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DEMOCRATISING VIRTUAL REALITY WITH CRITICAL PEDAGOGY, DESIGN AND MAKING

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ABSTRACT
This article narrates the work in an undergraduate first-year project-based industrial design studio subject that started with unprecedented students' isolation in the Covid-19 pandemic. It focused on user experience and the exploration to democratize new technologies, such as virtual reality, with the design, development, and testing of three degrees of freedom controllers, interfaces, and games. The project was based on critical pedagogy, design and making. Heuristics promoted an evolutionary process of experimentation and testing with no fear of failure. A gaming approach promoted the learning of coding and trialling through play. E-Portfolios helped students to develop their own autoethnography and critical assessment. Students' Feedback on Subject surveys showed that the subject is popular among them. They finalized their semester analysing their designs and user experience by playing individually and against each other with their controller and game working prototypes. Two years on and back to face-to-face delivery on campus, outcomes might enlighten readers as these demonstrate reliability that survived the challenge of Covid-19 lockdowns and show strengths and shortcomings relating to our new digital-physical reality in education and the profession. As participants, students understood that their projects fitted to a more significant research framework where the authors intend to facilitate collaboration, co-habitation, and sustainability, to augment human intelligence through the exploration of extended realities and human-computer interaction, and to innovate traditional design process, that is ideally concurrent but mostly sequential, in today's scenario of globally distributed collaborations that are building new singularity workflows of simultaneous ideation, prototyping, testing, and production.

Keywords: Autoethnography, codesign, critical pedagogy, human-computer interaction, user experience, virtual reality

1 INTRODUCTION
This article narrates the work in an undergraduate first-year project-based industrial design studio subject with a cohort of 60 students experiencing unprecedented isolation in the Covid-19 pandemic. The pandemic was a big disruptor of the normal in society worldwide. In Australia, it also affected the way that higher education delivered its learning and teaching when the country closed its international borders from the 20th of March 2020 to the 1st of November 2021 and slowly accepted the arrival of international students and those who were stranded abroad from 2022. With no government support, universities had to make do without the influx of international students who represented a strong contributor to their financial sustainability and went into restructuring. Many academics either lost their jobs or were casualized. Paradoxically, that dramatic impact also materialized the long-unfulfilled promise that information and communication technologies (ICT) would facilitate learning and teaching. A more than 15 years strategy that intended to implement e-learning in Western Sydney University was realized in two weeks in March 2020 to also enable online teaching to our local students. They lived mainly in the working- and middle-class western suburbs of Sydney that had their livelihood threatened under strict lockdowns, restrictions on travel, number of people per room, police patrolling the streets and heavy fines that intended to stop the spread of the virus. These limitations were slowly lifted in 2022 but created animosity. This was a tale of two cities in one. The western suburbs under lockdowns contained the population with the highest level of above 80% vaccination in the state and struggled with $42 million of unpaid Covid-19 fines. While eastern suburbs, where the pandemic started in Australia and did not experience lockdowns or restrictions, only reached 35% of vaccination in 2022 [1–4].

2 PROBLEM STATEMENT

The first author was given coordination of the first-year subject called *Designing for User Experience* in the spring of 2021. The challenge was, how to run individual applied design studio projects in industrial design education in a way capable to overcome the abnormal conditions presented by Covid-19 restrictions. As per the pre-approved template for the subject, the expectation was to deliver it face-to-face and have access to equipment and tools in our in-campus workshop as the means for *"creating strong emotional, sensorial, and functional connections essential in supporting inclusive design, engaged usability, and high-quality human-centred experiences when delivering successful products and services."* Informal views were that the previous year's students' learning experience was affected by Covid-19 restrictions. They were able to mostly do ideation and conceptualization and some modelling depending on a courier service between their home and the university's workshop (e.g., low-resolution 3D printing). However, there was no indication of full proof of concept, working prototypes and product, system and end-user experience testing at the end of it.

3 METHODOLOGIES

Normally, first-year projects are greatly teacher-centred with a controlled master-apprentice transmission approach. In our industrial design and design technology courses, students generally are high-school leavers who do not have a background in applied arts and are not savvy in the use of manual and electrical tools in a design workshop. The unusual circumstances for the subject during the Covid-19 pandemic required ingenuity to achieve the approved template since there was no way to control individual work, materials, and their use in each student's home. A reversal from transactional to transformational methodology was developed based on our Generation Z students who are characterized as digital natives comfortable with the use of the Internet, portable digital devices, and social media. Freire's [5] [6] critical pedagogy was used to propose the subject as a design research one to empower students' ownership. Their projects became a process of autoethnography, visual ethnography and action research where the apprentice was the master and the lecturer a moderator in the process of learning and generation of new knowledge. In those terms, the production of a product and its eco-system were the means for both, a critical design [7] to challenge assumptions, increase social and cultural awareness, and create discussion, and new ways of thinking, and a critical making [8,9] as a process of reflection and learning through hands-on productive actions that link physical and digital technologies for conceptual, prototype and user experience explorations.

4 METHODS

4.1 Technology

Online Zoom teaching became the predominant option to deliver classes from 2020 onwards in our university. There was even a risk of fines for staff and students who drove to campus in case they lived outside a suburb. Within these limitations, a clear challenge was proposed to gather students' Generation Z interest: *Resolving digital and physical gaps for virtual reality (VR),* which this time was in the form of a Three Degrees of Freedom (3DoF) VR controller. True to critical pedagogy, another option for students to create an AUD $70 to AUD $100 VR headset was discussed but was left aside for later work with more advanced students. The current cohort had no electrical engineering, model making and programming skills yet. The lecturer explained that VR is defined by its freedom of movement and interaction. VR with Six Degrees of Freedom (6DoF), like Quest 2 Pro, is totally immersive and works with controllers that allow movement in six spatial axes. Three main axes are translational and the other three secondary that are rotational. 3DoF only allows users to move in three axes, X, Y and Z (look left and right, look up and down, pivot and right).

The gap in the market was to produce a 3DoF controller that allowed users more movement, interaction with artefacts, other personas and environments, teleporting, selection of objects, experiencing gravity and physics, etc. The reason to work with 3DoF was also about access and cost. The 80-year-old undelivered forecast on the benefits of VR for all would only be possible if we made it accessible to everybody on their mobile phones and with a cost as inexpensive as the one of a social media app. There were signs that technology was moving that way when Asian mobile phone companies revealed their plan to include VR in their mobile phone plans (Singapore, South Korea). The task for the students was to research and find a solution with as small amount of money as possible with their mobile phones, free

and open-source software (FOSS), free Unity3D scripting, a minimum investment in Arduino equipment and either a Google Cardboard (cost between AUD $5 to AUD $40 in eBay) or a second-hand VR headset. The lecturer provided links for the cheapest headsets available in Sydney ready for shipping and presented a demonstration via Zoom and his iPhone mounted in a Zeiss VR ONE Plus headset bought from a local EB Games shop for AUD $19. Several students said to be excited about the project since they were already familiar with mobile games, or they were "old" gamers who had 3DoF VR headsets in their homes.

4.2 Curriculum

Student projects were helped by a new interpretation of the three assessments approved in the subject template. Previously, Assessment 1 was about sketching ideas for a new wearable design while Assessment 2 was a report (500 words) and three A3 posters with illustrated concepts on material selection, finish, technology, and wearability. Assessment 3 was a report (1,500 words) and one presentation on an A3 final proposal poster. From 2021, all assessments were converted to applied projects powered through critical design and critical making. Submissions were required via individual Turnitin and ePortfolio process diaries. The aim was to achieve a desirable, feasible, viable, and tested Product Value Proposition (PVP) developed as a finished working prototype also known as Minimum Viable Product (MVP) ready to play with it and to show how the design operates and how realistic its implementation can be. Human-centred design (HCD), user experience (UX), design thinking, and other similar methods complemented each other in three phases:

- Assessment 1 Scope and User Research (Week 4): An audit with annotations on direct UX through experimentation (Figures 1, 2) with up to five devices already available at home (e.g., mouse, keyboard, Xbox, Nintendo controller, Luna controller, Sony DualShock, Logitech F310) and tweaked to work with VR thanks to FOSS or inexpensive software (e.g., RiFCAT, vVRy, ALVR).
- Assessment 2 Ideation and Testing (Week 9): As a phase for designing, exploring, experimenting, and analysing results, failures, and amendments of several low fidelity to rough working prototypes (Figures 3, 4). Working with basic Arduino and Unity3D benefited from the self-learning exercises that started from the first week of the semester and the weekly support of the tutor (programming) and the lecturer (HCD, IxD).
- Assessment 3 Build Launch and Measure (Week 14): As a final stage for implementing, developing, operating, launching, and analysing the final high-fidelity MVP and PVP working prototype, students' user experience reflections and recommendations on their projects and the subject, and their projections and recommendations for the design as if they had to continue with their projects to reach manufacturing and commercialization stage (Figures 5 - 8). Assessment 3 included a Pecha Kucha pitch presentation that required self-evaluation.

4.3 Autoethnography, visual ethnography and action research

Critical pedagogy, design and making required tools to allow students to keep track of their work, in contact with each other, and the lecturers. Covid-19 isolation had reduced contact to two hours of live synchronous Zoom tutorials per week and asynchronous uploads to an LMS Blackboard subject repository (e.g., recorded lectures, announcements, instruction, digital materials, scripts, links, interactive games, interviews). The lecturer promoted the use of MyKnowledge Map (MKM) ePortfolio as a key tool for individual design process diaries. The tool was offered on trial by the Pro-Vice Chancellor Learning and Teaching Office which looked for exemplars to implement ePortfolio later in the university as part of its 21st Century Transformational Curriculum and Learning Futures strategies.
The value of the MKM ePortfolio was that it was an easy tool for combining autoethnography, visual ethnography and action research. These three types of annotation, reflection, and interpretation (*graphy*) complemented each other. Autoethnography [10] was simultaneously an ePortfolio method, a process, and a product that treated research as a socially conscious act. It showed self-reflective research to describe and systematically analyse personal experiences (*auto*) as the means to understand other people's behaviours as cultural experiences (*ethno*). The visual ethnography [11] was important since the participants were design students. Visualizations and their analysis are vital for their training. This was a research method that brought theory and practices together to get to know and interpret photographic, film and video recordings and annotations in an iterative cycle from observation to generation and communication of experiences. Action research [12] completed that process of critical design and critical making simultaneously facilitating the investigation and resolution of issues. This

was very important since the projects involved a lot of discussions and figuring out how the designs needed to evolve in both the physical and the 3D semi-immersive environments.
In practice, the MKM ePortfolio comprised weekly updates on tasks carried out by students individually and as a group. They were able to share their MKM ePortfolio as progress reports for discussions with the lecturer and other students in and outside the live Zoom sessions. Their learning of design and making was also assisted with additional tools that were later imported to MKM ePortfolio. For instance, exploration via YouTube video recordings and MIRO boards allowed synchronous and asynchronous individual and group work based on structured sets of UX templates for iterative analysis of data and observations as students progressed from Assessment 1 to 3 (e.g., concept modelling, empathy mapping, user persona, journey maps, taxonomies, affinity maps, UX and ePortfolio Checklists). Notably, students assessed weekly each result on what good progress was or needed to improve and develop further. A Four Sights Strategy especially prepared for the subject helped students to articulate whether previous assumptions on work and experiences were validated after testing them (backsight), what was the benchmark set by their counterparts and the industry (cross-sight), where were they based on their backsight and cross-sight observations (insight) and how and what did they need to do next for their projects next (foresight).

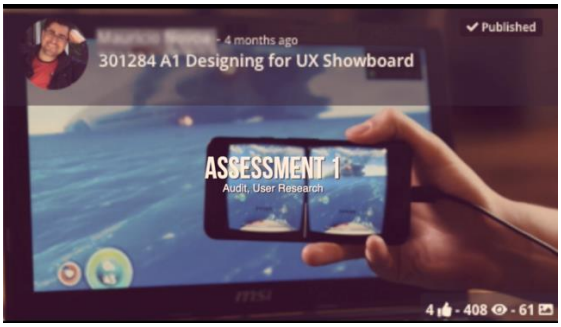

Figure 1. A1 VR Controllers testing

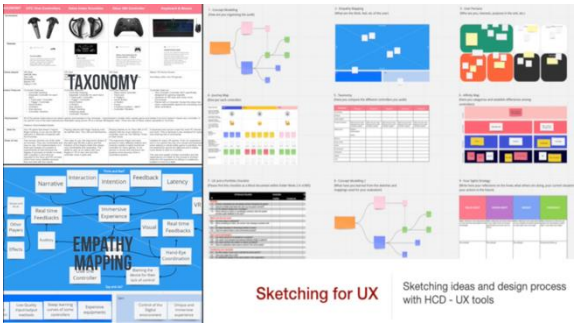

Figure 2. A1 MKM ePortfolio and UX

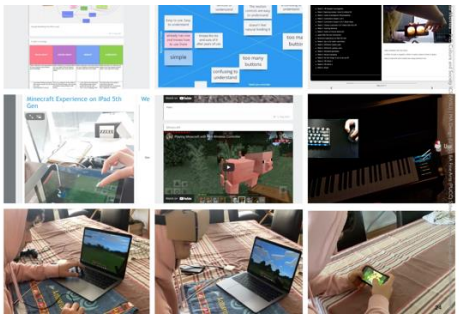

Figure 3. A2 VR Design and user evaluation

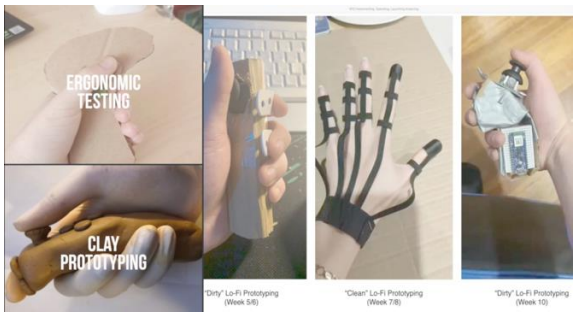

Figure 4. A2 Low-Fi and rough prototypes

Figure 5. A3 Working prototype testing

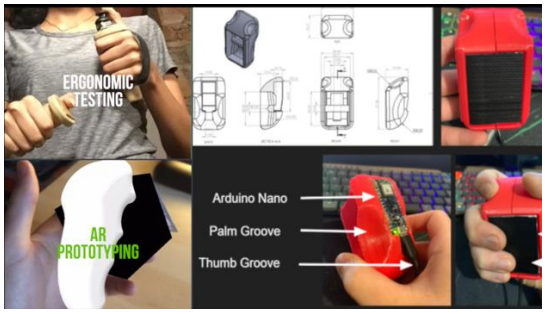

Figure 6. A3 AR test and physical prototype build

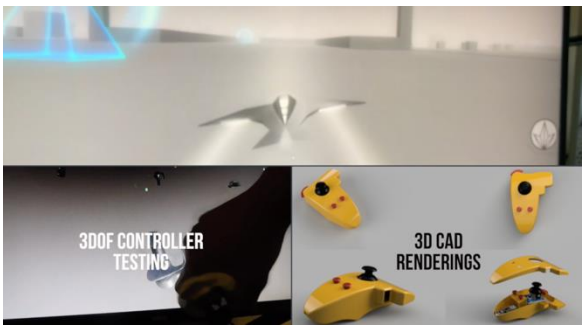

Figure 7. A3 final MVP prototypes

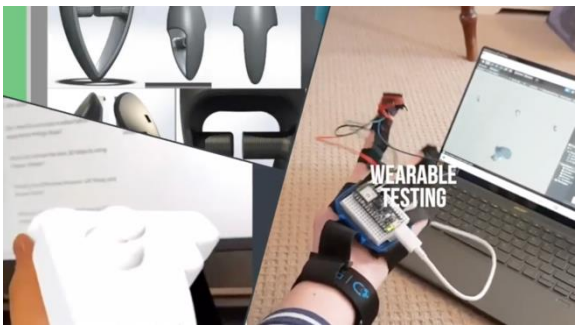

Figure 8. A3 final MVP prototypes

5 RESULTS AND DISCUSSION

Many challenges were conquered by the students in the coordination of the subject. From the start, students had to deal with general animosity created by pervading pandemic reasons larger than what they could manage. Further, they dedicated a great deal of their personal home space, which by today's standards is small, to work with new tools and materials that they did not know before. However, they were able to overcome adversity and their typical generational shyness and issues with concentration span. MKM ePortfolio work showed that they took to tinkering with simple materials (e.g., clay, origami, cardboard modelling) and using digital media with gusto to photograph, video record, take selfies, edit, and critique them in their process of analysis, design research and making. The heuristics approach of the subject helped them to increase their depth of learning and involvement as owners of an evolutionary process of experimentation and testing with no fear of failure. Gaming facilitated learning through play to code and trial their Arduino and Unit3D apps up to final MVPs and PVP working prototypes with verified evidence.

Certainly, independent university surveys on students' feedback on the subject and teaching showed their support. Broad agreement with the subject was at 100% and above our school and the university which was 92%. While explicit overall satisfaction was 86% and still above our school at 82% and the university at 80%, in detail inspection showed that students clearly supported 100% of the learning activities, and learning materials provided but the overall statistics were brought down by matters such as the lack of opportunities to work with other students (57%) and the available technology (86%) that were either unmanageable because of Covid-19 lockdowns or affected by students' own bandwidth access to the Internet. Positively, feedback on teaching was both broadly and explicitly 100% while school and university broad agreements were 93% and 94% and explicit agreement was 86% for the school and 87% for the university. Qualitative comments on Need for Improvement column ranged from answering "*None*" to the Best Aspects column with comments as being "*able to learn how to code and create a VR controller from scratch," "playing around with new technology"* and *"The hands-on parts of the subject, and the subject matter itself in tutorials".* Highlights on feedback on teaching showed that students appreciated the teachers were *"very approachable and willing to help with whatever issue I have"* and that students had access to *"previous work and putting up videos with examples to understand criteria and assessment tasks."*

Students' own survey feedback showed the same type of discussions held openly in class. A minority said to prefer that the lecturer provided checkbox lists and templates to copy and paste into their work. The larger group embraced an attitude against a *"high-school mentality" "where instructions and information are handed to you, rather than independent learning"* and *"adult learning."* Significantly among others, one feedback encapsulated the subject makeover to critical pedagogy, critical design, and critical making with playful learning best *"I really liked this unit and its assessments, designing a VR controller was such a cool and fun idea. I liked that each of the assessments followed the previous one, it was good practice in following the typical design process. I also appreciated the flexibility of the subject's marking criteria/outcomes, as in, there was no specific design, design process, prototype, fabrication method that had to be used/followed/produced in order to meet the desired ends. I believe that the way in which it was marked was a lot more realistic to working in the industry."*

Evaluation of the 2021 experience among the teaching staff helped to fine-tune the subject for 2022 with similar results. However, students enjoyed live classes and access to workshops, the in-campus attendance did not prove to influence remarkably better outcomes. Students said to relish socializing among themselves but that was simply an add-on to their ongoing digital media conversations through

direct messaging, Facebook, WhatsApp, etc. Besides that, they said that felt that they had gone back to business as usual. On the side of critical pedagogy and its corresponding critical design and making, students commented that tried to apply them now working face-to-face but, unfortunately, they seemed to be occupied with domestic matters that they did not have before, such as leaving earlier to attend other classes in different floors or buildings, going to check models downstairs in the workshop, or running back to the public carpark to drive home quickly and avoid parking fees. It was different to before when they concentrated on conversations and discussions in the live Zoom sessions. They also said that they missed our Zoom challenges when we played for who would win for the best photo or video background, and the funniest avatar or outfit.

6 CONCLUSION AND RECOMMENDATIONS

This paper showed an example that a subject can be converted from transactional to transformational pedagogy in one term and that students, nevertheless fresh in the first year of their course were able to adapt and run within student-centred and critical learning methodologies. Also, that excellence does not depend on the acquisition of expensive and sophisticated technology. Instead, often low-level and simple technologies that align with people's interests seem to be adopted and stay longer with end-users, like in the case of Zoom and playful learning. Our students excelled and raised above expectations in difficult times. However, it is still to be seen whether lessons from lockdown times can expand to all our industrial design subjects and courses. As per students' comments, they seem to be experiencing back-to-serious business as usual. Admittedly, we are not out of the Covid-19 pandemic yet and they are also feeling the pressure of raising costs of accommodation and living while there is no improvement in salaries. As for the subject of *Designing for User Experience* and its focus on VR, new areas of development emerged that should fit the interest of a new kind of industrial designer and colleagues in design and engineering education. From working with open-source platforms to transforming education into playful immersive learning and to redefining the design process with new singularity workflows that collapses and simultaneously move between ideation, design, development, production, and delivery of design artefacts and systems made from both physical and digital materiality.

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