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ICT & Generative Artificial Intelligence
Powered Hybrid Model for Future Education

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Abstract

The Hybrid Model, powered by Information and Communication Technology (ICT) for future education, enriched with Generative Artificial Intelligence (GAI), stands today as an advanced educational learning model. It ingeniously combines the strengths of ICT and generative AI to reshape the educational experience. Numerous academic institutions and organizations are embracing this transformative approach, harmonizing traditional classroom methods with state-of-the-art technologies and AI-driven innovations. In this study, we present an in-depth exploration of this novel ICT-powered hybrid model boosted by generative AI, dissecting its intricate components. We endeavor to unravel the advantages it bestows upon both students and educators, attempting to answer the pivotal question: what added value does this hybrid model bring to education? We embark on a meticulous enumeration of the diverse challenges encountered along the path of implementing this modern model. Additionally, we underscore the critical considerations that stakeholders must consider when deploying this educational evolution effectively.

1. Introduction

Information and Communication Technology (ICT) refers to technologies that facilitate the creation, storage, processing, and exchange of information. It encompasses a wide array of technologies and tools (software and hardware) designed to manage and communicate information. Its role in modern society is pivotal, influencing various aspects of daily life, including business, healthcare, and education. ICT serves as the backbone of the digital age, enabling data transmission, storage, and processing, ultimately shaping the way individuals and organizations operate in the 21st century (Roztocki, Soja, and Weistroffer 2019). In education, ICT plays a transformative role by providing access to vast resources, fostering collaborative learning, and expanding the reach of education beyond traditional classrooms (McDougall and Jones 2006).

In the context of education, ICT encompasses a diverse range of technologies. This includes hardware like computers, tablets, and interactive whiteboards, which serve as conduits for software applications and educational content. Educational software and platforms enable teachers and students to engage in interactive lessons, simulations, and

assessments. Communication tools, such as video conferencing and learning management systems, facilitate remote learning and collaborative projects, extending the boundaries of the physical classroom (Anderson and Dexter 2005).

ICT integration in education has already led to significant improvements in access, collaboration, and personalized learning, as well as in research and innovation (Wernsdorf, Nagler, and Watzinger 2022). The impact of ICT on education is profound. It is revolutionizing teaching methodologies and reshaping the learning experiences of students. The integration of ICT in the educational landscape is fostering an environment that not only facilitates learning but also empowers learners with a set of distinct advantages over traditional methods (Amutha 2020). One of the key advantages of ICT-enhanced learning environments is their ability to cultivate active and participatory learning experiences. Through digital tools and platforms, students are no longer passive recipients of information but are actively engaged in the learning process. This interactivity fosters a dynamic exchange of ideas and encourages critical thinking and problem-solving skills. Furthermore, ICT fuels creativity by providing learners with tools to express their ideas and explore their artistic inclinations. Digital platforms enable students to unleash their creative potential, whether it is through multimedia projects, digital art, or innovative storytelling. ICT also supports integrative learning, as it allows learners to explore a wide range of resources and perspectives. They can seamlessly access digital libraries, research databases, and online courses, enabling a holistic understanding of subjects and issues. ICT empowers evaluative learning by providing tools for assessments and feedback. Students can receive immediate insights into their performance, allowing them to self-assess and refine their understanding of the material. Teachers, too, benefit from data-driven insights to tailor instruction to students' needs.

Collaboration is another area where ICT shines. It promotes collaborative learning, enabling students to work together irrespective of their physical location. This interconnectedness expands the possibilities for group projects, peer learning, and knowledge sharing, enhancing the overall educational experience. In fact, research collaboration platforms have become increasingly vital in the academic world, fostering global connections among researchers and educators. Platforms like ResearchGate, Academia.edu, and Web of Science provide essential tools for sharing research findings, collaborating on projects, and staying up-to-date with the latest developments in education and beyond. Researchers use these platforms to disseminate their work, gain exposure, and connect with peers, thereby enhancing the collective knowledge base in the field. These platforms are transforming the way educational research is conducted and shared, promoting a culture of open collaboration and accelerating the dissemination of knowledge (Joshi et al. 2019).

Generative AI, a subset of artificial intelligence, focuses on creating content, including text, images, and even educational materials. Generative AI models, like ChatGPT, Bard, Claude, and Synthesia can generate human-like text and responses, making them valuable for educational content creation. AI-driven systems can provide personalized recommendations, analyze student performance, and support adaptive learning. Today, generative AI is poised to revolutionize the education sector by offering innovative solutions to long-standing challenges. This subfield of artificial intelligence focuses on creating intelligent systems/

models capable of generating content, including text, images, and more, with human-like fluency and creativity. In education, generative AI presents a range of applications, from personalized content creation and adaptive learning to intelligent tutoring systems and automated grading. Its ability to tailor educational materials to individual student needs, enhance engagement, and streamline administrative tasks holds great promise for the future of education. However, as with any transformative technology, there are also ethical considerations, such as data privacy and potential bias in algorithms, that necessitate careful exploration and regulation. As generative AI continues to advance, it is increasingly becoming a vital tool in the quest to deliver high-quality, tailored education to learners of all ages and backgrounds. Research in this field is evolving rapidly, with educators, researchers, and technologists working together to unlock its full potential (Ifenthaler and Schumacher 2023) (Tapalova and Zhiyenbayeva 2022).

However, generative AI comes with several problems, such as cheating in exams (Johnson 2023), plagiarism, data privacy, etc... That led the World Economic Forum and AI Commons to share a common objective and publish some guidelines for using generative AI. These guidelines, a collective effort involving 100 thought leaders and practitioners convened at a global summit in April 2023 (North), revolve around three pivotal themes: promoting responsible technology development, fostering international cooperation, and advancing societal progress, which includes transformative shifts in education.

In addition to the publication of UNESCO's guidance for generative AI in education and research in September 2023, this guidance represents the first-ever global guidance on generative AI in education and research, designed to address the disruptions caused by generative AI technologies and to regulate their use in education (UNESCO).

2. Key Components of the Model

The Hybrid Model of education, boosted by ICT and GAI, is characterized by different key components that work in concert to create a dynamic and effective learning environment. At its core, the model relies on cutting-edge online learning platforms, which serve as the digital backbone of the educational experience. These platforms house a wealth of educational content, resources, and assessments readily accessible to both students and instructors, promoting convenience and accessibility.

Furthermore, the incorporation of virtual classrooms plays a very important role in the hybrid model. These virtual spaces facilitate real-time interaction between students and teachers, transcending geographical boundaries and enhancing engagement and collaboration.

One of the innovative aspects of the hybrid model is the use of AI-powered content creation. Generative AI technology is harnessed to craft, customize, and adapt educational materials, including textbooks, quizzes, and assignments. This adaptive approach ensures that learning resources are tailored to individual student needs, ultimately enhancing the learning experience.

Data analytics tools constitute another integral element. By meticulously tracking student progress, these tools enable educators to identify learning gaps, thereby paving the way for

the creation of personalized learning pathways. In doing so, the model strives to address the diverse educational needs of students, promoting more effective and efficient learning.

Finally, the hybrid model thrives on blended learning, a methodology that combines in-person and online learning. This combination offers students flexibility in their educational journey, allowing them to navigate the learning process at their own pace while enjoying the benefits of a personalized and interactive learning experience. In essence, the hybrid model leverages these key components to create a 21st century educational framework that caters to the diverse needs of learners, embracing technology and innovation to enrich the educational landscape.

3. Advantages of the Model

The Hybrid Model of education, blending both in-person and online learning approaches, offers a multitude of advantages that have revolutionized the educational landscape. These benefits range from increased accessibility and flexibility to enhanced personalization and engagement. In this discussion, we will explore the different advantages that make the Hybrid Model a compelling choice for modern education.

3.1. Accessibility

The ICT-hybrid model can make education more accessible by removing geographical and physical barriers. It allows students from various locations and backgrounds, including those with disabilities, to access educational resources. For instance, Massive Open Online Courses (Anon) are a prime example of accessibility. Platforms such as Coursera (*Coursera*), Udemy (*Udemy*), and edX (*EdX*) offer a wide range of courses, allowing learners from around the world to access high-quality educational content, often for free or at a low cost. In fact, some universities and academic institutions offer a traditional course alongside a fully online version of the same course or other courses. They can compare enrollment, student demographics, and outcomes to assess the accessibility and impact of the online offering.

In France, the Ministry of National Education and Youth has created a MOOC, which is offered on the "FUN" platform (France Université Numérique) (*FUN MOOC*), made available to French higher education institutions and their academic partners worldwide. All courses on FUN are developed by professors from French universities and schools in collaboration with their international academic partners. Students and online learners can engage with these courses interactively and collaboratively at their own pace.

3.2. Personalization

Generative AI and personalized learning platforms can adapt content to individual student needs, creating tailored learning experiences that cater to different learning styles and abilities. For instance, adaptive learning software like DreamBox (*DreamBox Learning*), used in K-12 education, personalizes math instruction. The platform adjusts the difficulty of math problems based on a student's performance and adapts the curriculum accordingly.

Many schools and universities, such as ECE—Paris Graduate School of Engineering, in France, provide their students with multiple online courses to enhance their skills in math

and physics (Anon, Anon). This has been conducted for a couple of years; however, at ECE-Paris, conducting online courses has become mandatory since the pandemic to ensure that the students have the necessary background to start the engineering program. In fact, professors have observed that the general level of students has decreased dramatically because of the pandemic. High schools were not prepared for the sudden disruption of teaching. Most of the schools were not equipped with digital and online courses, neither were the students (Plakhotnik et al. 2021). In addition, students can customize the online courses by choosing different modules according to their levels and needs. These platforms are accessible 24/7, so the students can get back to them at any time.

In fact, in March 2023, the European Expert Network on Economics of Education (EENEE) published a report on how COVID-19 has affected the learning outcomes of students. The report (De Witte, François, and European Expert Network on Economics of Education 2023) covers the research developed in this field in many European countries between 2020 and 2022 such as the UK, France, Belgium, Italy, Denmark, Sweden, Spain etc... The key findings of this report are the following:

- The repercussions of the COVID-19 crisis on educational outcomes presented a multifaceted landscape. The effects ranged from minimal disturbances in some countries to substantial adverse consequences witnessed in others.
- The detrimental impact of the pandemic on learning achievements was notably amplified in countries where the physical closure of schools persisted for extended durations.
- Nations that had already made substantial progress in digitalization and the widespread adoption of information and communication technologies in education prior to the pandemic encountered relatively milder disruptions.
- Students facing pronounced socio-economic disadvantages experienced more significant setbacks in their learning, prompting concerns regarding the pandemic's impact on educational equity.

These observations represent a kind of evidence of the importance of digital resources and online learning in education (Hongsuchon et al. 2022) (Gopal, Singh, and Aggarwal 2021) and the data were collected from 544 respondents through online survey who were studying the business management (B.B.A or M.B.A. However, it is worth noting that the lockdown and the transition from traditional in-person classrooms to virtual online learning had profound physical and psychological effects on students. This shift amplified the incidence of psychological stress, anxiety, and depression among university students. Hence, it is crucial to offer students training that can shift their perspective on the educational experience, potentially reducing feelings of depression and stress-related growth. Additionally, there is a necessity to explore improved virtual teaching techniques to alleviate students' anxiety and apprehension regarding learning and exams (Azmi, Khan, and Azmi 2022; Bangert 2004).

On the other hand, language learning apps have embraced the potential of artificial intelligence (AI) to offer highly personalized and effective language instruction. For instance, popular apps like Duolingo (Anon) tailor language lessons by adapting to the learner's proficiency level, and providing customized exercises and feedback. Babbel (Anon)

personalizes instruction based on the user's native language, goals, and previous progress. Rosetta Stone (Anon) employs AI to assess pronunciation and adjusts exercise difficulty according to the learner's performance. Memrise (Anon) adapts its content to individual learning styles, utilizing mnemonic techniques and customized lessons. Tandem Language Exchange (Anon) matches users with compatible language exchange partners for real conversation practice using AI. Similarly, HelloTalk (Anon) utilizes AI to identify areas for improvement and recommends personalized lessons based on chat interactions with native speakers. These language learning apps harness AI to enhance the learning experience, making language acquisition more accessible and engaging for users.

Several educational institutions and organizations use advanced algorithms to craft customized learning materials. Carnegie Mellon University (Anon), for instance, has embraced AI-generated textbooks and study resources, ensuring that the content caters to individual student needs and aligns with specific curricula. This has been offered by the Human-Computer Interaction Institute (HCII) (Anon). Georgia Tech (Anon) has similarly integrated AI-generated quizzes and assignments into certain online courses, ensuring that assessments are directly in line with the course's learning objectives. Scribe (Anon), as a platform, employs AI to generate personalized notes and study materials, adapting to students' unique learning styles and preferences. Additionally, organizations like OpenStax (Anon) are utilizing AI to develop open educational resources, such as textbooks, making education more affordable and accessible to a broader range of students. These examples illuminate the expanding role of AI in generating educational content, enhancing customization, and aligning materials with specific educational goals, ultimately enriching the learning experience and outcomes.

3.3. Engagement

ICT tools and virtual classrooms can enhance student engagement by offering interactive, multimedia-rich content and facilitating collaboration among students.

Virtual reality (VR) in education is an excellent, engaging technology (Oyelere et al. 2020). Educational Institutions can create virtual field trips, lab simulations, and immersive learning experiences. As a kind of experiment, a school or university can experiment with VR technology in history classes. They can measure student engagement, knowledge retention, and overall interest in history using VR compared to traditional methods. For instance, students can explore ancient history using VR tours of historical sites. Novel methodologies for designing virtual environments (VEs) hold the promise of making valuable contributions to the education and understanding of history (Gibson et al. 2022; YILDIRIM, ELBAN, and YILDIRIM 2018).

Many universities and institutions have procured recently what we call VR laboratories, particularly during the pandemic. The VR laboratory offers a secure and unhindered environment for students to access laboratory equipment and conduct experiments. This minimizes the impact of potential errors made by students and enhances the user experience by enabling experiments to be repeated from various perspectives, including some that are unattainable in a physical laboratory because of the pandemic and disabilities of a simple

incapacity (Antonelli et al. 2023; Bashabsheh, Alzoubi, and Ali 2019; Kapilan, Vidhya, and Gao 2021; Román-Ibáñez et al. 2018; Schluse, Priggemeyer, and Roßmann 2020; Shakirova, Al Said, and Konyushenko 2020).

Regarding AI-based applications in early childhood education, there are a multitude of applications and platforms that are playing a pivotal role in fostering cognitive development and early literacy among young children. For example, applications like Homer (Anon) are designed to cater to children aged 2 to 8 by using AI to deliver age-appropriate activities, stories, and games that support early literacy skills. Osmo (Anon) is another interactive educational platform which employs AI to adapt content to each child's proficiency, ensuring a balance between engagement and challenging activities while nurturing early cognitive development. With respect to the school level, Kiddom (Anon) utilizes AI to assess student performance and recommend content tailored to the developmental stage, benefiting early learners. Speakaboos (Anon), an early literacy platform, personalizes reading experiences for children with interactive stories and activities that adjust difficulty levels and content based on individual progress. Similarly, ABCmouse (Anon) harnesses AI to provide a personalized curriculum for children aged 2-8 offering activities, books, and games that promote cognitive development and early literacy skills. These are just some applications among many that highlight how AI is enhancing early childhood education by customizing content to each child's skill level and learning pace, thus delivering engaging and tailored experiences to promote cognitive growth and literacy.

Other crucial tools that capture the attention of the students and provide them with the responses to their questions in a rapid and specific manner are AI-powered chatbots and virtual assistants. These chatbots have become indispensable tools for student support services across educational institutions. Examples include "Pounce" at Georgia State University, which offers personalized assistance in areas like course selection and academic support, while UC Berkeley's "Bear Chat" streamlines admissions and financial aid inquiries. Arizona State University employs "Ask Angie" to ensure students are informed about crucial dates and academic resources, while San Jose State University's "Rosie" assists with enrollment and academic advising. EdTech companies like "AdmitHub" provide AI-driven chatbots that guide students through the college application process, addressing admissions queries, financial aid concerns, and scholarship opportunities. Furthermore, the Paris Academy has introduced a virtual assistant, "Déa" (Anon), to assist students in their inquiries related to school assignments, specific programs, financial aid, and enrollment. These AI-driven solutions ensure that students have quick access to information and support, making their educational journeys more manageable and efficient.

And today, we have AI generative tools such as ChatGPT that play a vital role in education through their capacity to provide personalized, accessible, and scalable support to learners. For instance, a high school student struggling with a complex math problem can turn to ChatGPT or an equivalent tool for an immediate and detailed explanation, enhancing their understanding and problem-solving skills. In a different scenario, a college student studying history might use these AI generative tools to receive additional insights into a specific historical event, broadening their knowledge and facilitating independent research.

Furthermore, AI generative tools' versatility shines in various subjects. A biology student can seek clarification on a challenging concept, while an aspiring writer may request guidance on improving their essays, demonstrating its cross-disciplinary applicability. The 24/7 availability of these tools ensures that students can access support at their convenience, whether they are studying late at night or during the day. This accessibility fosters self-directed learning, empowering students to take charge of their educational journeys.

One should mention that AI generative tools are not limited to aiding students; they also assist educators in content creation. For example, a teacher can use them to generate custom quizzes, brainstorm lesson ideas, or receive additional explanations for their instructional materials, ultimately saving time and enhancing their teaching resources.

With their scalability, which we will expand on in the next section, AI generative can serve many students concurrently, making them invaluable resources for both individuals and educational institutions. In the dynamic landscape of education, generative AI's role in making learning more interactive, engaging, and effective is increasingly prominent and valuable.

3.4. Scalability

The scalability of the ICT-hybrid model means that online resources and AI-driven content can be easily expanded to accommodate a large number of students without significant increases in costs. One should take back the Massive Open Online Courses (MOOCs), like those offered, for example, by Harvard University and MIT on edX. "Harvard Online" is the online platform of Harvard University. It provides online courses that unite professors and knowledge from different areas of the university. These courses connect learners worldwide to tackle important global issues.

One can take the example of Coursera which functions as a platform that provides a wide array of courses, certifications, and degrees offered by universities and organizations globally. Established in 2012 by Stanford professors Andrew Ng and Daphne Koller, it has grown to become one of the largest online learning platforms available. Within Coursera, learners gain access to diverse courses spanning fields such as business, computer science, the humanities, and more. The course durations vary from a few weeks to several months.

The example of Coursera demonstrates the high-level of scalability of this hybrid model. According to the platform, there were nineteen million registered users in 2022. This trend seems to be continuing globally (Anon).

An educational institution could experiment with a traditional lecture-based course and a MOOC-style course on the same subject. They can assess the scalability and cost-effectiveness of the MOOC model compared to traditional classes.

4. Challenges and Considerations

Several works have studied the need to transform the current higher education system such as (Olivia 2023). The hybrid model of education discussed here, which combines in-person and online learning, offers a promising path forward for modern education. However, it is not

without its own set of challenges and considerations that need to be thoughtfully addressed to maximize its effectiveness.

> *"Generative AI has emerged as a game-changer in education. It can significantly impact student learning by adapting content to individual needs and offering a highly personalized learning experience."*

First, infrastructure is a crucial concern. To make the Hybrid Model inclusive and accessible to all, ensuring that every student has access to the necessary technology and the internet is paramount. This challenge is particularly pronounced in underprivileged areas where the digital divide remains a barrier to equitable education. Bridging this gap through adequate technology provisions and internet access is essential to providing equal learning opportunities for every student, regardless of their socioeconomic background.

Data privacy is another critical consideration. The utilization of student data for personalized learning is a powerful application of technology and AI. However, it must be done with strict adherence to data privacy regulations. Protecting the personal information of students is not only a legal obligation, but also an ethical imperative. Building trust through transparent data usage practices is essential for ensuring the responsible and ethical application of AI and ICT tools in education.

Teacher training is another essential aspect. Instructors may need training and professional development to effectively incorporate ICT and AI tools into their teaching methods. Proficiency in using these technologies is critical to harnessing their full potential and providing a high-quality educational experience for students.

Additionally, Generative AI has emerged as a game-changer in education. It can significantly impact student learning by adapting content to individual needs and offering a highly personalized learning experience. AI-generated content can make lessons engaging, relevant, and tailored to each student's level and learning style.

Nonetheless, the utilization of Generative AI raises copyright concerns. Creating educational materials with AI assistance may raise questions about intellectual property rights, authorship, and ownership. Striking the right balance between AI-generated content and copyright compliance is a challenge that educators and institutions need to navigate carefully.

Furthermore, managing the disruption that Generative AI introduces to education is a pressing issue. While it brings numerous benefits, its integration can be disruptive to traditional educational systems. Teachers and institutions need to adapt to these technological changes, which can alter the way education is delivered and experienced. Managing this transformation effectively while ensuring positive outcomes for students is a significant challenge in education today.

The Hybrid Model of education holds tremendous potential, but it comes with its share of challenges. Addressing issues related to infrastructure, data privacy, teacher training, Generative AI, copyright, and managing technological disruption are critical to ensuring that it can deliver on its promise of accessible, personalized, and effective education.

Addressing these multifaceted challenges associated with the hybrid model of education requires a concerted effort and a combination of strategies, as displayed in Figure 1.

Figure 1: Holistic Approach to Tackle the Challenges of ICT & GAI-Powered Models

- **Change Management**

Managing the disruption caused by Generative AI in education involves a shift in teaching methods, curricular design, and institutional policies. Institutions should adopt change management strategies to facilitate a smooth transition. Teachers should be provided with support and resources to adapt to new teaching methods effectively.

- **Collaboration and Research**

Collaboration between educational institutions, policymakers, and technology providers is vital. Research on the impact and effectiveness of the Hybrid Model, Generative AI, and related technologies should inform best practices and policies.

- **Equity-Centric Approaches**

Equity should be at the forefront of decision-making. Targeted interventions and support

should be directed toward underprivileged areas and students to bridge the digital divide, ensuring that all learners have equal access to quality education.

- **Stakeholder Engagement**

Engaging parents, students, teachers, and the broader community in discussions about the Hybrid Model's challenges and benefits can lead to more informed decision-making and foster a sense of shared responsibility for addressing these issues.

By adopting a holistic approach that combines policy development, investment, training, and research, educational institutions and policymakers can effectively tackle the challenges associated with the Hybrid Model and ensure that it realizes its potential to provide accessible, personalized, and effective education for all students.

5. Research and Data Analytics

Educational institutions have embarked on a journey of exploration and innovation by conducting extensive research and initiating pilot programs to gauge the effectiveness of the hybrid model in modern education (Chichekian and Benteux 2022; Ninaus and Sailer 2022). These endeavors are essential in shedding light on the potential of this approach to revolutionize the learning experience.

The research efforts are multifaceted and encompass various dimensions of the hybrid model's impact. A primary focus is on student learning outcomes, aiming to determine how the combination of in-person and online learning influences academic achievement and skill development. Educational researchers are closely examining whether this innovative model enhances student comprehension, critical thinking, problem-solving abilities, and knowledge retention, thus ensuring that the educational experience is not just accessible but also profoundly effective.

In parallel, these studies place a spotlight on student engagement. They seek to understand how the hybrid model affects students' motivation, participation, and interaction in the learning process. By examining the dynamics of student-teacher and peer interactions, researchers are striving to uncover how this model fosters active and collaborative learning experiences, making education more engaging and enjoyable for learners of all ages.

Scalability is another critical aspect under scrutiny that needs to be fully addressed. Researchers are evaluating the feasibility of scaling the hybrid model to accommodate a broader student population (Julia, Peter, and Marco 2021). This involves an exploration of the technologies, resources, and infrastructure required to ensure that the benefits of this model can be extended to a wide array of students without compromising quality.

In essence, educational institutions are committed to a process of rigorous examination and experimentation, driven by a shared goal of advancing education in an era defined by technology and innovation. The research and pilot programs being conducted are pivotal in providing insights that inform best practices and help navigate the path toward a more accessible, engaging, and scalable education system that empowers students to thrive in the digital age.

Regarding research works and studies on students' performance, data analytics and sciences have emerged as potent tools in educational institutions (Mougiakou et al. 2023), significantly shaping the landscape of modern education. By harnessing the capabilities of Data Analytics and Artificial Intelligence (AI), these institutions have unlocked a wealth of opportunities to enhance student learning, foster academic success, and create more personalized educational experiences (Hooshyar et al. 2023).

"AI-driven tutoring systems have the potential to revolutionize personalized learning."

One pivotal application of Data Analytics in education systems revolves around the tracking and analysis of student performance (Namoun and Alshanqiti 2021). This involves the systematic collection, organization, and interpretation of a wide array of data points, including grades, attendance, engagement metrics, and even feedback from teachers. These data are then subjected to advanced analytical algorithms that unveil valuable insights into student progress and areas of potential concern (Al Yousufi et al. 2023).

One notable achievement of data-driven systems in education is the early warning system. By employing predictive analytics, educational institutions can identify students who may be at risk of falling behind academically (Lawson et al. 2016); (Nimy and Mosia 2022), (Adnan et al. 2021). This is achieved through the detection of patterns and indicators that may not be immediately apparent to human educators. These early warning systems can flag students who exhibit warning signs, such as declining grades or irregular attendance, prompting timely intervention and support.

For at-risk students, this intervention can be a game-changer. Educational institutions can proactively reach out to these students, providing additional resources, tutoring, counseling, or other forms of assistance tailored to their specific needs. This timely support can prevent minor setbacks from snowballing into more significant academic challenges and increase the likelihood of these students successfully achieving their educational goals (Iatrellis et al. 2021).

Moreover, Data Analytics extends beyond student performance tracking. It can also be applied to curriculum improvement, helping educators identify areas where students may struggle or excel. This enables the refinement of teaching methods and the adaptation of curricula to better meet the needs of the learners (Gaftandzhieva et al. 2023); (Du 2022).

6. Conclusion

In summary, the hybrid model powered by ICT and using generative AI represents an innovative and promising approach to future education. By blending traditional and digital learning methods with the capabilities of AI, this model has the potential to deliver more personalized, engaging, and accessible educational experiences for learners worldwide. However, the model also comes with challenges related to infrastructure, data privacy, and teacher readiness that need to be addressed for its successful implementation. This cannot be done only if educational institutions and policymakers address the challenges of the hybrid

model effectively by taking a comprehensive approach, encompassing policy development, investments, training, and research. This approach ensures that the model reaches its full potential, offering accessible, personalized, and effective education for all students.

As we look ahead, AI-driven tutoring, Augmented Reality (AR) (Kamińska et al. 2023), and VR applications will further enhance this educational model, offering students an even richer and more immersive learning experience, redefining the way we learn and teach in the digital age.

AI-driven tutoring systems have the potential to revolutionize personalized learning . These intelligent systems can provide students with immediate feedback, adapt content to their specific needs, and offer customized learning pathways. This not only enhances comprehension but also allows learners to progress at their own pace, making education more inclusive and effective. In addition, as mentioned above, AR and VR are immersive technologies that can take learning to new heights. AR overlays digital information onto the physical world, making lessons interactive and engaging. For example, students can explore historical sites through AR applications, bringing history to life. VR, on the other han d, offers complete immersion into virtual environments, making complex concepts more tangible. Students can take virtual field trips or perform hands-on experiments in a virtual lab.

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