"An Experimental Study on the Effectiveness of Using Generative Artificial Intelligence Model: Meta Quest 2 Mixed Reality Headset (Oculus) in Piano performance training"

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1 - Introduction

Virtual Reality (VR) is a technology that offers synthetic, highly interactive three-dimensional (3D) spatial environments representing or imagined scenarios, as defined by Mikropoulos and Natsis (2011). It is regarded as a generative artificial intelligence (AI) model that can significantly impact student's creative thinking skills while providing instructors with insights to guide the use of AI in fostering creativity. (p. 769)[1].

in recent years, the integration of AI in classroom instruction has made substantial progress, crossing the boundaries of the music industry and delivering unprecedented immersive experiences. One notable application is in music education and training, where Virtual reality facilitates engaging and immersive experiences. It helps students enhance their music theory, composition, and performing skills in an interactive virtual environment[2].

The shift toward remote education driven by the COVID-19 pandemic has encouraged educators to adopt innovative technologies and methodologies. This momentum continues to drive the use of advanced tools like VR to enhance the quality of learning experiences. Moreover, VR's application in remote settings minimizes risks of contamination and reduces the use of personal protective equipment (PPE).[3]

In the context of music education, VR environment designed with educational principles and specific learning outcomes are referred to as

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[1] Tassos A. Mikropoulos, Antonis Nastsis, "Educational Virtual environments: A ten – year review of empirical research (1999-2099)", *Computers & Education international Journal 56, Elsevier,(2011).p.769*

[2] Tugce Tamer, "15 Examples of the use of Virtual reality (VR) in Music", capsule sight, 23 April 2023, accessed in 14 September, 2024.
https://capsulesight.com/vrglasses/15-examples-of-the-use-of-virtual-vr-in-music/

[3] Amin Gasmia,b and Rachid Benlamric, "Augmented realty, Virtual reality and New age technologies demand escalates amid COVID- 19", *Novel AI and Data Science Advancements for Sustainability in the Era of COVID-19, Elsevier,(2022).p.90.*
https://doi.org/10.1016/B978-0-323-90054-6.00005-2

Educational Virtual Environments (EVEs). Mikropoulos and Natsis (2011) confirm the pedagogical applicability of VR is applicable in in their literature review, demonstrating its effectiveness in achieving educational goals.

this article focuses on exploring the potential of VR as a creative tool for piano training, particularly during home quarantine or hospitalization. The aim is to develop a training approach that considers students' health conditions, avoids physical strain, and is suitable for tech-savvy piano learners.

Research Assumption

The study hypothesizes that non-standard technological creativity tools, such as VR, can be effectively used at home or in hospitals for piano training. These tools should prioritize students' health, minimize physical effort, and cater to students comfortable with technology.

Research Objectives

The present study examines the following:

1. **The strengths and weaknesses:** The strengths and weaknesses of using Piano VR as a training tool.
2. **Added Value:** the added value of simulating piano training in a VR environment.
3. **Student Awareness**: the current level of awareness among students regarding VR training and the purpose for which they are using it.
4. **Perceived Benefits and Limitations:** the perceived benefits and limitations of VR training for entrepreneurship education.

2 – Background and literature review

This section addresses multiple topics. The first section focuses on Artificial Intelligence (AI). The second examines the roles of Augmented Reality (AR), Virtual Reality (VR), Mixed Reality (MR) The third explores existing virtual environments for trainings in music education, specifically piano. The fourth discusses The Metaverse Model, followed by Learning in VR in the fifth section. Finally, a conclusion presents the state of the art.

2.1 Artificial intelligence (AI)

Artificial Intelligence (AI) is revolutionizing the entrepreneurial landscape by transforming how higher education and businesses are created,

grown, and operated (Chalmers et al., 2021)[1]. AI encompasses a broad range of digital technologies capable of efficiently processing knowledge to assist humans in completing diverse tasks (Haenlein & Kaplan, 2019)[2]. Unlike traditional computers, which remain static unless updated by humans, AI systems continuously learn and adapt independently.

Recent advancements in AI, such as automation, data analytics, and Natural Language Processing (NLP), have streamlined operations across various industries. AI not only enhances to established businesses but also supports the creation of new ventures. It influences entrepreneurial intentions, opportunity recognition, and the process of of identifying and exploiting business ideas (Chalmers et al., 2021).

The exponential growth of digital technologies technologies has increased the demand for AI fluency in music education. AI implementation in higher education offers numerous advantages. Educators can leverage AI to design courses, create teaching materials, grade assignments, respond to student inquiries, and conduct research. Students, in turn, can benefit from AI in practical instrumental training, receiving feedback, conducting orchestras, preparing project outlines, and gathering information efficiently (Cribben & Zeinali, 2023)[3].

AI can also be employed to create simulation games that enable students to test their learning and business ideas, simulating the start-up world in a virtual environment before entering real-world scenarios (Fox, 2018)[4]. The future of entrepreneurship education will likely feature technology-driven classrooms with immersive AI interactions (Ratten & Jones, 2021a)[5].

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[1] Dominic Chalmers, Niall Mackenzie, and Sara Carter, "Artificial Intelligence and entrepreneurship: implications for venture creation in the fourth industrial revolution.*"Entrepreneurship Theory and Practice Journal, Vol. 45 (5), Sage, (2021).* P, 1028-1053.

[2] Michael Haenlein, Andreas Kaplan, "A brief history of Artificial Intelligence: on the past, present, and future of Artificial Intelligence.*"California management review Journal, Vol. 61 (4), Sage, (2019).* P, 5-14.

[3] Ivor Cribben, Yasser Zeinali, "The benefits and limitation of ChatGPT in business education and research: A focus on management and data analytic". *"Operations Management and Data Analytics Journal, (SSRN), Elsevier, (2023).*

[4] Stephen Fox, "Domesticating Artificial Intelligence: Expanding human self – expression through applications of Artificial Intelligence in presumption", *"Journal of Consumer Cultural, Vol. 18 (1), Sage, (2018).* P, 169-183.

[5] Vanessa Ratten, Paul Jones, "Covid-19 and entrepreneurship education: implications for advancing research and practice", *"The International Journal of management Education, Vol. 19 (1), Elsevier, (2021).*, 100432

Artificial intelligence has been defined as "the science and engineering of creating intelligent machines'' (McCarthy, 2007, p. 2)[1]. It is a branch of computer science that combines machine learning, algorithm development, and natural language processing (Akgun & Greenhow, 2021)[2]. The importance of AI development is increasingly highlighted in secondary and higher education (Su et al., 2022)[3].

Figure : Components, types, and subfields of AI based on Regona et al (2022).[12]

Fig No. (1) AI Types.

2.2 The role of Augmented Reality (AR), Virtual Reality (VR).

Augmented reality technology (AR) generates computed images that overlay real-world visuals in various sizes and perspectives. Virtual Reality (VR), on the other hand, creates fully immersive virtual representations of environments[4]. AR/VR technologies can be used in head-mounted devices (HMDs) that interact with human body systems, including the brain. These devices use two primary

[1] Jone McCarthy, "from here to human-level AI", *" Artificial Intelligence Journal of management Education, Vol. 171 (18), Elsevier, (2007).*, 1174-1182.
[2] Selin Akgun, Christine Greenhow," Artificial Intelligence in education: Addressing ethical challenges in K-12 settings", *"AI and Ethics Journal, Vol. 2 (3), Springer, (2021).*, 431-440
[3] Jiahong Su, Yuchun Zhong," Artificial Intelligence (AI) in early childhood education: Curriculum design and future directions", *" Computers and Education: Artificial Intelligence Journal, Vol. 3, Elsevier, (2022).*, 100072
[4] Amin Gasmia, Rachid Benlamri," Augmented reality, virtual reality, and new age technologies demand escalates amid COVID-19" , *" Novel AI and Data Science Advancements for Sustainability in the Era of COVID-19" Academic Press, Elsevier, (2022).*, 89-111

visual processes: monocular (capturing one image at a time) and binocular (capturing two or more images). Binocular processing is widely accepted for its immersive effects and in-depth data structure, enabling 3D imaging via dual-image illustrations.

(IWAR'99, 1999)[1].

AR/VR. applications offer various projection types, including perspective projection (for smaller objects placed at a distance) and occlusion projection (displaying an object in front of blocked objects). These technologies vary in size, shades, and motion parallax (Abdel-Basset, Chang, & Mohamed, 2020)[2]

3D visualization modes can bridge the gap between memorization, reasoning, and understanding of complex structures, such as molecular geometries and biomolecular compounds. As VR evolves, students may use headsets to enhance learning through stereoscopic depth perception. Digital classrooms incorporating AR/VR can significantly improve learning outcomes (Held & Hui, 2011)[3].

Researchers demonstrate that AR/VR enhances educational environments while supporting pandemic-related precautions like social distancing. (Chang and O'Sullivan, 2005)[4] highlights how AR increases the likelihood of achieving higher learning objectives. (Carlson et al.2013)[5] emphasize emphasize the transformative potential of AR/VR in global education. Additionally. (Lo´pez-P_erez, P_erez-Lo´pez, Rodrı´guez-Ariza, and Argente-Linares, 2013)[6]and Balsa-Barreiro et al. (2020) underline the opportunities AR/VR provides for enhancing academic participation and interest. (Balsa-Barreiro, Vi_e, Morales, and Cebria´n, 2020)[7]

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[1] IWAR'99*"Proceedings 2nd IEEE and ACM international workshop on augmented reality*", (1999). ii-ii.

[2] Abdel-Basset, M., Chang, V., & Mohamed, RHSMA_WOA : A hybrid novel slime mould algorithm with whale optimization algorithm for tackling the image segmentation problem of chest X-ray images. *Applied Soft Computing* (2020)., 95, 106642

[3] Held, R. T., & Hui, T. T. (2011). A guide to stereoscopic 3D displays in medicine. Academic Radiology, 18(8), 1035–1048.

[4] Chang, A., & O'Sullivan, C. Audio-haptic feedback in mobile phones. *In CHI '05 extended abstracts on human factors in computing systems*, (2005). pp. 1264–1267.

[5] Carlson, K. M.,Curran, L. M., Asner, G. P., Pittman, A. M., Trigg, S. N.,&Marion Adeney, J. Carbon emissions from forest conversion by Kalimantan oil palm plantations. *Nature Climate Change, 3(3),* (2013), 283–287.

[6] Lo´pez-P_erez, M. V., P_erez-Lo´pez, M. C., Rodrı´guez-Ariza, L., & Argente-Linares, E. The influence of the use of technology on student outcomes in a blended learning context. *Educational Technology Research and Development, 61(4),* (2013). P, 625–638.

[7] Balsa-Barreiro, J., Vi_e, A., Morales, A. J., & Cebria´n, M "Deglobalization in a hyper connected World". *Palgrave Communications, 6(1*), (2020). 1–4.

Fig. No (2) AR/VR/MR Devices

2.3 Existing virtual environments for trainings in piano

2.3.1 State of the art

To the best of our knowledge, no comprehensive VR-based piano training system has been developed. However, some mixed reality and VR applications for piano training exist. For instance, the *VR Music Room* on Steam allows users to play virtual instruments (Serafin, Adjorlu, Nilsson, Thomsen, & Nordahl, 2017).[1] In testing, VR users demonstrated increased accuracy in musical performance (Innocenti et al., 2019)[2].

Other applications provide mixed reality simulations that offer real-time feedback to music educators. Teachers can ask questions in physical space while receiving answers via VR (Dalinger, Thomas, Stansberry, & Xiu, 2020)[3].

Another approach is simulating classroom environments entirely in VR. A study by Remacle et al. (2021)[4] compared teachers' vocal skills in real-life

[1]Serafin, S., Adjorlu, A., Nilsson, N., Thomsen, L., & Nordahl, R. (2017). Considerations on the use of virtual and augmented reality technologies in music education. *IEEE Virtual Reality Workshop on K-12* 40
Embodied Learning through Virtual & Augmented Reality (KELVAR), 1-4, https://doi.org/10.1109/KELVAR.2017.7961562

[2] Innocenti, E. D., Geronazzo, M., Vescovi, D., Nordahl, R., Serafin, S., Ludovico, L.A., & Avanzini, F. (2019). Mobile virtual reality for musical genre learning in primary education. *Computer & Education, 139,* 102-117. https://doi.org/10.1016/j.compedu.2019.04.010

[3] Dalinger, T., Thomas, K.B., Stansberry, S., & Xiu, Y. (2020). A mixed reality simulation offers strategic practice for pre-service teachers. *Computers & Education, 144,* 1-15. https://doi.org/10.1016/j.compedu.2019.103696

[4] Remacle, A., Bouchard, S., Etienne, A., Rivard, M., & Morsomme, D. (2021). A virtual classroom can elicit teachers' speech characteristics: evidence from acoustic measurements

versus VR settings. Their findings indicated that VR effectively elicited teachers' speech, though it lacked interactivity with students.

2.3.2 Affordances of simulations

Simulations in teacher education allow for the reconstruction of real-life classroom scenarios. These controlled environments enable in-service teachers to practice specific situations and refine their skills (Dalinger et al., 2020). A key advantage is the ability to make mistakes and retry without real-world consequences (Dieker, Rodriguez, Kraft, Hynes, & Hughes, 2014)[1].

While simulations are not intended to replace real-world teaching experience, they provide valuable preparation for real-life challenges. By practicing in virtual settings, teachers can build confidence and competence before entering a physical classroom (Dalinger et al., 2020).

2.4 The Metaverse Model and Mixed Reality (MR).

2.4.1 The essence of audio in Virtual Reality

The metaverse is a virtual environment where users engage in augmented reality (AR), mixed reality (MR), or virtual reality (VR) interactions and replicate real-world experiences (Mohamed et al., 2023)[2]. The spaces are intended to be immersive, interactive, and interconnected.

As Alang (2021)[3] puts it, the metaverse is "the layer between you and reality." While the global market for the metaverse in online gaming is projected to exceed USD 800 billion (Bloomberg Intelligence, 2021)[4], its potential reaches beyond

during in vivo and in virtuo lessons, compared to a free speech control situation. *Virtual Reality*, 1-10. https://doi.org/10.1007/s10055-020-00491-1

[1] Dieker, L.A., Rodriguez, J.A., Kraft, B.L., Hynes, M.C., & Hughes, C.E. (2014). The Potential of Simulated Environments in Teacher Education: Current and Future Possibilities. *Teacher Education and Special Education, 37*(1), 21-33. Doi: 10.1177/0888406413512683

[2] Mohamed, E. S., Naqishbandi, T. A., & Veronese, G. (2023). Metaverse!: Possible potential opportunities and trends in e-healthcare and education. International Journal of E-Adoption, 15(2), 1–21.

[3] Alang, N. (2021). Facebook wants to move to 'the metaverse' — Here's what that is, and why you should be worried. *The Star* https://www.thestar.com/business/opinion/2021/10/23/facebookwants-to-move-to-the-metaverse-heres-what-that-is-and-why-you-should-be-worried.html

[4] Bloomberg Intelligence. (2021). Metaverse may be $800 billion market next tech platform. https://www.bloomberg.com/professional/blog/metaverse-may-be-800-billion-market-nexttech-platform/

gaming to encompass business transactions, real estate, and other related areas (Wohlgenannt et al., 2020)[1].

Major corporations like Meta, Microsoft, IBM, and Nvidia are investing heavily in building the metaverse as the future of the internet (Banerjee,[2] 2021; Cross,[3] 2021; Wong & Duncan, 2021).

Facebook CEO Mark Zuckerberg, in rebranding his company as Meta, described this movement as an "embodied internet that you are inside of rather than just looking at (Wong & Duncan, 2021)[4].

Part of this movement is due to the COVID-19 pandemic accelerating the transition to online and hybrid models for daily financial activities, driving the adoption of digital solutions to address challenges in the financial sector. As digital interfaces become the norm, there are increasing attempts to integrate these spaces into the financial ecosystem having proper audio in VR contributes to the experience of the users. First of all, the amount of audio equipment, such as microphones and loud speakers, that are used to record, influences how accurately the sound of a real environment is reproduced (Au et al., 2021)[5]. Normally, more equipment leads to a more accurate reproduction. In combination with VR, the reconstruction of audio can let the users experience auralisation: thinking they are in a different acoustic setting (Au et al., 2021; Ballestero, Robinson, & Dance, 2017)[6]. The goal to create auralisation is to let the users be

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[1] Wohlgenannt, I., Simons, A., & Stieglitz, S. (2020). Virtual reality. *Business & Information Systems Engineering*, 62, 455–461.

[2] Banerjee, P. (2021). Microsoft details plans for building a metaverse for enterprises. *Mint*. https://www.livemint.com/industry/infotech/microsoft-reveals-metaverse-plans-for-theenterprise-11635897733673.html

[3] Cross, T. (2021). Who is trying to build the metaverse? *VideoWeek*. https://videoweek.com/2021/10/28/who-is-trying-to-build-the-metaverse/

[4] Wong, W. H., & Duncan, J. (2021). Facebook;s Metaverse won't be bound by physical borders—Neither are human rights. *The Globe and Mail*. https://www.theglobeandmail.com/opinion/article-facebooks-metaverse-wont-be-bound-byphysical-borders-neither-are/

[5] Au, E., Xiao, S., Justine Hui, C. T., Hioka, Y., Masuda, H., & Watson, C.I. (2021). Speech intelligibility in noise with varying spatial acoustics under Ambisonics-based audio reproduction system. *Applied Acoustics, 174*, 1-10. https://doi.org/10.1016/j.apacoust.2020.107707

[6] Ballestero, E., Robinson, P., & Dance, S. (2017). Head-tracked auralisations for a dynamic audio experience in virtual reality sceneries. *24th International Congress on Sound and Vibration*, 1-8. Retrieved from https://www.researchgate.net/publication/317370715_HEAD-TRACKED_AURALISATIONS_FOR_A_DYNAMIC_AUDIO_EXPERIENCE_IN_VIRTUAL_REALITY_SCENERIES

immersed in the virtual environment. Therefore, Ballestero, Robinson, & Dance (2017) state that it is necessary to deceive the human senses by recreating the sounds as accurately as possible.

Additionally, the quality of audio determines how precisely users can point to sound sources in the environment, which is being regarded as sound localization. Still, according to a study conducted by Haustein and Schirmer (as cited in Wu and Roginska, 2019)[1] people suffer from a localization blur, which is "the smallest angle difference needed for the person to detect a position-change of sound source" (p. 2). They concluded that humans perceived the sound the best in front of them. Humans suffer the most from this blur at 90 degrees. Concerning sound localization, humans also confuse the back with the front and vice versa. Visuals in VR help to overcome this confusion (Valzolgher et al., 2020[2]; Wu & Roginska, 2019). Next to visuals to overcome confusion, a study by Strelnikov et al. (as cited in Valzolgher et al., 2020) proved that audio-visual training results in a better performance of localizing sound than just an auditory explanation. Meaning both components in designing a virtual environment support each other (Valzolgher et al., 2020).

In conclusion, users are immersed in a virtual environment, when sounds from the initial environment are reproduced as accurately as possible and when audio is accompanied by visuals to accurately localize the position of a sound source.

The metaverse is an interconnected virtual 3D environment where people across the world can come together to share social experiences. 1 This environment can leverage immersive technologies such as augmented reality (AR), virtual reality (VR), and artificial intelligence (AI) to offer rich life-like experiences to people all over the world. Blending these technologies can enable seamless social interactions like office meetings, music concerns, e-sports, and more. Particularly, the metaverse and extended reality technologies like AR, VR, and AI have a lot to offer to all education industry.

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[1] Wu., Y., & Roginska, A. (2019). Analysis and training of human sound localization behavior with VR
application. *2019 AES International Conference on Immersive and Interactive Audio, 26,* 1-8. Retrieved from
https://www.aes.org/e-lib/browse.cfm?elib=20384

[2] Valzolgher, C., Verdelet, G., Salemme, R., Lombardi, L., Gaveau, V., Farné, A., & Pavani, F. (2020).
Reaching to sounds in virtual reality: A multisensory-motor approach to promote adaptation to altered auditory cues. *Neuropsychologia, 149*, 1-14.
https://doi.org/10.1016/j.neuropsychologia.2020.107665

Figure : Various manifestations of VR in music creation.

Fig. No (3)

2.5 Learning in VR

In section 2.5 there was elaborated on the performance of piano VR, when standing in front of a music class. As was explained in this article, even the smallest change in hand articulation might not be recognized. Learning can be encouraged by the Cognitive Affective Model of Immersive Learning (CAMIL) (Makransky & Petersen, 2021)[1]. This model provides a framework for the effectiveness of learning through immersive virtual reality.

[1] Makransky, G., & Petersen, G.B. (2021). The Cognitive Affective Model of Immersive Learning (CAMIL): a Theoretical Research-Based Model of Learning in Immersive Virtual Reality. *Educational Psychology Review*, 1-22. https://doi.org/10.1007/s10648-020-09586-2

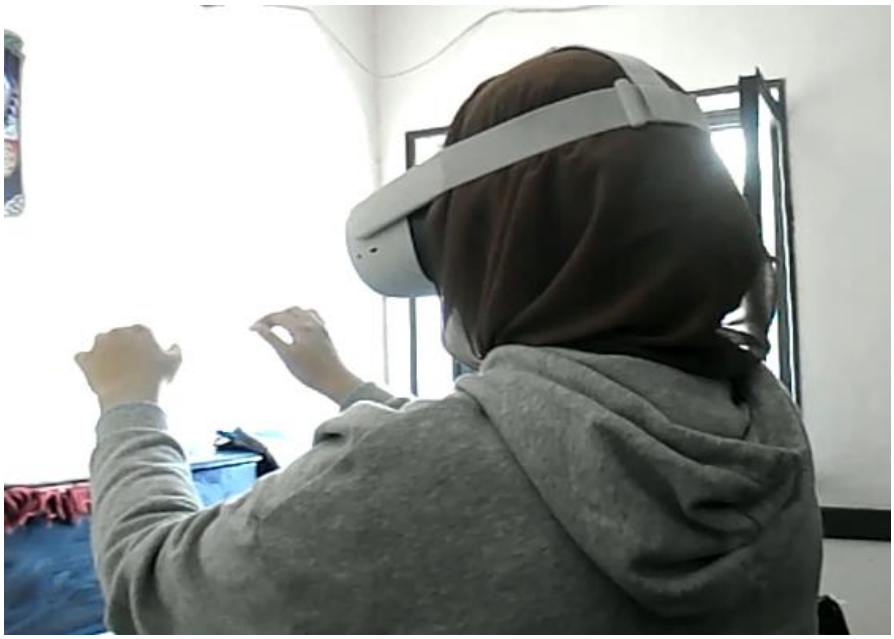

Fig. No (4) VR Piano hand articulation from Experimental Final test

According to this Makransky and Petersen (2021), a high presence (i.e. the realness of the environment) and high agency (i.e. control over the variables, control over one's own actions) positively affect the learning, as it encourages "interest, intrinsic motivation, self-efficacy, and embodiment" (p. 15). However, self-regulation and extraneous cognitive load should be taken into account. In VR there is a possibility to create an information overload through visuals or text. This causes a cognitive overload and it might lead to an obstacle for the users' their learning (Albus, Vogt, & Seufert, 2021)[1]. When a user learns in VR training, multiple cognitive processes are involved. By identifying these cognitive processes, it can help to design a proper pedagogical learning environment. In the literature review of Albus, Vogt, and Seufert (2021), three types of cognitive load were identified. The intrinsic cognitive learning (ICL) is the load from the difficulty of the tasks in the training. Secondly, the extraneous cognitive learning (ECL) is the redundant visuals etcetera in the virtual environment that does not have an influence on the learning outcomes. At last, the germane cognitive load (GCL) is the understanding of the tasks while making efforts in the virtual environment. If the extraneous cognitive load is diminished and self-regulated activities are present, it can, together with the other four affordances such as

[1] Albus, P., Vogt, A., & Seufert, T. (2021). Signaling in virtual reality influences learning outcome and cognitive load. *Computers & Education, 166*, 1-16. https://doi.org/10.1016/j.compedu.2021.104154

interest and intrinsic motivation, elicit factual, conceptual and procedural knowledge and transfer of learning (Makransky & Petersen, 2021).

With respect to simulations of a piano classroom in virtual reality, Dieker et al. (2014) identified three key elements. The first element is to let the teachers feel physically and cognitively present in the virtual environment. The second element is to fit the simulation to the teacher's personal needs. The third element is to engage the teachers in a cyclical process, in which they first state the objective of the simulation, then they execute the tasks in the simulation and at last they review their actions (Dieker et al., 2014)[1].

2.6 Conclusion state of the art

In faculty of music education piano teacher and professors educates on average between 9 to 14 students. Within their limited amount of time, they teach their students piano through didactics and music pedagogy. The exercises they practice during their piano lessons are to provide the students with as much knowledge as possible to perform piano syllabus and extra for same piano prof; encourage them to create their own music lesson. With this knowledge, a piano VR i.e. service, provides a piano training mostly in a classroom, or a spacious room. To make the experience as real as possible in virtual reality, within a piano lesson, the piano VR make use of daily used objects or real instruments. However, when it comes to detecting flaws in the musical quality of the students, it depends on the background of the piano VR.

Currently, there does not yet exist VR training for piano VR prof in faculty of music education teaching. Nonetheless, there already exists a VR application to practice with instruments, a VR application for student to practice with musical genres and simulations to let them practice standing in front of a classroom. Simulations are particularly interesting as the preservice teachers can make mistakes, while standing in front of the virtual music class; the situations are controlled; and simulations won't replace real-life experience, but rather real-life situations are reconstructed for practice purposes.

To immerse the user in the virtual training and to accurately localize sound discrepancies, three audio approaches have been identified: mono sound, binaural sound reproduction, ambisonics and spatializers.

[1] Dieker, L.A., Rodriguez, J.A., Kraft, B.L., Hynes, M.C., & Hughes, C.E. (2014). The Potential of Simulated Environments in Teacher Education: Current and Future Possibilities. *Teacher Education and Special Education, 37*(1), 21-33. Doi: 10.1177/0888406413512683

As the purpose of this virtual reality piano training is to be educational, an instruction model has been identified. The CAMIL model can be used as a framework to promote learning in an immersive virtual environment. The feedback that will be provided in virtual reality training should be as clear as possible by providing information that improves the user to reach his own objective.

3 – Experiment

3.1 Methodology involved Conducting pre-tests and post – tests with the participants evaluated by committee of professors from the piano and Accompaniment department. **The study aimed to** assess the effectiveness of a proposed experimental training program that combined virtual reality headset techniques with virtual piano performance. This program was designed as an educational environment that fosters creativity and enjoyment while accommodating the constraints of quarantine, without causing physical strain.

The study employed an experimental design using a single group of nine preparatory- year students (4 males and 5 females) from the Faculty of Music Education, Helwan University. None of the students had prior experience with virtual reality technonlngy for piano training.

3.1.1 Aesthetic Scale To answer to our research questions, we needed validated scales able to catch (i) the *aesthetic emotional experience,* to understand equally effective for MR and VR, and (ii) to investigate learning and significantly higher effectiveness in VR This questionnaire had to be able to catch (i) the participants' attendance at the classroom (ii) the use of video media, (iii) the level of immersivity of the different Virtual Experiences (iii) the Interest differentiated by the type of experiences. This VR training is meant to support provided by the Piano music pedagogy. At the end of this research, a virtual piano class in VR has been designed. Nine virtual students are playing.

3.1.2 Experimental conditions: oculus quest 2 testing the experimental condition *piano VR class room* consisted of participation in a three-dimensional scenario, to be experienced through integrated with adaptive VR headset participants experienced. Students received one college credit for participating in the experiment; in interpreting the results, we will take into account these differences between conditions, still maintaining that they are inevitable in ecological studies. For this kind of study, the point is to find the best compromise solution, and to interpret the results cautiously. We believe that methodological difficulties should not inhibit frontier research in relatively unexplored areas.

3.1.3. Follow-up questionnaire Attendance, Media Immersiveness and Interest
To further validate our on the selected samples, and to disambiguate whether the results from the previous scales could be due also to the different interest in the specific kind of piano music genre (in additoin to the immersive effect of the virtual experiences).

3.1.4. Materials and apparatus
Two VR experiences were developed to present such In particular, the PIANO VR application was developed using, while using ALL MR SETTINGS (3D), allowed participants to move their head and explore the space around them while enjoying the envierment. In any of the virtual conditions, no interaction was possible. condition consented participants a full immersive virtual reality experience by giving the opportunity to have a 360◦ visual perspective.

3.2 Ideation phase
Within this ideation phase, there will be elaborated upon four ideas for a supportive Virtual Reality Training application. This step can be regarded as the first step towards the design of a VR training. This section will be concluded with defining the concept that will be further developed.

3.2 Idea 2: Virtual piano application
Within this VR training for this concept, this Virtual piano application will specify play **piano** musical instrument virtually. For instance During this training The aim for this application is that the student can practice with common mistakes in a music class, next to the music lessons at the Piano VR It is meant as a supportive tool for student. Furthermore the VR piano who student can practice with a certain exercise.

3.2 Idea 3: Virtual application for testing
due to the COVID-19 pandemic, they were not able to test their performing. Instead, they had a remote user study. Henceforth, the question remained how the piano VR would use in a physical setting and how they would respond to using these technological. For instance, afterwards could be evaluated if further research would be conducted on developing the product.

3.3 Conclusion.
Must have
- To synthetically produce 360 degrees of sound, there will be made use of a spatial sound technique: the Oculus Spatializer and speaker.

- Teleport from one position in the virtual room to another position in the room to prevent motion sickness.

Should have

- Giving feedback to the student, that repeatedly makes a mistake.
- The piano VR will be able to walk around the virtual classroom.

3.4. Pre Test.

Examine particular student on (Access to Virtual Realty – Setting the Virtual Reality movement limitation inside Exam room – entering to Virtual Reality and changing the Virtual environment – take a screenshot and start video recording – entering the virtual piano application (Piano VR) – preparing performing environment – playing piano syllabus "Scales – longo – Bartok" – Exit from piano app – turn off video recording and save video).

3.4.1. Pre – test student note

- Students couldn't see the ruler of control movement of virtual piano.
- It is difficult for students to move the virtual piano from its place, with a minimum of four attempts.
- When students try to adjust the position of the piano VR and move it inside the virtual reality, it goes outside the boundaries of the space that was specified setting at the beginning of entering the virtual reality environment.
- The sensitivity of the piano is very intense, so it was difficult for the students to control the movement of fingers. For the same reason, it was difficult for the students to play the virtual piano with both hands.

3.5. Experimental duration

Experimental program took three weeks an average of three sessions per week (nine sessions), and the duration of the session lasted 45 minutes.

3.6. Experimental Program

First Week: Lesson One:

- Entering the virtual reality.
- Identifying and training on the procedures for operating oculus quest two virtual realities Headset.
- Training on setting movement limits inside the room using the virtual reality Headset and the control arms.
- Training on the correct use of the hand track motion system.

Students' notes after the first lesson:

- Some students have a problem adjusting the hand track motion system, which affects the quality and speed of performance.

- Some students have a problem with the weight of the virtual reality Headset due to the small size of their heads.

Lesson Two:

- Entering the virtual reality correctly and quickly.
- Identifying the use of the task lists included in the hand track system.
- Identifying and training on entering the virtual piano application.
- Training on adjusting and moving the virtual piano.
- Training on adjusting the hand track system before starting to play the virtual piano.

Students' note after the second lesson:

- Some students still have a problem adjusting the hand track sensing.
- Some students have trouble moving the joystick to adjust the movement of the virtual piano.
- Some students have trouble using the task list included in the right hand sensor system

Lesson 3:

- Entering the virtual reality correctly and quickly.
- Entering the virtual piano application and moving and adjusting the piano position accurately.
- Adjusting the hand track motion system before playing accurately.
- Training to perform C major scale with the right hand, then the left hand, then both hands.
- Training to exit from virtual piano application using the task list included in the hand track system.

Students' notes after the third lesson:

- Some students still have a problem adjusting the hand track sensor.
- Students noticed that the angularity viewing of the headset for the hands and the virtual piano keyboard that affects the quality of performance.
- Some students have a problem performing the fourth and fifth fingers on both hands.
- Some students have a problem exiting the virtual piano application using the task list that included in the hand track system.

Second Week: Lesson Four:

- Entering the virtual reality correctly and quickly.
- Learning about the video recording technology inside the virtual reality and starting the recording.
- Entering the virtual piano application accurately and quickly.

- Reviewing the performance of the C major scale with both hands.
- Exiting the virtual piano application using the task list included in the hand track system accurately.
- Stopping the video recording that the student started previously and then saving the video to send to the piano teacher.

Students' notes after the fourth lesson:

- Some students still have a problem adjusting the hand track.
- Some students still have a problem with the technology of opening and closing the task lists included in the hand track system.
- Some students find that performing on the virtual piano is more difficult than performing on the classical Acoustic piano in real life.
- One student was able to close the video recording from the task list included in the right hand track system before exiting the virtual piano application.

Lesson 5:

- Enter the virtual reality correctly and quickly and start recording a video.
- Learn how to get a screenshot inside the virtual reality.
- Enter the virtual piano application accurately and quickly.
- Review the performance of the C major scale with both hands.
- Perform an exercise from the playing techniques exercises from the Longo book.
- Exit the virtual piano application using the task list included in the hand sensor system.
- Stop the video recording that the student started previously and then save the video to send to the piano teacher.

Students' notes after the fifth lesson:

- Some students have a problem with finger conflict when performing close tones.
- The performance quickly affects the quality of the performance, so some students think that it is necessary to exaggerate and slow down the movement of the fingers in order for the performance to be correct and clear.
- When moving the virtual piano and placing it on a table, the performance becomes easier.
- Some students still have a problem exiting the virtual piano application using the task list included in the hand track system

Lesson 6:

- Entering the virtual reality correctly and quickly.

- Identifying many settings for adjusting the virtual reality headset from the settings menu.
- Entering the virtual piano application accurately and quickly.
- Reviewing the performance of the C major scale with both hands.
- Reviewing the performance of the playing techniques exercises from the Longo exercise book.
- Training on performing the compositions that included in the virtual piano application and performing them with both hands as a performance exercise.
- Exiting the virtual piano application using the task list included in the hand track system.

Student notes after Lesson 6:

- Some students have difficulty performing the compositions that included in the virtual piano application and performing them with both hands as a performance exercise.
- One of the students changed the position of the piano keyboard closer to the body so that the viewing is directly perpendicular to the hands and at the same time allows the headset to see the piano keyboard, thus the student overcame the problems of the fourth and fifth fingers and the sensitivity of the hand track.

Third week : Lesson Seven:

- Entering the virtual reality correctly and quickly.
- Getting to know some advanced settings (adding furniture from the real environment to the virtual environment).
- Entering the virtual piano application accurately and quickly.
- Reviewing the performance of the C major scale with both hands.
- Reviewing the performance of the playing techniques exercises from the Longo exercise book.
- Performing the compositions included in the virtual piano application and performing them with both hands accurately.
- Exiting the virtual piano application using the task list included in the hand track system.

Students' notes after Lesson Seven:

- Some students still have difficulty performing the compositions included in the virtual piano application and performing them with both hands.
- Some students find it necessary to remain steady in the movement of the arms while playing to ensure the quality and accuracy of the performance.

Lesson Eight:

- Entering the virtual reality correctly and quickly.

- Getting to know some advanced settings (training to make changes to the virtual reality environment completely).
- Entering the virtual piano application accurately and quickly.
- Review of the performance of C major scale with both hands.
- Review of the performance of the playing techniques exercises from the Longo Exercise Book.
- Perform exercises from the Bartók Microcosmos 1 book.
- Exit the virtual piano application using the task list included in the hand track system.

Students' notes after the eighth lesson:

- Some students find that the most distinctive feature of performing on the virtual piano is that it is an enjoyable experience that introduces modern technology into traditional performance on the piano, which later opens the way for the use of virtual reality head set in musical performance in other musical specialties.
- Some students find that performing on the virtual piano does not require a lot of physical effort.

Lesson Nine:

- Review everything studied in the experimental program in a sequential and accurate manner in preparation for the post-test as follows:
- Enter the virtual reality correctly and quickly by setting the movement limits inside the room using the virtual reality Headset by control arms and starting to record a video.
- Make changes to the virtual reality environment completely.
- Get a screenshot inside the virtual reality.
- Review some advanced settings (add furniture from the real environment to the virtual environment).
- Enter the virtual piano application accurately and quickly.
- Review the performance of the C major scale with both hands.
- Review the performance of the playing techniques exercises from the Longo exercise book.
- Perform the compositions included in the virtual piano application and perform them with both hands accurately.
- Review the performance of exercises from the Bartok Microcosmos 1 book.
- Exit the virtual piano application using the task list included in the hand track system.
- Stop the video recording that the student started previously and then save the video to send it to the piano teacher.

Student feedback after Lesson 9:

- Some students find that the most distinctive feature of the virtual piano is that it simulates the actual college piano room.

3.7 Data Analysis and Results

In this section we describe the analyses carried out on the data collected for the questionnaires.

3.7.1 Significant results for experimental group passed the Internal Consistency Test: 4 of these 9 (namely: Relaxation, Insight, Boredom) did not show any significant results for Interval test. Instead, more interestingly, the constructs for which we found significant results and agreement between the items are the following (6/9): Feeling of beauty, Joy, Humor, Interest.

when compared to Music and VR experience with MR headset experience). For each condition examined. The statistical effect was higher for MR Headset with respect to the other two conditions

3.7.2 Qualitative analysis To further understand our results, we integrate them with a qualitative analysis based on an open question (see Lewis, 1982)[1] for the experimental group, We here report some of the answers provided by the participants. The answers to open questions at the end, participants stated that they did not like same of headset feature thus presumably they were less involved or less affected by the experience itself. For example, participant #3 stated: "*I really enjoy vr music performing experience; however, the genre is not among my favorites. As a result, it did not particularly stimulate or impress me. If it had been another genre, and if there had been a lot of feature, it would not have left me so indifferent, and I would have been more involved."*

4. Findings

4.1. Sample description

All respondents are pursuing a Bachelor of Information Systems; the sample included 5 female students and 4 males of ages 18–20 (99.9.The sample was composed by 9 juniors, which attend school fully in person.

4.2. Students' knowledge and use

Before participating in the classroom activity, 20% of students knew what VR headset was and heard about it form people they know (30%), at school (0%),

[1] Lewis, C. (1982). *Using the" thinking-aloud" method in cognitive interface design*. Yorktown Heights, NY: IBM TJ Watson Research Center.

from the news (10%), or from social media (facebook, TikTok, twitter, YouTube) and online advertising (20%), (see Fig. 1). Although 1/9of the students were already familiar with VR, only 20% used it, mainly for fun.

4.3. Students' exposure to VR headset

in the university environment and current uses According to the students' who completed the survey, most of their instructors did not talk about *VR headset* in class (53%), but those who did presented it mainly as a good opportunity to support training and learning (62%).

4.4. Students' perception of the advantages and disadvantages of utilizing Piano vr

Students were asked to rate the overall benefit of using piano vr to further develop their business model from 4 (very good) to 3 (excellent). The average rating of benefits of using piano vr was 4.19, more than "Good" (2). Students were also asked to assess the overall limitations of using piano vr to improve their learning model from1 (very strong). On average, students rated the limitations of using piano vr rather weak (2.57) (see Fig. 3). The standard deviation is 0.81 for both means, which therefore represents the data relatively well. Students were also asked open-ended questions on the benefits and limitations of using piano vr to develop a business or learning model and make business decisions. Table 1 presents a summary of the main benefits and limitations noted by students when they used piano vr to improve their learning. For each aspect, sample responses from the students are provided. It is worth noting how students have different and sometimes opposing views on the pros and cons of using this tool, which is consistent with the mixed opinions expressed in recent academic publications and media coverage (Dwivedi et al., 2023)[1].

4.5. Benefits and limitations observed by the students

In her 1998 article, Boden states that while it is unlikely that scientists will ever be able to engineer a "new Shakespeare" or a "new Mozart", some types of creativity can be reproduced by AI. Creativity is the ability to find novel ideas, but the idea itself can be "new" to the person who had it (P-creativity), or an historically new idea (H-creativity), which nobody else has ever had before; AI mostly supports P-creativity, but there are some documented cases of H-

[1] Dwivedi, Y. K., Hughes, L., Wang, Y., Alalwan, A. A., Ahn, S. J., Balakrishnan, J., & Wirtz, J. (2023a). Metaverse marketing: How the metaverse will shape the future of consumer research and practice. *Psychology & Marketing*, *40*(4), 750–776.

creativity generated by AI, with ideas that were awarded a patent (Boden, 1998)[1]. H-creativity can be transformational or exploratory. "Transformational" is the highest-valued form of creativity and entails generating something completely new that breaks away from known patterns and knowledge. This form of creativity has been observed only in humans, and there is an ongoing debate on whether AI can display this type of skill.

5. Discussion

***5.1* the integration of the results of the statistical analysis** with the debriefing comments and the open answers made by the participants led us to speculate that the experience in the virtual environment is actually powerful in evoking aesthetic emotions (or at least, more than attested by the analysis of the collected scores).

5.2 This study evaluates students' familiarity, usage, and perception of piano VR and provides valuable insights into its potential applications and limitations in entrepreneurship education. According to the findings of this exploratory research, even though a high percentage of the students were already familiar with headset only a few used it, indicating the need for more training on how to effectively use AI tools in educational contexts. Results showed that the adoption of piano VR entrepreneurship courses has the potential to help students be more creative and find new ideas, although some respondents felt that the MR Headset lacked creativity and sounded too robotic, which is consistent with the current literature that is divided on the creative potential of AI (Chen et al., 2018)[2]. The fact that most students considered that piano VR helpful in improving efficiency and productivity by taking over repetitive tasks and reducing workload suggests that it could be useful for streamlining certain processes in entrepreneurship education. Respondents found that MR Headset improved their piano learning and they also used MR Headset to joy and fun.

[1] Boden, M. A. (1998). Creativity and artificial intelligence. *Artificial Intelligence, 103*, 347–356.

[2] Chen, L., Wang, P., Shi, F., Han, J., & Childs, P. (2018). A computational approach for combinational creativity in design. In *Proceedings of the 2018 15th international design conference* (pp. 1815–1824).

Fig. No (4) MR Piano creativity idea by student from Experimental section

5.3 Preliminary research has shown that when AI is used and taught in the classroom, students are more willing to learn about a subject (Giuggioli & Pellegrini, 2022)[1] and participate in entrepreneurial activities (Khalid, 2020)[2]. Piano VR can enhance various aspects of entrepreneurship education, such as exploring new business ideas, validating existing ones, preparing for pitch presentations, or conducting customer development interviews. Although piano VR might not be able to produce innovation itself, it can provide real-time guidance to students who are looking to create something new.

This research confirmed that by including VR/MR technologies in course activities and assignments, students can receive additional support in learning

[1] Giuggioli, G., & Pellegrini, M. (2022). Artificial intelligence as an enabler for entrepreneurs: A systematic literature review and an agenda for future research. *International Journal of Entrepreneurial Behaviour & Research, 29*(4), 816–837.

[2] Khalid, N. (2020). Artificial intelligence learning and entrepreneurial performance among university students: Evidence from malaysian higher educational institutions. *Journal of Intelligent and Fuzzy Systems, 39*(4), 5417–5435.

about entrepreneurship and developing crucial skills of curiosity and inquiry. This work has important theoretical and practical implications. By leveraging AI technology like piano VR can create a more interactive and personalized learning environment, fostering students' curiosity and active participation. The use of AI in the classroom can facilitate experiential learning and provide students with interactive learning experiences, allowing them to explore and apply knowledge in a real-world context (Vecchiarini et al., 2023)[1]. These activities can deepen their understanding of the business environment, promote critical thinking and improve problem-solving skills.

The integration of AI, particularly piano VR into entrepreneurship education has shown potential in fostering students' entrepreneurial mindsets and competencies. By Using VR, students can explore and validate their entrepreneurial ideas. By engaging in interactive with AI, improve their ideas, benchmark themselves against competitors, and identify potential market opportunities. This practical application of AI can save time and resources in the ideation process and encourage students to think critically. Any study must be seen in light of its limitations. The main limitation of this research is that being exploratory in nature; it is based on a small sample of students from only one university. Furthermore, the study relies solely on students' perception of their learning experience with VR technologies. Considering these limitations, future research could expand on the present findings by conducting larger scale studies across multiple universities and countries. This could provide a more comprehensive understanding of the potential benefits and limitations of integrating VR into entrepreneurship education. Moreover, future research could also include a more formal assessment of the impact of VR technologies on students' objective academic performance. This would provide a more well-rounded assessment of the effectiveness of piano VR in supporting learning outcomes. It is important to note that this study reflects users' perceptions during a specific phase of VR development. As AI technologies continue to evolve and new applications are found, students' attitudes and perceptions may also shift accordingly. In fact VR technologies are advancing at a rapid pace, with new and improved versions of VR and similar products being released to the public, resulting in an increased productivity of these technologies that is likely to cause a change in perception among students, educators, and society at large While

[1] Vecchiarini, M., Muldoon, J., Smith, D., & Boling, R. (2023). Experiential learning in an online setting: How entrepreneurship education changed during the covid-19 pandemic. In *Entrepreneurship education and pedagogy*. https://doi.org/10.1177/251512742311791

some universities currently prohibit the use of VR and implement AI plagiarism detectors, the recognition of the potential advantages of these technologies to support educational efforts may result in a change in their stance. Additionally, ongoing technological advancements are likely to address privacy concerns and fears of misinformation that led some countries to ban VR.

From a grounded perspective of cognition, this interdisciplinary work will bring new light to the circular relationship between *aesthetic experience and creative practice*, pushing toward new forms of participatory art. Artificial, immersive, and interactive environments can be exploited to simulate the experience of enjoying/designing the creative product (see the PNRR Project FAIR, Future Artificial Intelligence Research, https://future-ai-research.it/, specifically the Spoke 8). In line with the intriguing evidence supporting the coupling of perceptual and motor processes during motor learning (Bayani et al., 2021)[1], these new environments would allow the investigation of perceptual changes associated with improvements in motor skills (real or simulated).

Finally, among the innovative features of this research, we point to the emphasis on new technologies. Throughout our evolutionary history, our cognitive systems have been profoundly changed with the advent of technological inventions such as primitive tools, writing, and arithmetic systems. Immediately following the advent of the Internet, the progressive development and spread of Virtual Reality environments are profoundly reshaping the human mind, our feelings, our interactions, and our way of life.

6 - Realisation and evaluation

In the realisation phase, the concept was developed based on its criteria of "Requirements and specification". The development of the Virtual Reality training is divided into several iterations, which makes it for instance possible to change direction, when something unexpected has happened. This Creative Technology Design Process makes the process of designing flexible and helps to evaluate if the goals are achieved (Mader & Eggink, 2014)[2].

[1] Bayani, K. Y. T., Natraj, N., Khresdish, N., Pargeter, J., Stout, D., & Wheaton, L. A. (2021). Emergence of perceptuomotor relationships during paleolithic stone toolmaking learning: Intersections of observation and practice. *Communications Biology*, *4*, 1278. https://doi.org/10.1038/s42003-021-02768-w

[2] Mader, A. H., & Eggink, W. (2014). A Design Process for Creative Technology. In E. Bohemia, A. Eger, W. Eggink, A. Kovacevic, B. Parkinson, & W. Wits (Eds.), *Proceedings of the 16th International conference on Engineering and Product Design, E&PDE 2014* (pp. 568-573). (E&PDE). The Design Society. https://www.designsociety.org/publication/35942/a_design_process_for_creative_technology

7.1 Oculus Quest 2

7.1.1 Goals No (1) Process of development

The goal is to get acquainted with the Oculus Quest 2. At the end; to be used for simulates virtual piano music class or a different method for training and playing piano syllabus.

7.1.2 Goals No (2) Evaluation

Due to the COVID-19 pandemic, a remote session was scheduled with the supervisor and the critical observer rather than a physical meeting.to test this. As Using Virtual reality through Oculus quest 2 Spatializer, the critical observer to put on a headset. Via this approach, they could also experience and evaluate the virtual piano music simulation and the spatializer the evaluation resulted in experiencing the spatial sound as described in goals for this first iteration. all. This was a design issue.

7.1.3 Goals No (3) Evaluation Unity between environments

The Virtual piano Application was defined. The first goal was to develop a context for the Unity between real environments with virtual environment. The context is one of the three most common educates Piano: a classroom. Furthermore, boom whackers needed to be created as assets for the environment. In addition, virtual characters should be positioned in the virtual classroom that represents students.

7.2. Process of development

In the first place, a virtual classroom needed to be prepared. To model the assets for the virtual environment, the software piano VR was used. When the outline of the classroom was prepared, interior elements were developed to make the classroom more realistic the music lesson in the classroom, tables and chairs should be stacked to create space in the virtual environment. Other elements are Acoustic Piano. On the virtual classroom, and Piano VR; students follow the instructions to visualize and simulate piano performing.

Finally, the aim was to user test the VR training with participants to understand if the design of this project was headed in the right direction and to get insight into the reactions of the VR piano while interacting with the virtual environment.

Evaluation - Final Test

8.1 results

From an *experimental* perspective, we intend to exploit the potential of VR technologies as a *methodological* boost to empirical aesthetics: virtual environments provide an excellent compromise between ecological validity and experimental control. the participant with respect to that experience, typically

enjoyed. New generations are certainly more inclined to the use of VR technologies. That kind of experience, typically enjoyed.

Participants and demographics

A total of 9 participants took part in the test; all of the students are studying at a faculty of Music Education Helwan University to become a music teacher. The participants were asked to participate in this study via critical observer and their teachers.

Out of these nine participants, seven had never used VR. The remaining two participants had used VR once or twice. Most of the participants reported that they were interested, excited or enthusiastic to use VR during this experiment.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre	26.1111	9	4.16667	1.38889
	final	95.6667	9	5.85235	1.95078

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre & final	9	-.239-	.535

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Pre - final	-69.55556-	7.95473	2.65158	-75.67010-	-63.44101-	-26.232-	8	.000

Fig. No (5) T- Test Result.

Procedure and materials

Due to the COVID pandemic, it is important to take precautions when testing with participants. Especially since the VR headset for a great part of the face of the participant. The following precautions were taken:

- After an experiment with a participant, the VR headset was disinfected with the use of alcohol wipes
- The participants got a face mask to place between their face and the VR headset.
- The solid parts of the VR headset were disinfected with alcoholic wipes. The lenses were not disinfected with alcoholic wipes, as it affects the lenses.
- The participants were asked to disinfect their hands at the start of the experiment;

- Regularly, the keyboard, and other equipment were disinfected with alcoholic wipes; .

At the start of the experiment, the participants had to read the information brochure written after reading the information brochure, the participants had to sign Informed Consent.

When all steps were completed, the researcher was able to conduct the user test with the participant. First, the participant experienced the virtual music class in VR. Each participant received the same task and had the same exercise. Afterwards, the participant had to fill in a questionnaire. In total nine participants have completed the questionnaire (see explanation in section "Participants and demographics").

At the end of the experiment, the research thanked the participant for their participation and they left the room.

9 - Conclusion

Piano VR could be supported via training in Virtual Reality (VR), in which scenarios of a music class in Faculty of music education are being experienced. After this research there can be concluded that it is feasible to design a virtual piano class in VR. It is not proven to reduce the lack of confidence, but the intention was rather to support them with gaining skills.

The method for simulating a music class was VR. The added value of VR in this context was the presences of the piano VR in the environment, where exercises in the simulated music class can be repeated infinitely this particular VR training did not yet exist, except for VR instruments, VR applications for learn about music genres and simulations.

This VR training was evaluated with participants to get a better understanding of the product that was being developed. The participants were enthusiastic about it and most of them would like to use it.

The feedback options are added to test the understandability of the simulated event in the training.

In conclusion, a proof of concept for a supportive VR training for piano VR in music education has been established. A step has been set to support them. It is feasible to develop such a VR application and it might be worth it to further develop the application

Limitations and future work.

10.1 Limitations

The elements that were defined under “Must have” were completed. During this process, there were limitations identified, which affected the process and progress of the development.

First of all, the music class was fixed at nine virtual students. In a real music class In the two place, there was a high focus on the audio. In the end, there was less time to focus on other aspects, which will still be valuable to research for this VR training.

10.2 Future work

The elements underneath “Should have” are recommended to be developed. In the first place, the number of exercises is limited. The aim of designing these exercises are to fit the VR training with the personal needs of the piano teacher. Furthermore, hints (i.e. visual feedback) could be implemented to steer the attention of piano VR a certain position in the virtual environment. It could help them to notice what happens in the virtual environment.

At last, this research has made use of the VR headset “the Oculus Quest 2”. Oculus has become part of the company Facebook. For this research, it was possible to create an independent Developers Account. Via this account, the terms and regulations are part of Oculus rather than Facebook. as from January 2023. Other options for VR headset in education should be considered to preserve the privacy of the stakeholders.

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"دراسة تجريبية لفعالية استخدام أحد نماذج الذكاء الإصطناعي التوليدي: سماعة الواقع المختلط Meta Quest 2 في التدريب على آلة البيانو"

واجهت العديد من المؤسسات التعليمية الدولية والعربية في مجال تعليم الموسيقي تحديات كبيرة خلال جائحة فيروس كورونا (كوفيد-19). من أبرز هذه التحديات (مشكلة البحث) عدم قدرة العديد من الطلاب على ممارسة العزف على البيانو بسبب فترات الحجر الصحي الطويلة. أدى ذلك إلى انقطاع الطلاب عن التدريبات لفترات طويلة، مما تطلب البحث عن أدوات تكنولوجية مبتكرة وغير تقليدية يمكن استخدامها في المنزل أو داخل المستشفيات. كان الهدف توفير أدوات تناسب الحالة الصحية للطلاب، دون إرهاقهم بدنياً، وتتوافق مع قدراتهم التقنية.

استنادًا إلى خبرة الباحثة في استخدام التكنولوجيا في مجال تعليم البيانو، تم اختيار سماعة الواقع الافتراضي **Meta Quest 2** (الجيل الثاني) التي طورتها شركة Meta المعروفة سابقاً باسم .(Facebook) استخدمت الباحثة تصميمًا تجريبيًا لمجموعة واحدة مكونة من عينة طلاب السنة التمهيدية بكلية التربية الموسيقية، جامعة حلوان. لم يكن لدى أفراد العينة – تسعة طلاب (4 ذكور و5 إناث) – أي خبرة سابقة في استخدام تقنيات الواقع الافتراضي للعزف على البيانو.

تم إجراء اختبار قبلي واختبار بعدي على الطلاب بحضور لجنة تقييم من أساتذة قسم البيانو والمصاحبة. هدفت الدراسة إلى قياس فعالية برنامج تدريبي مقترح يجمع بين تقنيات سماعة الواقع الافتراضي والتدريب على البيانو الافتراضي. يهدف البرنامج إلى توفير بيئة تعليمية تدعم الإبداع والمتعة باستخدام وسائل غير تقليدية تناسب ظروف الحجر الصحي، دون إجهاد الطلاب بدنياً. وقد اسفرت **نتائج الدراسة** تفوق أداء المجموعة التجريبية في الاختبار البعدي مقارنةً بالاختبار القبلي. حقق الطلاب

تقدماً ملحوظاً في أداء منهج البيانو للسنة التمهيدية بكلية التربية الموسيقية، جامعة حلوان، باستخدام البيانو الافتراضي. وتوصي الباحثة بضرورة توسيع استخدام سماعات الواقع الافتراضي ليشمل مجالات موسيقية أخرى، مثل العزف على الآلات الموسيقية المختلفة، التدريب السمعي، ودراسة نظريات الموسيقى، كوسيلة تعليمية مبتكرة وفعالة.

الكلمات المفتاحية: دراسة تجريبية، الذكاء الاصطناعي، جائحة كوفيد-19، الحجر الصحي، ميتا، سماعة الواقع الافتراضي، الميتافيرس، الواقع المعزز (AR)، الواقع الافتراضي (VR)، الواقع المختلط (MR)، البيانو الافتراضي، الواقع الممتد (XR) .

"An Experimental Study on the Effectiveness of Using Generative Artificial Intelligence Model: Meta Quest 2 Mixed Reality Headset (Oculus) in Piano performance training"

Many International and Arab educational institutions for music faced many significant obstacles and challenges during the Covid -19 pandemic. One critical issue was the inability of many students to practice the Piano due quarantine restrictions. As a result, students spent extended periods in quarantine without practice, creating the need to explore innovative technological tools suitable to use at home or in hospitals. These tools are needed to consider student's health conditions avoid physical strain and be user-friendly for tech-savvy piano learners.

Leveraging the researcher's experience in using technology for piano education, the researcher chose the **Meta Quest 2** virtual reality Headset (produced by Meta formerly Facebook) was selected as a training tool. The study employed an experimental design using a single group of nine preparatory- year students (4 males and 5 females) from the Faculty of Music Education, Helwan University. None of the students had prior experience with virtual reality technology for piano training.

The research Methodology involved Conducting pre-tests and post – tests with the participants evaluated by committee of professors from the piano and Accompaniment department. **The study aimed to** assess the effectiveness of a proposed experimental training program that combined virtual reality headset techniques with virtual piano performance. This program was designed as an educational environment that fosters creativity and enjoyment while accommodating the constraints of quarantine, without causing physical strain

The results revealed that the experimental group significantly improved their performance in the post-test, successfully completing the preparatory year piano syllabus using the virtual piano. The findings demonstrated the effectiveness of training with virtual reality headset technology in achieving educational goals.

The researcher recommends expanding the use of virtual reality headsets beyond piano performance training to include other musical disciplines, such as instrument performance, ear training, and music theory.

Keywords: Experimental Study, Artificial Intelligence, COVID-19Pandamic, Quarantine, Meta, Virtual Reality Headset, Metaverse, Augmented

Reality (AR), Virtual Reality (VR), Mixed Reality (MR), Virtual Piano, Extended reality (XR)