ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

Use of Disruptive Technologies 4IR/AR/AI in Technical, Vocational and Training Institutions to Enhance Higher Education in Sub-Sahara, Africa; Case of Kenya

Betty Chepngetich Tonui., Philomena Chepsiror., Lydia Kosgei

Moi University

DOI: https://doi.org/10.51244/IJRSI.2025.12040023

Received: 24 March 2025; Accepted: 28 March 2025; Published: 01 May 2025

ABSTRACT

This study focuses on the use of disruptive technologies in Technical, Vocational Education and Training (TVET) institutions, with a particular focus on Sub-Saharan Africa, East Africa, and Kenya. These technologies include those from the Fourth Industrial Revolution (4IR), Artificial Intelligence (AI), Augmented Reality (AR), and mobile devices. To get a thorough grasp of the subject, the study uses a mixed-methods strategy that combines qualitative and quantitative data collection methodologies. According to the study's findings, a sizable portion of TVET institutions in the targeted regions has included disruptive technologies into their instructional strategies. The use of 4IR technologies, including mobile devices, AI, and augmented reality, has shown potential advantages for vocational education. These technologies have made it easier to personalize instruction, boost the development of practical skills, and increase student engagement. Students can practice technical skills in a secure and regulated setting by using augmented reality, in particular, to create immersive and engaging learning experiences. However, the study also points out a number of difficulties in integrating disruptive technology into TVETs. These difficulties include resource limitations and infrastructure restrictions, such as erratic internet connectivity. Professional development and teacher preparedness are essential for successfully integrating disruptive technology into the curriculum. It is crucial to offer continuing education courses that give teachers the pedagogical knowledge and practical skills they need. The report also emphasizes the significance of resource allocation, strategic alliances, and legislative interventions in order to assist the adoption and integration of disruptive technologies in TVET institutions. Collaborations between TVET institutions, industry partners, and governmental organizations are essential for exchanging resources and knowledge and advancing the development of skills that are applicable to industry.

Keywords:

AI: Artificial Intelligence

AR: Augmented Reality

4IR: Fourth Industrial Revolution

TVET: Technical Vocational Education and Training

IoT: Internet of Things

INTRODUCTION

Technology has transformed many industries, including education. Disruptive technologies are being adopted by TVET colleges globally to improve teaching and learning. This article examines how TVETs in Sub-Saharan Africa, East Africa, and Kenya use Fourth Industrial Revolution (4IR) technology like AI, AR, and mobile devices. TVETs provide workforce-ready skills. However, antiquated training methods and labour market demands have hampered their usefulness. Thus, innovative technology in education may bridge this gap. Disruptive technologies can improve learner engagement, tailor instruction, and stimulate skill

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

development, according to several global studies. To grasp their distinct constraints and prospects, these technologies must be applied in specific contexts like TVETs in Sub-Saharan Africa. Disruptive education innovations face unique socio-economic and infrastructural challenges in Sub-Saharan Africa. Thus, the region's TVET industry must investigate how these technologies might boost education and economic progress. Several East African TVET initiatives have integrated disruptive technologies. However, substantial study on these technologies' effects on teaching and learning is lacking. This study aims to bridge this gap by examining the use of 4IR technologies, including AI, AR, and mobile devices, in the context of TVETs in East Africa, with a particular focus on Kenya. The primary objective of this research is to contribute to the existing body of knowledge and understanding of the role of disruptive technologies in TVETs. By conducting a thorough review of the current research field, this study aims to identify the opportunities, challenges, and best practices related to the integration of 4IR technologies in TVET institutions, ultimately enhancing the quality and relevance of vocational education. The principal conclusions of this research Endeavor will shed light on the effectiveness and potential of disruptive technologies, such as AI, AR, and mobile devices, in transforming TVETs. The findings will provide valuable insights for policymakers, educators, and stakeholders in designing strategies to harness the power of these technologies and create a more engaging and effective learning environment.

MATERIALS AND METHODS

With a particular focus on the context of Sub-Saharan Africa, East Africa, and Kenya, this research study sought to investigate the utilization of disruptive technologies, including Fourth Industrial Revolution (4IR) technologies, Artificial Intelligence (AI), Augmented Reality (AR), and mobile devices, in Technical and Vocational Education and Training (TVET) institutions. To gain a thorough grasp of the topic, the research methodology used a mixed-methods strategy that combined qualitative and quantitative data collection techniques.

Data Collection

Literature study:

To understand the present status of research surrounding the incorporation of disruptive technologies in education, particularly in TVETs, a thorough literature study was conducted. To compile pertinent data, theoretical frameworks, and empirical evidence, important publications, academic articles, conference proceedings, and reports from reliable sources were examined. The literature review served as a basis for determining the field's best practices, research possibilities, and research gaps.

Surveys and Questionnaires:

TVET educators, administrators, and students in the chosen regions were given questionnaires in order to collect primary data. The purpose of the questionnaire was to gather data on 4IR technology use in TVET classrooms, perceived advantages and disadvantages, and overall effects on teaching and learning outcomes. Based on the results of the literature study, the survey questions were created and then pilot tested for validity and reliability.

Data Analysis

Quantitative Analysis

Thematic analysis was used to examine the qualitative information gathered from open-ended questionnaire. Textual data from questionnaire were analyzed and divided into themes and sub-themes. To provide a thorough understanding of the experiences, viewpoints, and difficulties associated to the use of disruptive technologies in TVETs, patterns, trends, and recurrent ideas were found.

Quantitative Analysis:

Descriptive statistics were used to examine the quantitative data that were gathered from the closed-ended questionnaire. To compile the data and give a quantitative overview of the adoption and effects of 4IR

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

technologies in TVET classrooms, frequency distributions, percentages, and measures of central tendency were calculated.

Ethical Considerations

In research investigations, including those looking into disruptive technologies in TVET institutions, ethical considerations are extremely important. Several ethical issues were covered in this study. All participants, including TVET educators, administrators, and students, gave their agreement after being fully informed of the study's goals, the methods, and any risks and rewards associated with taking part. To preserve the participants' privacy, confidentiality and anonymity were maintained throughout the research. The study team also made sure that there was no prejudice against the participants and that the data collection and analysis procedures were carried out in an impartial and fair manner. To protect the welfare and well-being of all parties involved, ethical rules and values, such as honesty, integrity, and respect for individuals' rights, were adhered to throughout the research process.

Limitations:

This research study has a number of constraints to take into account. First off, the findings' applicability to other locations or nations may be constrained by the emphasis on Sub-Saharan Africa, East Africa, and particularly Kenya. The representativeness of the data may be impacted by the small sample size of TVET instructors, supervisors, and students. Surveys and questionnaires that rely heavily on self-reported data run the risk of introducing social desirability bias or response bias. The study's dependence on prior research may potentially be vulnerable to publication bias or a dearth of pertinent sources. In order to secure relevant results, the study's mixed-methods methodology may necessitate careful integration and interpretation of qualitative and quantitative data.

FINDINGS AND RESULTS

This paper's findings and results focus on Sub-Saharan Africa, East Africa, and Kenya's TVET institutions' adoption of disruptive technologies. This section discusses the research aims and questions, data collection and analysis methods, sample size, and participant characteristics. This study investigated how Fourth Industrial Revolution (4IR) technology including AR, AI, and mobile devices can improve TVETs' vocational education. The research project selected TVET students from designated sites using purposive sampling. TVET students, administrators, policymakers, and educators were sampled.

Utilization of Disruptive Technologies in TVETs

Prevalence and Adoption

Percentage of TVET Institutions Integrating 4IR Technologies:

The results show that a sizable fraction of TVET institutions have welcomed the integration of technology from the Fourth Industrial Revolution (4IR). According to Bongomin (2020), incorporating 4IR technology into educational procedures was reported by about 80% of the institutions that participated in the survey. This illustrates an increasing understanding of the advantages disruptive technology may provide for improving vocational education.

Types of Computers most commonly used

Artificial Intelligence

Artificial intelligence (AI) is the term used to describe the creation of computer systems that are capable of carrying out operations that would ordinarily need human intelligence. AI can be applied to TVETs to create adaptive learning experiences, individualized education, and intelligent tutoring systems (Flavin, 2017). AI-driven educational platforms may examine student data, pinpoint unique learning requirements, and provide tailored feedback and content to improve the learning process.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

Augmented Reality

The term "augmented reality" (AR) refers to a technology that superimposes digital data, such as pictures, movies, or 3D models, onto the physical world. AR may be used in TVETs to develop immersive and interactive learning experiences (Almarzooq, Lopes, & Kochar, 2020). Students can, for instance, perceive and manipulate virtual objects, run simulations, and practice technical skills in a safe and regulated environment using AR-enabled devices, such as smartphones or tablets.

Mobile Devices

Smartphones and tablets, in particular, have become more and more common educational tools. Mobile devices in TVETs give students access to educational materials, online platforms, and interactive learning tools (Haque et al., 2022). Mobile devices allow for self-directed study, access to instructional videos, participation in group projects, and communication between classmates and teachers. Mobile devices enable learning anytime, anywhere because they are flexible and convenient.

Computers

Essential tools in educational environments, especially TVET institutions, are computers. They give access to various software programs, online learning environments, and digital resources. Students can use computers to learn technical skills, conduct research, produce digital material, and participate in online group activities (Goher et al., 2021). In TVETs, technical skills relating to engineering, design, and manufacturing are frequently taught and put into practice using computer-aided design (CAD) software and other computer-based tools.

Internet of Things

The term "Internet of Things" (IoT) describes a network of physically connected objects that are equipped with sensors, software, and connectivity to allow for data collection and exchange. IoT can be used in TVETs to develop intelligent learning environments (Schuelke-Leech, 2018). IoT sensors, for instance, can track and manage machinery, collect real-time data on business operations, and recreate realistic scenarios for training. IoT devices can be utilized to manage resources, measure student progress, and give performance feedback.

Factors Influencing the Adoption of Disruptive Technologies in TVETs:

The study found a number of variables that affect how disruptive technologies are adopted in TVET institutions. According to Baimas-George et al (2020), these elements consist of:

a. Perceived Benefits: Teachers and administrators are motivated by the perceived advantages of technology integration, such as higher student engagement, improved development of practical skills, and increased responsiveness to market demands.

b. Institutional Support: Promoting the adoption of disruptive technologies requires strong institutional support, which includes leadership commitment, devoted finance, and infrastructure development.

c. Teacher Readiness and Professional Development: The successful integration of disruptive technologies in teaching and learning practices depends on the teachers' pedagogical expertise, their readiness to embrace technology, and the availability of ongoing professional development opportunities.

d. Infrastructure and Resources: Having access to dependable internet connectivity, enough hardware and software, and technical assistance are essential factors for successful technology integration in TVETs.

e. Policy and Regulatory Frameworks: The adoption of disruptive technologies is aided by clear rules and regulations that enable their integration, guarantee data privacy and security, and promote stakeholder cooperation.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

Effectiveness and Impact on Teaching and Learning:

Improvement in Student Engagement and Motivation:

Disruptive technology in TVETs may have increased student interest and motivation. AR and AI-enabled immersive and interactive learning experiences engage students. Gamified elements and real-world simulations boost students' engagement and motivation.

Practical Skills Improvement:

Disruptive technologies boost TVET practical skills (García-Morales et al., 2021). Augmented reality (AR) lets students practice their technical skills in a safe environment through virtual hands-on learning. Students can improve their skills and receive targeted guidance with AI-powered feedback and customized learning pathways.

Personalization of Instruction and Adaptive Learning Experiences:

Disruptive technology in TVETs appears to increase learning outcomes and performance evaluation. Augmented reality (AR)'s interactivity and immersion improve comprehension and retention. AI-based evaluation tools give pupils timely feedback to track their progress and identify areas for improvement. Electronic and digital portfolios also demonstrate students' skills and talents through performance evaluation.

Opportunities and Benefits of Disruptive Technologies in TVETs:

Skill Development and Industry Relevance:

Acquisition of 21st-Century Skills through Technology Integration:

The results of this study imply that incorporating disruptive technologies into TVETs offers opportunity for students to pick up crucial 21st-century skills. These abilities include analytical thinking, problem-solving, working in a team, communicating, and using digital tools. By involving students in practical tasks, realistic simulations, and group projects, the interactive and immersive nature of technologies like AR and AI promotes the development of these abilities (Schuelke-Leech, 2018). These tools can help TVET colleges better educate their students for the dynamic, technologically advanced workforce of the future.

Alignment with Industry Demands and Workforce Requirements:

Disruptive technologies allow TVET colleges to meet industry needs with their programs and curricula. These tools help TVETs give students the skills employers want. AI can increase data analysis and automation skills, which are in demand across sectors. AR can also give students real-world, sector-specific training. Disruptive technology in TVETs makes learning 21st-century skills easier and ensures that they meet industrial needs. Industry-relevant skills from TVET institutes improve graduates' employability and competitiveness (Al-Imarah, & Shields, 2019). These benefits show how disruptive TVET technologies can overcome the skills gap and create a flexible, market-ready workforce.

Flexibility and Accessibility:

Overcoming Geographical Barriers and Expanding Access to Education:

According to the study's findings, incorporating disruptive technologies into TVETs can help remove regional restrictions and increase educational access. Learners in remote or underprivileged places can access high-quality vocational education through online platforms, virtual classrooms, and remote learning options. Disruptive technologies make it possible for TVET institutions to reach a larger audience, guaranteeing that all students, regardless of where they live, have equal access to educational opportunities (Horváth, 2016).

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

Blended Learning Approaches and Flexible Delivery Modes:

Disruptive technologies enable flexible delivery methods and blended learning strategies in TVETs. Blended learning mixes in-person training with online elements to provide a more individualized and flexible learning environment. Online access to course materials, participation in conversations, and assignment completion allow for scheduling and pace flexibility for learners (Moodie, 2016). Self-paced learning, adaptive content delivery, and individualized support, which respond to a variety of learning requirements and preferences, are made possible by the integration of technology like AI and mobile devices.

Innovative Teaching Approaches:

Simulation and Virtual Reality Applications for Practical Training:

Virtual reality (VR) and simulation are two disruptive technologies that offer creative methods for practical instruction in TVETs. Applications for virtual reality (VR) generate immersive and lifelike training environments that let users practice technical skills and processes in a secure environment. Through simulations, students can obtain practical experience without spending money on materials or equipment (Bozalek, Ng'ambi, & Gachago, 2013). This technology-driven methodology increases learner engagement, strengthens knowledge and skill retention, and lowers the hazards connected to practical training.

Gamification and Interactive Learning Experiences:

To make learning more interesting and interactive, TVETs use gamification strategies, such as the inclusion of game mechanics and elements. As a result of accomplishing learning objectives, students might earn incentives, badges, or points in gamified learning experiences made possible by disruptive technologies (Flavin, 2017). This method encourages learners to be motivated, compete, and work together, which improves their entire learning process and memory retention.

Collaborative and Project-Based Learning Facilitated by Technology:

Disruptive technologies support TVET project-based and collaborative learning. Online collaboration tools, communication platforms, and cloud-based collaboration software let students work remotely, collaborate, and share resources. These technologies improve teamwork, communication, and problem-solving by imitating workplaces. Students can apply their skills to real-world projects while learning more about career themes (Schuelke-Leech, 2018). Disruptive technologies in TVETs enable innovative teaching, accessibility, and flexibility. It facilitates integrated learning, flexible delivery, and removes regional barriers to education. Disruptive technologies enable project-based, collaborative, gamified, and simulation-based learning. These advantages make TVET learning environments more exciting, diversified, and productive, helping students gain sector-specific and job market-flexible skills.

Challenges and Barriers in Implementing Disruptive Technologies in TVETs:

Infrastructure and Resource Constraints:

Availability and Reliability of Internet Connectivity:

The availability and dependability of internet access is one of the major obstacles to the adoption of disruptive technologies in TVETs. High-speed internet connectivity may be restricted or unstable in some areas, particularly in rural or underdeveloped areas (Okolie et al., 2021). This hinders the efficient application of disruptive technologies by impeding the smooth integration of online learning platforms, real-time collaboration, and access to digital resources.

Technical Support and Maintenance Considerations:

Disruptive technology implementation demands ongoing technical support and upkeep. TVET institutions may have problems providing timely software updates, troubleshooting, and technical support (Olabiyi, & Chinedu,

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

2018). The efficient operation of technology-enhanced learning settings can be hampered by a lack of technical know-how and resources, which can cause disruptions and annoyance among educators and students.

Teacher Readiness and Capacity Building:

Needs for Professional Development and Teacher Training

The requirement for thorough teacher training and professional development presents a substantial obstacle to the adoption of disruptive technology in TVETs. It's possible that teachers lack the abilities, information, and self-assurance needed to successfully incorporate and apply disruptive technology in their teaching methods (Ismail, & Hassan, 2013). To close these gaps and give teachers the pedagogical approaches and technical know-how necessary to fully utilize disruptive technologies, ongoing training programs are essential.

Technology's Pedagogical Integration in TVET Curriculum:

When incorporating disruptive technologies into the TVET curriculum, pedagogical strategies and instructional design must be carefully taken into account. Technology integration may be difficult for teachers to coordinate with curricular objectives, learning objectives, and assessment methods (Liu, 2019). It can be difficult to strike a balance between the use of technology and hands-on, practical training; as a result, professional development opportunities that emphasize pedagogical integration and successful curriculum design are necessary.

Equity and Inclusivity:

Digital Divide and Socio-Economic Disparities in Access:

Disruptive technology deployment in TVETs is hindered by the digital divide and socio-economic inequities in technology access. Disadvantaged students may lack gadgets, internet access, and digital tools. To close this gap, technology must be accessible to all students (Moodie, 2016).

Ensuring Inclusivity for Students with Diverse Learning Needs:

Disruptive technology should accommodate TVET students' different learning needs. Technology integration may require particular assistive technologies or adjustments for students with disabilities or learning needs. Inclusivity requires that disruptive technologies consider accessibility guidelines and varied learning demands (Olabiyi, & Chinedu, 2018). Addressing these issues involves infrastructure development, financial investment, extensive teacher training, pedagogical assistance, and equitable access measures. TVET institutions can use disruptive technologies to improve vocational education and give equal chances by solving these concerns.

RECOMMENDATIONS

Policy and Strategic Interventions:

Technology Integration Policies:

TVET institutions should adopt comprehensive policies that explicitly encourage disruptive technology integration. These policies should link technology integration vision, goals, and strategies with national educational policies. Clear standards can help install technology and foster acceptance.

Funding and resource allocation:

TVET technology integration requires sufficient funds and resources. Governments, schools, and stakeholders should prioritize technological infrastructure, hardware, software, and technical assistance. Dedicated finances and partnerships with industry, philanthropy, and development agencies can assist maintain technological efforts.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

Collaboration and Partnerships between Stakeholders:

Technology integration requires collaboration and partnerships between TVET institutions, industry, government agencies, and other stakeholders. Collaboration helps share resources, information, and innovate. Industry partners can ensure technology integration meets industry needs and develops applicable skills in trainees.

Teacher Training and Professional Development:

Comprehensive and Ongoing Training Programs:

TVET institutions should prioritize teacher training programs. These programs should teach pedagogy, technology, and technology integration. Training, workshops, and online courses can help teachers use disruptive technologies.

Technology-Based Teacher Education:

Technology should be integrated into teacher education programs. Technology-enabled teaching should be taught in pre-service teacher education programs. In-service professional development should help instructors keep up with technology.

Infrastructure and Resource Enhancement:

Investment in Reliable Internet access and Infrastructure Development:

Governments and educational institutions should invest in enhancing internet access, especially in underserved areas. TVET technology integration requires reliable, high-speed internet. Technology-enabled learning environments need computer laboratories, devices, and maintenance assistance.

Access to Quality Hardware and Software Resources:

To facilitate technology integration, TVET institutions should prioritize quality hardware and software resources. This includes providing modern computers, mobile devices, VR technology, and vocational education software. Technology and software licenses can be obtained through industry partnerships or technology vendors.

TVET institutions can integrate disruptive technology into their curriculum by following these best practices. Technology integration requires policy backing, financing, teacher training, and infrastructural improvement. These approaches will help TVET institutions maximize disruptive technology, improve vocational education, and prepare students for the changing workforce.

CONCLUSION

With a focus on Sub-Saharan Africa, East Africa, and Kenya, this research study examined the use of disruptive technologies in TVET institutions. The study used a mixed-methods methodology, gathering data using both qualitative and quantitative methods. The results showed that a sizable portion of TVET institutions in the chosen regions had embraced disruptive technologies including artificial intelligence (AI), augmented reality (AR), and mobile devices. The incorporation of these technologies has the potential to enhance student engagement, the development of practical skills, and the individualization of instruction. To fully realize the advantages of disruptive technologies in TVETs, however, difficulties like infrastructural limitations, teacher preparedness, and fairness concerns must be resolved. To encourage successful technology integration in TVET institutions, policy initiatives, teacher training, and infrastructure improvement are suggested.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

REFERENCES

1. Al-Imarah, A. A., & Shields, R. (2019). MOOCs, disruptive innovation and the future of higher education: A conceptual analysis. Innovations in Education and Teaching International, 56(3), 258-269.
2. Almarzooq, Z. I., Lopes, M., & Kochar, A. (2020). Virtual learning during the COVID-19 pandemic: a disruptive technology in graduate medical education. Journal of the American College of Cardiology, 75(20), 2635-2638.
3. Baimas-George, M., Demartines, N., & Vrochides, D. (2022). The role of disruptive technologies and approaches in ERAS®: erupting change through disruptive means. Langenbeck's Archives of Surgery, 407(1), 437-441.
4. Bongomin, O., Gilibrays Ocen, G., Oyondi Nganyi, E., Musinguzi, A., & Omara, T. (2020). Exponential disruptive technologies and the required skills of industry 4.0. Journal of Engineering, 2020, 1-17.
5. Bozalek, V., 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.
6. Flavin, M. (2017). Disruptive technology enhanced learning: The use and misuse of digital technologies in higher education. Springer.
7. García-Morales, V. J., Garrido-Moreno, A., & Martín-Rojas, R. (2021). The transformation of higher education after the COVID disruption: Emerging challenges in an online learning scenario. Frontiers in psychology, 12, 616059.
8. Goher, G., Masrom, M., Amrin, A., & Abd Rahim, N. (2021). Disruptive technologies for labor market information system implementation enhancement in the UAE: A Conceptual Perspective. International Journal of Advanced Computer Science and Applications, 12(2).
9. Haque, M.U., Dharmadasa, I., Sworna, Z.T., Rajapakse, R.N. and Ahmad, H., 2022. " I think this is the most disruptive technology": Exploring Sentiments of ChatGPT Early Adopters using Twitter Data. arXiv preprint arXiv:2212.05856.
10. Horváth, I. (2016, October). Disruptive technologies in higher education. In 2016 7th IEEE International Conference on Cognitive Infocommunications (CogInfoCom) (pp. 000347-000352). IEEE.
11. Ismail, A., & Hassan, R. (2013, July). Issues and challenges of technical and vocational education & training in Malaysia for knowledge worker driven. In National Conference on Engineering Technology (Vol. 1, No. 2).
12. Liu, H. (2019). Barriers of project-based learning in teaching and learning of Chinese technical and vocational education and training (TVET): a review. TVET@ Asia, 12(1).
13. Moodie, G. (2016). Universities, disruptive technologies, and continuity in higher education: The impact of information revolutions. Springer.
14. Okolie, U. C., Elom, E. N., Igwe, P. A., Binuomote, M. O., Nwajiuba, C. A., & Igu, N. C. (2021). Improving graduate outcomes: Implementation of problem-based learning in TVET systems of Nigerian higher education. Higher Education, Skills and Work-Based Learning, 11(1), 92-110.
15. Olabiyi, O. S., & Chinedu, C. C. (2018). Perception of employers' in transforming technical and vocational education and training vis-a-vis emerging technology tools for sustainable workforce development in Nigeria. Traektoriâ Nauki= Path of Science, 4(4), 5001-5010.
16. Schröder, T. (2019). A regional approach for the development of TVET systems in the light of the 4th industrial revolution: the regional association of vocational and technical education in Asia. International Journal of Training Research, 17(sup1), 83-95.
17. Schuelke-Leech, B. A. (2018). A model for understanding the orders of magnitude of disruptive technologies. Technological Forecasting and Social Change, 129, 261-274.