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Emerging Technologies in Vocational Education and Training

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Abstract: This study explores into the dynamic landscape of vocational education, spotlighting the pivotal role played by emerging technologies in shaping pedagogy and skill development. The swiftly changing world of work demands educational adaptability, and emerging technologies offer innovative avenues to meet this imperative. Examining cutting-edge innovations such as Virtual Reality (VR), Augmented Reality (AR), Artificial Intelligence (AI), Machine Learning (ML), Internet of Things (IoT), Robotics, Automation, Big Data, Analytics, Blockchain, 3D printing, and Gamification, this research explores their application in vocational education. Drawing on a comprehensive literature review and diverse global case studies, the paper explores the transformative potential of these technologies and associated challenges. Despite cost and training concerns, the study suggests solutions like affordable access, educator training programs, and equitable technology distribution. It concludes by underscoring the necessity for strategic investments in professional development, technology accessibility, and inclusive educational programs to ensure responsible integration of emerging technologies, positioning vocational education as a catalyst for societal and economic advancement.

Keywords: Emerging Technologies, Vocational Education and Training, Vocational pedagogy, skill development

INTRODUCTION

Vocational Education and Training (VET) stands as a cornerstone in the development of skilled workforces worldwide. In the face of rapid globalization and technological advancements, the landscape of work is changing at an unprecedented pace. Ministry of Human Resource Development (2020) and National Steering Committee for National Curriculum Frameworks (2023) emphasises on holistic development of students and stresses on transformative vocational education for skill development. To bridge the gap between traditional education and the demands of the modern workforce, the integration of emerging technologies in VET is imperative. This paper delves into the transformative role of emerging technologies in reshaping pedagogy and skill development in vocational education and training, examining the background of vocational education and highlighting the increasing significance of emerging technologies in the educational context. This article will also provide insight to the policy makers and help the vocational teachers in schools to have an understanding of implementing and using these emerging technologies to teach vocational subjects in schools.

Emerging Technologies

Emerging technologies are new or evolving technologies that are poised to have a significant impact on society (Bailey, 2022). These technologies are often characterized by their potential to disrupt existing industries, create new markets, and solve complex problems. Some of the most promising emerging technologies include Virtual Reality (VR), Augmented Reality

(AR), Artificial Intelligence (AI), Machine Learning (ML), Internet of Things (IoT), Robotics and Automation, Big data and analytics, Blockchain and distributed ledger technology, 3D printing and additive manufacturing. These technologies have the potential to revolutionize fields such as healthcare, education, transportation, and manufacturing. While emerging technologies offer great promise, they also present challenges. These challenges include ethical concerns, privacy issues, and the potential for job displacement. It is important to carefully consider these issues before deploying emerging technologies on a large scale. Emerging technologies are a powerful force for change. These technologies have the potential to improve our lives in many ways, but it is important to use them wisely and responsibly (Srinivasan, 2008; Bergey, 2014).

Benefits of Emerging Technologies in Vocational Education

Emerging Technology is increasingly used in vocational education to enhance learning experiences. It has shown its capacity to foster an enabling environment along with institutional-wide engagement (Bozalek et al., 2013). A growing body of research is exploring the use of emerging technologies in vocational education. For example, a study has found that using virtual reality (VR) to train students for welding tasks resulted in significant improvements in performance and confidence (Price et al., 2019). Another study found that using augmented reality (AR) to train students for plumbing tasks resulted in reduced errors and increased completion rates (Kwiatek et al., 2019). The impact of emerging technologies on society, business, economy, and humanity is only going to increase in the coming decades (Siau, 2017).

Virtual Reality (VR) and Augmented Reality (AR) Applications

Virtual Reality (VR) and Augmented Reality (AR) have revolutionized the learning experience by providing immersive and interactive training environments. In vocational education, students can utilize VR to simulate complex tasks in a risk-free setting, enhancing their understanding of intricate concepts. Research has shown that with VR simulation learning can be personalised to suit individual learning needs and provide adaptive learning experience (tom Dieck et al., 2021). AR, on the other hand, overlays digital information onto the real world, enabling students to visualize and manipulate objects, making learning more engaging and tangible.

Artificial Intelligence (AI) and Machine Learning (ML) in Skill Enhancement

AI and ML technologies empower personalized learning experiences. AI algorithms analyze student behaviour, adapting the learning materials and pace to match individual needs. AI-driven tutors provide real-time feedback, identifying strengths and weaknesses, guiding students to mastery. AI-powered learning platforms can adapt to the individual needs of each student, providing them with the right level of challenge and support. This can help students to learn more effectively and efficiently (Maghsudi et al., 2021). However, Machine Learning algorithms, when applied to vocational tasks, help students refine their skills by analyzing patterns, thereby enhancing their expertise (Nafea, 2018).

Internet of Things (IoT) in Vocational Training

The integration of IoT devices in vocational training connects students to real-world applications. For instance, in automotive repair training, IoT sensors can monitor engine performance, allowing students to diagnose issues and apply solutions in a controlled environment. This practical, hands-on experience is invaluable, preparing students for the challenges of the modern workplace (Borgia, 2014).

Gamification and Interactive Learning Tools

Gamification techniques leverage game design elements to engage and motivate learners. Interactive learning tools, coupled with gamified approaches, enhance student participation and enthusiasm. Gamification has significantly demonstrated to boost active learning and motivation in online classes, resulting in increased engagement and reduced anxiety among students (Rincon-

Flores & Santos-Guevara, 2021). By incorporating game-like scenarios, students can tackle challenges, earn rewards, and collaborate with peers, fostering a competitive yet supportive learning environment.

Robotics and automation

The increasing prevalence of robotics and automation in the 21st-century industrial landscape is transforming not only the world of work but also the realm of education. Robotics and automation are the demand of 21st century industrial needs. They are replacing manual jobs and eventually revolutionalising every nation's economy (Zhao & Siau, 2017). This technological shift is not only enhancing efficiency and precision among learners but also fostering heightened collaboration and communication, while simultaneously facilitating personalized learning experiences (Madaev et al., 2023). Studies have shown Robotics Laboratory and Automation provide a wholesome experience to learners to draw on their basics and conduct advanced experiments at different stages of their learning process. Hence, Robotics and Automation are going to fundamentally change the mode of pedagogy and reform the way we learn (Siau, 2017).

Big data and analytics

The influence of a data-driven learning environment extends to teaching and assessment, offering a continuous monitoring mechanism. With the advent of virtual learning spaces, the role of Data and analytics has permeated the boundaries of education with constant data collection, continuous algorithmic assessment, and record retention. This has in turn dictated the desired learning outcomes, content creation, and assessment methods, shifting decision-making away from educators and diminishing the involvement of parents and students in the decision-making process (Zeide, 2017). It provides opportunities for dynamic information exchanges, which is essential for staying up to date in the field of vocational education.

Blockchain and distributed ledger technology

Blockchain and distributed ledger technology (DLT) are gaining recognition for their transformative potential in various sectors like Healthcare, Banking providing services like safe & secure transactions, transaction settlement, digital currency banks, and supply chain applications. With the incorporation of Blockchain along with Distributed ledger technology, it has paved a way to improve information management making it accessible and securing data privacy. It has proven to provide practical and safe technological ways for conducting digital certification, recording and so on (Yuliana & Agustina. 2022).

3D printing and additive manufacturing

The use of 3D printing and additive manufacturing in vocational education is a growing area of interest, with potential applications in design, manufacturing, and materials processing (Keaveney & Dowling, 2018). This technology can enhance learning experiences, particularly in mechanical engineering, by providing a hands-on approach to design and fabrication. However, its full potential is yet to be realized, and further research is needed to explore its use in instructional media (Ramdhani & Mulyanti, 2020). The current implementation of 3D printing in education is varied, with applications ranging from teaching and learning about 3D printing to creating assistive technologies (Ford & Minshall, 2019). Despite its potential, the use of 3D printing in vocational education is still in its early stages, and more research is needed to fully understand its impact and potential.

Challenges and Limitations of Emerging technologies in Vocational Education

While the benefits of integrating emerging technologies in vocational education are evident, it is not without challenges and limitations. One of the primary challenges is the initial cost of acquiring the necessary equipment and software (Schwendimann et al., 2018). It also requires Technical expertise for its maintenance for organisations with a limited Human Resource and Funds availability (Papathanassiou et al., 2013). Such training, and equity persist. Cost-

effective solutions are emerging as technology becomes more accessible. Training programs for educators are essential, ensuring they can harness the full potential of these tools. Addressing equity concerns involves providing access to technology both in schools and at home, promoting digital literacy among all students.

Case Studies: Successful Implementations of Emerging Technologies in Vocational Education

Australia's TAFE Queensland (2022) stands out as a pioneer, employing VR to train students in trades like plumbing, electrical work, and carpentry. Students can practise intricate tasks within a safe virtual environment, boosting their confidence and competence.

In Canada, the use of AR by the Canadian Welding Association has transformed welding training. Through AR simulations, students visualize welding techniques, reducing errors and material wastage. Singapore's Institute of Technology utilizes AI-powered tutors to create personalized learning plans for students, addressing their unique strengths and weaknesses effectively.

Chiang et al. (2022) conducted a systematic review on the Application of AR in Vocational Training spanning over a 20 years' time period from 2020 to 2021. The analysis of 80 relevant studies from various industries suggested improvement in vocational skills using AR training technologies. Findings revealed widespread adoption of AR in vocational education, medical training, and industrial maintenance and assembly. Common tools such as AR glasses, simulators, Unity3D game engine, 360° panoramas, AR systems, and applications were identified as prevalent in training scenarios, with recognized benefits. The research affirms that AR significantly contributes to the improvement of vocational training, particularly in fields like medical training and industrial maintenance. The study suggests that future investigations can explore the integration of intelligent technologies like AR glasses, simulators, and Unity3D game engine into vocational education for a more engaging learning outcome.

As per Fortune Business Insight (2024), the global Virtual Reality in education market share 2022 was dominated by the higher education segment (Figure 1). In 2022, virtual reality played a crucial role in providing students with seamless learning opportunities. The applications of VR in higher education encompass student recruitment, fundraising, and immersive learning experiences. Moreover, it is anticipated that the vocational training segment will exhibit the highest Compound Annual Growth Rate (CAGR) throughout the forecast period. This growth is attributed to the ability of VR in simulating real-world work environments, enabling students to practise skills without the associated risks of injury or damage. This proves particularly advantageous in industries with high risks or significant costs, such as aviation, construction, and healthcare.

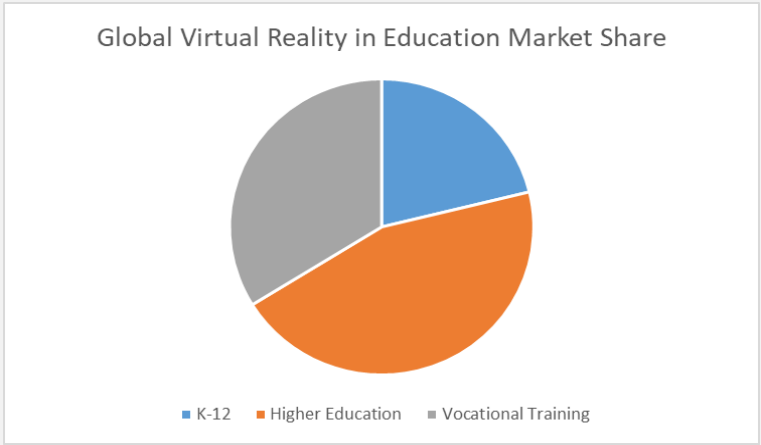

Figure 1. Global Virtual Reality in Education Market Share
(Source: www.fortunebusinessinsights.com)

In Sanjeewa's (2021) study on big data analytics in vocational education, it was found that the collection, tracking, and visualization of student data across various factors offer enhanced insight into a student's educational journey for VET providers, teachers, and even the students themselves. This approach enables timely intervention upon detecting potential risks of failure or dropout in a student's behaviour, academics, or support requirements. Additionally, the integration of critical business systems, such as a Student Information System (SIS) or a Learning Management System (LMS), with a learning analytics solution allows VET providers to access and interpret data at individual level, particularly in real time.

On the other hand, continuous data collection and analysis through a student dashboard provide educators with a rapid overview of their students' daily or weekly activities, allowing for timely responses to emerging trends or challenges.

Iosup & Epema (2014) introduced gamification toolbox in technical higher education and it was found out through evaluation that gamification proves to be a valuable approach for delivering technically demanding courses. Notably, it demonstrated a notable rise in pass rates and engagement in voluntary activities and challenging assignments, leading to enhanced student satisfaction.

At Guangzhou Light Industry Vocational School, China, ABB Robotics has equipped the school teachers with a comprehensive set of educational materials and instructor training, alongside a variety of ABB robots and assistance. This empowers students to unleash their potential, acquire the essential skills, and prepare for careers in industries related to robotics. In addition to supplying the robots, ABB actively participates in facilitating courses related to majors such as the Application of Electromechanical Technology and Application of Industrial Robot Technology. These courses are designed to equip students with the necessary skills for pursuing careers in an increasingly automated workplace (ABB, 2022).

Addressing Challenges Through Real-World Examples

To bridge the gap between theoretical potential and practical implementation, this paper is enriched by incorporating detailed case studies that illustrate how specific challenges associated with emerging technologies in vocational education have been successfully overcome. These in-depth explorations will provide valuable practical guidance for institutions contemplating the adoption of these technologies.

Virtual Reality (VR) in Welding Training: The American Welding Society partnered with VR training company STRIVR to address the shortage of skilled welders. VR simulations provide students with safe and realistic practice environments, overcoming limitations of traditional training methods like access to expensive equipment or real-world hazards (https://www.strivr.com/).

Augmented Reality (AR) in Aircraft Maintenance: Boeing utilizes AR technology to overlay instructional information onto real aircraft components, allowing trainees to visualize complex repair procedures and troubleshoot issues more efficiently. This addresses the challenge of bridging the gap between theoretical knowledge and practical application in complex technical fields (https://fieldserviceusa.wbresearch.com/boeing-ar-technology-strategy-maintenance-training-transform-ty-u).

Artificial Intelligence (AI) in Personalized Learning: The National Institute of Technology (NIT) in India uses AI-powered adaptive learning platforms to personalize learning paths for students based on their individual strengths and weaknesses. This addresses the challenge of catering to diverse learning styles and ensuring each student receives the support they need to succeed (http://nitindia.net/about-us/).

Big Data Analytics in Skills Gap Analysis: The World Economic Forum utilizes big data analytics to identify emerging skills demanded by the job market and predict future skill gaps. This information helps vocational institutions adapt their curriculum and training programs to stay relevant and address the evolving needs of the workforce (https://www.weforum.org/).

Gamification in Soft Skills Development: The Institute of Hospitality (IOH) in the UK employs gamified learning platforms to develop essential soft skills like communication, teamwork, and problem-solving in students. This addresses the challenge of fostering valuable skills that are not easily learned through traditional classroom methods and are increasingly sought after by employers (https://www.instituteofhospitality.org/).

Mixed Reality (MR) in Automotive Repair Training: Tata Motors, a leading Indian automaker, has implemented Mixed Reality (MR) technology in its training programs. The MR system overlays digital information onto real vehicles, allowing trainees to visualize internal components, diagnose faults, and practice repair procedures in a safe and interactive environment. This addresses the challenge of limited access to expensive equipment and complex automotive systems, while providing a more realistic and engaging learning experience compared to traditional manuals or classroom instruction (https://www.tatamotors.com/).

These examples illustrate how emerging technologies are effectively addressing various challenges in vocational education, fostering a more engaging, personalized, and future-proof learning experience for students.

Long-Term Impact and Future-Proofing Skills

The long-term impacts on the job market and how education systems can adapt to equip students with "future-proof" skills is detailed below.

The automation and AI advancements are likely to automate routine tasks across various industries, potentially displacing jobs in specific sectors (Karangutkar, 2023). Vocational education needs to address this by fostering adaptability, critical thinking, and problem-solving skills, enabling graduates to adjust to changing job demands and embrace emerging opportunities. Initiatives like incorporating design thinking principles or project-based learning that encourage innovation and problem-solving can contribute to this goal.

The rise of the "gig economy" and remote work necessitates a focus on digital literacy and communication skills. Integrating online collaboration tools and platforms into training programs can prepare students to thrive in these flexible work environments (Magen-Nagar & Shonfeld, 2018).

The increasing reliance on technology in various fields highlights the importance of "transversal" or soft skills like teamwork, communication, and interpersonal skills. These skills are crucial for effective collaboration in technology-driven workplaces, and vocational education can cultivate them through group projects, simulated work scenarios, or communication workshops. By proactively addressing these long-term trends and equipping students with essential skills, vocational education can ensure their relevance and success in the evolving job market.

Policy and Funding: Facilitating Tech Adoption in Vocational Education

The section examines how policy and funding frameworks influence the adoption of emerging technologies in vocational education. Here are five key examples to consider:

National Skill Development Mission (NSDM), India: This Indian government initiative provides financial and infrastructural support to vocational training providers. The NSDM could potentially incentivize technology integration by offering grants or subsidies for institutions that adopt VR/AR or other relevant technologies in their programs (https://www.msde.gov.in/).

SkillsFuture Singapore: This Singaporean government program promotes lifelong learning and skills development. It offers Skills Development Funds that can be utilized by companies and individuals for training initiatives, including those that incorporate emerging technologies (https://www.skillsfuture.gov.sg/).

European Union's Digital Education Action Plan: This plan emphasizes the importance of integrating digital technologies in education and training programs. It encourages member states to develop national strategies and provide resources for technology adoption in vocational education institutions (https://education.ec.europa.eu/focus-topics/digital-education/action-plan).

Apprenticeship Levy, UK: This UK policy requires large employers to invest a levy into apprenticeship training. A portion of these funds could be directed towards incorporating emerging technologies like VR simulations or gamified learning platforms into apprenticeship programs (https://www.gov.uk/guidance/pay-apprenticeship-levy).

Stackable Credentials Framework, USA: This framework promotes the creation of smaller, industry-recognized credentials that can be stacked together to build broader skillsets. This model could incentivize vocational education programs to utilize micro-learning modules delivered through emerging technologies like mobile apps or online platforms, making learning more accessible and adaptable to specific career goals (https://cte.ed.gov/initiatives/community-college-stackable-credentials).

By exploring these diverse examples, this paper highlights the critical role of policy and funding in fostering widespread technology adoption within vocational education, ultimately paving the way for a more future-proof and accessible learning experience for students.

Future of Emerging Technologies in Vocational Education: Opportunities and Implications

The rapid advancement of technology is transforming the landscape of vocational education, offering a plethora of opportunities to enhance teaching, learning, and skill development. Emerging technologies such as artificial intelligence (AI), virtual reality (VR), and augmented reality (AR) are revolutionizing the way vocational education is delivered, providing students with immersive and interactive learning experiences.

AI-powered adaptive learning platforms can personalize education by tailoring instruction to each student's unique needs and learning style. VR simulations allow students to practice skills and procedures in a safe and realistic environment, while AR overlays digital information onto the real world, enhancing understanding and engagement.

These technologies also hold the potential to widen access to vocational education, particularly for students in remote or underserved areas. Online vocational courses and virtual labs can provide students with flexible learning options, while mobile apps can deliver bite-sized training modules that can be accessed anytime, anywhere.

However, the integration of emerging technologies into vocational education also presents challenges. Ensuring equitable access to technology and infrastructure is crucial, as is providing teachers with the necessary training and support to effectively utilize these tools. Additionally, addressing ethical concerns and potential biases in AI algorithms is essential.

As technology continues to evolve, its impact on vocational education is bound to grow even more profound. By embracing these emerging technologies, vocational education institutions can prepare students with the skills and knowledge they need to thrive in the rapidly changing workforce of the future.

CONCLUSION

The integration of emerging technologies in vocational education marks a paradigm shift in pedagogy and skill development. By embracing VR, AR, AI, and other transformative tools, vocational institutions empower students with immersive, engaging, and personalized learning experiences. These technologies not only enhance student outcomes but also prepare graduates for the challenges of the modern workforce. By addressing challenges through strategic policies, training initiatives, and inclusive practices, vocational education can evolve to meet the demands of the future, creating a workforce equipped with the skills necessary for a thriving global economy.

REFERENCES

ABB. (2022). ABB Robotics helps students shape their future careers at Guangzhou Light Industry Vocational School. https://new.abb.com/news/detail/94474/cstmr-abb-robotics-helps-students-shape-their-future-careers-at-guangzhou-light-industry-vocational-school

Bailey, D. (2022). Emerging Technologies at Work: Policy Ideas to Address Negative Consequences for Work, Workers, and Society. *ILR Review, 75*, 527-551. https://doi.org/10.1177/00197939221076747

Bergey, P. (2014). Entrepreneurship in emerging markets. *IEEE Engineering Management Review, 42*, 2-2. https://doi.org/10.1109/EMR.2014.2314538

Borgia, E. (2014). The Internet of Things vision: Key features, applications and open issues. *Computer Communications, 54*, 1-31. https://doi.org/10.1016/j.comcom.2014.09.008

Bozalek, V.G., Ng'ambi, D., & Gachago, D. (2013). Transforming teaching with emerging technologies: Implications for higher education institutions. *South African Journal of Higher Education, 27*(2), 419-436. https://hdl.handle.net/10520/EJC144269

Chiang, F. K., Shang, X., & Qiao, L. (2022). Augmented reality in vocational training: A systematic review of research and applications. *Computers in Human Behavior, 129*, 107125. https://doi.org/10.1016/j.chb.2021.107125

Ford, S., & Minshall, T. (2019). Invited review article: Where and how 3D printing is used in teaching and education. *Additive Manufacturing, 25*, 131-150. https://doi.org/10.1016/j.addma.2018.10.028

Fortune Business Insights. (2024). Virtual Reality in Education Market Size, Share & Industry Analysis, By Component (Hardware, Software, and Content), By Application (K-12, Higher Education, and Vocational Training), and Regional Forecast, 2024–2032. In *Market Research Report*. https://www.fortunebusinessinsights.com/industry-reports/virtual-reality-in-education-market-101696

Iosup, A., & Epema, D. (2014). An experience report on using gamification in technical higher education. In *Proceedings of the 45th ACM technical symposium on Computer science education* (pp.27–32). https://doi.org/10.1145/2538862.2538899

Karangutkar, A. (2023). The Impact of Artificial Intelligence on Job Displacement and the Future of Work. *International Journal of Advanced Research in Science, Communication and Technology, 3*(1), 635-638. https://doi.org/10.48175/ijarsct-12096

Keaveney, S. G., & Dowling, D. P. (2018). Application of additive manufacturing in design & manufacturing engineering education. In *2018 2nd International Symposium on Small-scale Intelligent Manufacturing Systems (SIMS)* (pp. 1-6). IEEE. https://doi.org/10.1109/SIMS.2018.8355289

Kwiatek, C., Sharif, M., Li, S., Haas, C., & Walbridge, S. (2019). Impact of augmented reality and spatial cognition on assembly in construction. *Automation in construction, 108*, 102935. https://doi.org/10.1016/j.autcon.2019.102935

Madaev, S. M., Turluev, R. R., & Batchaeva, Z. B. (2023). Robotics and Automation in Education. In *SHS Web of Conferences* (Vol. 172, p. 01012). EDP Sciences. https://doi.org/10.1051/shsconf/202317201012

Magen-Nagar, N., & Shonfeld, M. (2018). The impact of an online collaborative learning program on students' attitude towards technology. *Interactive Learning Environments, 26*, 621-637. https://doi.org/10.1080/10494820.2017.1376336

Maghsudi, S., Lan, A., Xu, J., & Schaar, M. (2021). Personalized Education in the Artificial Intelligence Era: What to Expect Next. *IEEE Signal Processing Magazine, 38*, 37-50. https://doi.org/10.1109/MSP.2021.3055032

Ministry of Human Resource Development. (2020). *National Education Policy 2020*. Government of India. https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf

Nafea, I. (2018). Machine Learning in Educational Technology. *Machine Learning - Advanced Techniques and Emerging Applications*. https://doi.org/10.5772/INTECHOPEN.72906

National Steering Committee for National Curriculum Frameworks. (2023). *National Curriculum Framework for School Education 2023*. Government of India. https://ncert.nic.in/pdf/NCFSE-2023-August_2023.pdf

Papathanassiou, N., Pistofidis, P., & Emmanouilidis, C. (2013). Competencies development and self-assessment in maintenance management e-training. *European Journal of Engineering Education, 38*, 497-511. https://doi.org/10.1080/03043797.2013.811475

Price, A., Kuttolamadom, M., & Obeidat, S. (2019). Using virtual reality welding to improve manufacturing process education. In *2019 Conference for Industry and Education Collaboration*. American Society for Engineering Education. http://dx.doi.org/10.18260/3-2-370-31515

Ramdhani, F. F., & Mulyanti, B. (2020). Additive manufacturing in education. In *IOP Conference Series: Materials Science and Engineering* (Vol. 830, No. 4, p. 042093). IOP Publishing. https://doi.org/10.1088/1757-899X/830/4/042093

Rincon-Flores, E. G., & Santos-Guevara, B. N.(2021).Gamification during Covid-19: Promoting active learning and motivation in higher education. *Australasian Journal of Educational Technology, 37*(5), 43-60. https://doi.org/10.14742/ajet.7157

Sanjeewa, K. (2021). *How Vocational Education benefits from data analytics and visualization*. OctopusBI. https://octopusbi.com/how-vocational-education-benefits-from-data-analytics-and-visualization/

Schwendimann, B., Wever, B., Hämäläinen, R., & Cattaneo, A. (2018). The State-of-the-Art of Collaborative Technologies for Initial Vocational Education: A Systematic Literature Review. *International Journal for Research in Vocational Education and Training, 5*, 19-41. https://doi.org/10.13152/IJRVET.5.1.2

Siau, K. (2017). Impact of artificial intelligence, robotics, and automation on higher education. In *23rd Americas Conference on Information Systems (AMCIS 2017)* (p. 63). Association for Information Systems (AIS). https://aisel.aisnet.org/amcis2017/TREOs/Presentations/63/

Srinivasan, R. (2008). Sources, characteristics and effects of emerging technologies: Research opportunities in innovation. *Industrial Marketing Management, 37*, 633-640. https://doi.org/10.1016/J.INDMARMAN.2007.12.003

TAFE Queensland. (2022). TAFE Queensland and Arkio join forces. https://tafeqld.edu.au/news-and-events/news/2022/tafe-queensland-and-arkio-join-forces

tom Dieck, M. C., Jung, T. H., & Loureiro, S. (2021). *Augmented Reality and Virtual Reality: New Trends in Immersive Technology*. Springer. https://doi.org/10.1007/978-3-030-68086-2

Yuliana, K., & Agustina, R. (2022). Utilization of blockchain technology for future education. *Blockchain Frontier technology, 1*(2), 39-43. https://doi.org/10.34306/bfront.v1i2.51

Zeide, E. (2017). The structural consequences of big data-driven education. Big Data, 5(2), 164-172. https://doi.org/10.1089/big.2016.0061

Zhao, W., & Siau, K. L. (2017). Machine Learning Approaches to Sentiment Analytics. In *MWAIS 2017 Proceedings*. https://aisel.aisnet.org/mwais2017/25