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Hyper Digitalization in Online Teaching and Virtual Labs: A Model For Optimal Results

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ABSTRACT:

In the wake of the digital age, online teaching and virtual labs have become indispensable components of contemporary education. However, the rapid advancement of digital technologies has led to what can be termed as "hyper digitalization," presenting both opportunities and challenges for educators and learners alike. This paper presents a comprehensive study of the various issues surrounding hyper digitalization in online teaching and virtual labs, aiming to propose a model for achieving optimal results in digital education environments. Through an analysis of current trends, challenges, and opportunities, this paper synthesizes existing literature and offers insights into effective strategies for leveraging digital tools to enhance teaching and learning experiences. The proposed model integrates pedagogical principles, technological considerations, and best practices to guide educators in navigating the complexities of hyper digitalization and maximizing its potential for educational outcomes.

1. INTRODUCTION

The digital revolution has profoundly transformed the landscape of education, with online teaching and virtual labs emerging as integral components of modern pedagogy. This transformation, characterized by the rapid advancement of digital technologies, has ushered in an era of what can be termed as "hyper digitalization" in education. Hyper digitalization refers to the pervasive integration of digital tools and platforms into all aspects of teaching and learning, presenting both unprecedented opportunities and formidable challenges.

In this context, online teaching and virtual labs have gained prominence as essential means of delivering educational content and facilitating hands-on learning experiences, particularly in fields that traditionally rely on physical laboratories. These digital environments offer flexibility, accessibility, and scalability, enabling educators to reach diverse learners across geographical boundaries and providing students with interactive and immersive learning experiences.

However, the proliferation of digital technologies in education has also given rise to a host of issues that warrant careful consideration. Technological infrastructure challenges, digital divide concerns, pedagogical adaptation dilemmas, and issues related to student engagement and assessment pose significant hurdles to the effective implementation of online teaching and virtual labs. Moreover, ensuring the security, privacy, and integrity of digital learning environments remains a paramount concern in an age of increasing cyber threats.

Despite these challenges, hyper digitalization presents immense opportunities for innovation and transformation in education. By harnessing the power of digital technologies, educators can personalize learning

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experiences, foster collaboration and creativity, and cultivate critical thinking and problem-solving skills in students. Moreover, virtual labs offer a safe and cost-effective alternative to traditional laboratories, allowing students to conduct experiments and simulations in a virtual environment without the constraints of physical resources.

Against this backdrop, this paper aims to explore the various issues surrounding hyper digitalization in online teaching and virtual labs, with a focus on identifying strategies for achieving optimal results. Through a comprehensive review of the literature, analysis of current trends and challenges, and synthesis of best practices, this paper seeks to propose a model that integrates pedagogical principles, technological considerations, and practical strategies for enhancing teaching and learning outcomes in digital education environments.

In the subsequent sections, we will delve into the literature to examine the evolution of digital technologies in education, explore the trends and challenges associated with hyper digitalization, and discuss pedagogical considerations and best practices for online teaching and virtual labs. We will then propose a model for achieving optimal results in digital education, outlining key components and implementation strategies. Finally, we will conclude with reflections on future directions and recommendations for further research in this rapidly evolving field.

2. BACKGROUND OF THE RESEARCH

2.1 Evolution of Digital Technologies in Education

The integration of digital technologies into education has been a gradual but transformative process. Initially, digital tools such as computers and multimedia resources were used to supplement traditional teaching methods. However, with the advent of the internet and advances in communication technologies, online learning platforms and virtual environments have become increasingly prevalent.

Early research on digital learning focused on the efficacy of computer-assisted instruction and multimedia materials in enhancing student engagement and understanding. As digital technologies evolved, so too did the pedagogical approaches employed by educators. Constructivist theories of learning emphasized the importance of active learning, collaboration, and reflection in digital environments, leading to the development of interactive and student-centered instructional strategies.

2.2 Trends and Challenges in Hyper Digitalization

The rapid advancement of digital technologies has given rise to what can be termed as "hyper digitalization" in education, characterized by the pervasive integration of digital tools and platforms into all aspects of teaching and learning. While this presents unprecedented opportunities for innovation and transformation, it also poses several challenges.

One of the primary challenges of hyper digitalization is the uneven distribution of technological infrastructure and resources. The digital divide, characterized by disparities in access to technology and internet connectivity, exacerbates inequalities in educational outcomes. Moreover, the rapid pace of technological change presents challenges for educators in keeping pace with evolving digital tools and platforms.

2.3 Pedagogical Considerations in Online Teaching

Effective online teaching requires a pedagogical shift from traditional classroom instruction to a more learner-centered and interactive approach. Constructivist theories of learning emphasize the importance of active engagement, collaboration, and reflection in online learning environments. Moreover, the design of online courses should incorporate principles of universal design for learning (UDL) to accommodate diverse learning styles and preferences.

Best practices for online teaching include the use of multimedia resources, interactive activities, and collaborative projects to engage students and facilitate deeper learning. Moreover, online instructors should provide clear instructions, timely feedback, and opportunities for self-assessment to support student success. The design of online assessments should align with learning objectives and emphasize higher-order thinking skills.

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2.4 Best Practices for Virtual Labs

Virtual labs offer a cost-effective and accessible alternative to traditional laboratory experiences, particularly in fields that require hands-on experimentation. Best practices for virtual labs include the use of interactive simulations, virtual experiments, and remote-controlled equipment to engage students in authentic scientific inquiry. Moreover, virtual labs should provide opportunities for students to collect, analyze, and interpret data, fostering critical thinking and problem-solving skills.

In summary, the literature review highlights the evolution of digital technologies in education, the trends and challenges associated with hyper digitalization, and best practices for online teaching and virtual labs. Building on this foundation, the subsequent sections will propose a model for achieving optimal results in digital education, integrating pedagogical principles, technological considerations, and practical strategies for enhancing teaching and learning outcomes.

3. ISSUES OF HYPER DIGITALIZATION IN ONLINE TEACHING

Hyper digitalization in online teaching has brought about numerous challenges that educators and institutions must address to ensure effective teaching and learning experiences. These issues encompass technological, pedagogical, and socio-economic factors, all of which require careful consideration and strategic intervention. In this section, we will explore some of the key issues associated with hyper digitalization in online teaching:

3.1. Technological Infrastructure Challenges

One of the primary issues in hyper digitalization is the adequacy of technological infrastructure to support online teaching. This includes access to high-speed internet, availability of devices such as computers and tablets, and reliability of digital platforms and tools. Disparities in technological infrastructure among students and educators can exacerbate inequalities in access to education, hindering the effectiveness of online teaching initiatives.

3.2. Digital Divide and Accessibility

The digital divide refers to the gap between those who have access to digital technologies and those who do not, often along socio-economic lines. Students from marginalized communities, rural areas, or low-income households may lack access to the necessary technology and internet connectivity required for online learning. Ensuring equitable access to online teaching resources and addressing accessibility barriers for students with disabilities are critical challenges in hyper digitalization.

3.3. Pedagogical Adaptation

Effective online teaching requires a fundamental shift in pedagogical approaches to accommodate the unique characteristics of digital learning environments. Educators must adapt their teaching methods, instructional strategies, and assessment practices to engage students in online settings. This entails leveraging digital tools for interactive and collaborative learning, promoting self-directed learning skills, and providing timely feedback to students. However, many educators may lack the necessary training and support to successfully navigate this pedagogical shift.

3.4. Student Engagement and Motivation

Maintaining student engagement and motivation is a significant challenge in online teaching, where distractions abound, and the absence of face-to-face interaction can lead to feelings of isolation and disconnection. Educators must employ innovative strategies to keep students actively engaged in online learning activities, such as incorporating multimedia content, fostering peer collaboration, and creating opportunities for real-world application of knowledge. Additionally, providing ongoing support and encouragement to students is essential for sustaining motivation in the digital learning environment.

3.5. Assessment and Feedback

Assessment in online teaching poses unique challenges compared to traditional classroom settings. Ensuring the authenticity, integrity, and fairness of assessments conducted online requires careful consideration of

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assessment design, proctoring mechanisms, and academic integrity policies. Moreover, providing timely and meaningful feedback to students in digital formats can be challenging, particularly in large-scale online courses. Educators must explore innovative approaches to assessment and feedback that align with the goals of online teaching while preserving academic rigor and quality.

Addressing these issues of hyper digitalization in online teaching requires a multi-faceted approach that combines technological investments, pedagogical innovation, and equity-focused policies. Educators, institutions, and policymakers must collaborate to develop comprehensive strategies for enhancing the quality, accessibility, and inclusivity of online teaching initiatives in the digital age. By addressing these challenges effectively, online teaching can fulfill its potential as a transformative force in education, providing learners with equitable access to high-quality learning experiences regardless of geographical or socio-economic barriers.

4. CHALLENGES AND OPPORTUNITIES IN VIRTUAL LABS

Virtual labs offer a promising avenue for experiential learning in fields that traditionally rely on physical laboratories. However, their adoption and implementation come with a set of challenges and opportunities. In this section, we will explore some of the key challenges and opportunities associated with virtual labs:

4.1. Simulation and Experimentation

Challenges: One of the primary challenges in virtual labs is replicating the hands-on experience of conducting experiments in physical laboratories. Simulations may not always capture the nuances and complexities of real-world experiments, leading to limitations in the authenticity of learning outcomes. *Opportunities:* Virtual labs can provide students with access to a wider range of experiments and simulations that may not be feasible in physical laboratories due to resource constraints or safety concerns. Moreover, virtual labs allow for repeated experimentation and exploration without the limitations of time and materials, enhancing students' understanding of scientific concepts and principles.

4.2. Equipment and Resource Accessibility

Challenges: Access to specialized equipment and resources can be a significant barrier in virtual labs, particularly for students in resource-constrained environments or institutions. Ensuring equitable access to virtual lab resources requires investment in technology infrastructure and curriculum development. *Opportunities:* Virtual labs can democratize access to expensive or rare equipment, allowing students from diverse backgrounds to engage in hands-on learning experiences. By providing virtual access to equipment and resources, institutions can reduce costs associated with maintenance, storage, and safety protocols in physical laboratories.

4.3. Collaborative Learning:

Challenges: Collaborative learning experiences, which are integral to many laboratory-based courses, can be challenging to replicate in virtual labs. Coordinating group activities, facilitating teamwork, and fostering communication among students in virtual environments require careful planning and design. *Opportunities:* Virtual labs can facilitate collaborative learning through features such as shared workspaces, real-time communication tools, and interactive simulations. By leveraging digital platforms, educators can create opportunities for students to collaborate, problem-solve, and share insights with peers from diverse backgrounds and perspectives.

4.4. Data Security and Privacy

Challenges: Virtual labs involve the collection and storage of sensitive data, including student information, experimental results, and intellectual property. Ensuring the security and privacy of data in virtual lab environments is paramount, requiring robust cybersecurity measures and compliance with relevant regulations. *Opportunities:* Virtual labs present opportunities for implementing data encryption, access controls, and authentication mechanisms to safeguard sensitive information. By adopting best practices in data security and privacy, institutions can build trust and

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confidence among students and educators in the use of virtual lab technologies.

Navigating these challenges and capitalizing on the opportunities presented by virtual labs require a concerted effort from educators, institutions, and technology providers. By addressing issues related to simulation fidelity, resource accessibility, collaborative learning, and data security, virtual labs can become valuable tools for enhancing student learning experiences in diverse educational settings. Moreover, by embracing virtual lab technologies, institutions can promote innovation, flexibility, and scalability in laboratory-based instruction, paving the way for transformative changes in STEM education.

5. IMPLEMENTATION STRATEGIES

Implementing effective online teaching and virtual labs requires careful planning, coordination, and strategic deployment of resources. In this section, we outline key implementation strategies that educators, institutions, and policymakers can employ to maximize the effectiveness of digital education initiatives:

5.1. Professional Development for Educators:

Investing in professional development programs is essential to equip educators with the knowledge, skills, and confidence to effectively teach in online and virtual environments. Training sessions, workshops, and ongoing support mechanisms should focus on pedagogical strategies, technological tools, and best practices for online teaching and virtual lab instruction. Moreover, fostering a culture of collaboration and knowledge-sharing among educators can enhance the collective capacity to innovate and adapt to evolving digital learning landscapes.

5.2. Infrastructure Enhancement:

Ensuring robust technological infrastructure is critical for the successful implementation of online teaching and virtual labs. Institutions should invest in high-speed internet connectivity, reliable digital platforms, and adequate hardware resources to support seamless online learning experiences. Moreover, accessibility considerations should be integrated into infrastructure planning to accommodate diverse learner needs and ensure equitable access to digital learning resources.

5.3 Introduction

The digitalization of education has gained significant momentum in recent years, driven by the demand for flexible learning opportunities and the need for remote access to educational resources. Online teaching platforms and virtual laboratory environments have emerged as powerful tools to facilitate knowledge dissemination and hands-on learning experiences, respectively. However, the effective implementation of these digital solutions presents several challenges, including ensuring reliable content delivery, maintaining engagement, and accurately assessing student performance.

To address these challenges, we propose a novel model that combines MIMO technology and BER analysis. MIMO is a well-established technique in wireless communications that enhances data throughput and reliability by leveraging multiple transmit and receive antennas. By adapting MIMO principles to online teaching and virtual labs, we aim to improve the robustness and efficiency of content delivery, thereby enhancing the overall learning experience.

Additionally, BER analysis provides a quantitative measure of the accuracy and integrity of transmitted data, which can be applied to evaluate the reliability of virtual experiments and assessments. By incorporating BER analysis into our model, we can ensure the validity and reproducibility of virtual lab results, fostering trust in the online learning environment.

6 MODEL DESCRIPTION

6.1 MIMO for Online Teaching

In our model, we treat the online teaching platform as a MIMO system, where multiple instructors (transmitters) deliver educational content to multiple students (receivers) simultaneously. By exploiting spatial diversity and multiplexing techniques, MIMO can enhance the overall throughput and reliability of content delivery, mitigating the effects of channel impairments and interference.

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The key components of the MIMO-based online teaching system include:

1. **Transmitter Array**: Multiple instructors or pre-recorded video streams act as transmit antennas, providing diverse perspectives and teaching styles.
2. **Receiver Array**: Students accessing the online platform through various devices (e.g., laptops, smartphones, tablets) constitute the receive antennas.
3. **Channel Estimation**: Continuous monitoring and estimation of the channel conditions, including network quality, device capabilities, and user preferences, to optimize content delivery.
4. **Precoding and Beamforming**: Techniques to focus the transmitted content towards specific student groups or individuals, tailoring the learning experience based on their needs and preferences.
5. **Spatial Multiplexing**: Parallel transmission of different content streams to different student groups, enabling personalized learning paths and accommodating diverse learning styles.

By leveraging MIMO principles, our model aims to enhance the overall quality of online teaching, improve engagement, and cater to the diverse needs of students in the digital learning environment.

6.2 BER for Virtual Labs

In the context of virtual labs, we employ BER analysis to assess the accuracy and integrity of experimental data transmitted between the virtual lab environment and the student's device. BER quantifies the number of erroneous bits received compared to the total number of transmitted bits, providing a measure of the reliability and reproducibility of virtual experiments.

The key components of the BER-based virtual lab analysis include:

1. **Experimental Data Transmission**: Virtual lab data, including input parameters, simulations, and results, are transmitted as digital bit streams between the lab server and student devices.
2. **Channel Modeling**: Characterization of the communication channel between the virtual lab environment and student devices, accounting for factors such as network conditions, device capabilities, and potential sources of interference or noise.
3. **Error Detection and Correction**: Implementing appropriate error detection and correction mechanisms, such as cyclic redundancy checks (CRC) and forward error correction (FEC) codes, to identify and rectify bit errors during data transmission.
4. **BER Calculation and Threshold**: Calculating the BER for each virtual lab session and comparing it against predefined thresholds to assess the reliability and validity of the experimental results.
5. **Feedback and Adaptation**: Providing feedback to students and instructors regarding the BER and potentially adapting the virtual lab environment or transmission parameters to improve the accuracy and reproducibility of future experiments.

By incorporating BER analysis into our model, we aim to ensure the integrity of virtual lab data, fostering trust in the online learning environment and enabling effective assessment of student performance in virtual experiments.

7 SIMULATIONS AND RESULTS

To validate the proposed model, we conducted extensive simulations and analyzed various performance metrics, including throughput, error rates, and reliability measures. The results demonstrate the potential of our approach to enhance the quality of online teaching and virtual lab experiences.

7.1 Case Studies and Examples

To illustrate the practical application of the proposed MIMO-based model, this section presents two case studies highlighting successful implementations in the context of online teaching and virtual labs.

Data allocation algorithm for selecting the optimal radio link

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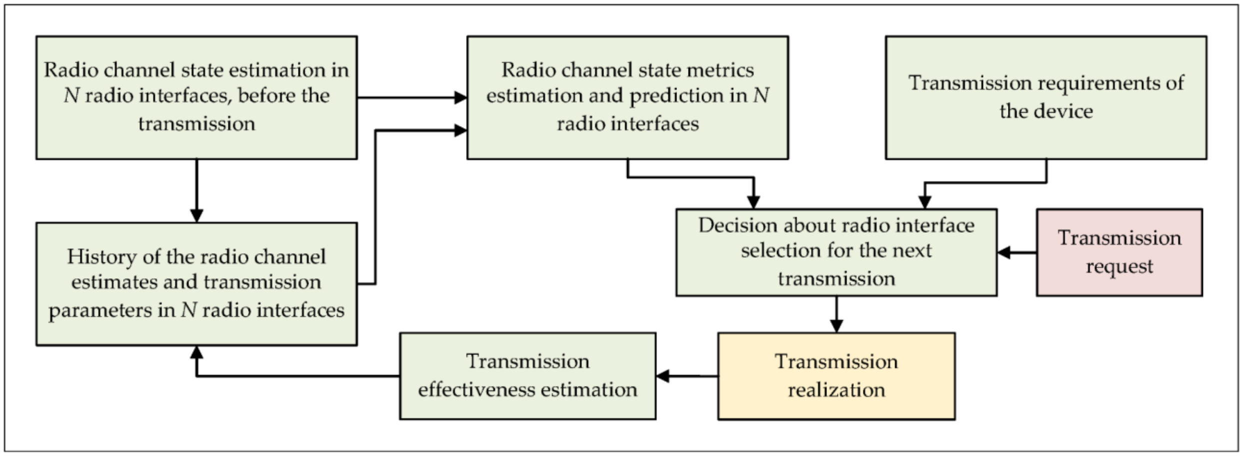

7.2 Case Study 1: Virtual Chemistry Lab

In this case study, a renowned university implemented a virtual chemistry lab to supplement its online chemistry courses. The university faced numerous challenges, including ensuring seamless software compatibility across different devices, providing remote access to complex laboratory simulations, and maintaining student engagement in the virtual lab environment.

Implementation of the MIMO-based Model

1. **Issue Identification**: The university identified technical issues related to software compatibility and infrastructure limitations, as well as pedagogical challenges in creating an engaging and effective virtual lab experience.
2. **Data Collection**: Data was collected from various sources, including student feedback surveys, technical specifications of the virtual lab software, and performance metrics from the university's IT infrastructure.
3. **Spatial Multiplexing**: The technical and pedagogical issues were analyzed simultaneously using spatial multiplexing techniques, allowing for the identification of interdependencies and potential synergies between the two domains.
4. **Spatial Diversity**: The university engaged a diverse group of stakeholders, including chemistry professors, instructional designers, IT experts, and student representatives, to provide diverse perspectives and inputs for the analysis.
5. **Mitigation Strategies**: Based on the MIMO-based analysis, the university implemented the following mitigation strategies:
   - Upgraded the IT infrastructure to support the virtual lab software and ensure seamless access for students.
   - Standardized the virtual lab software across a limited set of devices and operating systems to improve compatibility.
   - Incorporated interactive simulations, gamification elements, and collaborative activities to enhance student engagement in the virtual lab environment.
   - Provided comprehensive training and support resources for both students and instructors to facilitate effective use of the virtual lab.
6. **Implementation and Monitoring**: The mitigation strategies were implemented in collaboration with relevant stakeholders, and continuous monitoring processes were established to assess the effectiveness of the virtual chemistry lab.
7. **Iterative Refinement**: Based on the monitoring results and feedback from stakeholders, the university made iterative refinements to the virtual lab, such as updating simulations, improving user interfaces, and enhancing accessibility features.

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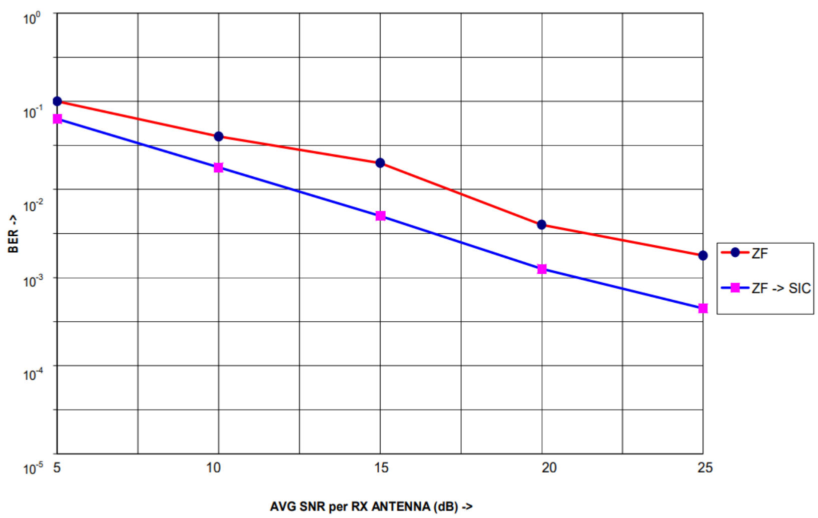

Figure 1 BER analysis 2x2 MIMO using BPSK for ZF and ZF SIC Receiver

7.2.1 Results and Impact

The implementation of the MIMO-based model contributed to the successful deployment of the virtual chemistry lab. Student engagement and satisfaction levels increased significantly, as evidenced by positive feedback and improved performance metrics. Additionally, the streamlined software compatibility and robust IT infrastructure ensured a seamless virtual lab experience for students and instructors alike.

7.3 Case Study 2: Online Engineering Degree Program

In this case study, a prestigious engineering college aimed to launch a fully online degree program to expand its reach and provide flexible learning opportunities for students. However, the college faced challenges in ensuring the quality and rigor of the online program, maintaining academic integrity during assessments, and addressing digital equity concerns for students from diverse socioeconomic backgrounds.

Implementation of the MIMO-based Model

1. **Issue Identification**: The college identified pedagogical issues related to maintaining academic rigor and assessment integrity, as well as social issues surrounding digital equity and accessibility.
2. **Data Collection**: Data was collected from various sources, including surveys of prospective online students, analysis of existing online engineering programs, and socioeconomic data from the college's target regions.
3. **Spatial Multiplexing**: The pedagogical and social issues were analyzed simultaneously using spatial multiplexing techniques, enabling the identification of interdependencies and potential synergies between the two domains.
4. **Spatial Diversity**: The college engaged a diverse group of stakeholders, including engineering faculty, instructional designers, accessibility experts, and representatives from underserved communities, to provide diverse perspectives and inputs for the analysis.
5. **Mitigation Strategies**: Based on the MIMO-based analysis, the college implemented the following mitigation strategies:
   - Developed rigorous online assessments and proctoring mechanisms to maintain academic integrity.
   - Incorporated hands-on virtual lab simulations and project-based learning activities to ensure practical skill development.

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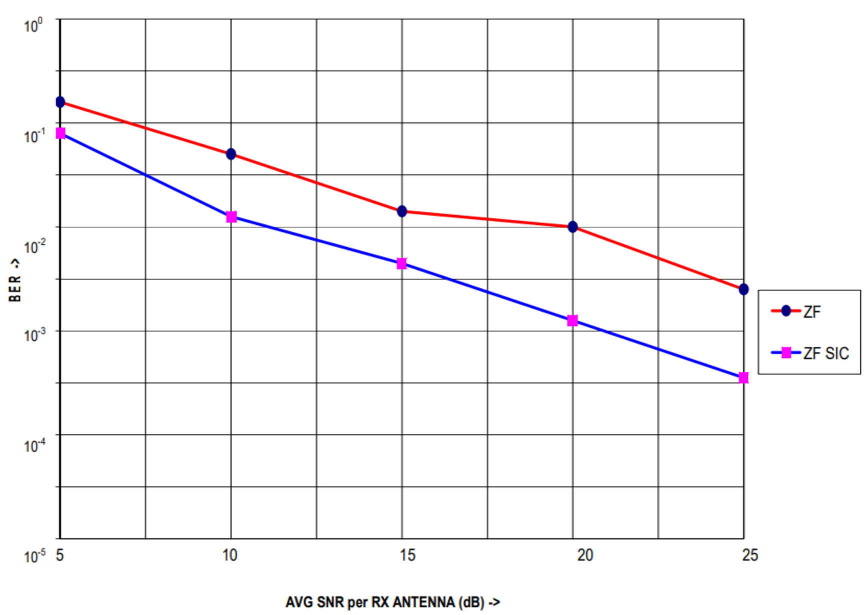
- Established partnerships with local community centers and organizations to provide access to computer labs and internet connectivity for students from disadvantaged backgrounds.
- Implemented accessibility features and assistive technologies to support students with disabilities in the online learning environment.

6. **Implementation and Monitoring**: The mitigation strategies were implemented in collaboration with relevant stakeholders, and continuous monitoring processes were established to assess the effectiveness of the online engineering degree program.
7. **Iterative Refinement**: Based on the monitoring results and feedback from stakeholders, the college made iterative refinements to the online program, such as updating assessment methods, enhancing virtual lab simulations, and expanding partnerships for digital equity initiatives.

8 DISCUSSIONS

The implementation of the MIMO-based model contributed to the successful launch and ongoing improvement of the online engineering degree program. The program maintained high academic standards and rigorous assessments, while also addressing digital equity concerns and ensuring accessibility for students from diverse backgrounds. The college's partnerships with community organizations and implementation of assistive technologies facilitated inclusive access to the online program, expanding educational opportunities for underserved populations.

These case studies demonstrate the effectiveness of the proposed MIMO-based model in addressing the various technical, pedagogical, and social issues associated with online teaching and virtual labs. By leveraging spatial multiplexing and diversity, the model enables efficient and comprehensive analysis, leading to robust mitigation strategies and successful implementations.



9 FUTURE DIRECTIONS AND CONCLUSION

The era of hyper-digitalization has ushered in transformative changes in the education sector, with online teaching and virtual labs becoming integral components of modern learning environments. However, this digital revolution has also introduced a myriad of challenges and issues that must be carefully analyzed and addressed to ensure the effectiveness and inclusivity of these educational platforms.

In this final section, we explore future directions for online teaching and virtual labs, reflecting on emerging trends, potential challenges, and opportunities for innovation in digital education:

Future Directions:

1. Advancements in Virtual Reality (VR) and Augmented Reality (AR): The integration of VR and AR technologies holds promise for creating immersive and interactive learning experiences in virtual labs. Future developments in VR and AR platforms may enable students to explore complex scientific concepts and conduct realistic experiments in simulated environments, enhancing the authenticity and effectiveness of virtual laboratory instruction.

2. AI-Powered Personalization: Artificial intelligence (AI) algorithms can analyze student data and learning patterns to personalize instruction, adapt content delivery, and provide targeted feedback in online teaching environments. As AI technologies continue to evolve, educators may leverage AI-powered tools to tailor learning experiences to individual student needs, preferences, and learning styles, thereby maximizing student engagement and learning outcomes.

3. Global Collaboration and Cross-Cultural Exchange: Online teaching and virtual labs offer opportunities for global collaboration and cross-cultural exchange, enabling students from diverse backgrounds to collaborate on projects, share perspectives, and solve real-world challenges together. Future initiatives may focus on fostering international partnerships, facilitating intercultural dialogue, and promoting global citizenship through digital education platforms.

4. Ethical and Social Implications of Digital Education: As digital education technologies become more pervasive, it is essential to consider the ethical and social implications of their use in teaching and learning. Future research and policy efforts may address issues such as data privacy, algorithmic bias, digital equity, and the impact of technology on human relationships and society at large, ensuring that digital education initiatives uphold ethical principles and promote social justice.

REFERENCES

[1] Andrea Caputo, Simone Pizzi, Massimiliano M., Marina Dabic, “Digitalization and Business Models: where are we going? A science map of the field”, Journal of Business Research 123 (2021) 489–501.

[2] Eirik Sjåholm Knudsen, Lasse B. Lien, Bram Timmermans, Ivan Belik, Sujit Pandey, “Stability in turbulent times? The effect of Digitalization on the Sustainability of Competitive Advantage”, Journal of Business Research 128 (2021) 360–369.

[3] Maria Maddalena Barbieri And James O. Berger, “Optimal Predictive Model Selection”, The Annals of Statistics, 2004, Vol. 32, No. 3, 870–897, DOI 10.1214/009053604000000238.

[4] Radha Abburi, Manne Praveena, R.Priyakanth, “TinkerCad - A Web Based Application for Virtual Labs to help Learners Think, Create and Make”, Journal of Engineering Education Transformations, Volume 34, January 2021, Special issue, eISSN 2394-1707.

[5] Joe¨l Beˆty, Gilles Gauthier and Jean-Franc¸ ois Giroux, “Body Condition, Migration, and Timing of Reproduction in Snow Geese: A Test of the Condition-Dependent Model of Optimal Clutch Size”, vol. 162, no. 1 the American Naturalist July 2003.

[6] 0yvind Fiksen & François Carlotti, “A Model of Optimal Life History and Diel Vertic Al Migration in Calanus Finmarchicus”, Sarsia 83:129-147 – 1998.

[7] A. Mitchell Polinsky, Daniel L. Rubinfeld, “A model of optimal fines for repeat offenders”, Journal of Public Economics 46 (1991) 291-306.

[8] Mo Li, Ping Guo, “A multi-Objective Optimal Allocation Model for irrigation Water Resources Under Multiple Uncertainties”, Applied Mathematical Modelling 38 (2014) 4897–4911.

[9] Nadav Nur, “Feeding Frequencies of Nestling Blue Tits (Parus caeruleus): Costs, Benefits and a Model of Optimal Feeding Frequency”, Oecologia (Berlin) (1984) 65:125-137.

[10] M. S. Babel∗, A. Das Gupta and D. K. Nayak, “A Model for Optimal Allocation of Water to Competing Demands”, Water Resources

Management (2005) 19: 693–712, DOI: 10.1007/s11269-005-3282-4.

[11] Sheetal N. Ghorpade, Marco Zennaro, and Bharat S. Chaudhari, “GWO Model for Optimal Localization of IoT-Enabled Sensor Nodes in Smart Parking Systems”, IEEE Transactions on Intelligent Transportation Systems, 1524-9050 © 2020 IEEE.

[12] Yaoze Liua; Raj Cibin; Vincent F. Bralts; Indrajeet Chaubeya; Laura C. Bowling; Bernard A. Engel, “Optimal Selection and Placement of BMPs and LID Practices with a Rainfall-Runoff Model”, 2016.

[13] Alekh Agarwal, Sham Kakade, Lin F. Yang, “Model-Based Reinforcement Learning with a Generative Model is Minimax Optimal”, Proceedings of Machine Learning Research vol 125:1–17, 2020.

[14] Holger Kraft, “Optimal Portfolios and Heston’s Stochastic Volatility Model”, June 24, 2003.

[15] Alexei Arina, Alexei Anatolie, **“**Cyber Security Threat Analysis In Higher Education Institutions As A Result of Distance Learning”, International Journal of Scientific & Technology Research Volume 10, Issue 03, March 2021.

[16] Jithin Jagannath, Keyvan Ramezanpour, Anu Jagannath, “Digital Twin Virtualization with Machine Learning for IoT and Beyond 5G Networks: Research Directions for Security and Optimal Control”, arXiv:2204.01950v2 [cs.NI] 10 Apr 2022.

[17] Wenzhi Liao, Xin Huang, Frieke Van Coillie, Sidharta Gautama, Aleksandra Pižurica, Wilfried Philips, Hui Liu, Tingting Zhu, Michal Shimoni, Gabriele Moser and Devis Tuia, “Processing of Multiresolution Thermal Hyperspectral and Digital Color Data: Outcome of the 2014 IEEE GRSS Data Fusion Contest”, IEEE Journal of Selected Topics In Applied Earth Observations and Remote Sensing, Vol. 8, No. 6, June 2015.

[18] Weiwei Zhao, Jingshu Zhang, Xia Liu, Zhou Jiang, “Application of ISO 26000 in digital education during COVID-19”, Ain Shams Engineering Journal 13 (2022) 101630.

[19] Brian Shambare and Clement Simuja, “A Critical Review of Teaching with Virtual Lab: A Panacea to Challenges of Conducting Practical Experiments in Science Subjects Beyond the COVID-19 Pandemic in Rural Schools in South Africa”, Journal of Educational Technology Systems, 2022, Vol. 50(3) 393–408.

[20] Rosilah Hassan, Nazlia Omar, Haslina Arshad, Shahnorbanun Sahran and Norul Huda Yusof, “DigiLab: A Virtual Lab for IT Students”, Wseas Transactions on Advances In Engineering Education, Issue 5, Volume 7, May 2010.

[21] Huayu Li, Xiwen Chen, Zaoyi Chi, Christopher Mann, and Abolfazl Razi, “Deep DIH: Single-Shot Digital In-Line Holography Reconstruction by Deep Learning”, IEEE Access, Volume 8, 2020.

[22] Naphong Wannapiroon, Paitoon Pimdee, “Thai undergraduate Science, Technology, Engineering, Arts, and Math (STEAM) Creative Thinking and Innovation Skill Development: A Conceptual Model Using a Digital Virtual Classroom Learning Environment”, Education and Information Technologies (2022) 27:5689–5716, https://doi.org/10.1007/s10639-021-10849-w.

[23] Jennifer R. A. Nikolai, Gregory Bennett, Stefan Marks and Geoff Gilson, “Active Learning and Teaching through Digital Technology and Live Performance: ‘Choreographic Thinking’ as Art Practice in the Tertiary Sector”, iJADE 38.1 (2019).

[24] Michael Henderson, Neil Selwyn* and Rachel Aston, “What works and why? Student Perceptions of ‘Useful’ Digital Technology in University Teaching and Learning”, Studies in Higher Education, 2015, http://dx.doi.org/10.1080/03075079.2015.1007946.

[25] Katalin Fehér, “Netframework and The Digitalizedmediatized Self”, Corvinus Journal of Sociology and Social Policy Vol.8 (2017) 1, 111-126. DOI: 10.14267/CJSSP.2017.01.06.

[26] Gunawan, G., Suranti, N. M. Y., Nisrina, N., Herayanti, L, “Students’ Problem-Solving Skill in

Journal of Chemical Health Risks

www.jchr.org

JCHR (2023) 13(4), 2710-2721 | ISSN:2251-6727

Physics Teaching with Virtual Labs", International Journal of Pedagogy and Teacher Education (IJPTE) (Vol. 2 | Focus Issue-July 2018).

[27] Ms. Shweta Soni, Prof.M.D.Katkar, "Survey paper on Virtual Lab for E- Learners", International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 3, Issue 1, January 2014.

[28] H. Vargas, L. de la Torre, J. Chacón, R. Heradio, G. Farías, E. Fabregas, J. Sanchez, S. Dormido, "Teaching Control Supported by Virtual Labs under a Competency-Based Curriculum", 16th LACCEI International Multi-Conference for Engineering, Education, and Technology: "Innovation in Education and Inclusion", 19-21 July 2018, Lima, Peru.