socioeconomic status. Anyone can access these tools at a much lower cost than university education and empower themselves with a personalized multidisciplinary team.

MEDICAL RESEARCH AND AI

I began looking at more abstract ways to use AI for creatives, and more specifically, designers. Referencing Mclean's magazines articles titled *'The Future of AI'* (Sultan, 2023), I explored some more imaginative ways people have envisioned AI being used. These varied from extremely hopeful and beneficial concepts to very morbid and terrifying ideas. The article titles are as follows: 'Ai Customer Service'; 'Machines That Will Read Our Minds'; 'Robots Will Cure Loneliness'; 'Sex Bots'; 'AI Enabled Scams'; 'Political Deepfakes'; 'Autonomous Weapons'; 'Ai That Will Make Our Food Tastier and Healthier'; 'Worldwide Cyber-Attacks'; 'Studios That Will Steal Identities'; and 'New Drugs in Months'. One concept I wanted to touch on is the idea of AI for medical design and what it could allow us to do.

> "Personalized, preventative medicine: A few hospitals are already leveraging AI and seeing great results. At the Vector Institute, where I work, we collaborated with Unity Health Toronto's St. Michael's Hospital to implement an AI model trained on historical data that determines which inpatients are most at risk of escalating to the ICU or dying, based on metrics like age, biological sex and vital-sign measurements. The hospital implemented this algorithm in 2020, and even in the context of the pandemic, it reduced ICU escalation and death by more than 20 per cent. We estimate that this translated to about 100 deaths avoided annually, and staff report that it has relieved stress and workload, allowing them to focus their attention on patients who need it most." (Sultan, 2023)

Considering all the risks involved with this technology is important, but it is also crucial that we leverage the benefits it can have for humans as a species. Specifically, its ability to organize and connect data and ideas to visualize large, wicked problems that we may otherwise not be able to solve effectively. Teaching this type of workflow in medical education may be able to access problem-solving solutions on a larger scale. Thus, the scalar implications of these new technologies are unlimited, and could create broader, and more far-reaching solutions to complex problems if taught effectively.

SYNTHETIC USER RESEARCH

The next area of AI applications I looked at is *synthetic user research*. This is a type of research that takes data from a suspected user group and creates millions of profiles that simulates the target group, then testing products such as user interfaces, websites, products and more, using this group (SyntheticUsers, 2023). This essentially allows designers to do mass-scale user testing without having to expend the financial undertaking of testing a product on a large scale with real people. The benefits of this are that designers could do a smaller initial round of testing with real people and then feed that information to the AI tool and then upscale the results to view larger, overarching trends. It seems to be a powerful tool that will revolutionize the way we work as designers (SyntheticUsers, 2023), but it is important to consider the ethics involved with this tool as well. To remain human-centered designers with users in mind, we must maintain a connection with our target user group. It is difficult to imagine designing products for a user we have never actually interacted with, and I believe it is important to keep this in mind when we use these tools. Similarly, to other tools and techniques explored earlier, it is important we use these tools in conjunction with authentic human work to cross-reference and maintain the validity of our work.

AI IMAGE GENERATION: ILLUSTRATING LEARNINGS

Throughout my research, I was constantly searching for some kind of imagery or metaphor to embody the vision I have for the future of AI tools for creativity and design education. This technological advancement is far more influential and powerful than any other development in the past. Comparing this development with previous industrial revolutions and incorporations of technology proved to be difficult. Even comparing AI to the first use of computers wouldn't fully show the implications it truly has on our industry and focus of study. I decided the best way to show it was to compare it with ourselves as the creative designers that are trying to revolutionize the way we interpret the world. As a way of using the tools discussed in this paper, I used an AI image generator to illustrate my understanding from my research on the topic. I prompted the AI (Stable Diffusion) with some ideas about the way I envisioned our future with AI. These prompts resembled: "industrial designer sketching with clouds of ideas floating above his head", which were relatively straightforward and yielded results similar to what I had envisioned in moments. In *Figure 1 (below)*, we see ourselves, the designer, sketching and prototyping, trying to find new ways to illustrate ideas and form new concepts to aid people in our society. The ballons or clouds of ideas floating around in our minds are seldom easy to connect into larger systematic structures. The feeling of creative writer's block is a familiar experience among all designers and all creatives. This feeling can be extremely limiting and restrict the pace at which we are able to execute our ideas effectively. In *Figure 2 (below)*, we see a designer using AI tools to enhance their work effectiveness. The ideas floating around their mind are glowing in interconnected clouds of information, forming a network of concepts and ideas in a systematic way to aid the development of larger solutions to the problems we face.

Figure 1: Designer without AI tools

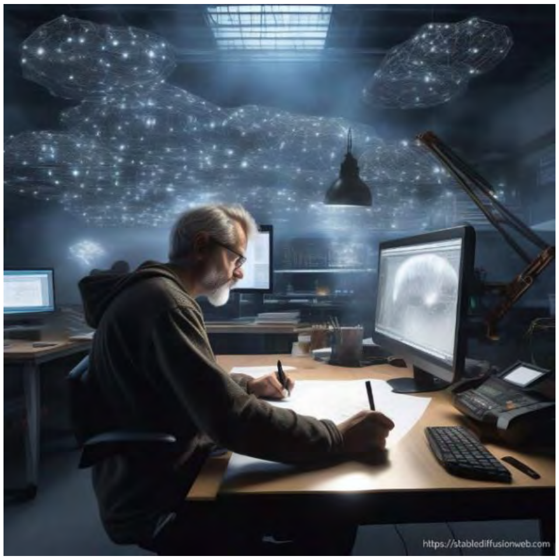

Figure 2: Designer with AI tools

CONCLUSION

This is by no means a singular solution for any problem. It is crucial we consider the risks involved with using these tools in our profession. After research into the risks and benefits involved with our creativity and our education as designers, it is clear the adoption of these tools is important for the future of design education. Further, it seems from the literature that it is much more important to educate students adequately on the risks involved with using these tools, than the integration of these tools themselves in academic settings. By doing so, we will be able to limit the consequences that may ensue. Students will use the resources they have at hand whether it is encouraged or not. As a result, it is the responsibility of educational structures to teach students how to mitigate the negative outcomes while it is possible. To preserve and foster the authentic human creativity we search for and desire in this profession, it is imperative that we educate students on how to use these tools properly and not to replace one's authentic creative ideas. Ai tools should be used in conjunction with authentic human work to cross reference and support concepts or ideas being explored.

To conclude, I will answer my research questions. Will Ai help or hinder creatives? The answer I found is inconclusive… It depends. It depends on how the user is applying the tools and how they use the insights and information to inform their decisions. As this technology becomes more present in our spaces, it becomes more crucial that we educate ourselves and others on how to properly use them while maintaining our individuality and authenticity. It is evident that the intersection of these fields presents both exciting opportunities and critical challenges. But how might we incorporate AI tools in creative education while preserving human authenticity and engagement? The answer is like the first question, it depends. Similar to previous industrial revolutions, education is needed to provide the upskilling that is required to optimize the benefits of these new technologies. There is a need to educate creatives of the information bias present and how to limit them, the ethical considerations involved with using these tools, and the social implications and how this will affect people in the real world. Through proper informative education, creatives will be able to use these tools to empower themselves and capitalize on their skills. The benefits are exponential in terms of possibilities of applications. Soon we will see designers solving complex wicked problems with the use of these tools, by connecting and organizing data and ideas in a way that supports us and does not overshadow our own ideals and intentions. Through adequate education this will become possible. This exploration unveiled a plethora of issues that may become relevant soon. It also shines a light on the importance of adaptive educational systems and the need for further research into the implementation and adoption of these technologies. Pushing the limits of human capability while maintaining the critical importance of responsible, ethical, and thoughtful integration to maintain AI as a catalyst for creativity, without compromising the human touch that is required to have true innovative, intentional, human-centered design.

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Ethics and Inclusivity

Designing products that respect
diverse cultures,backgrounds, and abilities

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AI and the Pipeline of Talent: Crafting a Future Workforce

ETHICS AND INCLUSIVITY |FARAH ELABD

Introduction

In our ever-evolving world, the integration of artificial intelligence (AI) into various aspects of society has become a crucial topic for discussion. As we navigate the potential impacts of AI on the workforce, it is vital to address the potential disruptions and job displacement that may occur. This report thoroughly examines the complex dynamics of this transformative era, delving into historical parallels from previous technological revolutions, ethical considerations related to AI implementation, and the strategic alignment of government policies, business models, and educational initiatives. In this exploration, key questions arise: How can we proactively shape a future in which AI enhances rather than replaces jobs? What roles do government policies, ethical frameworks, and innovative partnerships play in creating a resilient "pipeline of talent"? Through this exploration, I aim to provide a comprehensive understanding of the challenges and offer practical recommendations for fostering a harmonious coexistence between humans and AI in the ever-changing employment landscape.

Ethics and Inclusivity in the Fourth Industrial Revolution

As we venture into the uncharted territory of the Fourth Industrial Revolution, with the rapid integration of new technologies in various industries, it is imperative that we address the ethical implications of this advancement. History has shown us that during previous revolutions, such as the Digital Revolution, there were unintended consequences that had significant impacts on society. Therefore, as we navigate this transformative landscape of a new industrial revolution, it is crucial to consider the ethical implications and strive towards an inclusive approach for all.

One of the major concerns surrounding the new technologies of this revolution is their potential impact on inclusivity. With disparities in access to resources and opportunities already prevalent in our society, there is a fear that these technologies may exacerbate these existing social inequalities. For example, if AI is used in hiring processes, it may perpetuate biases and discrimination against marginalized groups. Furthermore, the use of AI in decision-making processes can also have detrimental effects on inclusivity by reinforcing systemic inequalities.

This brings us to the central focus of this discussion - to shed light on the ethical considerations intertwined with the Fourth Industrial Revolution and highlight the importance of an inclusive approach to ensure that the benefits of AI are equitably distributed. By examining historical context, current concerns, and research insights, my group aims to provide a comprehensive understanding of the ethical landscape surrounding AI and its potential impact on inclusivity in the workforce.

Looking back at past technological revolutions, it is clear that ethics often took a backseat to innovation and economic growth. The consequences of this neglect can still be seen today, with issues such as privacy violations and unequal distribution of wealth stemming from previous technological advancements. Hence, it is crucial that we learn from these lessons and prioritize ethical considerations as we advance into this new era.

Moreover, current concerns around some new technologies revolve around transparency and accountability. As AI continues to evolve and make decisions autonomously, it is essential to have mechanisms in place to understand how these decisions are made and hold individuals and organizations accountable for any unethical actions. Additionally, there is a need for ethical guidelines and regulations to ensure that AI is developed and used in a responsible and ethical manner.

Overall, the intersection of technology and ethics stands as a critical focal point in the Fourth Industrial Revolution. As we move forward and integrate AI into various industries, it is our responsibility to consider its ethical implications and strive towards an inclusive approach. By learning from history, addressing current concerns, and utilizing research insights, we can pave the way for an ethically sound industrial revolution.

How can the disruption and dislocation of jobs caused by AI create a new “pipeline of talent”?

When considering the impact of AI on the workforce, the idea of a "pipeline of talent" emerges as an important concept for the future. This vision imagines a world where technology and human potential work together in a harmonious way. Drawing from research by Carl Benedikt Frey ("The Future of Jobs and Growth: Making the Digital Revolution Work for Many," 2017) and Greg Shaw ("The Future Computed: AI and Manufacturing," 2018), this discussion explores how AI can transform the workforce into one that is resilient and adaptable.

Frey's analysis shows that technological change happens in cycles, similar to what we have seen in previous industrial revolutions. While some jobs may become obsolete, others emerge, creating new opportunities. The "pipeline of talent" aligns with this idea, suggesting a continuous flow of individuals learning and adapting to meet changing demands (Frey, 2017).

Shaw's insights from "The Future Computed" further demonstrate how AI is becoming essential in many industries, particularly manufacturing. As AI integrates into these fields, it becomes crucial for workers to not only have technical skills but also be able to collaborate effectively with AI systems. This collaboration is described as a symbiotic relationship where AI enhances human abilities and intelligence, leading to a more efficient and innovative working environment (Shaw, 2018).

In simpler terms, we must think of the "pipeline of talent" as a pathway where people continuously acquire new skills and knowledge to match the ever-evolving job market. This pathway involves embracing technological changes, collaborating with AI, and embracing a culture of ongoing learning.

With each passing day, AI becomes an increasingly essential part of our society and workforce. It is clear that this trend will continue in the future, and as such, individuals must adapt to this change by developing the necessary skills and mindset for a harmonious relationship with AI technologies. This incorporation of AI into the workforce is not about replacing human potential, but rather it is an evolution that requires a flexible and adaptable pipeline of talent. By acknowledging the history and origins of AI, individuals can better understand its capabilities and limitations. Additionally, keeping up with advancements in technology is crucial in order to stay relevant and competitive in the job market.

However, the successful integration of AI into the workforce also requires a collaborative attitude. Instead of seeing AI as a threat or competition, individuals should embrace it as a tool to enhance their own abilities. This includes working closely with AI systems and learning how to effectively utilize them in daily tasks.

Additionally, it is important for individuals to recognize the advantages that AI brings to the table - increased efficiency, accuracy, and productivity - while also being aware of any potential pitfalls. By fostering a resilient and creative mindset, individuals can navigate this pipeline of technological progress and ensure that they are prepared for the changing landscape of work.

In "Race Against the Machine: How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy" by Eric Brynjolfsson and Andrew McAfee (2012), the authors delve into the profound impact of the digital revolution on employment, productivity, and the overall economy. The paper offers detailed insights into the displacement of jobs, shedding light on the mechanisms through which technology, particularly AI, accelerates innovation.

Brynjolfsson and McAfee argue that advancements in digital technologies, including artificial intelligence, have brought about a transformative shift in the nature of work. They highlight how automation, enabled by these technologies, has led to the displacement of routine, rule-based tasks traditionally performed by humans. As AI systems become more sophisticated, they are increasingly capable of handling routine, repetitive tasks with greater efficiency and accuracy than human counterparts.The authors also discuss the concept of "technological unemployment," emphasizing how the rapid pace of technological innovation can outstrip the ability of the workforce to adapt. Jobs that are routine, manual, or involve predictable tasks are particularly vulnerable to automation. This displacement, as outlined in the paper, contributes to a restructuring of the job market, with a potential hollowing out of certain job categories. Additionally, the authors introduce the idea of a "bifurcation" in the job market, where high-skill, high-wage jobs and low-skill, low-wage jobs may see growth, while the middle-skill jobs face the risk of decline. This polarization is attributed to the fact that high-skill jobs often involve tasks that are challenging for machines to replicate, whereas low-skill jobs are less susceptible to automation due to their non-routine and varied nature.

Moreover, Brynjolfsson and McAfee discuss the concept of "skill-biased technical change," suggesting that technological advancements tend to complement higher-skilled workers while substituting for routine tasks performed by lower-skilled workers.The detailed analysis in "Race Against the Machine" underscores the complexities of the displacement of jobs in the face of digital revolution and AI integration. It provides a nuanced understanding of the challenges posed by automation, emphasizing the importance of skills development and adaptive strategies for the workforce to navigate this transformative period.

Overall, as we continue on this path towards a more technologically advanced world, it is crucial for individuals to adapt and evolve alongside AI. With a combination of historical knowledge, technological literacy, collaborative attitudes, and flexibility, we can create a strong and cohesive relationship between humans and AI, ultimately leading to a resilient and creative workforce.

In the ever-evolving world of AI and its impact on the job market, agile workforce policies have emerged as a crucial strategy for governments to effectively respond to these challenges. Drawing inspiration from past adaptations to technological shifts, it is imperative that governments design and implement policies that allow the workforce to easily adapt to the rapidly changing demands of AI-driven industries. This requires a focused effort on reskilling and upskilling programs, equipping individuals with the necessary skills to thrive in an AI-integrated environment (Frey, 2017).

To further encourage and facilitate these necessary transformations, policymakers should consider implementing financial incentives for businesses investing in job reallocation initiatives. These incentives would incentivize the creation of new roles and industries aligned with the demands of AI, fostering a dynamic and resilient job market (Frey, 2017).

An essential aspect of harnessing the transformative potential of AI lies in encouraging partnerships between businesses and AI technologies. This collaborative innovation involves integrating AI tools to enhance productivity, streamline operations, and unlock new business opportunities. As highlighted in "The Future Computed" by (Shaw, 2018), this symbiotic relationship between businesses and AI

systems is crucial for creating a workforce that leverages both human ingenuity and technological efficiency.
Moreover, it is vital for businesses to prioritize employee training and support programs as they integrate AI technologies into various job roles. Establishing a supportive environment for continuous learning and development is crucial in empowering employees to adapt to the ever-changing technological landscape (Shaw, 2018).

The role of educational institutions in preparing individuals for the rapidly advancing AI-driven workforce cannot be overstated. It is crucial to integrate AI education into curricula, equipping students with essential skills to thrive in a technological landscape that is constantly evolving. As emphasized in "The Future Computed," this aligns with the need for educational strategies that promote adaptability and collaboration with AI systems (Shaw, 2018).
Moreover, it is imperative to promote lifelong learning initiatives within and beyond educational institutions. By cultivating a culture of continuous education, individuals are better equipped to navigate changing job requirements throughout their careers. This fosters a resilient workforce capable of embracing the challenges and opportunities presented by AI-driven changes (Shaw, 2018).
To address the complex challenges posed by AI integration, collaborative efforts across sectors are necessary. Governments, businesses, and educational institutions must establish platforms for joint problem-solving, information sharing, and comprehensive strategy development. The insights from each sector contribute to a holistic approach that considers the multifaceted impacts of AI on the workforce.
In light of the ethical implications of AI integration, it is essential for governments and industry bodies to collaborate in establishing ethical guidelines and standards for responsible implementation. These guidelines should address issues such as bias, privacy, and transparency, ensuring that AI technologies are deployed with integrity and fairness at their core (Frey, 2017).
Furthermore, community engagement programs initiated by governments and businesses are vital to ensure equitable distribution of benefits from AI-driven changes. This involves supporting community projects, organizing job fairs, and fostering local initiatives that enhance the overall well-being of affected communities. By prioritizing community engagement, the transformative potential of AI can become a force for positive change that benefits individuals and communities alike.

Conclusion

As we navigate the uncharted waters of the Fourth Industrial Revolution, our comprehensive exploration into the impact of artificial intelligence on the workforce unveils a complex and transformative landscape. Rooted in historical insights, ethical considerations, and practical recommendations, this report provides a holistic perspective on the challenges and opportunities presented by AI integration.
The examination of historical echoes, as articulated in Carl Benedikt Frey's "The Future of Jobs and Growth: Making the Digital Revolution Work for Many" (2017), illuminates the cyclical nature of technological disruptions. The parallels drawn between past industrial revolutions and the current wave of AI integration underscore the transformative potential of innovation. The displacement of jobs, a recurring theme in technological shifts, becomes a focal point in our understanding of how the workforce must adapt to stay relevant.

Furthermore, Eric Brynjolfsson and Andrew McAfee's work in "Race Against the Machine" (2012) contributes valuable insights into the accelerated innovation brought about by the digital revolution. The concept of technological unemployment, the restructuring of job markets, and the bifurcation of employment underscore the urgency for adaptive strategies as automation reshapes the nature of work.

In conclusion, addressing ethical considerations becomes imperative as we embark on this transformative journey. The fusion of AI with employment necessitates a moral compass that guides responsible implementation. The establishment of ethical guidelines and standards, as advocated in "The Future Computed" by Microsoft (Shaw, 2018), provides a framework for ensuring the fair and equitable deployment of AI technologies. This emphasis on ethical considerations aligns with a vision of inclusivity, where the benefits of AI-driven changes are shared equitably among diverse communities. The practical recommendations outlined in this report offer a roadmap for governments, businesses, and educational institutions to navigate the challenges and harness the potential of AI. Agile workforce policies, financial incentives for job reallocation, and community engagement programs constitute a comprehensive approach to fostering a resilient workforce. Partnerships between businesses and AI technologies, prioritizing employee training, and integrating AI education into curricula contribute to building a workforce capable of thriving in an AI-driven landscape.

At the heart of our exploration lies the vision of a resilient 'pipeline of talent.' This metaphor encapsulates a dynamic process where individuals continuously acquire new skills and knowledge, adapting to the evolving demands of the job market. In embracing collaboration with AI systems, fostering a culture of continuous learning, and prioritizing ethical considerations, this pipeline becomes a conduit for innovation and inclusive growth. To sum up, the integration of AI into the workforce is not a deterministic force of displacement but an opportunity for transformation and innovation. The lessons from history, ethical considerations, and practical recommendations converge to outline a pathway for navigating the challenges posed by AI in employment. As we race against the machine, the choices we make today will determine the future of work. Through collaboration, adaptability, and a commitment to ethical principles, we can shape a harmonious future where AI augments human potential rather than replaces it. The vision of a resilient 'pipeline of talent' stands as a testament to our collective ability to thrive in the age of AI, ensuring that innovation serves as a catalyst for inclusive prosperity.

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ETHICS IN SURVEILLANCE DATA COLLECTION

ETHICS AND INCLUSIVITY | ALEXANDRA SHEVTSOVA

INTRODUCTION

Big data and evolving technology has become a big part of our everyday life, shaping our habits and the way we use technology. With the increasing volume and quality of such data constantly collected around us, ethical concerns inevitably arise. As more and more data about people is becoming publicly available, such advancements pose risks to our safety, comfort and privacy. This inevitably leaves us wondering – how will these changes affect us as individuals and as humanity as a whole? The 4th Industrial Revolution is all about rapid technology advancements, and our team focused on the definition of Ethics in Data Collection in order to uncover whether ethical procedures that the world has in place today can keep up with the changing technology. For this report, I wanted to review the overall ethical concerns that are expected to appear with new technology in the nearest future, as well as use public surveillance technology as an example to define its ethical issues and potential solutions. For the expected outcomes of the research, the report focuses on uncovering the designers' role in defining ethics of the new era and the processes required to do that.

Through research and discussions, it was concluded that, while the negative effects of evolving technology may be inevitable, the risks can be addressed upfront through safe-by-design approaches, technology assessments and responsible learning practices.

ETHICS AS SUBTOPIC DISCUSSION

Our team focused on the subtopic of Ethics and Inclusivity, which is a broad theme that can be applied in any area of life. From business ethics and inclusivity in the workplace to research ethics and social justice, these terms are well known in any industry and require consideration. To apply these notions to the 4th Industrial Revolution, our team chose ethics and inclusivity in digital technology and current existing issues in the areas of social media, data collection, AI-assisted technologies and AI-driven job dislocation.

Historically, the notion of ethics involved the constant search of how to best live life, or, as quoted by Socrates, "the most important thing is not life, but the good life" (Vallor & Bartlett, n.d.). Ethics then evolved into different areas and is now applied in philosophy, politics, personal life, workplace, community life, and technology. Because technology is created by humans and shapes the quality and the values in our life, it is not "ethically neutral" – it will reflect whichever values were used to create it or distribute it (Vallor & Bartlett, n.d.). This poses an issue when technology advances with unprecedented speed and scale like today, and the current regulations and laws cannot keep up with these changes. Through journal research and team activities, each member has defined a scope for their investigation and created a hypothesis based on the information reviewed.

We applied solution oriented research to address the main concerns about the Ethics and Inclusivity topic – which is the ambiguity and uncertainty of ethical procedures that comes with rapidly changing technology. The research was used to create a basis for suggesting strategies to mitigate these ethical risks. The application of this subtopic in ethical data collection context is further discussed below.

DATA ETHICS AS TITLE DISCUSSION

For my personal topic, I focused on the changing definition of ethics and ethical data collection that comes with the enhancement of technology during the 4th Industrial Revolution. Big data is affecting us daily, and with the quality of data increasing, its effect on people is growing too. This can be anything from social media platforms selling data for personalized advertisement, to data breaches from big companies that reveal personal information, or even illegal and non-monitored surveillance data collection and storage.

As Vallor and Bartlett highlight, “ethical issues are everywhere in the world of data'' because how this data is treated will always affect the individual that the data was taken from in one way or the other (Vallor & Bartlett, n.d.). Ethical procedures related to technology thus include regulations on data security, protection, consent to receive information, and respecting privacy and anonymity (Clough, n.d.). The identified issue with these methods is that all these regulations are usually taken by individuals conducting research or smaller scale companies, while bigger corporations do not identify their data collection practices clearly and have bigger data risks (Janiszewska et al., 2020). This poses privacy and safety concerns especially when technologies are improving so rapidly. Emerging technologies will redefine the way we interact with the world and affect global balances of power, which is why it is crucial to address these issues upfront and use the proper ethical regulations to protect the world’s data (Al-Rodham, 2015). It is especially true for visual data collection technologies like surveillance cameras, that keep improving over the years. Nowadays the cameras not only record videos and take images, but also use AI assisted algorithms to detect people’s faces and car’s license plates. These pose concerns when it comes to “the trade-off between individual privacy and collective security”, as well as the issues of storing the data and informing individuals who are unaware of surveillance (*Balancing Privacy and Security: The Ethics of CCTV Surveillance*, 2023).

Designers and ethical professionals have the power to create ethical procedures to account for potential risks that the emerging technology can bring. Evie Kendal highlights these important approaches in her paper, which include precautionary principles, safe-by-design approaches, technology assessments and scenario approaches (Kendal, 2022).

THREE QUESTIONS

To guide the research process, each team member created three questions for their subtopic. The questions were altered throughout the research process and the final questions below formed the basis of this report.

1. What are current ethical procedures and are they able to address the evolving surveillance and big data collection technology?

2. How may ethical procedures evolve with the increasing quality of public surveillance and volumes of collecting, storing and sharing personal data?

3. How can designers reimagine the existing ethical procedures to make them sustainable in the evolving world?

This paper aims to answer these questions and suggest a hypothesis for what the designer’s role in defining ethics is and what processes they can use to address.

JOURNAL RESEARCH

To answer these questions, the first step was to narrow down the title theme to a tangible example – from reviewing overall ethical implications in technology and data collection to using surveillance cameras as an example. Based on the findings from that stage, I reviewed the current ethical procedures and issues and the overview of emerging technologies and potential future issues from industry professionals. From there, secondary research helped me identify the gap between current procedures and future issues, and compile a list of approaches that designers can take to address the gap and create new sustainable ethical procedures for emerging technologies.

To understand current ethical procedures, I have reviewed an article by Segalla and Rouzies – “The Ethics of Managing People’s Data” – to learn about current ethical issues in data collection and how they can evolve. Their work introduces the “5 ‘P’s of Ethical Data Handling” which include provenance, purpose, protection, privacy, and preparation (Segalla & Rouzies, 2023). Provenance includes making sure the consent was acquired and that data was collected legally, as well as understanding where the data came from. Purpose means keeping track of data sources and making sure that data remains within the parameters and the scope of its original collection rules (Segalla & Rouzies, 2023). While protection and privacy rules can be interpreted as usual, preparation means keeping track of missing data, improving its accuracy and putting correct cleaning procedures in place (Segalla & Rouzies, 2023). The article also highlights the important role of Institutional Review Boards (IRBs) in large companies, consent, data ownership and anonymisation. The authors conclude with how AI increases the risks of data abuse, and underline the importance of responsible data practices (Segalla & Rouzies, 2023).

To further review the topic, I have researched current ethical procedures in place, and Paul Clough's article "3 Key Steps to Ethical Data Collection" was a great resource to get started. The article explains the three main rules of GDPR, or the General Data Protection Regulation that was introduced in Europe. These include receiving clear and well identified consent to collect information, avoiding collection of personally identifiable information, protecting participants' anonymity and confidentiality during the process, and incorporating the data minimisation principle (Clough, n.d.). The last one requires the party that is collecting the data to clearly state the intentions of gathering data and to retain certain information for less than 12 months (Clough, n.d.). These principles, however, may be challenging to implement in practice, simply because not every purpose can be identified in advance and because bigger corporations find ways around user agreements and get consent unethically (Clough, n.d.).

When it comes to ethical regulations related to surveillance cameras, it has been identified that the privacy concerns are rising proportionally to the advancement of this technology (Lancia, 2022). Sam Lancia, a video engineer and a co-founder of video security company, believes that the advancements in surveillance technology must go "hand in hand with transparency and privacy" – it needs to be clear who is the owner of the data collected from surveying systems and where that data can be shared after (Lancia, 2022). The data must be stored securely and must be protected from the unregulated access of third parties, in order to prevent data monopolization (Lancia, 2023). Overall, even with the speedy advancement that the surveillance technologies are going through – be that the increasing volumes of data, better image and video quality or AI-powered features like facial recognition, surveillance technology is beneficial to society in many ways and the negative effects that come with it can be mitigated by using the strategies described above.

The research results so far helped me identify the regulations existent right now and the challenges that will inevitably come with new technologies. As mentioned above, the gap between these concepts is the issue that we as designers can address. From here, with the knowledge of what specifically needs to be addressed, further research helped explore the designers' role in approaching these issues and the potential strategies they may take.

In her paper, Evie Kendal reviews the ethical and social implications of technology and provides design strategies that can be used to address these issues. She talks about the precautionary principle that is a strategy used to assess technology by asking 4 questions - "is the technology known to have 'intolerable risks', does it yield substantial benefits", can the benefits solve crucial problems and could those problems be solved in a safer way (Kendal, 2022). If the answers to questions 2 and 3 are positive, technological development must not be allowed to proceed (Kendal, 2022). This is an effective way to quickly assess technology advancements, but what if the answers to these questions are not as simple? Kendal also reviews the "safe-by-design approach", which involves reviewing potential safety and ethical concerns on each step of technological development before the technology is fully released (Kendal, 2022). This approach focuses heavily on learning and on integrating the knowledge iteratively, which means step by step during the design process. Another approach, technology assessment, includes evaluating ideas, plans and visions for future technology to help predict consequences of that technology and thus helps deal with uncertainty (Kendal, 2022). Design process objects are like models, prototypes, roadmaps and scenarios are useful for this analysis (Kendal, 2022). Finally, responsible learning is a broader process that can be used to identify and mitigate risks – it involves "proceeding in the face of uncertainty", and exploring potential risks step by step as the technology is being developed (Kendal, 2022).

After identifying the gap and possible solution strategies, I was able to compile the research and correlate it to the proposed strategies. From there, the three most relevant strategies were identified – the "Safe-by-design" approach, technology assessment and responsible learning.

CONCLUSION

Overall, the theme of ethics and inclusivity is greatly affected by technology and poses serious concerns because it directly involves people. Individuals are the heart of this topic and their interaction with technology is not fully uncovered yet. The technological advancement, however, is accelerating day by day, which brings new insights and considerations into the already existent problems. While all the industries need to consider technological progress and how it affects our lives, the designers are equipped with distinct approaches that can help shape the ethics and inclusivity of the new era, all while thinking about the end user and considering their needs.

Through the research process, the focus of the study shifted from observing the changing ethical procedures to reviewing the current ones and researching how they can evolve and account for more issues that arise with technology. With public data collection technology such as surveillance cameras, ethical issues increasingly and inevitably arise and need to be addressed in order to make sure the new technology is introduced into the world safely. To answer my first question and to sum up the ethical procedures that are in place right now, the following are the most important ones: protecting the data that was collected, receiving consent to collect information, respecting users' anonymity and providing explanations of what is intended to be done with data. Unfortunately, they are not able to account for the evolving data collection technology.

The answer to the second question closely relates to the issues that the new technology brings in the near future, because these problems identify what specifically the regulations need to address. These include no clear data ownership, keeping data for longer than needed, not educating people of surveillance data collection, data breaches to third parties, and collecting identifiable information. It is also important to account for the potential implications of technology that will happen but cannot be clearly identified right now.

In addition to these issues, the Collingridge dilemma states that it is impossible to certainly know the consequences and implications of an emerging technology at its early stages, however, once the technology is established and its ethical consequences are clearly seen, it is extremely difficult to intervene and alter the outcomes (Kendal, 2022). This means that initial assessment and specific design approaches are crucial to make necessary pivots early on, because once the technology reaches a certain stage, "it is too late to intervene" (Kendal, 2022). To answer the third question, a combination of the design approaches discussed above is a good way to prevent the creation of potentially harmful and dangerous technologies. As creative problem-oriented thinkers who are not only considering solutions and outcomes but also the user's side of the issue, designers can be successful in addressing these emerging ethical issues and reviewing all possible solutions and approaches. The strategies reviewed in this report include design and technology oriented approaches for solving ethical problems.

It is important to understand that the implications of unethical data collection with modern technology pose serious risks and can be harmful to individuals, so they require serious regulations in place in order to decrease the negative effects. Designers, professionals, and even ethics boards have to always remember that "even when data practice is legal, it may not be ethical" (Vallor and Bartlett, n.d.) and choose the appropriate ethical regulations to guide their activities.

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FOSTERING INCLUSION OF PEOPLE WITH INTELLECTUAL DISABILITIES BY IMPLEMENTING ARTIFICIAL INTELLIGENCE IN ASSISTIVE TECHNOLOGIES

ETHICS AND INCLUSIVITY | ELA ST. MICHAEL

INTRODUCTION

Technology has become a vital part of our daily lives. It has shaped how we interact as a society and created a pipeline of opportunities to foster connections around the globe, however its rapid innovations have resulted in a pattern of social isolation for people with intellectual disabilities (USEEOP, 2013). The fourth industrial revolution presents advancements in digitization, machine learning, and the use of the Internet of Things, which has reshaped human interaction with the goal of improving overall quality of life (Nam et al., 2018). However, existing inequalities, specifically faced by those with intellectual disabilities, have revealed fundamental ethical concerns in technological innovation with the prevalence of challenges experienced. Technological innovations currently lack inclusivity for people with intellectual disabilities, resulting in social isolation, a decrease in well being, and a series of mental health concerns (Adigun & Nzima, 2021).

This paper aims to understand the pattern of social isolation that people with intellectual disabilities experience as a result of the fourth industrial revolution and explore methods of fostering inclusion to promote long term independence. Valuable opportunity exists to explore the implementation of artificial intelligence in assistive technologies to promote autonomy of people with intellectual disabilities. While there are many ethical limitations that may restrict the ability to apply this connection, there is significant potential to positively influence the lives of targeted populations and the people around them and overcome the challenges that are currently being faced. This is an example of the opportunities the fourth industrial revolution can present to advance our society to become more ethical and inclusive, instead of contributing to a pattern of inequalities.

ETHICS AND INCLUSIVITY OF PEOPLE WITH INTELLECTUAL DISABILITIES

The population of people with intellectual disabilities surpasses two hundred million individuals worldwide (Rafi, 2021). People with intellectual disabilities experience challenges with knowledge acquisition and are typically diagnosed before the age of eighteen when they display impairments in conceptual, social, and practical skills (*Adults With Intellectual Disabilities*, 2021). These impairments are influenced by reduced intellectual and adaptive functioning, affecting communication, social skills, self care, home living, health and safety, problem solving, and academic learning (USEEOP, 2013). Consequently, challenges faced often inhibit the ability to live independently, pursue an education and build a career (Schaepper et al., 2021).

The recent rise of technology in the workplace and schools, including remote work opportunities, networking, and education technology, creates significant potential for people with intellectual disabilities to thrive in these environments, however the direction of innovations lacks consideration for these individuals. People with intellectual disabilities are 50% less likely to find employment, and those who do build a career often make $21000 less annually (Rafi, 2022). Because of this, financial limitations further inhibit the ability to be able to afford to live independently. As a technology dependent society, financial constraints limit the ability to access technology, resulting in social isolation (Rafi, 2022).

While intellectual disabilities are lifelong conditions, methods can be taken to improve functioning, helping to promote autonomy and empower independence (Schaepper et al., 2021). Assistive technologies are tools designed to enable people with disabilities to manage the tasks of living independent lifestyles, therefore improving their quality of life and overall well being (Dange, 2023).
Assistive technologies designed specifically for people with intellectual disabilities exist to help promote autonomy and independence. An example of this is an app called Proloquo. This app is a communication tool that is designed for people who are nonverbal, or struggle with oral communication, to help them communicate and develop their language skills. This

app offers simple, icon-based interactions, designed specifically for this demographic, and has proven to be an impactful tool in regard to its usability (AssistiveWare, 2023). Proloquo, and many other similar tools, offer inclusive usability design consideration, however, they can be very expensive, limiting its accessibility within this target population. Since many people with intellectual disabilities face financial challenges, additional expenses, such as assistive technologies, are often out of reach. These tools utilize technological advancements to try to promote inclusivity, however, additional factors need to be addressed to improve their accessibility, and impact (Stefánsdóttir et al., 2018).

The development of inclusive technology must involve participants from targeted populations in the research and design process. When conducting research with people who have intellectual disabilities, there are many ethical guidelines that must be considered. Receiving consent is a complex challenge in this process due to the impaired decision-making abilities that people with intellectual disabilities often experience. Legal restrictions exist to prohibit research from being conducted with people who lack the capacity to consent to participate. People with intellectual disabilities are included within this group, therefore cannot participate in research without taking further actions to accommodate them (Harding, 2021). These regulations require additional ethical approval by an authorized body and engagement with a consultee in order to proceed with participation in the research being conducted. Approval is only given if the study pertains to an impairment that affects the individuals, therefore excluding them from much of the technological innovations that are essentially vital tools in today's society (Harding, 2021). If approval constraints are met, consent must not only occur before the conduction of research, but it must also be continuous throughout the research process. If someone loses the capacity to consent at any point, they are no longer allowed to participate in the research. These complex and rigorous ethics regulations are in place to protect vulnerable participants; however, they create barriers in the ability to participate in research not related to health and social care issues (Harding 2021). Research conducted on technology or design developments not specifically targeted to aid those with intellectual disabilities therefore lack the insights required to be inclusive of this population. Consequently, this leads to a pattern of innovations that isolates the population of people with intellectual disabilities. The fourth industrial revolution has accelerated innovation, therefore continuing to contribute to this pattern of isolation (Harding 2021). It is important to implement rules and regulations to protect vulnerable groups, however, participation from these populations must be included in design research in order to bridge the gap of social isolation that these people experience and promote inclusion in our society (Harding, 2021).

Opinions and knowledge of people with intellectual disabilities are necessary to strengthen society's human centered and inclusive values. With current gaps in income and accessibility of technology and information, mental well being, and quality of life are negatively impacted. People with intellectual disabilities experience very poor mental health, with mental disorders occurring two to three times more than the rest of the population (*Adults With Intellectual Disabilities*, 2021). In addition to increased mental health challenges, people with intellectual disabilities also face barriers in receiving mental health care when needed (Lunsky et al., 2022). Accelerated by the COVID-19 Pandemic, virtual healthcare and online support systems have been designed and implemented to allow people to get the help they need at their own pace. Improving access to mental health services utilizing technology requires digital literacy and reading comprehension skills, which is inaccessible to many people with intellectual disabilities. Contextual factors such as internet access and quality, reliability of devices, and software are additional variables that can be restrictive in mental health care (Lunsky et al., 2022).

It is evident that many technological innovations resulting from the fourth industrial revolution have negatively affected people with intellectual disabilities due to the lack of inclusion in design research. In order to improve this, people with intellectual disabilities must be included in the design process to promote inclusivity in today's society.

FOSTERING INCLUSION OF PEOPLE WITH INTELLECTUAL DISABILITIES BY IMPLEMENTING ARTIFICIAL INTELLIGENCE IN ASSISTIVE TECHNOLOGIES

Participation from non-designers in the design process helps identify relevant problems, knowledge, ideas, behaviors, and opportunities that are informed by unique life experiences. Participation of people with intellectual disabilities in design research allows their life experiences to be heard and valued in the context of design development, shaping inclusive innovations. Recent advances in codesign research participation have shifted the research structure from being a subject of research, to a collaborator in the design process. This shift emphasizes the values of each individual's knowledge and experiences, creating a supportive and collaborative environment (González et al., 2020). Reshaping design research methods creates opportunities to promote and prioritize inclusion. A recent study explored how participation can be achieved through a codesign process, focusing on offering accommodations, methodical adaptation, and support throughout the design process to ensure valuable and inclusive participation (González et al., 2020). Accommodations such as collective decision making, multimedia communication, and step by step guides were implemented to motivate participants and promote autonomy throughout the entirety of this process (González et al., 2020). The early inclusion of participants with intellectual disabilities aimed to identify their needs, desires, and priorities. Not only does this help inform the direction of the design research outcomes, it also helps guide the research process itself, resulting in stronger insights and ideas (González et al., 2020).

Codesign research methods not only have the potential to improve the quality of research insights and usability of solutions, it can also empower participants to adopt and learn new tools. An example of this is present in a codesign workshop where team members worked to ideate different methods of communication that could be used to help identify someone in a crowded space. Within this study, each participant voluntarily shared their opinions on each concept that was presented. Demonstrations of solutions and scenarios were also enacted, promoting further communication and collaboration. Conversations regarding strengths and barriers of concepts were guided by the participants through the ideation workshop (González et al., 2020). When in an environment that values the opinions of people with intellectual disabilities, these individuals were able to work with designers through the design process, helping to inform decision making. Not only does this design of research allow for participation from vulnerable populations, it also presents opportunities for new research approaches to be implemented that can reflect each unique group of participants involved. Research teams must learn and adapt to presented challenges, such as informed consent processes, accommodating the ability to take steps back and learn throughout the process, and simplifying research goals into a clear, sequential timeline (González et al., 2020). Codesign research methods can empower participants with intellectual disabilities to practice decision making, creating thinking, and communication skills. The collaborative nature exposes potential users to innovations early on, therefore improving trust and open mindedness to new tools.

Innovation opportunities exist to implement artificial intelligence into assistive technologies to promote the long-term autonomy of people with intellectual disabilities (Stefánsdóttir et al., 2018). Codesign research methods can be conducted to identify relevant areas that artificial intelligence can be used as a tool, supporting user needs. Artificial intelligence already has many advancements in voice technologies. Examples of these include Siri and Alexa. These can be used as information comprehension tools which can help read text out loud, summarize information, or improve accessibility to information depending on individuals needs. Voice technologies could also be used to adjust how information is presented to another method that is easier for users to understand, aiding comprehension. These tools may provide support in areas such as home, work, or school, empowering users to solve problems and overcome challenges independently. As skills improve, they can be applied throughout one's education and career, supporting long term autonomy (De Freitas et al., 2022).

Similarly, AI tools can support commuting and workflow planning. Tasks such as wayfinding, scheduling and time management can present challenges for people with intellectual disabilities. Artificial intelligence tools can be implemented to aid with scheduling meetings and setting up reminders, ensuring productivity and efficiency when needed. Additionally, changes in schedules or plans can be adjusted alongside users to help improve these skills and practice problem solving. This could be extremely beneficial in school or in the workplace (Dange, 2023).

The recent diversity in artificial intelligence applications and abilities create a promising opportunity to apply this technology as a tool to help achieve personal autonomy. Assistive technologies can implement artificial intelligence to allow for personalization and evolution of support, making it a strong application for a user group who can experience very unique needs, across many different settings (Dange, 2023). Due to the flexibility and adaptive nature of this tool, it can learn about each individual user, providing more human-like and personalized information or responses. Another benefit of the personalized tool is that it can be developed in a cost-effective manner, supporting inclusivity of people with intellectual disabilities who may experience financial constraints. Alternatives to assistance, such as therapy, existing apps, and education support, can be very expensive, making this an attractive alternative (De Freitas et al., 2022).

Limitations of this application do also exist, restricting its current implementation ability. Data privacy and biases potentially risk the well being of users. Additionally, artificial intelligence does also pose a threat of undermining autonomy by over influencing decision making (Wangmo et al., 2019), These challenges could result in additional harm to users, however, they stem from the design of the assistive technology. If users are included as participants and co-designers throughout the design process, these limitations could be minimized.

In addition to highlighting threats in the design of AI assistive technologies, it is important to prioritize improving the autonomy and independence of users. Assistive technologies aim to empower self reliance, therefore assistance should support decision making and equip users with the tools they need to achieve this, instead of heavily influencing the choices they make. This approach to assistive technologies offers solutions that are context aware, personalized, and continually adapting to changing user needs. Because of this, integration of Artificial intelligence based assistive technologies can provide a supportive solution to empower self reliance and build life skills, resulting in stable and long-term independence (Dange, 2023).

CONCLUSION

People with intellectual disabilities deserve equal opportunities to benefit from society's developments and pursue their life goals. Researchers and designers must prioritize inclusivity throughout the entirety of their processes in order to take a step towards closing the gap in technological accessibility and social isolation challenges that are currently being faced (Harding, 2021).

Tools such as artificial intelligence assistive technologies can be developed alongside target users in order to create solutions that result in a positive impact on the lives of people with intellectual disabilities. While significant research must be conducted to face the ethical concerns that currently exist, codesign methods can be used to identify relevant and beneficial areas to apply Artificial intelligence. If inclusive action is taken throughout the entirety of the research and design process of this application, there is significant potential to help people with intellectual disabilities develop the skills they may experience limitations in, empowering long term autonomy. Additionally, this can increase the willingness to adopt new technologies, and the usability and accessibility of assistive tools, resulting in a positive impact that can spread to other innovations. Any step towards inclusivity creates a powerful impact on society as a whole, moving away from a pattern of creating barriers, and focusing on empowering change (González et al., 2020).

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INTRODUCTION

The Fourth Industrial Revolution is a transformative era characterized by the merging of digital, physical, and biological technologies, has ushered in an unprecedented wave of innovation and disruption across various sectors. As we navigate the complexities of this technological disruption, it also becomes important to understand the profound implications it holds for society, economies, and industries. Because of these complexities, our group chose to focus our report on the subtopic 'Ethics and Inclusivity in Design'. We believe ethical design and inclusivity within the fourth industrial revolution offers a unique and untapped layer of design. As our group members bring forth a multitude of unique experiences and perspectives from across the globe ourselves, we believe there is a power in diversity within design and aim to dissect the roles ethics and/or inclusivity play within this era.

To better grasp the focus of my report, a real-life incident involving the critique of addictive design features of Facebook's infinite scrolling and auto-play video features will be used as an example. The infinite scrolling feature, which continuously loads new content as users scroll down their feed without a natural endpoint, encourages users to keep scrolling, leading to extended periods of time spent on the platform. Auto-play videos, which automatically start playing as users scroll through their feed, add to the immersive and potentially addictive nature of the Facebook experience. These features were implemented to increase user engagement and time spent on the platform and were criticized for contributing to addictive behaviors and potentially negatively impacting users' mental health. In fact, in 2018, former Facebook executive Chamath Palihapitiya publicly voiced concerns about the platform's impact on society during an interview at Stanford Graduate School of Business. Palihapitiya expressed guilt about his role in building Facebook's user engagement metrics, stating that the platform was "ripping apart the social fabric of how society works." He specifically pointed to the dopamine-driven feedback loop created by features like infinite scrolling and auto-play videos. This incident was one of many which formed my initial curiosity for this report as it brought attention to the real-life ethical implications of designing platforms to maximize user engagement at the potential expense of user well-being. In the realm of social media applications, the intentional incorporation of addictive techniques has become a strategy to enhance user engagement on social media platforms. This essay delves into the impact of deliberate addictive design, focusing on elements such as infinite scrolling and personalized content recommendations, with a primary emphasis on the social media application, Instagram. The analysis encompasses changes in user engagement patterns and the broader implications for designing responsible and ethical user experiences. Furthermore, it explores the delicate balance designers must strike between creating engaging features and ensuring responsible usage, particularly in the context of the Fourth Industrial Revolution and lastly, investigates the ethical challenges posed by rapid technological advancements, emphasizing user privacy, data security, and the proliferation of misinformation in the age of the Fourth Industrial Revolution. My three research questions for my report are:

1. From a designer's standpoint, how has the deliberate implementation of addictive design techniques, such as infinite scrolling and personalized content recommendations, in social media platforms such as Instagram contributed to changes in user engagement patterns, and what implications does this have for designing responsible and ethical user experiences?
2. How do designers balance the demand for engaging, addictive features with the responsibility to prevent negative social and psychological consequences, and what design framework should guide their decision-making in the Fourth Industrial Revolution's context?
3. How do the rapid technological advancements of the Fourth Industrial Revolution impact the ethical design of social media, particularly in terms of user privacy, data security, and the spread of misinformation?

DISCUSSION ABOUT SUBTOPIC

In the midst of the Fourth Industrial Revolution, where technological advancements are reshaping the fabric of society, the discourse on ethics and inclusivity in design has taken a spotlight. This extremely transformative era demands us to examine the ethics within the design processes and the importance of promoting inclusivity, making sure that the advantages of technological advancements are fairly shared among various communities. Our team recognized that along with the technological advancements, the Fourth Industrial Revolution brings forth major issues that challenge the ethical foundations of design. A few of the concerns brainstormed amongst our team members were biases in algorithms and AI, Addictive design in technology, Privacy and data security, AI accessibility in design etc. I became intrigued by the addictive design in the technology sector as I had recently become aware of the deliberate addictive design features implemented on social media applications when a friend of mine wanted to take a break from Instagram for her mental health and temporarily deactivate her account on the application. However, what should have been a straightforward process in deactivating her account, turned into a frustrating ordeal. SO frustrating that we both had to watch a Youtube video on how to temporarily deactivate ones account from Instagram. It became clear that the Instagram interfaces were deliberately designed to make it challenging for the user to find the deactivation button. Every button my friend pressed on the application, she was met with confusing headers or dead ends. This raised a few scary questions about the ethics of the Instagram application. Are these interfaces intentionally convoluted to discourage users from leaving the platform? Is the goal to keep users on the application and infinite scrolling, even if it could result in harming its own users. This experience formed my initial curiosity and led me to pursue this topic for my report.

To better understand the ethical design landscape within social media I began by conducting primary and secondary research. For secondary research, I studied the prominent documentary called 'The Social Dilemma' that takes the testimonies of former execs and employees of Google, Facebook, Twitter, Instagram explores the impact of social media platforms on society, shedding light on the business models and algorithms that drive user engagement. The main takeaway from the documentary revolves around the ethical implications and potential societal harm caused by these platforms. The documentary highlights how social media platforms use sophisticated algorithms to manipulate user behavior and maximize engagement. The goal is to keep users scrolling, clicking, and interacting for as long as possible. The design features, such as notifications and infinite scrolling, are intentionally crafted to create addictive experiences. This constant connectivity can have detrimental effects on mental health, contributing to issues like anxiety and depression, especially among younger users. The experts interviewed in the documentary, many of whom are former tech industry insiders, call for a re-evaluation of the ethics surrounding technology design. They advocate for more responsible practices that prioritize user well-being over maximizing engagement metrics. Another resource I used is the 'Ruined by Design' book by Mike Monteiro, which explores the ethical responsibilities of designers in the tech industry. The book addresses issues such as the role of designers in creating addictive technologies, the impact of design on user privacy, and the consequences of designing products without considering their broader social and ethical implications. Monteiro argues that designers have a responsibility to consider the ethical implications of their work. Design decisions, whether intentional or not, can have far-reaching consequences, and designers should be aware of the impact they have on users and society. The book challenges the notion that designers are mere tools in the hands of clients or companies. Monteiro emphasizes that designers are stakeholders in the projects they work on and should actively advocate for ethical practices, even if it means pushing back against clients or employers. Lastly, Monteiro proposes the idea of a Designers' Code of Ethics, a set of principles that designers can follow to ensure ethical practices in their work. This code includes considerations for transparency, accountability, and a commitment to designing for the greater good. These similar points were echoed in the interview with an UX designer from Microsoft to learn about the ways ethical design is practiced in their everyday design work and where they believe the ethical design boundaries lay.

After primary and secondary research were conducted, I developed answers to my three research questions.

From a designer's standpoint, how has the deliberate implementation of addictive design techniques, such as infinite scrolling and personalized content recommendations, in social media platforms such as Instagram contributed to changes in user engagement patterns, and what implications does this have for designing responsible and ethical user experiences?

- **Answer:** These addictive design techniques influence user behavior by: increasing user engagement, social valuation and dopamine release, Algorithmic Bias, Negative Impacts on Well-being, and Addictive Behaviors. Some possible implications of responsible and ethical user experiences include transparency and control, Balancing Engagement and Well-being, Mindful Design Practices (frameworks), and User Empowerment through Education.

How do designers balance the demand for engaging, addictive features with the responsibility to prevent negative social and psychological consequences, and what design framework should guide their decision-making in the Fourth Industrial Revolution's context?

- **Answer:** Balancing the demand for engaging and addictive features with the responsibility to prevent negative social and psychological consequences is a complex challenge for designers, particularly in the context of the Fourth Industrial Revolution. To navigate this delicate balance, designers can adopt a comprehensive design framework that prioritizes ethical considerations and user well-being. User-Centric Design, Principle: Prioritize the needs and well-being of users over maximizing engagement metrics. Application: Design with empathy, understanding the diverse needs and vulnerabilities of users. Conduct user research to gather insights into their behaviors, preferences, and concerns. Transparency and Informed Consent, Principle: Be transparent about how the platform functions and the potential impact on users. Obtain informed consent for data collection and usage. Application: Clearly communicate the purpose of features, algorithms, and data collection practices. Provide users with accessible and easily understandable information to make informed choices.

How do the rapid technological advancements of the Fourth Industrial Revolution impact the ethical design of social media, particularly in terms of user privacy, data security, and the spread of misinformation?

- **Answer:** The rapid technological advancements associated with the Fourth Industrial Revolution significantly impact the ethical design of social media platforms, particularly in the realms of user privacy, data security, and the spread of misinformation. User Privacy, Impact: Advances in data collection, artificial intelligence, and machine learning enable social media platforms to gather extensive user data, often without users' explicit knowledge or consent. Ethical Considerations: The collection and utilization of personal information for targeted advertising and content recommendations raise ethical concerns regarding user privacy. Designers must prioritize transparency, providing clear information about data practices, and ensuring that users have control over their personal information. Data Security, Impact: The increasing interconnectedness of devices and platforms poses challenges to data security. The Fourth Industrial Revolution brings about new technologies, such as the Internet of Things (IoT), that create additional entry points for potential security breaches. Ethical Considerations: Designers must implement robust security measures to safeguard user data from unauthorized access, hacking, and breaches. Ethical design practices involve prioritizing user trust by adopting encryption, secure authentication methods, and regular security audits. Spread of Misinformation, Impact: Social media facilitates the rapid dissemination of information, making it a powerful tool for spreading both accurate and false information. Algorithms designed to maximize engagement can inadvertently amplify misleading or sensational content. Ethical Considerations: Designers have an ethical responsibility to address the spread of misinformation by implementing features that prioritize accuracy. This includes fact-checking mechanisms, algorithmic adjustments to reduce the virality of false content, and promoting media literacy to help users discern credible information.

DISCUSSION ABOUT INDIVIDUAL WORKING TITLE

When initially developing my working title, I struggled trying to consciously word my working title. My initial working title was 'Ethical Design Frameworks & Habit-Forming Technologies', however I received feedback to shorten my title and simplify the language used for the audience. I further polished and developed my working title to be 'Designing Responsible and Ethical Social Media Experiences: Navigating the Impact of Addictive Design Techniques in the Fourth Industrial Revolution'. With my final working title reading 'Designing Ethical Social Media: Addressing the Impact of Addictive Design Techniques'.

CONCLUSION

The Fourth Industrial Revolution has ushered in a transformative era where technological innovations wield profound influence over our daily lives. As we witness the pervasive nature of social media platforms, it becomes increasingly evident that the quest for user engagement must be tempered with ethical responsibility. The balance between creating captivating, addictive features and safeguarding users from negative consequences necessitates a conscientious and intentional design approach.

The call for ethical social media design encompasses a multifaceted approach. It involves incorporating features that allow users to set boundaries, control their digital experiences, and be mindful of their screen time. At the same time, it requires a commitment to inclusivity, ensuring that design decisions do not perpetuate biases or exclude particular groups. In an era where technology is a ubiquitous part of the human experience, inclusivity is not merely a buzzword but a core ethical principle that designers must champion. The ethical design of social media is not a static destination but a journey of continuous improvement, where designers, companies, and users collectively contribute to a digital landscape that aligns with values of transparency, accountability, and user well-being. In navigating this journey, the ethical compass guiding social media design becomes not just a tool but a moral requirement, ensuring that technology serves humanity instead of the other way around.

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Embracing AR and VR Technologies in the Fourth Industrial Revolution

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The Application of VR and AR in Ground Search and Rescue Operations

Introduction/Background

In the rapidly evolving world of industrial design, advancements in technology such as Virtual Reality (VR) and Augmented Reality (AR) are providing new possibilities to revolutionize product and system designs. This report examines the integration of VR and AR within the context of ground search and rescue (SAR) operations, with the goal of investigating the profound impact these increasingly accessible technologies can have on enhancing the efficiency and effectiveness of SAR, leading to positive outcomes for victims and personnel.

According to the Canadian armed forces and the Canadian coast guard; "Search and Rescue comprises the search for, and provision of aid to, persons, ships or other craft which are, or are feared to be, in distress or imminent danger", (Canadian Armed Forces, 1998). Each year, the Canadian Armed Forces search and rescue program is involved in around 9000 search and rescue calls, assisting more than 20 000 people and saving more than 1200 lives (Defence, 2021). Demonstrating the potential impact advancements in technology could have in the sector. The term search and rescue encompasses various types of rescues across different terrains. Including; mountain, marine and urban search and rescue. For the purpose of my research I will focus on ground reach and rescue which consists of lowland areas and inland lakes (Leis, 2021).

The efficiency and effectiveness of Search and Rescue operations play a critical role in ensuring the safety of personnel and mitigating potential disasters. Although traditional SAR methods are proven, they often face challenges in navigating complex environments and providing real-time situational awareness. This research explores the crossroads of VR, AR, and industrial design, exploring the potential for these immersive technologies to augment and enhance SAR operations. By researching the current and future capabilities of VR and AR, I aim to address the limitations of traditional methods and outline industrial designs' contribution to the development of more efficient, safer, and adaptable search and rescue strategies.
The integration of VR and AR can be categorized into three distinct sections: pre-emergency, emergency response, and post-emergency. Virtual Reality immerses users in computer-generated environments, allowing for realistic simulations and training scenarios. Comparatively, Augmented Reality overlays digital information onto the physical world, providing an enhanced, context-aware view of the surroundings. Both technologies have demonstrated incredible potential by offering new ways to visualize and interact with complex information in various industries. Industrial design plays a crucial role in this application, exploring how these immersive technologies can be tailored to meet the specific demands of search and rescue operations within harsh environments. Ensuring that the VR and AR solutions are not only technologically advanced but also ergonomic, durable, and systematically designed for use in challenging conditions, contributing to the overall effectiveness of search and rescue missions.

Findings

Part 1: Search and Rescue Preparation

Annually, an average of 300 000 hours are spent on training and prevention (Search and rescue volunteer association of canada 2015). Understanding the proactive measures taken during the pre-emergency stages of ground search and rescue operations is essential. These missions, characterized by diverse geographical landscapes and potential challenges such as difficulties extracting survivors, even in good weather conditions (Defence, 2021). The integration of VR and AR technologies during pre-emergency stages becomes important in addressing some of these challenges. By using VR and AR training modules alongside traditional training, personnel can immerse themselves in realistic simulations, allowing them to familiarize themselves with the terrain, practice coordination strategies, and encounter potential obstacles before moving into the field.

To begin, medical training is crucial for search and rescue teams as it prepares responders to handle unpredictable medical emergencies possible in SAR missions. With the ability to assess and address injuries, administer first aid, and stabilize patients in challenging environments, proper medical training is essential for ensuring the well-being of both rescuers and those in distress. Studies show that VR training can achieve knowledge retention comparable to or exceeding traditional methods. According to (Samadbeik et al 2018), who reviewed 21 papers, using virtual reality has improved learning in 74% of studies and a higher accuracy in medical practice by people trained through VR was reported in 87% of studies reviewed.

Aviation training is pivotal in search and rescue (SAR) operations, enabling skilled pilots and crew to navigate challenging terrains, conduct aerial searches, and execute precise rescue missions. Specifically, the United States Air Force (USAF), has embraced XR to enhance pilot training. Combining VR headsets with physical controls, the USAF reduced pilot training time significantly. The success of XR in rotor-wing operations, evidenced by the Project Da Vinci initiative, reported reducing pilot training time by 35% while being able to add an additional 15 hours of training. This resulted in students being able to ‘hover, taxi, and perform various other helicopter maneuvers unassisted by their instructor pilots on their very first flight’ in an actual aircraft (Hawkins, 2019). VR aviation training is essential for SAR as it enhances pilot preparedness and competence in responding to the dynamic and often hazardous conditions encountered in SAR operations.

Taking into account the extensive use of aviation resources and medical knowledge required for SAR, the outlined benefits of VR and AR training in these fields can be translated to SAR, potentially leading to increased effectiveness of operations.

Part 2: Search and Rescue response

Natural environments present unique challenges for search and rescue teams, characterized by difficult terrain, potential hazards, and limited visibility. The conventional use of maps, radios, and basic navigational tools, while essential, may fall short in providing comprehensive and real-time insights crucial for effective SAR operations.

Effective communication is paramount in search and rescue (SAR) operations as it serves as the linchpin for coordinated and efficient responses. In the dynamic and often unpredictable environments where SAR missions unfold, clear and timely communication among team members is essential for ensuring the safety of both responders and those in distress. Communication facilitates the sharing of critical information, such as the location of survivors, potential hazards, and strategic plans, enabling responders to make informed decisions. Furthermore, seamless communication supports the coordination of resources, both on the ground and in the air, optimizing the deployment of personnel and equipment. AR and VR technologies can play a pivotal role in enhancing communication by providing immersive platforms for real-time data sharing, enabling remote collaboration, and offering visualizations of complex information. In situations where every second counts, the integration of AR and VR can significantly improve the efficiency and effectiveness of communication in search and rescue missions.

Currently, a startup named EDGYBEES is using AR and VR to revolutionize the display of critical information in disaster relief situations. Their innovative applications overlay essential data onto real-world environments, providing first responders with enhanced situational awareness. In disaster-stricken areas, where the traditional communication landscape may be compromised, EDGYBEES' AR and VR solutions enable responders to visualize key details such as geographical layouts, infrastructure conditions, and resource locations. This immersive technology facilitates more informed decision-making, accelerates search and rescue efforts, and improves overall coordination in the challenging and rapidly evolving contexts of disaster relief operations. When applied to search and rescue operations, this technology could provide unparalleled benefits. By overlaying critical information onto real-world environments, responders can swiftly assess terrain, identify hazards, and locate survivors, accelerating decision-making and improving team coordination. This streamlined communication and enhanced situational awareness in real-time can significantly reduce response times, increasing the efficiency and success of search and rescue missions in critical situations.

Figure 1: Edgybee AR overlay of critical information

To improve SAR through the integration of AR technologies, a new system called; The Search and Rescue AR Visualization Environment (SAVE), leverages spatial mapping capabilities through the use of the Microsoft HoloLens 2, providing real-time and dimensionally accurate environmental data (Luksas et al., 2022). This feature enhances SAR personnel's ability to navigate complex and dynamic environments with greater accuracy, especially in areas with challenging terrains or limited visibility. SAVE offers a set of interactive tools, including the Line Tool, Area Tool, Picture Tool, and Draw Tool. These tools enable SAR team members to annotate their surroundings, measure distances, capture images, and annotate the environment with virtual markings. SAR personnel wear AR headsets providing them with a heads-up display of relevant information overlaid on the real-world environment. This is possible by using the spatial mapping capabilities of the HoloLens 2, which employs a combination of visual, time-of-flight, and inertial sensors to generate, with the help of existing spatial maps, a detailed and dynamic spatial mesh of the surrounding environment. These tools improve situational awareness which allows team members to quickly assess their surroundings, identify points of interest, and collaborate more effectively during SAR missions. The system combines these features with the Chat Tool, enabling SAR team members to send direct or group chat messages using AR-supported interfaces enhancing the overall efficiency of SAR responses. It is also designed to be user-friendly, considering the needs of SAR personnel and addressing potential challenges, ultimately improving their ability to navigate, communicate, and coordinate during search and rescue missions.

Utilizing the Microsoft HoloLens 2 as its AR testbed, faces several challenges and considerations. Hardware limitations, including the HoloLens 2's restricted field of view and potential outdoor tracking issues, may impact the system's overall effectiveness, particularly in seamless integration into diverse search and rescue (SAR) scenarios. Spatial mapping challenges, especially in featureless or visually repeating environments, pose potential accuracy and reliability issues for environmental data. Additionally, user training and acceptance is essential for AR adoption which poses concerns about the learning curve and resistance within established SAR practices. While the article mentions a tutorial for hand gestures, broader user training implications are not extensively addressed. The communication infrastructure needed for multi-user capabilities is briefly mentioned, but challenges in establishing reliable networks in remote or disaster-stricken areas are not deeply explored. Real-world testing plans lack specificity regarding the diversity of environments and scenarios, essential factors in assessing the system's applicability across different SAR missions. Additionally, integration with existing SAR systems is a crucial consideration for successful adoption, requiring further exploration of compatibility and interoperability with current tools and protocols.

Part 3: Search and Rescue Analysis

While the potential applications of Virtual Reality (VR) and Augmented Reality (AR) in post-emergency search and rescue scenarios are promising, very little research has been conducted in this specific area. The limited literature shows a gap in our understanding of the benefits and challenges associated with integrating VR and AR technologies into post-emergency operations. Consequently, the following is informed speculation, drawing on the broader context of VR and AR applications in emergency response and disaster management. By drawing from related fields and considering the potential advantages of immersive technologies, we can explore theoretical scenarios and propose hypothetical use cases. Future research is essential to validate and refine these speculations, allowing for a greater understanding of the role that VR and AR can have for optimizing post search and rescue efforts and analysis.

In the aftermath of emergencies a substantial amount of data is generated. This can range from information about affected areas, population density, infrastructure damage, and weather conditions. The effective analysis of this data is pivotal for decision-making and resource allocation during the post-emergency phase. Virtual Reality has potential to be valuable in this context by enhancing the visualization and analysis of intricate datasets. By recording the environment, it can provide an immersive three-dimensional recreation of the environment, allowing emergency responders to visualize data in 3D and comprehend the relationships in the affected area more effectively. Additionally, VR platforms can enable responders to interact with GIS data, overlay different information layers, and identify patterns or anomalies more effectively than traditional two-dimensional representations. Furthermore, VR recreations can empower responders to plan and strategize their actions virtually before the future deployment of resources on the ground. Collaborative decision-making is also supported through VR environments, allowing multiple parties to interact with the same dataset simultaneously. This can enhance communication and coordination among various agencies involved in the post-emergency response.

Optimizing resource allocation is another benefit of using VR. By analyzing data related to resource availability, distribution, and demand, emergency management teams can make informed decisions on how to allocate personnel, medical supplies, and equipment to areas with the greatest need. As previously discussed, VR can be a great tool to train SAR personnel and the ability to analyze data virtually in post SAR situations can ensure better resource deployment in future real-world scenarios. In essence, the utilization of VR for data visualization and analysis in post-emergency situations can help provide responders with a comprehensive and intuitive understanding of the situation. This, in turn, enables more informed and effective decision-making throughout the recovery and rescue efforts in the future.

To address the limited research on post-emergency search and rescue scenarios, new research could involve conducting in-depth case studies of recent incidents and interviews with emergency responders and disaster management personnel. These qualitative approaches can provide valuable insights into the challenges faced and opportunities for integrating VR and AR technologies in these operations. Additionally, the development of virtual scenarios using VR technology, combined with longitudinal studies and collaborative workshops, offers a varied methodology to gauge the potential impact of the technology over time and encourage interdisciplinary collaboration between emergency management experts and VR/AR technology developers. By employing a combination of qualitative and quantitative methods, future research could contribute to a more comprehensive understanding of the role VR and AR can play in optimizing post-emergency response efforts.

Discussion: the role of industrial designers

Ground search and rescue operations are complex and require a problem solving method that looks at the eternity of the systems within. This approach acknowledges the connectedness of different components, including rescue teams, medical personnel, aviation units, and communication networks. It is in this intricate web that the design of effective AR and VR solutions finds its foundation. This task demands a collaborative effort that spans disciplines such as technology development, industrial design, human factors, and emergency management. Through interdisciplinary collaboration, we can ensure that the resulting AR and VR solutions align seamlessly with the true needs of search and rescue missions by addressing the challenges posed by the dynamic and unpredictable nature of emergency response scenarios. Human-centered design is also a crucial aspect of this approach, particularly within the context of search and rescue. Recognizing the unique needs, preferences, and challenges faced by users in the field, human-centered design focuses on the physical and psychological stressors found in rescue operations. This thoughtful consideration extends to the iterative design process, actively engaging rescue teams, pilots, and medical personnel. By using design methods continuous feedback loops, we can ensure that the evolution of AR and VR solutions is guided by real-world insights. Enhancing the efficacy in meeting the operational requirements of search and rescue missions.

Throughout the entire design process is a commitment to research-driven design principles. The development of AR and VR solutions for search and rescue goes beyond intuitive design by incorporating empirical research findings of industrial design. Rigorous studies are conducted to discern the effectiveness of immersive technologies in critical areas such as training, communication, and decision-making within the specific context of search and rescue missions. Therefore research-driven design can ensure that the resulting AR and VR solutions are not only theoretically robust but also grounded in practical applications, enhancing user performance in the complex and dynamic real-world scenarios encountered during search and rescue operations.

The convergence of a systems-based approach, human-centered design, and research-driven design form the basis of effective AR and VR solutions for ground search and rescue. This perspective, employed by industrial designers acknowledges the intricate ecosystem of operations, places the user at the forefront of design considerations, and integrates empirical research findings to create technology that not only meets immediate needs but also contributes substantially to the overall success of search and rescue missions.

Conclusion

In conclusion, this research demonstrates the impact of Virtual and Augmented Reality on ground search and rescue operations. Showcasing their potential to revolutionize critical aspects of mission preparedness, execution, and analysis. With a focus on a comprehensive systems-based approach that acknowledges the various elements within search and rescue, including rescue teams, medical personnel, aviation units, and communication networks, the significance of industrial design is evident. This research advocates for a holistic approach to the design and implementation of AR and VR solutions in search and rescue. By combining a systems-based perspective, human-centered design, and research-driven principles, the study aims to contribute substantially to the success of ground search and rescue missions. VR and AR, when integrated effectively, offer a intriguing path forward, addressing challenges, enhancing safety and ultimately optimizing the success of critical search and rescue endeavors.

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Figure 1: Edgybee AR overlay of critical information Sourced on December 11th, from: https://www.roboticsbusinessreview.com/unmanned/augmented-reality-drone-overlays-feed-data-to-first-responders/

Augmented Reality (AR) and Virtual Reality (VR) in Museums

Augmented Reality (AR) and Virtual Reality (VR)|Jade Bruins

INTRODUCTION / BACKGROUND

This report will be exploring Augmented Reality (AR) and Virtual Reality (VR) in the era of 4th Industrial Revolution, specifically within the field of Museums.
In recent years, AR and VR have improved rapidly, and become available to the masses. Despite the improvements, it is still an emerging technology, and has yet to be fully adopted by societies across the globe.

VR is a digitally created simulation environment. It fully removes the users from reality, and creates a "sensory illusion of being present in another environment" (Zhou et al., 2022). Users typically wear a headset and hold tracked controllers to navigate.
AR combines physical and virtual space, usually by superimposing "Digital Augmentations" (Zhou et al., 2022) (overlays) onto the physical environment. It does not remove users from reality entirely, instead distorting it. Users typically can experience these "Digital Augmentations" through mobile device applications, using the camera to record the physical environment.

AR and VR technology is applicable to several fields, including design.
The individual working title, Exploring AR/ VR in Museums, was initially chosen due to interest in pursuing design in this field. Additionally, AR and VR have been implemented in exhibits in Ottawa and have drawn in huge crowds due to the marketability of the new technology.
The three main questions addressed within this topic are:
How can VR enhance in person learning and create unique experiences for viewers? How can AR/VR technology improve user interaction and broaden the viewership of artifacts? And finally, what are the main current limitations faced that prevent museums from implementing this technology today?

Through this report, it is expected that a multifaceted approach will allow for a deeper understanding to be gained. Understanding current use scenarios of this technology and predictions of future use cases of AR/VR is expected. How this will affect museum learning and attendance will be investigated.

DISCUSSION ABOUT SUBTOPIC: AUGMENTED REALITY (AR) AND VIRTUAL REALITY (VR) IN INDUSTRIAL DESIGN IN THE ERA OF 4TH INDUSTRIAL REVOLUTION

AR and VR technology are both immersive technologies that adapt our senses, particularly visuals. User experiences are also intrinsically linked to the devices used. The technology was first developed in the 20th century. One pioneered device was "The Sensorama" developed by Morgan Heilig in 1957. It was a mechanical device with a screen, fans and a motion chair that sadly never went into production (ARchy, 2019).
AR and VR technology quickly advanced in the 21st century, in the 4th Industrial Revolution. Rapid development of mobile devices, nanotechnology, robotics, the Internet of things and more have allowed this technology to take shape and be affordable.

The future potential of AR and VR is vast, however there are several concerns that prevent it from being widespread currently. Cost, hardware, software, training, data sharing and privacy issues are just a few. This is the time for designers to adopt these new technologies, embrace them and to use their full potential. We can help address some of these concerns appropriately and play a role in this technological advancement.

The focus of this paper is on AR and VR in museums, within the 4th Industrial Revolution. This has become a hot topic with Museum Practitioners, as the technology is currently creating a shift in museum development. It offers a new, immersive way of learning within the museum space that transcends traditional means. This dynamic and engaging technology can be used to draw in the younger generations back to museums.

AR and VR in the Museum context currently allows for more digital information to be integrated into visitor experiences. AR allows for the space to be adapted, promoting interaction and personalization. VR can take users to a new space, providing immersive journeys and storytelling narratives.

The investigation approach consisted of secondary research into accredited articles and journals, as well as real life examples of technology implementation. Using a variety of sources provided a holistic view of the subject, understanding both the theoretical frameworks and the practical implications of how museums are currently adopting AR and VR technology.

Further exploration into the question answers is available in the following section.
For a brief overview, VR enhances learning and creates unique experiences as it is a new way of storytelling, creating content and delivering information to viewers. This is done through 'body swapping' VR experiences, or VR reconstructions of historical events.
AR and VR technology broadens the viewership of artifacts. It is a great tool for artifact and exhibition preservation. It also increases engagement during exhibit visits using "Mobile Augmented Reality (MAR)" (Moropoulou et al., 2019).
Current limitations for AR and VR specifically in museums are cost, staffing, technology issues, isolation, and inaccessibility.

Overall, the integration of AR and VR in museums during the 4th Industrial Revolution shows how prevalent this revolution is, that cultural institutions are adopting this new technology. Although there are many concerns currently, seeing a glimpse into how this technology can assist our world and provide meaningful learning experiences in museums soon is uplifting.

DISCUSSION ABOUT INDIVIDUAL WORKING TITLE: AR AND VR IN MUSEUMS, WITHIN THE 4TH INDUSTRIAL REVOLUTION.

AR and VR can be used as a research and learning tool within Museums. It aims to create "engaging and appealing learning experiences" (Zhou et al., 2022) for viewers. Currently, the technology is mostly offered in temporary exhibits (Shehade & Stylianou-Lambert, 2020). The impact it creates on viewers is promising, and we will continue to see the adoption of AR and VR in the coming years.

This section investigates three critical questions related to the working title. Starting off with:

How can VR enhance in person learning and create unique experiences for viewers?

Museums are first and foremost interested in creating enriching experiences for viewers, and using technology that will serve audiences needs appropriately (Shehade & Stylianou-Lambert, 2020). AR/VR offers a new way of storytelling, creating content and delivering information to viewers, which is creating a paradigm shift in the field. (Shehade & Stylianou-Lambert, 2020). This has shown to have a profound effect on cognition, behavioural skills and positive emotions (Zhou et al., 2022).

Museum Practitioners are curious about implementing VR into exhibits so viewers can experience artifacts in their own ways that best suit them. Accommodating all learning methods is a top priority, so everyone can gain a deeper understanding of the topics explored. Creating a "coherent mental representation" (Zhou et al., 2022) of artifacts allows viewers to fully undergo the cognitive process. Researchers are expanding even further, by incorporating "multimedia learning theory" (Zhou et al., 2022) into AR and VR tools. They aim to enhance emotional experiences, meaning making and understanding, to promote active learning and motivate viewers to critically analyse the presented material (Zhou et al., 2022).

VR heritage site reconstructions are one example of a unique experience museums have been developing. Viewers are transported to a historic site or society, and witness the dynamic scene virtually (Zhou et al., 2022). The expansive amount of information creates a holistic experience and enhances learning. This vastly outweighs the traditional museum experience of reading tombstones and viewing stand-alone artifacts to learn about a historic event (Zhou et al., 2022).

London's Natural History Museum took VR technology in stride. Released in 2018, they partnered with VRVoyaging, to build 'Sky VR: Hold the World'. A Nature documentary style VR experience, hosted by Sir David Attenborough. Viewers can fully manipulate artifacts using VR controllers, walk through the museum virtually and explore restricted areas. Just like his documentaries, he explores historical natural elements like "bone and fossil specimens' (Kulp , 2023). He explains where they belong on full skeletons, discusses the creatures themselves and how they were found. Additionally, viewers get to walk through different exhibitions such as the 'geology library or fossil lab' and restricted behind-the-scenes areas during the experience.

Figure 1: "Sir David Attenborough right in front of you!" Kulp, A. (2023). Sir David Attenborough right in front of you! VRVoyaging. Retrieved December 10, 2023, from https://www.vrvoyaging.com/sky-vr-hold-the-world/.

Another VR experience explored by Museum researchers is 'body swapping'. This is when viewers are fully immersed and placed in someone else's shoes. This experience provokes powerful emotions like empathy and "support[s] a wider social good". This is a beneficial technique for exploring a diverse range of important social topics, such as homelessness or immigration. VR is the perfect tool, as it fully removes all personal autonomy, and places you in a separate realm instantaneously (Shehade & Stylianou-Lambert, 2020). Viewers gain a deeper and meaningful understanding quickly that normally cannot be felt through traditional mediums, like text or 2D visuals.

It is clear that VR creates meaningful, personal experiences for viewers that provokes critical thinking and active learning. It has been shown that the additional information shown through the VR environment results in deeper understanding, and higher grades are achieved on standardised tests. (Zhou et al., 2022)

How can AR/VR technology improve user interaction and broaden the viewership of artifacts?

AR/VR technology is implemented heavily in museum preservation and viewing exhibition content. The interactive nature of the technology promotes engagement and is a marketable tool to attract more visitors.

VR is a heavily discussed topic in museum preservation. VR can be used to preserve artifacts, by taking a 360° video or photographs. This is a great tool for record keeping, specifically artifact deterioration tracking. Conservators have more information regarding the artifact's life, which allows them to make calculated decisions when determining the best course of action when restoring artifacts (Moropoulou et al., 2019). The same technology can also be used to preserve exhibitions. This way viewers have access to the work virtually, at any time. This increases the viewership of artifacts and exhibits. As they can 'live' indefinitely, costly, and thoughtful work is not 'wasted' when the physical space is changed. Tangible and intangible elements can also be captured fully in VR software.

“Mobile Augmented Reality (MAR)” has been implemented in exhibits for viewing additional content that appeals to all senses (Moropoulou et al., 2019). Viewers can download an “Enhanced Reality application” (Moropoulou et al., 2019) on their mobile devices. While visiting displays, they can view the area through the downloaded application. Depending on how the museum Practitioners designed the experience, museum guides, digital overlays and/or simulations can be seen on the screen. The combination of multi-media content promotes experiential and situated learning in museums, by making the experience interactive and engaging for viewers. This creates positive perceptions of the content and museum. Currently, the avenues that have been explored are: Providing an accurate and comprehensible museum map to aid wayfinding, Overlays created by superimposing text and additional images onto artifacts, adding graphical elements to simulate intangible or abstract phenomena and simulating narrative scenarios by adding voice recordings (Zhou et al., 2022).

This is a huge improvement in terms of interaction and engagement, compared to traditional forms of museum content. Museum Practitioners had limited ability to engage viewers and describe complex topics with physical captions and artifact displays. Many viewers quickly become disengaged and skip over important content throughout their visit. Incorporating visual elements in an exciting manner through AR, improves viewer retention rates and creates positive perceptions. Therefore, viewers will absorb more content, leading to an increase in learning.

Additionally, AR allows for a more personalized and detailed experience. Museum Practitioners have to consider graphical layouts and hierarchies heavily for traditional physical displays. They hand pick important information to maintain clarity and simplicity, to draw in viewers and deliver information in bite size chunks. If a viewer is very interested in a specific topic, there may not be more information available to them. This is where AR comes in. It can cater to both the viewers that want to learn base level content, and those that want expert level knowledge. Viewers can access more detailed content though the AR technology and drop-down menus.

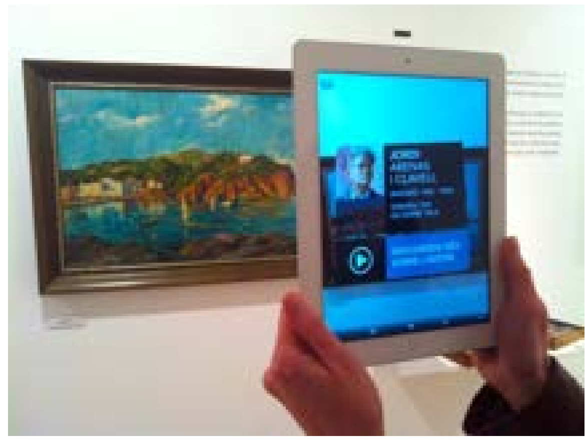

Figure 2: Augmented reality at Museu de Mataró linking to Catalan Kippelboy. (2012). Augmented reality at Museu de Mataró linking to Catalan . Wikimedia Commons. Retrieved December 10, 2023, from https://commons.wikimedia.org/wiki/File:Augmented_reality_at_Museu_de_Matar%C3%B3_linking_to_Catalan_Wikipedia_%2818%29.JPG.

Moreover, the novelty of AR and VR technology is a marketable tool. Museum visitors, especially the younger generation, are interested in trying these new experiences. They may come visit the museum just for AR or VR experiences. Therefore, the whole experience and use cycle of this new technology is considered by Museum Practitioners.

Both AR and VR improve the viewership of artifacts. VR is very useful in artifact and exhibition preservation. AR can be easily implemented into existing museum exhibits, and significantly improves viewer retention rates. It is also a marketable attraction that can draw in new visitors to the museum.

What are the main current limitations faced that prevent museums from implementing this technology today?

The current limitations that museums face when implementing AR and VR technology are cost, staffing, technology issues, isolation and inaccessibility.

Cost is by far the most prevalent issue for VR technology. Most museums cannot afford the technology to accommodate the daily quantity of visitors that would be interested in using the equipment. To combat this, many museums collaborate with VR developers to borrow the required equipment and reduce costs (Shehade & Stylianou-Lambert, 2020). This means that most exhibitions with VR are temporary (Shehade & Stylianou-Lambert, 2020), as museums cannot justify investing in risky, new equipment.

Cost barriers for AR technology are lower, which is why they are more utilized for museum learning. Visitors can use their own mobile device to access the "Enhanced Reality Application" (Moropoulou et al., 2019), or a provided tablet, which is more cost effective than VR equipment (Zhou et al., 2022).

Customer service is also a concerning issue. Most visitors have never used VR or AR equipment previously. Museums need full-time staff assisting visitors at the respective booths (Shehade & Stylianou-Lambert, 2020). This is an added expense for museums. Furthermore, the whole visitor experience has to be considered, including interactions with equipment and staff, not just the interactions with the VR itself. Ensuring that customer service is helpful and welcoming when visitors approach the area, and when they're finished with the experience, is difficult to regulate. These service interactions are almost more important than the VR experience itself (Shehade & Stylianou-Lambert, 2020).

Technology and troubleshooting equipment is a large issue that could easily create customer dissatisfaction. All staff have to be trained on handling, and troubleshooting to solve any unexpected issues with the new equipment (Shehade & Stylianou-Lambert, 2020). This is once again, an added cost.

VR relies on WIFI and Bluetooth networks. The network speeds have to be fast to run the programs smoothly, especially when setting up and connecting multiple headsets. Interference and slowing wifi speeds are huge concerns that could be affected by the building's available bandwidth, and uncontrollable issues, dampening the user experience.

AR also relies on WIFI, facing the same issues. If there are multiple visitors downloading the "Enhanced Reality Application" (Moropoulou et al., 2019), they could stress the WIFI bandwidth, leading to slower downloading times. Less visitors would be interested in downloading the application if it takes a significant amount of time. The second complication is the variation in visitors' mobile phones creates an inconsistent experience for visitors. WIFI lags, older devices and incompatible equipment have a varying effect on the applications performance. To minimise this, significant and heavy hardware testing needs to be done by technicians.

Some Museum Practitioners commented that they don't want to implement VR in the museum as it is isolating for visitors. VR is meant to be used individually, but most visitors come to museums in groups. The VR also takes users out of their current reality, and puts them in a new one. This takes the users out of the already immersive space of a museum (Shehade & Stylianou-Lambert, 2020).

AR and VR technology has not been well tested for all users, including those with disabilities. VR is off putting for deaf or blind users, as it blocks critical senses of the outside world. The equipment is also uncomfortable for children. Therefore they will have an impoverished experience at the museum as they are unable to fully access the tools available to able bodied adult individuals (Shehade & Stylianou-Lambert, 2020). Some museums cater to children as their main demographic, so if the VR technology is uncomfortable and unavailable to all of them, this creates a major divide in visitor experience.

CONCLUSION

In conclusion, through exploring AR and VR in the 4th Industrial Revolution, a deeper understanding on the transformative potential this technology has on just museums is profound. Although there are a lot of challenges, the potential for providing better learning experiences is undeniable. Through this research, it is clear why Museum Practitioners are heavily investigating this topic. This subtopic reflects the broader impact that all facets of the 4th Industrial Revolution are having on our everyday life. We must embrace all this new technology, for it to best serve our needs, and further enhance our society.

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ARTIFICIAL AND VIRTUAL REALITY IN GOLF TRAINING

EMBRACING AR/VR TECHNOLOGY IN THE FOURTH INDUSTRIAL REVOLUTION|Steven Chiang

INTRODUCTION / BACKGROUND

IDES 4001A, the design seminar course, provides an exciting opportunity for students to explore the topics of design philosophy, technological innovation, and industrial design's real-world applications. This seminar creates an environment where students actively participate in discussions, honing their presentation and critical thinking skills in contrast to traditional classroom settings that are dominated by textbooks and exams. This distinct approach is especially important as we explore the complex landscape of the fourth industrial revolution, an era characterized by the rapid integration of emerging technologies into various aspects of our lives.

In this seminar, we specifically address the relationship between design and the fourth industrial revolution, with a focus on the significant influence of Augmented Reality (AR) and Virtual Reality (VR) technology. Through this innovative research, students have the opportunity to engage with experts and former students, acquiring knowledge about real-world applications and challenges. The chosen subtopic of embracing AR/VR technology in the fourth industrial revolution sets the stage for an in-depth exploration of these technologies' transformative potential in the field of sports training, with a particular emphasis on golf. The purpose of this introduction is to lay the groundwork for future research on the potential synergies between AR/VR, AI, and sports training. This is a topic that has significant implications for user movement analysis, ergonomics, and the overall functionality of immersive training environments. Throughout this report, we will explore the path of our team's exploration, discussing significant questions, activities, research findings, and insights garnered from the Design Seminar course.

Moreover, to comprehend the significance of our chosen subtopic, we must first comprehend the overall goal of the design seminar course. Students can use this course as a starting point to help them understand the complex nature of contemporary industrial design issues. Students enhance their knowledge and improve their critical analysis and participation in the discussion surrounding modern design challenges by participating in writing, debates, and discussions. In this seminar, we will examine the possible effects of the fourth industrial revolution and how design is a key factor in influencing the future, both individually and collectively. The deliberate choice of the subtopic—embracing AR/VR technology—highlights the importance of the discussions to the greater picture of how the design landscape is changing.

DISCUSSION ABOUT SUBTOPIC

The incorporation of AR/VR into the fourth industrial revolution represents an important shift in how we perceive and interact with the world around us that can be utilized in a variety of fields, including sports, medicine, education, entertainment, etc. The topic our team chose with our topic of embracing AR/VR technology in the fourth industrial revolution includes AR/VR in Golf Training, AR/VR for Search and Rescue, AI Integration for AR/VR in Education, and AR/VR in Museums. Our team's primary focus is on recognizing and overcoming significant problems connected with implementing AR/VR technology in the multidisciplinary field as well as investigating how these technologies might improve user experiences. The central argument revolves around the possible opportunities and problems that arise at the intersection of AR/VR and industrial design. Even though this paper emphasizes the topic of sports training, these topics depict a turning point in the relationship between humans and machines. Our research takes a multifaceted approach, integrating literature reviews, case studies, and team meetings to exchange ideas. In addition, an interim group presentation facilitated great feedback from both the instructor and classmates, adding to the iterative development of our exploration.

To fully understand the possible impact of sports training, it is vital to understand the historical background of this transformation. Sports training has always developed in connection with technology, moving from basic tools to complex training platforms and creating immersive experiences that go beyond the limits of traditional teaching approaches. Secondary research broadened our understanding by investigating current systems like REPS and STRIVR training platforms that use AR/VR for sports training further illustrating that the application of AR/VR in sports seeks to transform training approaches by providing athletes with dynamic and realistic settings for skill improvement. REPS is a multi-sport training platform that offers sports such as football, water polo, baseball, and basketball whereas STRIVR is an enterprise virtual reality learning platform that emphasizes immersive learning technologies. In addition, multiple case studies demonstrate the efficacy of AR/VR sports training.

Take two case studies from STRIVR with different sports as examples: The Washington Wizards used Strivr to improve team performance in the 2016–17 NBA season, emphasizing play knowledge, strategy, and mental preparation. A notable example was Wizards center Ian Mahinmi, who saw significant improvement in his free throw shooting accuracy after working with Strivr. Despite his injuries, Mahinmi's free throw percentage rose noticeably in the Strivr-trained weeks as compared to the non-training weeks, demonstrating the usefulness of the visualization tool for skill development (Strivr Labs, Inc.,2023). In another case, Skiers had little opportunity to practice on the real slopes during the 2018 Winter Olympic Games in South Korea, which made it difficult for them to learn critical turns. By offering skiers endless virtual runs on the precise slopes, Immersion Learning transformed their training and helped them understand turn movement, terrain specifics, and gate positions. In addition to improving competition readiness through course inspections, the use of VR and 360-degree video-assisted in athlete rehabilitation by utilizing how the brain responds to virtual slopes to improve real-life performance (Strivr Labs, Inc.,2023). These sources demonstrate that a new era of personalized and immersive training experiences is being set off in this field by the introduction of AI and AR/VR.

The three guiding questions act as a compass for us as we explore the vast landscape of our subtopic. The first question explores the numerous applications of AI in AR/VR sports training. The initial research has demonstrated a potential landscape in which AI, AR, and VR are converged to reinvent sports training. The articles "Artificial Intelligence in Sports Training" (Raturi, 2023) and "Future of AI in Sports Training" (Frąckiewicz, 2023) highlight the use of AI in real-time movement analysis and performance evaluation. The first source, Frąckiewicz's "The Future of AI in Sports Training: From Analytics to Performance," provides information on how sports organizations and sports training programs are using AI to analyze data and derive insights. In this scenario, applying AI might involve anything from studying game data to fine-tuning training regimens (Frąckiewicz, 2023). Furthermore, Raturi's (2023) Artificial Intelligence in Sports Training, which uses AR and VR to enhance sports training, was also mentioned. According to this resource, "AI can be used to analyze an athlete's performance in these virtual environments, providing real-time feedback and guidance on how to improve"(Raturi, 2023). This technology can be especially beneficial for athletes who are recovering from injuries because it allows them to continue training and honing their skills without putting undue strain on their bodies" (Raturi, 2023). This synthesis establishes the foundation for our investigation into the ways AI can support the creation of AR/VR sports training, with a focus on the comprehension of user actions in golf. AI's transformative potential is demonstrated by real-time movement analysis, dynamic program adjustments, and personalized training plans that are driven by machine learning algorithms. As mentioned, reading through the literature already available makes it clear that AI is a dynamic force that is transforming how athletes learn, adapt, and perform. It is beyond being a tool for data analysis.

The second question explores the fundamentals of industrial design by concentrating on the modularity and configuration of AR/VR handles of golfer ergonomics. This research reveals the complex relationship between form and function, where handles transform from being mere accessories to essential parts of a golfer's training equipment. The idea of modular design opens up the opportunity for a customized and adaptable training experience by accommodating a range of sizes and preferences. This is enhanced by the incorporation of AI-driven feedback systems, which give golfers comprehensive performance and technique insights.

The third question discloses the complexity involved in combining AI, VR, and AR in sports training by examining downsides and possible benefits in terms of functionality. Although there are obstacles to overcome, like the cost of implementing AI, technology dependency, and privacy issues, there are also positive aspects. A potentially revolutionary approach is the smooth merging of virtual and physical training environments, combining the best features of both domains to produce a comprehensive learning experience.

DISCUSSION ABOUT INDIVIDUAL WORKING TITLE

Pursuing my individual working title has been a journey of introspection and innovation. This working title conveys the essence of how industrial design redefines the parameters of sports training. In this section, we delve into the specifics of the chosen working title, delving into the reasoning behind "How Industrial Design Can Enhance AR/VR in Golf Training" and the potential implications it holds within the broader context of the Fourth Industrial Revolution.

The central premise of our working title is to discover opportunities where industrial design intersects with AR/VR and AI to revolutionize golf training. The role of AI in analyzing user movements and providing real-time feedback has transformative potential. The system can dynamically customize training regimens by utilizing machine learning algorithms, providing athletes with individualized insights into their learning preferences and performance. More specifically, AI's ability in performance assessment, tracking metrics such as accuracy and form, enables data-driven insights. These data can be used to tailor individual training programs for athletes to target their areas of weakness. On top of that, the ability of AI to replicate situations is critical for athletes. By constructing realistic and dynamic scenarios, virtual environments can be used by athletes to train in ways that mimic the actions of opponents or game situations.

As an aspiring industrial designer, the modularity and configuration of AR/VR handles are at the forefront of my research. As I examine current literature and sports training platforms, the nuanced aspects of design become clear. A key idea in designing handles that go beyond the one-size-fits-all method is the idea of interchangeable parts, which is a modular design that takes club sizes/weights and personal preferences into account and allows for simple adaptation. Industrial designers can create handles that comfortably and uniquely fit every golfer. By providing golfers with immediate feedback on their technique and enabling a more individualized training experience, the incorporation of AI-driven feedback mechanisms into these handles opens up new possibilities. Sensors integrated into the handles record grip pressure, swing speed, and other relevant information, enabling precise adjustments that can help improve golfers' overall technique with recommended adjustments. This can be a beneficial instrument for all skill levels of golfers, whether they are beginners or professionals. To accomplish this, industrial designers need to investigate the evolving concept of simulating impact in AR/VR golf training. Understanding how users experience the impact of hitting a ball in a virtual environment presents an interesting challenge for an industrial designer. This aspect, which is tied to learning user movements, golf equipment, and the sensory experience, creates opportunities for creative and innovative design solutions that can connect the virtual and physical worlds. In addition, this also highlights the interdisciplinary nature of industrial design. In this case, to develop a comprehensive and successful solution in the Fourth Industrial Revolution, industrial designers must work closely with professionals in AI, VR, and sports training. The collaboration of these fields is critical in creating an immersive, ergonomic, and functional AR/VR golf training experience.

The integration's potential for transformation is highlighted by the synthesis of findings regarding the role of AI in user movement learning, the modularity of AR/VR handles, and the broader functionality issues. One challenge is the potential cost of implementing AI, which may prevent some athletes or organizations from participating. Reliance on technology also comes with risks, like the possibility of connectivity problems or system failures, which could make training sessions inefficient. Consideration should also be given to privacy, as the collection and analysis of user data for customized training may raise ethical issues that require careful consideration. However, these challenges that arise also come with the opportunity to develop a comprehensive learning environment that smoothly combines the virtual and real-world aspects of sports training. More specifically, there is an opportunity to combine AR/VR technology with real golf courses, creating a seamless transition between online and offline golf training taking advantage of the strengths of both virtual and physical practice environments.

The current investigation acts as a stimulant for subsequent investigations, establishing the foundation for additional study and innovation in the developing field of industrial design during the fourth industrial revolution. Our findings are important not only for the seminar room but also for shaping our understanding of and contributions to the field of design in the technologically driven future.

CONCLUSION

A nuanced viewpoint becomes apparent as we conclude the investigation of the subtopic and working title. The fourth industrial revolution, marked by the rapid integration of AI, VR, and AR, offers unprecedented opportunities for improving sports training. The limited information that is currently available indicates that the viability of integrating AI into AR/VR sports training is still in the early stages. However, the promising resources and conceptual idea of enhancing AR/VR with AI point to a promising future. This exploration provides a spark for more research and innovation in the field of industrial design as it changes in the context of the fourth industrial revolution. Our findings have implications that go beyond the seminar room, impacting our understanding of and ability to influence design in the technologically driven future.

Furthermore, researching the individual working title reveals that industrial design is more than just a bystander in this transformative landscape. Design takes on the role of an active agent, influencing how technology is integrated and how users interact with it. The possibilities in sports training are expanded by the modularity and configuration of AR/VR handles in conjunction with AI-powered feedback mechanisms. When technology and design are combined, human factors are not replaced but rather enhanced, resulting in an ecosystem where innovation and human-centric principles meet.

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INDIVIDUAL FINAL REPORT

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Course: IDES 4001A

Industrial Design Seminar (FA 2023)

Dated: Dec 12, 2023

Introduction

An overview of AI, VR, and AR

In the era of the 4th industrial revolution, technological advancements have sought to change the way we as designers interact with both the digital and physical worlds around us. This has brought forth a new level of innovation specifically in regards to AI (artificial intelligence), VR (virtual reality) and AR (augmented reality). While the rapid advancement of these technologies has allowed us to design and interact with each other in new and exciting ways it has presented challenges redefining how we view the human experience.

Although AI, VR and AR by themselves represent a fundamental shift in the future of the design landscape, the fusion of these technologies represents the cornerstone of this ongoing technological revolution.
This exploration seeks to examine the convergence of AI, VR and AR, and their potential to revolutionize user experiences specifically concerning remote education and the related ethical considerations. Through this lens, we can examine how these converging technologies will impact the future of learning, privacy and data security.

Importance of integrating AI with VR/AR

The conjunction of AI, VR and AR is a pivotal step in the advancement of how these technologies are being used and their place within the 4th industrial revolution. Ai's integration with VR and AR is a pivotal advancement in the realm of remote education as it promises to revolutionize the learning experience by enhancing the learning experience, personalizing the curriculum and providing adaptive learning modules. By catering to individual student learning needs educators can optimize content and teaching methodologies to provide real-time insights into student learning behaviors.
In the context of remote learning, the harmony of AI and VR/ AR more seamlessly facilitates collaboration and a realistic work environment which overcomes physical or geographical barriers. The focus of this section is aimed at the significance of AI in conjunction with VR/AR in the remote classroom and how our approach to online learning should revolve around the strengths of the online environment as opposed to trying to replicate the traditional educational setting.

The thesis statement outlining the essay's focus on enhancing user experiences in education, remote work, and ethical considerations

This essay looks to explore how AI with VR/AR is reshaping the approach to online and remote learning experiences while uncovering the need for ethical considerations in a rapidly advancing technological landscape.
It aims to uncover ways in which this integration can redefine remote education dynamics for both educators and students alike and intends to scrutinize concerns relating to privacy, data security and algorithmic biases.
By exploring the intersections of remote education and ethical considerations this essay seeks to provide an analysis of how AI integration with VR/AR shapes and influences the human experience in the 4th industrial revolution.

AI Integration in Enhancing User Experiences in Education with VR/AR

The current landscape of education technology

The current landscape of education technology is quite interesting and challenging as we adapt from the exclusively online classroom and try to blend our online experiences with in person. Due to the COVID-19 pandemic education technology saw a sudden rapid growth and adoption as the world switched to online platforms. This exposed several challenges with the online environment including mental health, privacy, technological disparity and a shift in how educators adapted their teaching methodologies. Students in online classrooms reported they found it difficult to stay engaged and without a physical classroom, many felt isolated leading to a decline in mental health. Educators may have found it difficult as well to keep their students engaged with new ways to conduct assignments while overcoming technological hurdles. These challenges led to countless improvements in online school systems and e-learning websites; however, the interaction between students and online learning systems lacked humanization. Moving forward it is important to analyze these lessons learned from the challenges faced during the pandemic and apply them to the future of integrated technology and education.

How AI improve personalized learning experiences in VR/AR

As we move towards a future with more accessible integrated VR/ AR technology there are several ways AI integration can enhance and personalize the learning experience. Firstly AI algorithms in conjunction with VR/ AR allow for more personalized learning experiences. AI algorithms can personalize learning experiences by adapting content and difficulty levels according to individual student needs. Data and analysis provided by AI tools can adapt and provide educators with real-time insights about their student performance, engagement and areas for improvement. Although these benefits have focused on the AI side the VR/ AR applications to online education have allowed for more interactive and immersive learning experiences as well as supporting students as a collaborative learning platform.

Example successful integration

AI has been integrated with VR and AR in many ways through their combined conception. Whether it is through adaptive learning and providing AR with improved real-world object recognition or allowing VR environments to have more realistic representations of real-world environments the breadth of AI's influence has been long and impactful. This, however, is where many of the challenges arise. That being AI and VR/ AR have often been marketed and developed as entertainment and recreational tools as opposed to education or professional practice. That being said there are several examples of new AI VR/ AR integrated technologies moving into the professional and educational workplace. For example, San Diego State University used a virtual teaching and learning tool for their nursing students allowing them to more easily observe and treat virtual patients in real-time (Price. 2018). The technology used in this scenario was the m Microsoft Hololens allowing them to blend the real and virtual worlds. Other examples include computer-aided language learning models such as those implemented in Turkey to measure how tertiary-level students perceive the impact of humanization in their electronic language learning tools.

Challenges and limitations in implementing AI in educational VR/AR

Although there have been successful examples of integrating this technology, the educational sphere is often slow to adopt new technology. Primarily the safety of students and educators takes top priority over new technological benefits but there are challenges involved with complexity and integration, data security and lack of training and support. In order to address these challenges and limitations of AI and VR/ AR more collaborative efforts between educators, developers and policymakers are required. Tackling the hurdles mentioned above is critical if we want the full potential of AI-integrated VR/ AR technology in education while ensuring equitable and safe access for everyone involved.

AI Integration's impact on providing new opportunities for remote learning

Remote learning trends pre-AI integration

Before the incorporation of AI in-person learning was mostly dependent on traditional digital platforms and communication methods. Similarly, the main components of remote learning were video lectures, internet materials, and basic learning management systems. These systems lacked any forms of AI-driven interventions catered to individual learning styles, personalized feedback mechanisms, or advanced adaptive learning capabilities.

Advantages of AI-powered VR/AR in remote learning environments

The integration of AI in VR/ AR has allowed for a shift in how we approach remote learning environments. It has allowed us to offer students and educators a new approach to online and remote education, which solves some of the biggest challenges with remote education. By using AI and VR/ AR tools learners and educators can expect a unique learning experience as opposed to an attempt to mimic in-person learning. AI-powered VR/AR environments revolutionize remote education by offering immersive and personalized learning experiences. Students can engage in three-dimensional simulations, interactive experiences, and adaptive learning methods tailored to individual needs, enhancing understanding and engagement. The ability of AI and VR/ AR technology to simulate real-world environments that may not be available in the classroom is a benefit as well that has been adopted not only by primary and secondary education but also by higher education and professional training.

Ethical Considerations and Implications of AI, VR, and AR Integration

Overview of ethical concerns in AI, VR, and AR separately

While the integration of AI with VR and AR technology has uncovered several ethical concerns about the technologies' use in the education environment it is important to understand that often people and policy view each of these mediums as individual when in reality they are often intertwined. Therefore it is necessary to regard the mulitfaced ethical concerns of each AI, VR and AR respectively. The main ethical problems with AI are related to bias in algorithms, privacy difficulties with data gathering and use, and possible effects on jobs and social structures. VR and AR present ethical concerns in relation to permissions and user privacy in immersive environments, possible psychological repercussions, and the blending of virtual and real-world boundaries.

Ethical implications of combining AI with VR/AR technologies

The integration of AI and VR/ AR combines these ethical concerns and forces users such as students, educators and policymakers to approach their analysis using a more holistic approach. The innate nature of AI's use in VR and AR technology potentially raises questions in regard to its purpose as a tool to replace the in-person experience or as an unethical way to gather large amounts of data about subconscious human interaction, biases and methodologies. Particularly users may be wary of the nature of VR and AR concerning informed consent, as they may be unaware of the extent or implications of data collected within these simulated environments. Moreover, the AI algorithms influencing these virtual or augmented environments may have inherent biases present in the training data. This is especially important because this biased data may lead to unfair or discriminatory outcomes of methodologies during the learning process. Due to somewhat recent exploration of this technology, there is also little data on the prolonged impact on users who use these learning tools to help facilitate or enhance their learning experiences.

Past implementations and their ethical implications

It is important to note that these ethical considerations regarding VR/ AR and especially AI algorithms are not unfounded. For example, “algorithms used to schedule medical appointments in the USA predict that Black patients are at a higher risk of no-show than non-Black patients, though technically accurate given existing data that prediction results in Black patients being overwhelmingly scheduled in appointment slots that cause longer wait times than non-Black patients.” (Shanklin et al., 2022). Despite the fact the AI has been trained on unbiased data the result of the data and its decision-making still perpetuates further racial inequality.

Discussion on privacy, data security, and bias issues

As we navigate the ethical implications of integrating AI with VR/AR technologies, it's evident that the combination of these technology poses multifaceted ethical challenges, requiring a comprehensive approach from users, including students, educators, and policymakers. The fusion of AI within VR and AR environments raises questions about its role: whether as a tool enhancing experiences or a potential ethical concern for extensive data collection on human interactions and biases. Concerns particularly arise regarding informed consent in these immersive environments, where users might lack awareness of collected data and its implications. Additionally, the influence of AI algorithms within these settings introduces worries about inherited biases from training data, potentially leading to unfair outcomes in learning methodologies. The limited historical data on long-term impacts further complicates understanding the effects of these learning tools on user experiences.

Future Trends and Considerations

Predictions for the future of AI-integrated VR/AR in remote education

Based on the findings of this essay there is still considerable work that needs to be done before we will see the full breadth of benefits provided by AI and VR/AR integrated technology. That being said the possibilities of integrated AI and VR/ AR tools for education are limitless. Greater personalization, adaptive experiences, improved skill development, simulated environments, and more in-depth student insights will ensure that the development of these technologies continues in the educational sphere.

Technological advancements and their potential impact

The impact of this technology will shape how individuals learn, live and interact with their educational environment. This technology has the potential to make learning much more accessible catering to those suffering from disabilities or geographical barriers. This would allow students and educators to collaborate worldwide in a more immersive scenario.

Addressing ongoing ethical concerns and potential solutions

The ongoing challenge of ethical considerations will be required as the technology rapidly advances. Primarily surrounding data privacy, consent and bias it will be important to monitor how we train our AI models and what impact they can have on the VR and AR platforms they are integrated with. Transparent data practices and policies, ethical audits, and adherence to guidelines that identify and mitigate biases are some of the first steps toward making sure this technology evolves responsibly and its deployment into our education system prioritizes ethical design and inclusivity.

Conclusion

In conclusion, the integration of AI and VR/ AR technology has been a turning point for the future of online education and design in the 4th industrial revolution. It beckons a new era of immersive, personalized and collaborative technologies that will shape the future of learning and teaching experiences. At its core, the combination of AI and VR/ AR technology lies in the need to make education more accessible and to enhance the learning experience for each student. Although there are many possibilities for this AI with VR/ AR technology is one of many tools that can help educators personalize the learning experience and get more in-depth data on their student's strengths and weaknesses. This benefit has opened the door for this technology to provide tailored and adaptive learning experiences such as interactive modules, simulated environments, and personalized adaptive learning pathways. Students irrespective of geographic barriers may be able to collaborate in real time with educators in simulated or semi-simulated environments breaking down distance and accessibility barriers.

As these technologies advance to the forefront of educational technology they bring with them vast amounts of challenging ethical considerations. Students, educators and policymakers must be aware of how guidelines are created and enforced during development. Moreover, biases inherent in some AI algorithms used within these immersive environments could perpetuate discrimination or unfair treatment. reducing biases requires ongoing monitoring, auditing, and retraining of algorithms to ensure fairness and equity in decision-making processes. Attention to privacy, algorithmic biases and consent have concerning ethical considerations if not handled properly and may have broader implications on societal well-being.

Final thoughts

This educational technology has the potential to make great changes to the remote education experience; however, it is important to consider that other forms of education may also see great benefits. As mentioned before, in-person education has also been able to adapt and use AI technology in VR and AR applications. The ability to augment the physical classroom/ learning experience is another area of focus for this technology and would allow for even more applications such as enhanced visual and experiential learning, increased interactivity as well as faster skill development and information retention. Similarly, it shares some of the ethical concerns and highlights new challenges such as the digital divide, and student autonomy in the classroom. This topic, though it shares many similar qualities could make up an entirely new exploratory essay.

The path forward with this technology will be a conjunctive effort and balance between innovation and ethical consideration. Other factors for this technology also prevent its widespread use today such as cost, training and infrastructure. Needless to say, responsible practices spearheaded by educators, policymakers, students and developers will be required to make AI integration with VR and AR in education a success. By fostering a culture of responsible innovation we can make sure that the potential of AI in VR/ AR is put to good use to create a more inclusive engaging and impactful educational landscape.

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