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RESEARCH ARTICLE

ARTIFICIAL INTELLIGENCE IN NURSING EDUCATION: OPPORTUNITIES AND CHALLENGES

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Abstract

This review provides an overview of the possibilities of using Artificial Intelligence (AI) in nursing and how it can address the challenges faced by the nursing sector, particularly in nursing education.AI has the potential to significantly transform nursing education by enhancing personalized learning, improving clinical decision making, and providi ng advanced training simulations.AI tools, such as adaptive learning platforms, natural language processing (NLP), and generative AI, can create tailored educational experiences that cater to individual student needs.Simulation-based learning through Virtual Reality (VR) may offer immersive, hands on practice and enhance clinical skills in a contr olled and safe environment.AI technologies can also assist in data analysis and predictive analytics, supporting nurses in making informed clinical decisions.AI-powered telehealth applications could improve access to healthcare and resource efficiency, thereby making healthcare education more inclusive.Additionally, AI has the potential to enhance time management skills and help nursing students optimize their workload, leading to better job performance and patient care.Despite these transformative possibilities, challenges related to data privacy, ethical concerns, resistance from educators, and financial constraints remain.A balanced and ethical integration of AI into nursing education that addresses these challenges could significantly advance the field, ultimately contributing to the development of competent and compassio nate nurses ready for the demands of modern healthcare.

Introduction:-

The advent of technologies such as big data, cloud computing, neural networks, and machine learning has enabled the development of artificial intelligence (AI), which is defined as systems that can perceive, learn, and solve problems [1, 2].AI can revolutionize workplaces [3], act as disruptive innovation [4]. As a key component of the fourth industrial revolution, AI may also drive a transformation in education, with AI education already being incorporated into school curricula [5, 6]. However, like earlier technologies, such as television and computers, it may enhance access to information without fundamentally changing educational practices, and educators are thus

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encouraged to explore ways to optimize learning experiences. AI is being promoted for its strategic value in education [7]. According to Loeckx, it has the potential to be an effective learning tool, reducing the workload of both teachers and students while providing enhanced learning experiences for students [8]. This potential is rooted in its long history of integration into education,dating back to the 1950s, when it garnered limited interest[3].

AI gained traction in the 1970s and the 1980s with advancements in computing technology [1].Prior to this, early applications of AI in education began to take shape in the 1960s with the introduction of computer-assisted instruction.Additionally, by the late 1960s, natural language processing had emerged as one of the first machine learning systems [4].In the 1970s, the development of multimedia learning resources, simulations, and tutorials further showcased AI's potential of AI to revolutionize teaching and learning experiences [1].By the 1990s, the introduction of learning analytics and intelligent tutoring systems had enabled more personalized and active learning approaches [1, 5].Furthermore, global investments in AI education, such as China's national AI development plan and South Korea's dedicated efforts to cultivate AI talent, emphasize the growing recognition of AI's role in preparing students for the workforce of the future [7]. Similarly, the European Union and the U.S. have made strides in promoting AI in education, focusing not only on enhancing learning but also on addressing equity issues [8].

Together, these advancements highlight the transformative power of AI in shaping the future of education globally.
AI technology holds significant promise for nursing education, particularly for the development of advanced simulations that enhance students' critical thinking and prepare them for real-world patient care.These simulations created realistic scenarios, allowing students to practice clinical skills and decision-making in a safe and controlled environment.As AI continues to advance, these simulations will become increasingly sophisticated, offering immersive and interactive learning experiences and the benefits of AI integration in nursing education, such as interactive learning opportunities and time-saving efficiencies.However, these advancements also have potential risks that necessitate a cautious and ethical approach.Tools such as the ChatGPT, Gemini, Claude, Perplexity, etc., for instance, raise concerns about academic integrity and intellectual property theft.To fully harness the benefits of AI, it is essential to implement these technologies with proper guidelines to ensure ethical and responsible use[2,7].

The integration of AI technology in nursing education has the potential to revolutionize the field, as follows:

- Providing Personalized Learning Experiences: Tailoring education to meet individual student needs, thereby enhancing the learning experience.
- Improving Efficiency and Outcomes: Streamlining educational processes to boost learning efficiency and effectiveness.

It is equally important to address the challenges associated with AI:-

- Addressing Ethical and Legal Concerns: Carefully consider issues such as privacy, security, bias, and adherence to professional standards.
- Promoting Continued Research and Innovation: Exploring best practices for incorporating AI technology while evaluating its impact on student learning and program effectiveness.

Current uses of AI in Nursing:-

Numerous scholars have applied AI systems to address various clinical challenges, such as virtual consultations, brain tumor feature identification, community healthcare systems, predictive modelling, and medical diagnostic systems, etc., as shown in Table 1.

Table 1: List of AI based Medical Diagnostic System

Contribution	Reference
AI system to analyze multimodal magnetic resonance images for brain tumor features identification.	Li et al. (2016) [9]
Community healthcare system reducing missing data.	Wang et al. (2018) [10]
Virtual counseling AI for nursing communication skills training.	Shorey et al. (2019) [11]
AI-based medical diagnostic system for breast cancer detection.	West and West (2000) [12]

AI prescriptive and predictive analytics improving inpatient care management and reducing nurse workload.	Moreno&Fergusson et al. (2021) [13]
AI standardized electronic handover system for pediatric patient safety and quality improvement.	Zhou et al. (2022) [14]
AI technology-based medical information processing for emergency first aid nursing management.	Liu et al. (2022) [15]

In addition to addressing clinical challenges using AI, researchers have explored the application of AI in nursing through systematic reviews.Ng et al. [16] and Seibert et al. [17] conducted scoping reviews to examine AI's role of AI in various aspects of nursing including documentation, diagnosis formulation, care planning, patient monitoring, care prediction, and wound management.Similarly, Von Gerich et al. [18] analyzed issues, such as identifying potential AI users and target patient groups in nursing.

Revolutionizing Education:-

AI has been employed in various areas of education, especially nursing, focussing on personalized learning, intelligent tutoring systems, adaptive learning platforms, and automated grading systems.These technologies reshape the educational landscape by providing customized learning experiences, reducing administrative burdens, and improving instructional methods.

Table 2: Represents the applications of AI in various fields of education

Use of AI	Description
Personalized Learning	AI generates instruction to meet individual students' learning styles, improving outcomes and engagement [19].
Intelligent Tutoring Systems	AI-powered tutoring systems adapt to students' needs in real-time, offering personalized support [20].
Adaptive Learning Platforms	AI adjusts content and pace based on student performance, creating a more personalized learning environment [20].
Automated Grading Systems	AI automates grading, providing instant feedback and reducing teachers' administrative workload [21].
Reshaping Teaching Methodologies	AI analyzes data to provide insights on student performance, helping teachers improve instructional strategies [22].
AI-powered Analytics	AI identifies patterns in student performance, enabling data-driven decisions in teaching and learning strategies [22].
Optimizing Administrative Processes	AI improves efficiency in administrative tasks like student assessment and lesson planning, saving teachers' time [23].
Enhancing Learning Experiences	AI creates more engaging, tailored educational experiences, fostering greater student motivation and academic growth [24].
Automating Routine Tasks	By automating tasks such as grading and lesson planning, AI allows teachers to focus on more meaningful interactions [21].

Improvement in Nursing Education using AI:-

The following subsections discuss the various aspects of AI and how they can benefit nursing education.They provide detailed descriptions of personalized learning, natural language processing, generative AI, etc.

Personalized Learning:-

Personalized education has been a long-standing goal in educational practice and theory, with educators and policymakers advocating it as a solution to closing achievement gaps, improving student motivation, and enhancing overall instruction.Broadly defined, personalization involves adapting instructions to individual learners, in contrast to traditional methods aimed at whole groups. By tailoring the mode, content, or pace of learning based on a student's unique needs, educators aim to address weaknesses and enhance learning opportunities [25].One significant argument for personalized learning's effectiveness stems from research showing that one-on-one tutoring can lead to gains up to two standard deviations higher than traditional classroom teaching [26].This challenge of scaling one-on-one tutoring's effectiveness for larger groups is known as the 2-sigma problem in educational psychology [27].Although more recent studies have reported smaller effects [28], the pursuit of bringing personalized benefits to broader classrooms continues to be a central focus of research and educational innovation [25].

AI is transforming education by offering personalized learning experiences that cater to individual students' needs.AI-powered adaptive learning systems use algorithms to analyze student performance data such as quiz scores and learning progress to create customized learning paths.These systems provide personalized instruction and support, ensuring that students receive the correct level of challenge and assistance.One of the key features of these systems is their ability to tailor learning materials according to each student's learning style and pace.For students struggling with specific concepts, the system offers additional resources, whereas advanced learners provide more challenging materials. This personalized approach enhances student engagement, motivation, and academic performance. Another benefit of AI-powered systems is their ability to provide immediate feedback, allowing students to quickly identify their strengths and areas needing improvement.Educators also benefit from AI's data-driven insights, enabling them to track progress more effectively and intervene early, when necessary [29]. AI also helps accommodate diverse learning styles, addressing individual student needs while alleviating resource constraints in education [30]. For students in remote areas, AI creates virtual learning environments that simulate hands-on experiences and provide valuable educational opportunities [31].

Simulation and Virtual Reality (VR) in Education:-

Simulation-based learning is a widely recognized method in nursing education that offers hands-on experience without the need for clinical placement. Skills labs allow repeated practice of psychomotor skills using various technologies, from low- to high-fidelity simulations, such as mannequins and role-play, to enhance clinical skills and decision-making. These simulations provide a safe environment for practicing complex nursing tasks and mitigating patient-safety risks [32].However, traditional simulations have limitations, such as high costs, space and resource demands, and the need for physical interaction, which pose infection risks [33].Virtual Reality (VR) is emerging as an alternative that offers affordable, resource-efficient, and contactless learning opportunities that are not time- or location-bound, with benefits for pandemic education.VR provides immediate feedback and low-risk learning; however, there is often confusion regarding the correct use of VR terminology [34].VR's immersive nature of VR, defined by its ability to stimulate multiple senses, enhances learners' presence in the virtual environment.Although VR has a long history in medical education, its adoption in nursing is still in its early stages.Further research is required to explore its potential in nursing education [32].

Data Analysis and Predictive Analytics:-

AI health technologies (AIHTs) are becoming popular in healthcare because they can analyze large amounts of research and patient data, which helps improve decision making.Data analysis plays a key role in this process, allowing the identification of important patterns.Machine learning (ML) is an important part of AI that mimics how humans make decisions using algorithms.Predictive analytics uses ML to examine data patterns and is becoming increasingly important in clinical settings.AI-powered decision support systems are now helping nurses make better clinical decisions based on these data.As these technologies advance, they are expected to greatly change nursing practices over the next decade [35].

Natural Language Processing (NLP):-

Natural Language Processing (NLP) models have been evolving since the 1950s; however, they have gained significant attention in the last decade owing to advancements in deep learning and large datasets.In higher education, these models are becoming increasingly relevant, enabling personalized learning, on-demand support, and innovative teaching methods.Notable examples include ChatGPT using OpenAI and Google Bard, which can generate human-like responses to various academic prompts.Their popularity in early 2023 highlights their potential

to enhance student learning across different contexts such as language learning and research.NLP models also offer personalized study recommendations by analyzing vast amounts of textual data and can be utilized to create chatbots and virtual assistants for real-time student support. Overall, NLP technology is poised to significantly aid students in their academic pursuits [36].

Generative AI:-

Generative AI (GAI) has significantly transformed educational practices in the 21st century, driven by advancements in technology and machine learning. It encompasses models that generate new content, such as images, text, audio, and video, by analyzing existing digital materials to understand their patterns and distributions.Two prominent techniques within GAI are Generative Adversarial Networks (GANs) and generative pretrained transformers (GPT).GANs consist of two neural networks: a generator, which creates synthetic data (such as images), and a discriminator, which evaluates the authenticity of these data.The process continues until the discriminator can no longer distinguish between the real and synthetic content [37].GANs are widely used in applications such as voice generation, graphics, and video production [38].The study by Linh Duc Tran et al. [39] highlighted the relevance of GAI, particularly DALL-E, in nursing education.This demonstrates that GAI has significant potential to enhance visual storytelling and bridge gaps in educational content. While these tools provide cost-effectiveness and accessibility, they also present challenges, including text-related errors, misinterpretation of user prompts, and legal concerns.Ultimately, GAI models like DALL-E offer promising solutions for improving visual narratives in nursing education. However, successful integration necessitates a collaborative approach, in which educators engage with these tools as co-pilots.By leveraging the capabilities of GAI while addressing its potential drawbacks, educators can fully harness its potential to enrich learning experiences by compelling visual narratives.

Clinical Decision Support:-

Research has indicated that integrating AI into healthcare offers numerous advantages.It can aid disease diagnosis, interpret patient clinical data, assist in selecting treatment plans, automate surgical procedures, perform risk stratification for primary prevention, and enhance clinical decision-making.In certain domains, AI has demonstrated performance comparable to that of human experts, particularly in areas such as serum analysis, drug–drug interaction alerts, radiology image review, melanoma diagnosis via dermoscopy, and evaluation of fundus photographs for diabetic retinopathy.Clinical decision support (CDS) tools that utilize AI can provide timely information to improve patient care, assist healthcare teams by streamlining routine tasks, filter relevant information, and alert professionals to potential issues. These applications have been shown to positively affect patient outcomes and overall healthcare quality [41].

Remote Learning and Telehealth:-

The use of telehealth in nursing has several positive effects, including reducing the carbon footprint, improving resource efficiency, and enhancing patient outcomes. By minimizing the need for patient travel to healthcare facilities, telehealth significantly lowers carbon emissions associated with transportation. Additionally, AI in telehealth enables more efficient use of healthcare resources by predicting health risks, allowing for early intervention and reducing the need for costly, resource-intensive treatments.This approach also improves patient outcomes through personalized care plans, particularly for chronic condition management, which helps reduce hospital visits and emergency department admissions.Telehealth also enhances access to health care, especially for individuals in rural or remote areas, thereby promoting greater equity in care availability. The integration of telehealth has implications for nursing education, necessitating that nursing students become proficient in telehealth technologies, including skills related to remote patient assessment, digital communication, and the application of AI in healthcare decision-making [42].

Enhancing Time Management Skills for Improved Nursing Performance:-

Nurses face significant challenges in managing their time effectively, which directly affects their ability to provide optimal care.A study [43] highlighted how time constraints force nurses to prioritize tasks such as medication distribution over more comprehensive patient care.Saintsing et al. [44] found that 80% of entry-level nurses admitted to making errors due to time pressure, underscoring the importance of efficient time management.Time-wasting behaviors such as engaging in non-essential activities and poor task organization further reduce productivity and work performance. Studies have shown that ineffective time management results in missed nursing care, increased stress, and lower job satisfaction [45].Knezevic et al. [46] revealed a strong correlation between poor time management and decreased job satisfaction, while Ozkan and Timbil [47] linked it to medication errors and missed

nursing care.Training programs aimed at improving time management skills are recommended, as they can enhance job satisfaction and reduce stress. Numerous studies affirm that time management interventions improve organizational skills, reduce work-related stress, and ultimately elevate the quality of care provided by nurses [43] [40].Thus, effective time management is not merely a goal to be achieved; rather, it is a habit that can be cultivated and refined through experience and practice to handle diverse tasks efficiently.This habit should be nurtured early on, starting during one's education, as an individual's time management behavior during their educational years profoundly influences their workplace performance.In this context, AI has emerged as an effective strategy for equipping students with better time management skills, as demonstrated by numerous case studies. GAI applications have proven valuable in enhancing student behavior and decision-making across multiple areas. Through ML, these systems can analyze large datasets and provide tailored recommendations to boost student productivity and optimize resource use. Specifically, AI-powered time management tools can assess a student's past performance and scheduling habits to generate personalized timetables that maximize efficiency and minimize downtime [48].

Challenges in Contemporary Nursing Education and use of AI:-

The study conducted by Ashrafal Sadat Hakim (2020) [49] highlights the key challenges faced in nursing clinical education, particularly from the perspectives of nursing educators and students.Clinical education is crucial for nursing students to develop practical skills necessary for patient care.However, both students and educators face several challenges.

1. **Influence of Nurses**: Nurses in clinical settings have both positive and negative impacts on students' learning experiences. Students benefit from their mentorship but can be hindered by the complexities of patient care in busy environments.
2. **Crowded Clinical Environments**: Clinical education in crowded and complex settings, where patient care is prioritized, creates challenges for effective learning. Students often struggle to balance their learning with the demands of these environments.
3. **Concern over Clinical Education Quality**: Nursing students expressed concern about the effectiveness of their clinical education.Poor implementation of clinical education can hinder future professional goals and overall readiness for practice.
4. **Shortage of Nurses**: There global shortage of nurses, who are needed to be present physically with the patients for care, with low- and middle-income countries(LMIC) particularly affected.Recruitment into nursing is challenging because of the emotional, physical, and mental demands of the specialty.
5. **Lack of Expert Faculty**: There scarcity of specialized nursing faculty worldwide, particularly in LMICs.Nurses need to be trained by experienced professionals from their own fields, such as pharmacists in pharmacology, rather than by physicians, who may lack in-depth knowledge of nursing practices.Even High-Income Countries (HICs) such as Singapore face a shortage of qualified faculty, particularly those with doctoral degrees.International collaborations can address these faculty shortages through academic and research capacity-building programs.
6. **Social and Cultural Factors**: Cultural taboos and stigmas surrounding cancer can discourage nurses from working in or specializing in this field. Beliefs about cancer treatment also impact nurses' willingness to care for cancer patients, posing additional challenges in recruiting and retaining nurses.
7. **Cost of Specialized Education**: The cost of advanced education is another barrier, particularly in LMICs, where funding and resources for specialized nursing programs are limited. Even where training is available, the cost can be prohibitive for many nurses to pursue specialized qualifications

Nursing education faces several pressing challenges that hinder the preparation of competent nursing professionals.One significant issue is the misalignment between educational programs and the rapidly evolving practice environment, particularly in complex healthcare systems where funding is fragmented and technology integration is advancing quickly.Additionally, a persistent shortage of qualified nursing faculties affects the quality of education and mentorship available to students.While curricular enhancements are necessary to keep pace with healthcare innovations, many nursing programs struggle to incorporate relevant content and modern teaching methodologies that reflect the current clinical demands.Cultural diversity in nursing education poses another challenge, as educators must effectively address the needs of an increasingly diverse student body, while fostering an inclusive learning environment.Economic barriers, such as high tuition costs and limited access to nursing programs in rural areas, further complicate the efforts to recruit and retain nursing students.Moreover, the integration of technology in education presents challenges in balancing traditional caregiving practices with modern technological tools, ensuring that future nurses are equipped to provide holistic and compassionate care in an increasingly advanced healthcare landscape [51].AI is not a one-step solution to all of these global challenges, but it

can play a significant role in addressing them and improving the situation.For instance, implementing AI in bridging programs can help support both academic and clinical practice environments.Establishing academic-practice partnerships with a wide range of community organizations and healthcare providers offers nursing students broader learning opportunities.While faculty may traditionally view an ideal clinical training environment as one in which students are paired with instructors in a one-to-one ratio, partnerships with hospitals and various clinical settings can offer invaluable learning experiences, where AI can further enhance training through data-driven insights and decision support.

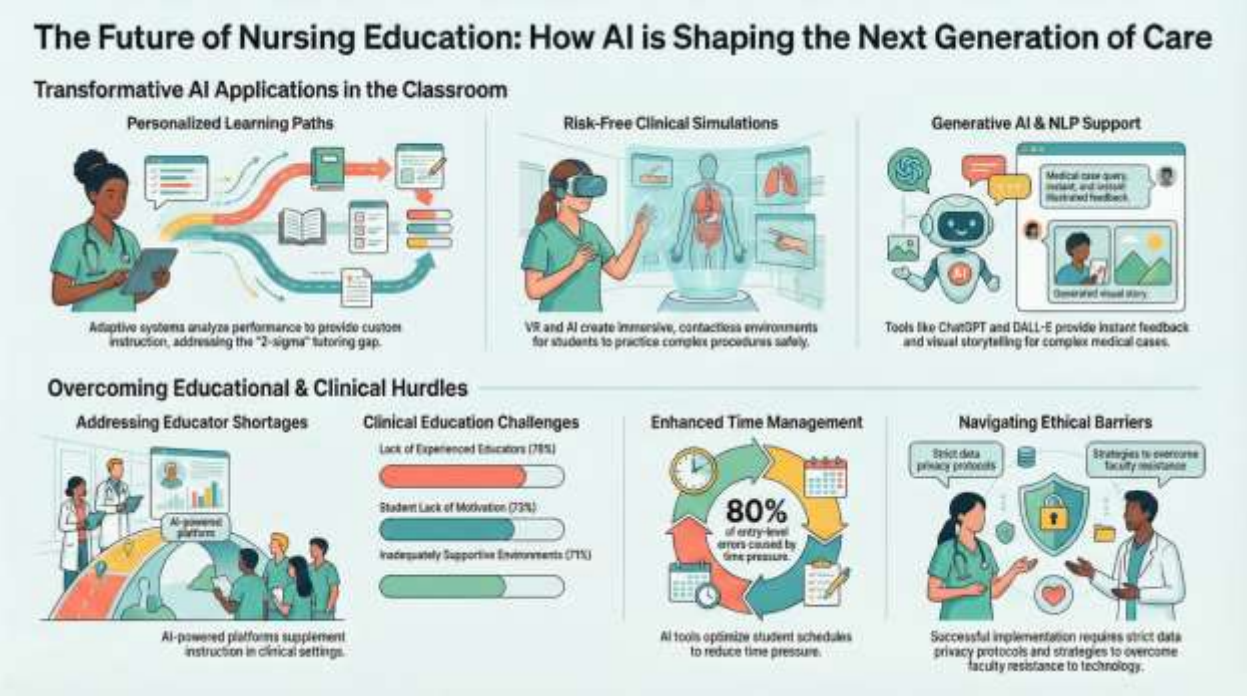
Other solutions such as internships and simulation-based learning can also benefit from AI integration by offering personalized feedback and helping students navigate complex clinical scenarios.AI is not meant to replace current educational solutions, but rather to complement and enhance them, serving as a supportive tool that can improve the overall learning experience and efficiency of nursing education.Although AI may not play a superhero role, it can certainly act as a valuable supporting element that enriches various educational strategies.The integration of AI in nursing education presents several challenges. Privacy and security are major concerns because AI requires access to personal data, making it crucial to have strong measures in place to protect student information and prevent breaches.Ethical issues, such as data bias and increased inequalities, also require attention to maintain professional standards.Resistance to adoption is common, as faculty members may fear increased workloads, a steep learning curve, or that AI might replace human educators.It is essential to ensure that AI supplements, not replaces, human interaction, critical thinking, and creativity, key elements of nursing education.Educators need proper training and support to understand AI's capabilities of AI and use them effectively in teaching.The implementation of AI tools involves high costs related to software, hardware, and infrastructure, which can be challenging for institutions.However, securing adequate funding through resource reallocation, grants, and partnerships with the industry can help address these financial challenges.Collaboration among instructional designers, nurse educators, and AI researchers can help create a balanced approach that maximizes AI's benefits of AI while preserving human interaction. These efforts can ultimately enhance nursing education, producing skilled and compassionate nurses ready to deliver high-quality care in an evolving healthcare environment [52].

Conclusion:-

In conclusion, the integration of AI into nursing education offers tremendous transformative potential by addressing key challenges and enhancing the overall learning experience of future nurses. AI technologies, such as personalized learning, virtual simulations, predictive analytics, natural language processing (NLP), generative AI, and clinical decision support, hold the promise of revolutionizing nursing education, much like their impact on other fields. AI-powered personalized learning systems can adapt to individual student needs, thereby improving motivation, engagement, and academic outcomes. Through immersive simulations and virtual reality (VR), students can practice clinical skills in safe environments free from the limitations of traditional training methods.Moreover, data and predictive analytics can assist in decision-making by providing valuable insights into complex clinical scenarios.NLP tools offer personalized support and enhance learning outcomes, while generative AI adds value by enabling creative visual storytelling in educational contexts.AI-powered clinical decision support also enhances patient care by aiding in diagnosis and treatment planning.Additionally, the growing adoption of telehealth and remote learning technologies has expanded access to healthcare and education, particularly in underserved areas. AI-powered time management tools help nursing students develop effective strategies for managing workloads, which directly impacts job performance and the quality of patient care.

However, the adoption of AI in nursing education must address challenges, such as data privacy concerns, ethical considerations, resistance from educators, and financial constraints related to infrastructure.Overcoming these issues will require strategic investment, proper training, collaboration among stakeholders, and commitment to preserving the core human elements of nursing education, such as critical thinking, empathy, and creativity.By adopting a balanced approach, AI can significantly enhance the efficiency and quality of nursing education, ultimately preparing skilled and compassionate nurses to meet the needs of an evolving healthcare landscape.Although AI is not a superhero that can solve all the challenges faced by nursing education, it can play a valuable supporting role.When incorporated thoughtfully, AI can enhance and improve various areas and complement traditional approaches to produce more effective outcomes.

Graphical Abstract:-



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The graphical abstract image above was created by using Notebook L

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