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XR Opportunities in the Competency Based Curriculum in Kenya

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Abstract: Today, Augmented Reality and Virtual Reality technologies are making waves in the education sector. XR technologies have become key innovation areas in research where new learning tools that create new learning experiences for learners are being developed. These emerging and engaging technologies are fast supplanting textbooks by a large part. The technological capacity to overlay multimedia content virtually in 3D and augmenting objects onto the real world for interaction means that educational content can be availed to students instantly as they require it. Extended reality thus, is poised to enable the fruition of the objectives of competency-based curriculum. In Kenya, the development and implementation of a competency-based curriculum in the education system without the right educational technologies do not guarantee the acquisition of the pre-determined competencies. Hence, the successful implementation of technologies such as augmented reality and virtual reality could make the difference. Yet, there is little that has been done to marry the developments in augmented reality or virtual reality and curriculum in Kenya. The objective of this paper was to investigate curriculum content for grade 3 STEM subjects that can be integrated with XR technologies for simulation in regard to competence-based curriculum. The study population comprised of primary level schools in Chesumei Sub-County, Nandi County. A three-stage sampling method was used to arrive at the study sample from a population of 166 schools. The findings from this paper will be used in developing a prototype for XR gaming application in identified areas. These results will benefit actors in the education sectors such as policy makers, curriculum developers, implementors of CBC and other partners in education. These findings add to the body of literature on the use of educational technologies.

Keywords: Virtual Reality, Augmented Reality, CBC, educational technologies, simulation

I. INTRODUCTION

The integration of Extended Reality (XR) technologies, specifically Augmented Reality (AR) and Virtual Reality (VR), in the education sector has gained significant attention in recent years. XR technologies are being recognized as key areas of innovation in educational research, offering new learning tools and experiences for learners. These immersive technologies have the potential to replace traditional textbooks by providing interactive and multimedia-rich learning content in a 3D virtual environment.

The use of XR technologies aligns well with the objectives of competency-based curriculum, as it enables the delivery of educational content to students in real-time and as per their individual needs. In the context of Kenya, the implementation of a competency-based curriculum in the education system requires appropriate educational technologies to ensure the acquisition of predetermined competencies. Augmented reality and virtual reality hold promise in this regard, but their integration with the curriculum in Kenya is still limited.

Objective

The objective of this paper was to investigate the curriculum content for grade 3 STEM (Science, Technology, Engineering, and Mathematics) subjects that can be integrated with XR technologies for simulation within the competency-based curriculum.

II. LITERATURE REVIEW

This chapter provides a comprehensive overview of the relevant literature related to extended reality (XR) integration in the curriculum. It explores various technologies used in education, teaching approaches, the 8.4.4 and CBC systems of education in Kenya, and the role of technology in enhancing teaching and learning experiences. The literature review aims to identify gaps in existing research and establish the theoretical and conceptual framework for this study.

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The advancements in information technology and the internet have revolutionized education and training methods. Information technology is now widely used in classrooms and e-learning platforms, empowering teachers with efficient tools for instruction,[2],[17]. Technology integration in education, commonly referred to as EdTech or Edutech, offers opportunities for creativity, collaboration, and the development of essential competencies. Extensive research supports the effectiveness of technology in enhancing teaching and learning outcomes. Educational institutions worldwide have recognized the need to implement and integrate technology into their curriculum and instructional practices [13],34].

However, the rapid evolution of technology presents challenges in its effective utilization. The sheer volume of new technologies entering the market, such as applications in the Apple Apps store, has made it difficult for teachers and administrators to keep up. Additionally, the limited lifespan of technological gadgets and internal institutional barriers hinder schools from fully integrating novel technologies. Despite these challenges, it is crucial to acknowledge that media technology, including educational technologies, plays a significant role in facilitating communication, exchanging ideas, and enhancing cognitive abilities,[18][19].

XR educational technologies, such as augmented reality (AR), have the potential to disrupt the education landscape [20],[27]. AR overlays interactive digital elements in the physical environment, offering new ways of presenting information without losing context or clarity [3],[5],[12][28]. The development of immersive technologies, combining AR with virtual reality (VR), has further expanded the possibilities of information packaging. However, the integration of XR technologies into curricula and teaching platforms requires careful consideration to ensure reliability, proper system integration, and structured implementation guidelines [15],[17],[26].

Among the interactive learning technologies, game-based interactive learning has gained significant attention. The immersive nature of educational games allows students to engage intrinsically, motivating them to learn. The widespread popularity of digital games among students, especially boys, presents an opportunity to leverage game-based learning in education [14],[16],[24],[28]. However, the discourse around games in the classroom environment requires qualification and careful consideration of the specific genre and learning objectives. Gamification, incorporating game elements and incentive systems, can also enhance motivation and engagement in learning.

The 8.4.4 and CBC systems of education are models that focus on different approaches to curriculum development. The 8.4.4 system judges students collectively rather than individually and often requires the study of subjects that may not be relevant to students' future careers [19],[20]. In contrast, the competence-based and process-driven models prioritize individual learning outcomes and interdisciplinary approaches. These models align with the goal of developing skills that are applicable in the workplace [11],[30].

The literature review highlights the transformative potential of XR integration in the curriculum. The advancements in technology, particularly in XR technologies such as AR, offer new possibilities for interactive and immersive learning experiences. However, careful planning, effective teacher training, and clear guidelines are essential to ensure successful integration and adoption [16][21][23]. The review also emphasizes the need to address institutional barriers, such as lack of technical knowledge and skepticism, to promote technology integration in education. By leveraging XR technologies and incorporating game-based learning and interactive presentation tools, educators can enhance student engagement, motivation, and learning outcomes. Additionally, aligning curriculum development with competency-based approaches can better prepare students for the evolving demands of the modern workforce [1],[16],[24]28].

III. METHODOLOGY

This section provides a discussion of the methodology employed in the research. It covers various aspects such as the research philosophy, study design, variables, study population, participants, sampling procedure, sample size and data. The study design used in this research is an experimental research design, which allows for the examination of causal relationships between variables. It aims to measure the effectiveness of extended reality (XR) technology in presenting educational content to grade 3 students.

The study population consists of primary level schools in Chesumei subcounty, Nandi County, Kenya. A three-staged sampling technique was employed, involving purposive selection of the study site, stratified sampling to select schools from different wards, and simple random sampling to select one school from each ward. The data collection process involved familiarizing with the curriculum content, revisiting the research objectives, and developing a framework for indexing and coding the data. Quantitative data were collected through open-ended questions administered to learners and teachers, and the responses were analyzed to identify the areas where XR technologies could be integrated. The study population consisted of 166 schools with a sample size of 45 schools.

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A pilot study was conducted to test the reliability and validity of the research instruments. Content validity and face validity were assessed to ensure that the instruments measure what they are intended to measure. Cronbach's alpha was used to check for internal consistency of item scores in the questionnaire. The Cronbach's alpha coefficient of the 43 items indicated .843.

Data collection was carried out which involved using a questionnaire administered to grade 3 teachers in the sampled 45 schools. Data analysis involved descriptive statistics which included frequencies, percentages, means, standard deviation.

IV. FINDINGS AND DISCUSSIONS

Data analysis from the demographic data of the school and technology use is presented as follows: that 62.2% of the respondents' schools were public, while 37.8% were private. Only 8.89% of the schools had a dedicated ICT lab, while 91.11% did not have this facility. among the schools with an ICT lab, 3 were private schools and 1 was a public school. Asked on the teaching method, 100% of the teachers used traditional teaching methods, largely chalk and chalkboard. All the schools 45 (100%) were connected to electricity, which is crucial for effective ICT integration. On use of technology devices, 17.8% of the schools used a projector, 55.6% used smartphones, and 26.7% used computers for teaching. 62.22% of the teachers used digital devices once in a term, 22.22% used them twice, and 15.56% used them more than three times. Thus, the majority of teachers did not integrate technology frequently in their teaching. 31.1% of the teachers had developed content for digital platforms, while 68.9% had not engaged in such development.

Teachers' opinion based on sub-strands from Mathematics, Hygiene and Environmental Studies was analyzed as follows: the teachers were asked about the use of technology to enhance learning in mathematics. The responses indicate that 20% of the teachers (9 respondents) mentioned performing multiplication as a topic that would benefit from technology integration. Similarly, 22% (10 respondents) mentioned performing division, 4% (2 respondents) mentioned capacity of objects, 32% (14 respondents) mentioned identifying positions and directions, and 22% (10 respondents) mentioned making and working with different shapes. In summary, in Mathematics sub strands in geometry, learners were exceeding expectations in identifying numbers and meeting expectations in other areas of mathematics. However, there was need for improvement in performing multiplication, performing division, lengths of objects, identifying time, and working with different shapes.

Data analysis focusing on the use of technology in teaching hygiene indicated that that 20% (9 respondents) of the teachers mentioned proper use and storage of medicine at home, 22% (10 respondents) mentioned kitchen garden, 49% (22 respondents) mentioned care of toilets, latrines, and urinals, and 9% (4 respondents) mentioned bed making as topics that could be enhanced with technology integration. Thus, learners were meeting expectations in most areas of hygiene, such as oral hygiene and cleaning the classroom. However, there are areas that need improvement which include making water safe for drinking, care of toilets, latrines, and urinals, and bed making.

The teachers were asked about the use of technology in teaching environmental topics. The results indicate that 12% (5 respondents) mentioned exploring unfavorable weather conditions, 9% (4 respondents) mentioned effects of unfavorable weather conditions, 13% (6 respondents) mentioned keeping safe during unfavorable weather conditions, 11% (5 respondents) mentioned categorizing plants, 13% (6 respondents) mentioned importance of handling plants well, 18% (8 respondents) mentioned dangers of heat energy at home, and 24% (11 respondents) mentioned dos and don'ts during a fire outbreak as topics that could benefit from technology integration. In Environmental studies, learners were meeting expectations in areas such as making water safe for use, exploring characteristics of soil, and different food products from animals. However, areas that need improvement include exploring unfavourable weather conditions, making water safe and clean by filtering, and handling plants and heat energy.

Drawing from the analysis of the teacher's opinion in comparison to the descriptive statistics from each of the three subjects; in Mathematics, identifying position and direction 2.4111 and being able to make and work with different shapes with a mean of 2.1778 scored the least mean and was rated with 32% and 22% respectively by the teacher from the open-ended questions. These topics were pointed out as areas where technology would be used to improve learning.

In Hygiene; care of toilets, latrines and urinals with a mean of 2.3333 and making water safe for drinking 2.2667 scored the least mean. However, none of the teachers indicated that IT would be used to enhance students learning in the topic making water safe for drinking and instead 49% of the teachers pointed out that IT would play a major role in teaching the topic care of toilets, latrines and urinals. This would be attributed to the rural setting where most of the pupils come from. Most rural homes use pit latrines and not flash toilets and urinals. Further some teachers indicated that latrines are not safe places to teach around or from and so the use of IT especially simulation would demonstrate how such places should be well taken care of.

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Analysis from Environmental studies showed that, dangers of heat energy at home scored the least mean of 2.4889 which also was rated by 23% of the teachers as an area that where IT would come in handy. Though, 33% of the teachers rated the topic dos and don'ts during a fire outbreak as an area that would most highly be perceived better with the use of IT by the learners but from the descriptive analysis the topic dos and don'ts during a fire outbreak was rated 2.5778 which can be interpreted to mean that the learners are meeting expectations. Generally, the data analysis suggests that the majority of teachers believe that integrating technology in these specific topics would enhance student learning outcomes in mathematics, hygiene, and environmental studies.

The researcher drew results from this analysis and picked on Mathematics, identifying position and direction 2.4111 as well as being able to make and work with different shapes with the lowest mean of 2.1778 that were both rated 32% and 22% from the teacher's opinion on use of IT respectively. The two topics make up 54% which is the highest in the overall topics in each subject area. The researcher summed up all the percentages in each main topic to come up with the topic with the highest percentage score. The two topics are categorized under Geometry in the grade 3 curriculum.

Mathematics is a core subject in most of the course in the Kenyan tertiary institutions. It is a subject that is mandatory to all students at primary and senior secondary school. It is also a requirement for all science courses at tertiary level and recently it is a requirement for those training to be teachers. Mathematics is very important; not just when one is in school, but even after school. It is a life skill that applies to everyone. It is the language for all professions not just those in sciences but also accountants. Many of the innovative advances we witness today are as a result of mathematics and so a good foundation of mathematics is a life time skill for every learner and should be founded on a firm ground from an early age. It is evident from the results presented in this chapter that in Chesumei sub-county most teachers still do not integrate technology in the teaching process which would be hindering most visual learners from attaining their competencies. The pupils in the CBC system of education cannot attain full potential without the use of technology. Based on the curriculum content of each level, IT is in cooperated to ensure pupils involvement in learning.

In Mathematics, topics such as identifying position and direction, as well as working with different shapes, were identified as areas where technology, specifically simulation and gaming applications, could enhance learning. Similarly, in Environmental Studies, topics such as care of toilets, latrines, and urinals, and dos and don'ts during a fire outbreak were highlighted as areas that could benefit from the use of technology.

The use of technology-based interactive devices to support learning via technologies such as XR systems that combine the physical and virtual worlds is on the rise [15],[27]. XR technologies have are proved to lead students to prefer different learning styles. XR platforms have become a new tool to enhance creative learning. These technologies support collaborative learning thus promoting learners' social interaction in terms of learners' engagement, self-learning, promotion of confidence and enjoyment. As such learners who were feeling inferior and could not be part of class groups have become easily accepted by their peers thanks to their technological skills [1].

Yuen et al. (2011) posit that XR technology encourages learners to explore information independently, creates a learning atmosphere suitable for various learning styles and ages, facilitates the understanding of concepts that learners cannot easily understand without realistic experiences, motivates the learner and boosts their creativity and capacity for imagination and comprehension.

Ahmad (2020) agrees that XR technology can be of great benefit to math students, increasing their self-assurance and comprehension. This technology has been demonstrated to be of particular help in geometry and 3D shape learning, as the augmented reality provides an engaging visual experience, allowing learners to examine objects from varied perspectives and improving their understanding of mathematical concepts.

These findings suggest that there is a need for increased integration of technology in teaching, as well as training and support for teachers in developing digital content. There are also areas in mathematics, hygiene, and environmental studies where students' performance could be improved.

V. CONCLUSION

The emergence of XR technologies in the education sector has opened up new possibilities for creating engaging and immersive learning experiences. These technologies have the potential to revolutionize traditional teaching methods by providing students with instant access to multimedia content and interactive learning opportunities. The integration of XR technologies into the competency-based curriculum holds great promise for enhancing the acquisition of predetermined competencies. This study highlights the need for greater integration of technology in the teaching process, particularly in the context of visual learners who may struggle to attain their competencies without the use of technology.

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The results indicate that there is potential for incorporating augmented reality and virtual reality technologies into the curriculum, particularly in subjects such as Mathematics and Environmental Studies. This study will have significant implications for various stakeholders in the education sector, including policymakers, curriculum developers, and implementers of the competency-based curriculum. By bridging the gap between educational technology advancements and curriculum design, this research aims to pave the way for a more effective and engaging learning experience for students.

Furthermore, this study adds to the existing body of literature on the use of educational technologies, particularly in the context of XR applications in curriculum integration. It highlights the importance of leveraging XR technologies to create innovative learning tools and experiences that align with the objectives of the competency-based curriculum.

In conclusion, the successful integration of augmented reality and virtual reality technologies into the curriculum has the potential to revolutionize education in Kenya and beyond. It is crucial for educators and policymakers to recognize the transformative power of XR technologies and actively explore their implementation to enhance student learning and competency development in the 21st century.

VI. RECOMMENDATIONS

The majority of teachers expressed the belief that integrating technology in specific topics would enhance student learning outcomes. Therefore, it is recommended to actively incorporate latest technologies such as XR into teaching practices, particularly in subjects like mathematics, hygiene, and environmental studies. This can include using educational software, interactive tools, online resources, or multimedia materials to support and enhance instruction.

To ensure effective integration of technology in the classroom, it is essential to provide teachers with adequate professional development opportunities. This can include training sessions, workshops, or online courses that focus on the use of technology tools and strategies specifically tailored to the subjects mentioned. Professional development should empower teachers with the knowledge and skills necessary to effectively utilize technology in their teaching practices.
The findings highlight specific topics within each subject area where technology integration can be particularly beneficial. It is recommended to review and update the curriculum to incorporate these topics and align them with the potential use of technology. Curriculum designers should explore ways to incorporate digital resources, interactive activities, and hands-on experiences that leverage technology to engage students and deepen their understanding.

Encouraging collaborative learning experiences can amplify the benefits of technology integration. Teachers can design activities that promote peer interaction, group projects, or online discussions to foster collaborative problem-solving and knowledge sharing. Technology tools, such as online collaboration platforms or virtual classrooms, can facilitate these interactions and create an engaging learning environment. With these recommendations, educators can leverage XR technologies to enhance student learning experiences, promote active engagement, and foster a deeper understanding of the subjects mentioned. It is important to continually evaluate the impact of technology integration and make adjustments as needed to ensure its effectiveness in supporting student achievement.

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