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Review on Emerging Trends in Pharmacy Education: Artificial Intelligence (AI), Virtual Reality (VA), Augmented Reality (AR) in Teaching

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ABSTRACT

Artificial Intelligence (AI) emerged as an intervention for data and number-related problems. This breakthrough has led to several technological advancements in virtually all fields from engineering to architecture, education, accounting, business, health, and so on. AI has come a long way in healthcare, having played significant roles in data and information storage and management – such as patient medical histories, medicine stocks, sale records, and so on; automated machines; software and computer applications like diagnostic tools such as MRI radiation technology, CT diagnosis and many more have all been created to aid and simplify healthcare measures. AI technology has been identified for analyzing as well as interpreting some important fields of pharmacy like drug discovery, dosage form designing, polypharmacology, and hospital pharmacy. To characterize how virtual reality (VR) has been and is being used in pharmacy education, and evaluate the projected utility of VR technology in pharmacy education in the future. Virtual reality technology can provide an immersive and interactive learning environment, overcoming many of the early challenges faced by instructors who used virtual activities for pharmacy education. With further technological and software development, VR has the potential to become an integral part of pharmacy education. Augmented reality (AR) and gamification, which involve the use of mobile devices, tablets, and laptops to enhance learning experiences, are relatively new in tertiary education. This article calls for the implementation of AR and gamification in pharmacy education in African countries and other low-resource settings.

Keywords: Artificial intelligence (AI), Pharmacy, Virtual reality, Immersive, Technology, Augmented reality,Gamification,Implementation,Pharmacy education.

Artificial Intelligence (AI)

Introduction

AI is a stream of science related to intelligent machine learning, mainly intelligent computer programs, which provides results in a similar way to the human attention process.This process generally comprises obtaining data, developing efficient systems for the uses of obtained data, illustrating definite or approximate conclusions, self-corrections, and adjustments. Recently, AI technology becomes a very fundamental part of the industry for useful applications in many technical and research fields. Reflecting on the past 25 years, pharmacy has done a great job of addressing the growing demand for prescriptions, even when faced with pharmacist shortages, growing operating costs, and lower reimbursements.[1] Pharmacy has also done a great job of leveraging enabling technology automation to improve workflow efficiency and lower operating costs while promoting safety, accuracy, and efficiency in every pharmacy setting. Automated dispensing gives pharmacists more time to engage with a greater volume of patients while also enhancing their health outcomes. Recently, several programs focusing on drug therapy have been described.They guide drug interactions, drug therapy monitoring, and drug formulary selection. There are many aspects of pharmacy that AI can have an impact on and the pharmacists to consider these possibilities because they may someday become a reality in pharmacy practice.[2]

AI general overview: The term AI (also known as machine intelligence) is very commonly confused and used interchangeably with robotics and

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automation. While robotics is simply the creation of machines that can carry out difficult repetitive tasks, AI refers to the exhibition of human-like behaviors or intelligence by any computer or machine.Traditionally, robots were not built to possess these "intelligent capabilities" even though they may be able to move or carry objects independently using a designed program and surface sensors in a process known as automation.[3] AI, in essence, is the field of computer science that specializes in the creation of intelligent machines, developed with the ability to perform tasks that will ordinarily be associated with a human being.[4]

AI CLASSIFICATION

AI can be classified in two different ways [5]

- **A.** According to caliber
- **B.** According to the presence

Based on the caliber	Weak intelligence Artificial narrow intelligence Artificial general intelligence Artificial super intelligence
Based on presence	Type 1 reactive machine Type 2 limited memory system Type 3 is based on the theory of mind Type 4 self-awareness

Table:1-AI classification

Based on their caliber, AI system is classified as follows:

1. **Weak intelligence or Artificial narrow intelligence (ANI)**: This system is designed and trained to perform a narrow task, such as facial recognition, driving a car, playing chess, and traffic signaling. E.g.: Apple SIRI virtual personal assistance, tagging in social media.
2. **Artificial General Intelligence (AGI) or Strong AI**: It is also called Human-Level AI. It can simplify human intellectual abilities. Due to this, when it is exposed to an unfamiliar task, it can find the solution. AGI can perform all the things as humans.
3. **Artificial Super Intelligence (ASI):** It is brainpower, which is more active than smart humans in drawing, mathematics, space, etc; in every field from science to art. It ranges from the computer just little than the human to a trillion times smarter than humans.[6]

Arend Hintze,an AI scientist classified the AI technology based on its presence and not yet present. They are as follows:

- **Type 1:** This type of AI system is called a Reactive machine. E.g. Deep Blue, the IBM chess program which hit the chess champion, Garry Kasparov, in the 1990s. It can identify checkers on the chessboard and can make predictions; it does not have the memory to use past experiences. It was designed for narrow purposes use and is not useful in other situations. Another example is Google's AlphaGo.
- **Type 2:** This type of AI system is called a Limited memory system. This system can use past experiences for present and future problems. In autonomous vehicles, some of the decision-making functions are designed by this method only. The recorded observations are used to record the actions happening in the future, such as changing the lanes by car. The observations are not in the memory permanently.
- **Type 3:** This type of AI system is called as "theory of mind". It means that all humans have their thinking, intentions, and desires which impact the decisions they make. This is a non-exist AI.
- **Type 4:** These are called self-awareness. The AI systems have a sense of self and consciousness. If the machine has self-awareness, it understands the condition and uses the ideas present in others' brains. This is a non-existing AI.[7]

AI and development of pharmaceuticals

Top pharmaceutical companies are collaborating with AI vendors and leveraging AI technology in their manufacturing processes for research and development and overall drug discovery. Reports show nearly 62 percent of healthcare organizations are thinking of investing in AI shortly, and 72 percent of companies believe AI will be crucial to

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how they do business in the future. To get a better sense of the future of AI in the sector, *Pharma News Intelligence* dives into current AI use cases, the best uses for the technology, and the future of AI and machine learning. The McKinsey Global Institute estimates that AI and machine learning in the pharmaceutical industry could generate nearly $100B annually across the US healthcare system. According to researchers, the use of these technologies improves decision-making, optimizes innovation, improves the efficiency of research/clinical trials, and creates beneficial new tools for physicians, consumers, insurers, and regulators. Top pharmaceutical companies, including Roche, Pfizer, Merck, AstraZeneca, GSK, Sanofi, AbbVie, Bristol-Myers Squibb, and Johnson & Johnson have already collaborated with or acquired AI technologies. In 2018, the Massachusetts Institute of Technology (MIT) partnered with Novartis and Pfizer to transform the process of drug design and manufacturing with its Machine Learning for Pharmaceutical Discovery and Synthesis Consortium.[8]

AI in pharmacy practice in hospital and community pharmacies

Machine learning models allow e-mails to be personalized at a speed and accuracy greater than that of any human being. Chatbots can be used to increase the efficiency of service delivery. Chatbots are capable of mimicking interactions between customers and customer care of sale staffs. Chatbots are capable of automatically resolving customer complaints and queries and the difficult questions are transferred to human staff. In retail pharmacy, this principle can be applied. The chatbots can be programmed to mimic pharmacist-patient interaction.[9]

Applications of artificial intelligence(AI)

AI in diagnosis and targeted genomic treatments

There are several applications of AI in hospital-based health care systems in organizing dosage forms for individualized patients and selecting suitable or available administration routes or treatment policies.

- ❖ **Maintaining of medical records:** Maintenance of the medical records of patients is a complicated task. The collection, storage normalizing, and tracing of data are made easy by implementing the AI system.
- ❖ **Treatment plan designing:** The designing of effective treatment plans is possible with the help of AI technology. When any critical condition of a patient arises and the selection of a suitable treatment plan becomes difficult, then the AI system is necessary to control the situation.[10]

- ❖ **Assisting in repetitive tasks:** AI technology also assists in some repetitive tasks, such as examining the X-ray imaging, radiology, ECHO, ECG, etc., for the detection and identification of diseases or disorders. Medical Sieve (an algorithm launched by IBM) is a “cognitive assistant” having good analytical and reasoning abilities
- ❖ **Health support and medication assistance:** In recent years, the uses of AI technology are recognized as efficient in health support services and also, for medication assistant.[11]

Virtual Reality (VR)

Introduction

Over the past few decades, instructional technology has progressed from chalkboards to computer-based slideshows and beyond; however, the format of pharmacy classes has been slower to evolve. No matter what technology has been available, pharmacy education typically involves an instructor standing at the front of a large classroom, delivering content, hoping to impart knowledge. Low classroom attendance is likely multifactorial; however, there is some evidence to suggest that increasingly poor attendance is supported by lecture and lecture content being accessible through digital means. As qualitative and quantitative evidence has proven that active learning is more effective than passive learning, instructors are now seeking alternative pedagogies to lectures. Providing alternatives to lectures appears to be particularly important for 21st century students, who prefer more independent, task-based learning strategies and the integration of technology.[12] To address the learning needs oftoday’s student, educators have begunto adapt their teaching styles to engage

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learners through the use of active-learning and through incorporation of educational technology.In everyday practice, pharmacists use problem-solving skills to address numerous patient care issues. The Accreditation Council for Pharmacy Education (ACPE) emphasizes that pharmacy programs provide students with the knowledge, skills, and abilities to provide patient-centered care and solve problems.Therefore, pharmacy students must be provided ample opportunities to hone their skills. Practice experiences are arguably the best way to prepare students for a career in pharmacy.[13]

Methods:
A literature search was conducted for this review using PubMed, Scopus, ERIC, Google, and Google Scholar. Terms searched for included "virtual reality," "augmented reality" "mixed reality," and "pharmacy education." The search was limited to articles describing either the use of head-mounted displays or virtual activities in pharmacy education. Websites for the manufacturers of head-mounted displays were reviewed for technical specifications. Additionally, websites for VR, AR, and MR software were evaluated for educational contents.[14]

Table:1-Definitions of virtual reality, Augmented reality and Mixed reality

Type	Environment	Interaction
VR	Computer generated graphics unrelated to the real world.	Virtual objects interact with the user and other virtual objects .
AR	Computer generated graphics and the real world simultaneously.	Virtual objects interact with the user and other virtual objects.
MR	Computer generated graphics blended with the real world.	Virtual objects interact with the user, other virtual objects and objects in the real world.

Advancements in Immersive VR Technology

Participants' ability to immerse themselves in VR activities depends on the sense of presence that the experience affords. According to Slater, the sense of presence in a virtual world is dependent on two primary components: place illusion and plausibility illusion. Place illusion describes how much a person believes that they are in the virtual world, in other words, immersion. Plausibility illusion describes how much a person believes that what is happening in the virtual world is real.Both of these components are necessary to provide a sense of presencein a virtual world.Place illusion can be achieved with high quality computer-generated visual information and accurate head and movement tracking.Recent advances in video card technology have allowed for the development of VR headsets with high-quality visual displays. Accurate tracking technology has also been developed that allows headsets to recognize the six degrees of freedom required for "room-scale VR." To enable roomscale VR, headsets must recognize the rotation of the head in all three directions (tilting forwards and backwards, rotating left to right, and tilting sideways), and movement across all three planes (moving forwards and backwards, left and right, up and down). Room-scale VR allows a person to move around the virtual space in the same way as the real world, and thus greatly adds to immersion. Tracking technology, combined with high quality visual displays, have allowed the current generation of VR headsets to provide VR experiences that are far more immersive than previous technology.[15]

Potential Uses of VR Technology in Pharmacy Education

Active engagement has become widely acknowledged as an important element of the learning process.Historically, lecture-based curricula generally encourages passive student engagement. However,instructors are transitioning in their role from a "sage on the stage," where the teacher is delivering content at the front of the classroom, to a "guide on the side," where teachers facilitate learning instead.The "guide on the side" posturing is readily seen in active-learning pedagogies such as problembased learning (PBL) and team-based learning (TBL), which are becoming more popular as evidenced by increased use in universities, specifically in healthcare education.Both PBL and TBL have demonstrated benefits by promoting critical thinking, problem solving, communication, teamwork, and creativity.These pedagogies help students to learn theory but do not always provide the opportunity for students to apply what they have learned to real-world scenarios. [16]

Technological Advances That May Impact Pharmacy Education

The impact of VR technology on health professions education will largely depend on future technological advancements, and we are just beginning to see the considerable potential of VR in pharmacy education. For the most part, room-scale VR experiences involve being tethered to a computer. The attached wire can interfere with the user's immersion and present a potential tripping hazard. Add-on equipment for VR headsets is now available that allows wireless room-scale VR with minimal latency, allowing a high-quality untethered VR experience. Standalone room-scale VR headsets were released in early Stand-alone room-scale VR headsets negate the need for an expensive computer and include "insideout" tracking. Inside-out tracking involves the headset tracking what is around the user, rather than stationary "lighthouses" (sensors) tracking the headset within a predetermined zone.[17]

Limitations of VR Technology

- Although it may be tempting to dive into VR and all that it has to offer, there are limitations to consider. One of the biggest problems with VR is that wearing a VR headset for prolonged periods is uncomfortable.
- Virtual reality sickness is a possibility for many people. Although not fully understood, simulator sickness seems to occur when there is a discrepancy between visual information informing the body of movement and proprioception.
- Symptoms of virtual reality sickness include nausea, cold sweating, and pallor.77 Ensuring that there is alignment between visual information on movement and actual movement appears to minimize the likelihood of VR sickness.
- Use of VR sickness detection methods may also help developers to identify and correct problems that could cause VR sickness during the development of VR applications.
- Desensitization is possible with even the most high-intensity VR experiences (eg, rollercoaster simulations) with repeated exposure, and therefore may become less of a problem with continued VR exposure.
- Current headsets primarily rely on visual information to provide a sense of realism, which does not provide a fully immersive experience and may exclude users who are visually impaired.[18]

Augmented Reality (AR)
Introduction

Augmented reality (AR) is an immersive technology that superimposes digital objects into the physical world; It creates a reality where users can engage with a virtual environment without losing the authenticity of the real world. For students, AR can provide a realistic learning experience. AR in education is a student centred learning approach that augments traditional teaching methods such as face-to-face learning. AR enhances the understanding of complex and abstract topics by its ability to turn conceptual and difficult-to visualise subject topics into fundamental and observable concepts, thereby increasing the motivation to learn. AR tools also serve as flexible learning platforms allowing easy accessibility and visitation of learning content at any time or location outside of classroom settings. Gamification, also known as game-based learning, involves using game mechanics in a non-game context to digitally engage and motivate people to construct new knowledge, achieve their goals and solve real world problems. Game mechanics are tools, techniques, and applications that increase users' interactivity, rewards, and motivation. Goals, competitions, badges, scores and leaderboards are examples of mechanics used to motivate learners.[19] Although commonly used in marketing strategies, gamification is now being introduced into educational programmes. It helps educators find the balance between achieving their set objectives and catering to evolving needs of students. [20]

Methods:

Search strategy

A search for relevant articles was conducted on three databases (PubMed, PubMed Central, and Google Scholar). The following keywords were used in the search: 'gamification', 'education', 'augmented reality',

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'game-based learning', 'medical education', 'pharmacy education', 'low resource settings', 'history', 'rationale' and 'challenges'. Combinations meant to capture AR and gamification in pharmacy education, their rationale, framework design, history, and challenges were among the search terms.

Eligibility criteria

The articles that were included in this review were:

1) Studies conducted using game-based learning applications or AR to assess their use and impact amongst students in tertiary institutions,
2) Studies conducted on game-based learning and AR towards pharmacy education,
3) Studies on implementation of AR and game-based learning in tertiary education and
4) Studies that identified challenges in implementing the AR and game-based learning in tertiary education.
5) Papers that were not written in English were excluded. The search was restricted to articles published between 1997 and 2022.
6) It contained articles that provided a timely overview and history of AR and gamification.
7) The search included a thorough screening of full-text publications, reviews, and reports, with only those highly relevant to this study being chosen.
8) The reference lists of the identified articles were screened, and articles were selected if they met the eligibility criteria.

Historical perspective

Technology's evolution can be seen in its influence on the world in the past 25 years, as new ideas, concepts, and products aimed at improving the life of mankind are introduced into different aspects of life, including the industrial, commercial, and educational sectors. A prominent are of technological innovation today is the concept of AR. While the idea of using virtual images to improve day-to-day activities in the real world has a long history, the concept of AR can be traced back to the work of a computer interface pioneer, IvanSutherland, in 1965. With Bob Sproull, Ivan Sutherland created the first prototype AR system, called 'Helmet Mounted Display. Although the term 'Augmented reality' was coined by Tom Caudell and David Mizell in 1992, its application in the education sector has only been established recently. Researchers and educational professionals are now improving their learning systems by applying AR at primary, secondary, and tertiary levels.Gamification, however, was introduced as an innovation targeted specifically to increase individuals' motivation and compliance by adopting elements from games. The concept of gamification began in 1961 when French sociologist Roger Caillois wrote an article titled Man, Play, and Games; In the article, he discussed sophisticated forms of games that entertain. However, the first paper introducing the modern meaning of gamification to the world of academic research, written by Sebastian Deterding, Dan Dixon, Rilla Khaled, and Lennart Nacke, was published in 2011.[21]

Results

Rationale for adoption in Africa and other low resource settings

One of the most critical challenges faced by pharmacy students is understanding the content of the course;
this often creates negative emotions and experiences, leading to increased rejection and dropout rates from pharmacy school.The limited number of lecturers, underdeveloped infrastructure, paucity of knowledge, research challenges, restricted educational resources, and lack of pedagogy related to teaching courses are challenges faced by pharmacy students in low-resource settings like Nigeria and wider Africa. Furthermore, enhancing the way while promoting active and scientific thinking is critical.Therefore, the integration and adoption of AR and gamification in pharmacy education would significantly improve the learning and teaching processes in these low-resource settings. AR application has become more widespread with the rapid developments in handheld devices and subsequent ease of use which creates a student-centred approach to learning.The design and predicted learning effectiveness of AR are underpinned by constructivist learning theory and situated learning theory.

A study by Thompson and Chapman (2022) involving 68 undergraduate pharmacy students

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revealed that AR increased their motivation towards learning when compared with a conventional method and, as such, is a useful learning tool. Moreover, with the success of
digital games in education, gamification is becoming increasingly accepted as an effective learning strategy for creating highly engaging learning experiences. Many studies have investigated the effects of gamification, producing results in support of its potential to improve: motivation, engagement, and social influence while allowing students to immerse
themselves in experiential learning.The adaptation of gamified concepts will enhance pharmacy students' positive learning outcomes, most especially in low-resource settings in low-and-middle income countries, specifically the global south such as Africa.

Conclusion

This study highlights pharmacy students' generally positive perception of AI as a supportive tool in healthcare, emphasizing its potential to improve decision-making, reduce errors, and enhance patient care. However, significant gaps in specific knowledge areas, such as AI's technical aspects and its ethical implications, were evident. Furthermore, while students recognize the potential benefits of AI, there remains a cautious approach due to concerns about dehumanization and ethical issues. In this review, we discussed the utility of VR in the context of pharmacy education, including a discussion of previous iterations of VR technology, how recent progress in VR technology may benefit pharmacy education, and what we may see in the next decade of VR technology. Earlier versions of VR have been used to provide pharmacy students with active-learning opportunities for many years. This study reviewed the need to implement AR and gamification in pharmacy education in Africa and other low-resource settings with insights on the historical perspective, challenges, rationale for adoption and a proposed framework for the implementation. AR and gamification technologies have demonstrated the potential to provide motivating, engaging and compelling solutions in the educational and learning context in higher education institutions.

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