Exploring the Challenges of Future Social Studies Educators in the Age of Industry 4.0

ABSTRACT

In the era of Industry 4.0, technological advancements are not just a supplemental tool but a fundamental component of the new educational landscape.The level of awareness and preparedness towards technological advancements, and the challenges of 239 future social studies educators in the era of Industry 4.0 are explored in this study. It employed a mixed-methods approach, combining quantitative and qualitative research methods, which enabled a comprehensive assessment of the challenges and the level of awareness and preparedness of future social studies educators in the era of Industry 4.0. Findings revealed that future educators are highly aware of technologies like QR codes, AI, and VR but only moderately aware of others like hologram and cloud computing. In terms of preparedness, educators felt moderately prepared for various indicators, with biometrics being the highest-ranked. Significantly, the study reveals a strong positive correlation ($P < 0.001$) between awareness and preparedness, underscoring the need for robust technological literacy within teacher education programs. Challenges educators face, such as limited technological infrastructure, technical issues, and disparities in technology access, require attention to ensure that future social studies educators are well-equipped for the era of Industry 4.0.

Keywords: Industry 4.0, challenges, future educators, social studies, education

1. INTRODUCTION

1.1 Background of the Study

Fourth Industrial Revolution, IR 4.0, or Industry 4.0 (Bai et al., 2020), is a buzzword and neologism describing rapid technological advancement in the 21st century (Ross & Maynard, 2021). The term gained widespread use in 2016 after being introduced by Klaus Schwab, the World Economic Forum founder and executive chairman. According to Javaid et al. (2022), Industry 4.0 integrates developments in emerging technology, robots and artificial intelligence, advanced sensors, cloud computing, the IoT, mobile enforcement, and many other applications. These technological advancements are reshaping how people learn, live, and work.

According to Alakrash and Razak (2021a), technological advancements have positively influenced various aspects of life, including business, education, and more. The integration of technological devices and software in educational settings has not only benefited learners but also skyrocketed their enthusiasm for learning. Educators and government institutions have observed an increasing interest among students in learning more (Hameed & Hashim, 2022). It is no doubt that technology has a significant impact on today's educational landscape. Thus, it is indispensable to transform education to empower students with the knowledge and skills they need to thrive in this ever-evolving environment.

In today's industry, the growing presence of advanced technology is irresistible. Therefore, it is crucial for future social studies educators to be well-informed and ready to adapt to these changes in order to remain relevant after completing their degree programs. It is essential to assess the current level of awareness and preparedness of future educators at Pangasinan State University, San Carlos City Campus, with regard to Industry 4.0 and explore the challenges they face. By doing so, the university can attain its vision and mission of becoming an industry-driven state university and producing dynamic, responsive, and future-ready individuals.

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* E-mail address: rsoriano.sancarlos@psu.edu.ph

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1.2 Literature Review

The historical evolution of education accentuates its continual adjustments to align with societal and technological advancements. From the introduction of the printing press, which revolutionized knowledge dissemination, to the widespread use of computers and the internet, which transformed access to information and communication, education has constantly evolved to remain relevant [6]. With the proliferation of IR 4.0 on a global scale, there is an immediate need for higher education institutions to quickly adapt and incorporate the methodology and components of these rapidly changing trends and evolving demands of the industry into their existing curriculum [7], and foster critical thinking, problem-solving, digital literacy, and other 21st-century skills essential for success in the digital age [8]. Failing to do so will result in cohorts of graduates becoming part of the redundant workforce, where their acquired knowledge and skills become obsolete quickly [9].

Further, Pangandaman et al. [10] emphasize that technological advancements are one of the attributes and crucial determinants of a higher education institution's readiness and capability to become relevant to Industry 4.0. This assertion is supported by James [11], who highlights that in order to prepare future graduates for work, universities must align their teaching and processes with technological advancements. Halili [12] enumerated new technological advancements, which include 3D printing, augmented reality, virtual reality, cloud computing, hologram, biometrics, paper-thin smartphones, multi-touch LCD screens, internet of things (IoT), artificial intelligence, big data, and QR code. According to Vawn [13], incorporating these latest technologies can raise the effectiveness of the teaching and learning process.

However, integrating Industry 4.0 technological advancements into education presents challenges. There are concerns about equitable access to technology, the need for ongoing teacher training and support, and the potential for these technologies to exacerbate existing inequalities [6]. Eslit[14] identified obstacles such as financial constraints, lack of teacher training, technological infrastructure, and connectivity issues. Hameed and Hashim [5] noted the lack of internet connection, exposure or knowledge of using technology, and lack of technology equipment in school. Moreover, according to Emirates Scholar [15], ensuring equitable access to technology, addressing privacy and security concerns, and adapting the curriculum and teaching methods are some challenges educators and policymakers must grapple with. Unequitable access to digital technologies, lack of funding and research, knowledge of teachers, public policy on the fourth industrial revolution and new technologies, technological challenges, and data privacy and security of data collected are the challenges identified in the study of Juma & Patel [16].

Despite the challenges, it is indisputable that IR 4.0 essentially restructures different societal entities, especially the education sector, which demands a paradigm shift in teaching and learning practices. The social studies program, which aims to foster critical thinking, civic engagement, and historical understanding, is susceptible to the impact of Industry 4.0. Therefore, the future educators under the said program must be aware of and prepared for the advancements and challenges of the Fourth Industrial Revolution. Then, curricula must be adjusted to make them more technology-compatible [17].

Though the potential of IR 4.0 to be incorporated into the social studies program is unequivocally acknowledged, there is still a significant gap in understanding the awareness and readiness of future educators in this context. Specifically, there is a lack of studies navigating the extent to which future social studies educators at Pangasinan State University (PSU), San Carlos City Campus, are aware of Industry 4.0 technologies and challenges.

1.3 Research Questions

This study aimed to contribute to the understanding of Industry 4.0 in the Social Studies Program of Pangasinan State University, San Carlos City Campus, by investigating the challenges of future educators. Specifically, the study sought to answer the following research questions:

1. What is the level of awareness of future educators towards Industry 4.0 in terms of technological advancements?
2. What is the level of preparedness of future educators towards Industry 4.0 in terms of technological advancements?
3. What is the significant relationship between the level of awareness and preparedness of future social studies educators?
4. What are the challenges encountered by future social studies educators in the era of Industry 4.0?

2. METHODOLOGY

2.1 Research Design

The research design for this study employed a mixed-methods approach, combining quantitative and qualitative research methods. This design enabled a comprehensive assessment of the challenges and the level of awareness and preparedness of future social studies educators in the era of Industry 4.0. According to Soriano [18], the use of both quantitative and qualitative data enhanced the robustness of the findings and offered a more holistic understanding of the study. The qualitative phase focused on gaining in-depth insights into the challenges faced by future social studies educators in the midst of Industry 4.0.

2.2 Research Locale

The participants selected for this study are specifically future social studies educators studying at Pangasinan State University, San Carlos City Campus. The inclusion criteria encompass incoming 2nd, 3rd, and 4th-year students of the 1st semester, A.Y. 2024-2025.

2.3 Research Participants

A total of 239 future social studies educators are involved in the study, with 20 from the incoming 2nd year, 90 from the incoming 3rd year, and 129 from the incoming 4th year. Incoming first-year students are excluded from this study due to their limited experience within the university setting.

The sampling process utilized in the study is a non-probability sampling technique specifically, a convenience sampling method. This decision is based on the assumption that 2nd to 4th-year students would provide a more relevant and informed perspective.

2.4 Research Instrument

The primary tool used in gathering quantitative and qualitative data for this study was a semi-structured questionnaire adopted from Soriano [19], modified by the researcher and touted as “Semi-structured Questionnaire for Exploring the Challenges of Future Social Studies Educators in the Age of Industry 4.0”. A modified semi-structured questionnaire is consisted of three parts. Part I was designed to assess the awareness level of future social studies educators, Part II aimed to gauge their level of preparedness, and Part III was focused on exploring the challenges by providing predetermined answers to guide participants' responses.

2.5 Data Gathering Procedure

The study first obtained official permission from the Campus Executive Director with the help of the Research Coordinator and the Program Chairperson of the Social Studies Department. After the approval was secured, the researcher conducted the survey using Google Forms. The data from the respondents' answers were automatically collected, tallied, and organized into Google spreadsheets. The researcher then downloaded the tabulated data, organized them into corresponding tables, and proceeded with the interpretation of the results. This study examined the gathered data using descriptive statistics such as mean and rank to accurately determine the level of awareness and preparedness of future social studies educators in the era of Industry 4.0. Frequency counts were utilized to identify both common and specific challenges emerging from the data.

3. RESULTS AND DISCUSSION

3.1 On the Level of Awareness of Future Educators towards Technological Advancements

Table 1 shows the level of awareness of future educators from the Social Studies program towards Industry 4.0 regarding technological advancements. It could be derived that among the technological advancements of Industry 4.0, only three have a descriptive equivalent of "Highly Aware," and the rest have a descriptive equivalent of "Moderately Aware."

Table 1. Future Educators' Level of Awareness Towards Technological Advancements

Indicators	Mean	DE	Rank
QR code.	4.02	Highly Aware	1
Artificial Intelligence	3.84	Highly Aware	2
Virtual Reality	3.79	Highly Aware	3
Biometrics	3.50	Moderately Aware	4
Multi-touch LCD Screen	3.46	Moderately Aware	5
3D Printing	3.35	Moderately Aware	6
Paper-thin Smartphone	3.24	Moderately Aware	7
Internet of Things (IoT)	3.23	Moderately Aware	8
Augmented Reality	3.09	Moderately Aware	9
Big Data	3.07	Moderately Aware	10
Hologram	2.99	Moderately Aware	11
Cloud Computing	2.98	Moderately Aware	12
Average Weighted Mean	**3.38**	**Moderately Aware**	

Legend: 1.00-1.50: Very Slightly Aware (VSA), 1.51-2.50: Slightly Aware (SA), 2.51-3.50: Moderately Aware (MA), 3.51-4.50: Highly Aware (HA), 4.51-5.00: Very Highly Aware (VHA)

Future educators are "Highly Aware" of "QR Code," "Artificial Intelligence," and "Virtual Reality" (VR), which have means of 4.02, 3.84, and 3.79, respectively. These data imply that future educators are fully conscious of the existence of technological advancements and know they are often used in learning or the classroom. However, the respondents are "Moderately Aware" of the remaining technological advancements with weighted means that range from 3.50 to 2.98, such as "Biometrics", "Multi-touch LCD Screen", "3D Printing", "Paper-thin Smartphone", "Internet of Things (IoT)", "Augmented Reality", "Big Data", "Hologram", and "Cloud Computing". These suggest that the respondents are aware of the presence of technological advancements and know that they are sometimes used in learning or the classroom.

Based on the ranks, it is significant to note that the "QR Code" got the highest, and Cloud Computing is at the bottom. The respondents displayed the highest level of awareness of QR codes due to the fact that these are commonly available on smartphones through QR code generators and scanners and are usually seen in product packaging, newspapers, and books [19]. This is supported by the study of Demir et al. [23], which revealed that among 241 college students, 80% of them recognized QR Codes as they usually see these on product packaging, pharmaceutical and drug packaging, coupons, magazines, and catalogues. Also, the study revealed that college students use QR Codes with their pre-installed scanners on their mobile phones to access additional information and make purchases. According to Walsh and Andrew [24], some of the beneficial uses of QR Codes include bridging printed materials to electronic materials, reaching voiced materials, opening embedded videos, providing libraries with external resources, and reaching appropriate help. Future social studies educators commonly enjoy these uses as they have a higher level of awareness of QR codes.

As regards technological advancement that has the lowest weighted mean, it is worth noting that students identified Cloud Computing as the least among the technological advancements. This is due to poor awareness of using cloud computing in education and the lack of internet connection at home. Accordingly, as stated in the blog report of Maropost.com [25], cloud computing is the use of hardware and software to deliver a service over a network, typically the internet. So, it is very clear that an internet connection is needed in order to enjoy the benefits of using cloud computing at home or in school. However, among those students who have mobile phones, only 20% of them have access to the Internet [19].

In support of this finding, Bagish[26] conducted a study at Aden University, Yemen, that focused on the engineering students' awareness of cloud computing and how often they use cloud computing applications. Findings showed that most of the students are not familiar with cloud computing due to a lack of resources—the internet and gadgets.

The table generally shows that future social studies educators are "Moderately Aware," with technological advancements having an average weighted mean of 2.53. The moderate level of awareness would suggest that these future social studies educators may not fully integrate technology into their learning. This would result in a more traditional approach to social studies education, potentially missing out on the benefits of technology in terms of interactive learning and access to diverse resources.

3.2 On the Level of Preparedness of Future Educators towards Technological Advancements

Regarding the respondents' preparedness toward technological advancements, they believed they are "Moderately Prepared" in all indicators in Table 2, which would mean that respondents are prepared to do and/or implement them sometimes in learning or the classroom. Out of 12 indicators, "Use my face, fingerprints, and eyes to sign in for daily classroom attendance" got the highest rank with a weighted mean of 3.42.

Table 2: Level of Preparedness of Students along Technological Advancements

Indicators	Mean	DE	Rank
Use my face, fingerprints, and eyes to sign in for daily classroom attendance.	3.42	Moderately Prepared	1
Manage my own data, know how well I am learning, and determine my academic performance using big data.	3.31	Moderately Prepared	2
Employ artificial intelligence to write historical narratives and essays, complete assignments, and participate in online quizzes and activities.	3.22	Moderately Prepared	3
Establish rapid communication and interaction with my colleagues in and outside the classroom through the Internet of Things.	3.18	Moderately Prepared	4.5
Create stations to learn about specific events and people, and create a hot spot to navigate websites and video clips quickly.	3.18	Moderately Prepared	4.5
Employ cloud computing for storing homework, digital textbooks, assignments, and real-time document sharing.	3.15	Moderately Prepared	6
Write onscreen content with other people simultaneously, brainstorm, present, and analyze text or images through the multi-touch LCD screen.	3.11	Moderately Prepared	7
Utilize virtual reality to immerse in historical settings, diverse cultures, and complex geographical concepts.	3.05	Moderately Prepared	8
Avail and use Paper-Thin Smartphones to read historical, political, social, and economic e-books and other online reading materials.	3.02	Moderately Prepared	9.5
Use 3D printing to create engaging social studies lessons that bring geographical features, historical artifacts, and political symbols to life.	3.02	Moderately Prepared	9.5
Utilize augmented reality apps to interact with digital content in real-time, manipulate virtual objects, conduct virtual experiments, or solve puzzles.	2.97	Moderately Prepared	11
Immerse in simulations of events and cultures through holographic technology (e.g., table holograms, light field display holograms).	2.79	Moderately Prepared	12
Average Weighted Mean	**3.12**	**Moderately Prepared**	

Legend: 1.00-1.50: Very Slightly Prepared (VSP), 1.51-2.50: Somewhat Prepared (SP), 2.51-3.50: Moderately Prepared (MP), 3.51-4.50: Well Prepared (WP), 4.51-5.00: Very Well Prepared (VWP)

Future social studies educators are most prepared for the rank 1 indicator because they are used to using faces, fingerprints, and eyes to open gadgets and applications and carry out online transactions for security purposes. Biometrics provides not only maximum security but also convenience in daily transactions. According to the Bayometric website [27], biometrics can prevent unauthorized access and improve safety. Thus, inside the classroom, it would be harder for someone else to falsely record attendance.

According to Lamin et al. [28], biometric attendance systems can significantly reduce the time and effort required for both students and instructors. By utilizing students' unique biometric data, such as fingerprints or facial recognition, these systems eliminate the need for manual attendance marking or ID card scanning. This saves time for students and instructors and minimizes the potential for errors or inaccuracies in attendance records. This is further reinforced by the findings of Sharma et al. [29], in which the potential of biometrics to improve the accuracy and reliability of attendance data, especially those students who might be struggling with absenteeism, is highlighted.

At the bottom is "Immerse in simulations of events and cultures through holographic technology (e.g., table holograms, light field display holograms)" with a mean of 2.79. This would be attributed to the complexity and the cost of the hologram. It is one of the unexplored technological advancements in the field of education; thus, future social studies educators put this on the lowest rank. According to Barkhaya[30], hologram involves spatial displays that detach the

display technology from the user and integrate it into the real environment. This type of technology has been introduced with proven advantages for several decades, especially in digital art and medicine, but yet to be explored in education. Holographic technology allows instructors to present their knowledge to many classrooms at once [19]. However, the usage of hologram in education is quite ideal and very expensive as the faculty will need laser lights, beams, or holo lenses. This type of technology fosters motivation among students, but this fosters a burden on the faculty as accessibility to this kind of technology is costly.

3.3 On Significant Relationship Between the Level of Awareness and Preparedness of the Future Social Studies Educators Toward Technological Advancements

As reflected in Table 3, the awareness of future social studies educators toward technological advancements has a significant value of $P<0.001$ in relation to their level of preparedness. This indicates that the correlation between future social studies educators' awareness of technological advancements and their preparedness is highly statistically significant. This would mean that there is strong evidence to suggest that the respondents' awareness of technological advancements plays a pivotal role in their preparedness, and the observed relationship is unlikely to be due to random chance.

Table 3: Level of Preparedness of Students along Technological Advancements

			Level of Preparedness
Level of Awareness	Spearman's rho	Correlation Coefficient	.996**
		Sig. (2-tailed)	<.001

***. Correlation is significant at the 0.01 level (2-tailed).*

3.4 On the Challenges Encountered by Future Social Studies Educators in the Era of Industry 4.0

In Table 4, the challenges encountered by future social studies educators are displayed in which, among the eight identified challenges, three are "Highly Challenging", such as "Limited technological infrastructure in school", "Dealing with technical issues, such as unreliable internet connectivity or software glitches", "Disparities in access to digital technologies," with percentages of 78.24, 70.71, and 61.92, respectively.

Table 4: Challenges Encountered by Future Social Studies Educators in the Era of Industry 4.0

Indicators*	Freq	Percentage	DE
Limited technological infrastructure in school	187	78.24	Highly Challenging
Dealing with technical issues, such as unreliable internet connectivity or software glitches	169	70.71	Highly Challenging
Disparities in access to digital technologies	148	61.92	Highly Challenging
Managing distractions from technology, such as social media and online content	134	56.07	Challenging
Insufficient funding and research support for technology integration in social studies classrooms	126	52.72	Challenging
Addressing data privacy and security of information collected through digital tools and platforms	110	46.03	Challenging
Lack of the necessary knowledge and expertise to effectively use technology tools for social studies learning	102	42.68	Challenging
Adjusting to innovative teaching methods that integrate technology into the social studies curriculum	100	41.84	Challenging

**Multiple responses*

These findings reveal that most future social studies educators face substantial challenges related to technology access and reliability. "Highly Challenging" challenges are significant and demanding obstacles that hinder future social studies educators from being relevant and, more importantly, being prepared in the era of Industry 4.0. Thus, these require considerable attention and effort to overcome.

A high percentage of limited technological infrastructure is attributed to limited funding or resources by the institution or the government [31]. This challenge deprives future social studies educators of the basic technological foundation for effective technology integration. Dealing with technical issues like unreliable internet connectivity and software glitches is unavoidable in developing nations like the Philippines. Indeed, this challenge escalates educational inequities among future social studies educators and poses a potential threat to social studies programs. Belleza et al. [32] support this claim by pointing out that slow and unreliable internet connections are a significant challenge. The highly challenging nature of disparities in access to digital technologies underscores the persistent digital divide and its threat to educational equity. Future social studies educators without adequate technology access at home are at a significant disadvantage. They miss out on educational opportunities, which will limit their ability to engage deeply with the social studies curriculum, develop their essential digital literacy skills, and reach their full potential. The digital divide can perpetuate and even worsen socioeconomic and other disparities for already underserved groups [33].

A relevant study conducted by Mahyoob et al. [34] among EFL teachers examined similar challenges of e-learning adoption like lacking technological infrastructure and disparate access to digital technologies. Their research reinforces the need to address these persistent obstacles, as also surfaced in the present investigation of preparedness among future social studies educators. Equipping teachers-in-training to leverage technology would require strategies to mitigate impediments rooted in unreliable infrastructure and digital inequity.

The remaining challenges are labelled as “Challenging” and do not necessarily hinder future social studies educators from being prepared for the era of Industry 4.0. However, they still need to be addressed, albeit not immediately, to make them more relevantly prepared.

3.5 Implications

The findings highlight a significant need for teacher education programs to prioritize technological literacy and preparedness among future educators. Given that future social studies educators show a high level of awareness of certain technological advancements like QR codes, AI, and VR, but only moderate awareness of others such as big data, hologram, and cloud computing, teacher education curricula should be updated to provide more comprehensive training on a wider range of technological tools. This could include hands-on workshops, integration of technology into teaching practice sessions, and exposure to emerging technologies currently underutilized in education. By equipping future educators with a deeper understanding and familiarity with these tools, they will be better prepared to incorporate them into their teaching methods, enhancing student engagement and learning outcomes in a rapidly evolving educational landscape. Additionally, the strong correlation between awareness and preparedness suggests that increasing awareness directly influences educators' preparedness to use technology in the classroom. Teacher education programs must, therefore, not only focus on building awareness and preparedness but also on addressing the highly challenging challenges faced by future educators in the era of Industry 4.0, such as limited technological infrastructure, technical issues, and disparities in access to digital technologies. To address and overcome these challenges, the institution must invest in robust technological infrastructure such as high-speed internet and reliable hardware, venture into industry-academia collaboration for access to cutting-edge technologies, provide training and dedicated tech support, promote digital literacy, supply devices to the underprivileged, explore flexible learning models, and collaborate with community organizations.

4. CONCLUSION

The study delved into the awareness and preparedness of future social studies educators towards technological advancements associated with Industry 4.0. The findings reveal that these future educators are highly aware of technological advancements such as QR codes, artificial intelligence, and virtual reality, but their level of awareness of other key technologies, including hologram, cloud computing, and the Internet of Things (IoT), is only moderate. Furthermore, the findings derived from this study highlight that preparedness levels among future social studies educators are moderate, suggesting a potential gap in fully utilizing technological advancements in educational settings. The gap in the level of awareness is significant, as it directly correlates with their overall preparedness to integrate these technologies into educational practices.

This study is significant because it identifies the relationship between awareness and preparedness, emphasizing that a higher awareness level is crucial for educators to utilize technological tools effectively in the classroom. Moreover, the study underscores the challenges faced by future educators, particularly the limited technological infrastructure, unreliable internet connectivity, and disparities in access to digital technologies. These challenges pose significant obstacles to fully integrating Industry 4.0 technologies into education.

For future research, it is recommended to examine effective strategies to bridge the gap between awareness and preparedness among future social studies educators. Additionally, further studies could investigate the specific barriers that hinder the adoption of these technologies in educational settings and develop targeted interventions to address these challenges. Research could also focus on studying the role of collaborative efforts and institutional support in overcoming challenges related to technology access and reliability. A research study that delves into the potential of emerging technologies, such as holographic technology, in transforming educational practices and improving student engagement

could also be explored. These foregoing future research would provide valuable insights into the long-term impact of technological advancements on education in the era of Industry 4.0 and help shape future educational policies and practices.

Ethical Considerations

It is imperative to prioritize both data confidentiality and active willing participation to uphold the ethical standards of research. To address this, the study meticulously outlined the survey's purpose, allowing participants to make informed decisions about their involvement, a cornerstone of informed consent [20]. Furthermore, by explicitly guaranteeing the confidentiality of responses [21], the study aimed to foster a secure environment conducive to honest and open sharing. Finally, emphasizing the value of participant insights [22] aimed to encourage thoughtful engagement and highlight the significance of their contribution to the research. This multifaceted approach reflects a commitment to ethical data collection practices that prioritize participant well-being and data integrity.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1.
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REFERENCES

1. Bai, C., Dallasega, P., Orzes, G., & Sarkis, J. (2020). Industry 4.0 technologies assessment: A sustainability perspective. *International Journal of Production Economics, 229*. doi.org/10.1016/j.ijpe.2020.107776
2. Ross, P., & Maynard, K. (2021). Intelligent Buildings International. *Intelligent Buildings International, 13*(3), 159-161. doi:https://doi.org/10.1080/17508975.2021.1873625
3. Javaid, M., Haleem, A., Pratap, S. R., Suman, R., & Gonzalez, E. S. (2022). Understanding the adoption of Industry 4.0 technologies in improving environmental sustainability. *Sustainable Operations and Computers*, 203-217. doi:https://doi.org/10.1016/j.susoc.2022.01.008
4. Alakrash, H., & Razak, N. (2021a). Technology-Based Language Learning: Investigation of Digital Technology and Digital Literacy. *Sustainability, 13*(21). doi:https://doi.org/10.3390/su132112304
5. Hameed, B. S., & Hashim, H. (2022). Challenges Faced by Teachers in Integrating 4th Industrial Revolution (4IR) Technology in Teaching English as a Second Language (ESL). *13*(5). doi:10.4236/ce.2022.135113
6. Reddy, J. (2018). Past, Present and Future of Multidimensional Education. *International Research in Geographical and Environmental Education*. doi:https://www.researchgate.net/publication/358570778_Past_Present_and_Future_of_Multidimensional_Education_by_Dr_Jayarama_Reddy
7. Kozák, Š., Ružický, E., Štefanovič, J., && Schindler, F. (2018). Research and Education for Industry 4.0: Present Development. *2018 Cybernetics & Informatics (K&I).* Lazy pod Makytou, Slovakia: IEEE. doi:10.1109/CYBERI.2018.8337556
8. Yuen, K. K., & Wong, A. O. (2020). Development Roadmap for Launching Online Education: A Case Study of an Online Graduate Certificate Course. *2020 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE).* Takamatsu, Japan: IEEE. doi: 10.1109/TALE48869.2020.9368482
9. Wermann, J., Kliesing, N., Walter, A., && Moraes, E. C. (2015). Impact of new ICT trends for the educational curriculum in the area of Industrial Automation and Engineering. *IECON 2015 - 41st Annual Conference of the IEEE Industrial Electronics Society.* Yokohama, Japan: IEEE. doi:10.1109/IECON.2015.7392667
10. Pangandaman, H., Ali, N., Lambayong, J. H., & Ergas, M. L. (n.d.). Philippine Higher Education Vis-À-Vis Education 4.0: A Scoping Review. *International Journal of Advanced Research and Publications, 3*(3), 65-69. Retrieved from https://www.ijarp.org/published-research-papers/mar2019/Philippine-Higher-Education-Vis-vis-Education-40-A-Scoping-Review.pdf
11. James, F. (2019). Everything You Need to Know about Education 4.0, URL: https://www.qs.com/everything-you-need-to-know-education-40/

12. Halili, S. (2019). Technological Advancements in Education 4.0. The Online Journal of Distance Education and e-Learning, 7(1).https://www.tojdel.net/journals/tojdel/articles/v07i01/v07i01-08.pdf
13. Vawn, H. (2019). Technology in the Classroom in 2019: 6 Pros & Cons. URL: https://tophat.com/blog/6-pros-cons-technology-classroom/, date retrieved: March 12, 2020
14. Eslit, E. (2023). Charting the Future of Philippines Education: Navigating the Intersection of K-12 Education, the Fourth Industrial Revolution (IR 4.0), and Internationalization. doi:10.20944/preprints202307.1578.v1
15. *Education 4.0: The Integration of Technology in Learning and Teaching.* (2023). Retrieved from Emirates Scholar: https://www.emiratesscholar.com/education-4-0-technology-teaching/
16. Juma, H., & Patel, D. G. (2022). A REVIEW OF CHALLENGES AND OPPORTUNITIES OF. *A Global Journal of Interdisciplinary Studies, 5*(8). Retrieved from https://www.gapinterdisciplinarities.org/res/articles/
17. Alakrash, H. M., & Razak, N. A. (2021b). Education and the Fourth Industrial Revolution: Lessons from COVID-19. *Computers, Materials & Continua*. doi:https://doi.org/10.32604/cmc.2022.014288
18. Soriano, R. B. (2024). Responsiveness of Graduate Programs to the VUCA Challenges of Industry 4.0: A Curriculum Redirection
19. Soriano, R. B. (2020). Preparedness of Faculty and Students of Pangasinan State University towards Education 4.0.
20. Vermeiden, T., Braat, F., Medhin, G., Gaym, A., Akker, T. v., & Stekelenburg, J. (2018). Factors associated with intended use of a maternity waiting home in Southern Ethiopia: a community-based cross-sectional study. BMC Pregnancy Childbirth, 18(38). https://doi.org/10.1186/s12884-018-1670-z
21. Chowdhary, S., Kawakami, K., Gray, M., Suh, J., Olteanu, A., & Saha, K. (2023). Can Workers Meaningfully Consent to Workplace Wellbeing Technologies? 2023 ACM Conference on Fairness, Accountability, and Transparency (FAccT '23). Chicago, IL, USA. https://doi.org/10.1145/3593013.3594023
22. Chandarasorn, M. (2012). Public Management as Citizen Compliance: A Case Study Of Income Tax Compliance Behavior In Thailand. University of Kansas. Retrieved from https://kuscholarworks.ku.edu
23. Demir, et al. (2015). Usage level and future intent of use of quick response (QR) codes for mobile marketing among college students in Turkey. Procedia - Social and Behavioral Sciences, 405-413. Retrieved June 2020, from https://pdf.sciencedirectassets.com
24. Walsh, Andrew (2011). Blurring the boundaries between our physical and electronic libraries: Location aware technologies; QR codes and RFID tags. The Electronic Library, 29 (4). pp. 429-437. ISSN 0264-0473
25. Five Real-World Examples of Cloud Computing. (2017). Retrieved from Maropost: https://www.maropost.com/blog/5-real-world-examples-of-cloud-computing/
26. Bagish. (2014). Student's Awareness of Cloud Computing: Case Study Faculty of Engineering at Aden University, Yemen. International Journal of Engineering Development and Research. Retrieved June 2020, from https://www.semanticscholar.org/paper/Student's-Awareness-of-Cloud-Computing%3A-Case-Study-Bagish/54713aec9fa7f717bb236819f5c778f8b475305f
27. Biometrics in Education. (n.d.). Retrieved from Bayometric: https://www.bayometric.co.uk/biometrics-in-education/
28. Lamin, N., Jusoh, W. N., Zainudin, J., & Samad, H. (2021). Implementing Student Attendance System Using Fingerprint Biometrics for Kolej Universiti Poly-Tech Mara. *International Colloquium on Computational & Experimental Mechanics (ICCEM 2020).1062.* Malaysia: IOP Publishing. doi:10.1088/1757-899X/1062/1/012037
29. Sharma, C., Shah, K., Patel, S., & Gharat, S. (2017). Wireless Biometric Attendance Management System Using Raspberry Pi in IaaS Environmen. *International Proceedings on Advances in Soft Computing, Intelligent Systems and Applications.628.* Singapore: Springer. doi:https://doi.org/10.1007/978-981-10-5272-9_24
30. Barkhaya, N., & Halim, N. (2016). Barkhaya, N.M., & Halim, N.D. (2016). A review of application of 3D hologram in education: A meta-analysis. 2016 IEEE 8th International Conference on Engineering Education (ICEED), 257-260. doi:10.1109/iceed.2016.7856083
31. Mukuni, J. (2019). Challenges of educational digital infrastructure in Africa: A tale of hope and disillusionment. *Journal of African Studies and Development, 11*(5), 59-63. doi:https://doi.org/10.5897/JASD2019.0539
32. Belleza, S., Ronamo, C., Vestil, C., & Ompoc, R. (2022). Teaching through the screen voices of tertiary PE teachers. *International Journal of Research Studies in Education, 11*(4), 37-43. doi:10.5861/ijrse.2022.107
33. Moore, R., Vitale, D., & Stawinoga, N. (2018). The Digital Divide and Educational Equity. *ACT's Center for Equity in Learning*. Retrieved from https://equityinlearning.act.org/wp-content/themes/voltron/img/tech-briefs/the-digital-divide.pdf
34. Mahyoob, M., Algaraady, J., &Elmahdi, O. E. H. E. (2024). Challenges and sustainability of e-learning adoption among EFL teachers in the post-COVID-19 era. In P. Jacques, C. W. Yang & S. Phan (Eds.), Educational technology in a post-pandemic world: Sustainable practices for the future (pp. 428-447). IGI Global. https://doi.org/10.4018/978-1-5266-6215-8.ch017