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# Reshaping teaching and learning engineering through next-gen learning technologies

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**Abstract**

Technology is the backbone of all the various activities that any organization does. The education industry is no different. The education sector is replacing archaic and obsolete teaching methods with more interactive and collaborative teaching methods that provide a more engaging and collaborative learning experience. By enabling students to work in groups to solve real-world problems, they are helping to enhance soft skills like leadership, communication, and teamwork, which are critical to success in school, college, and the workforce. Next-generation technologies and instructional design have significant implications for learning augmentation and engineering in the distance and online education and blended learning. Learning engineering can help students understand information and analyze data, such as by showing a schematic of a mechanical system moving or a visual timeline of historical events. It can also be used to help students build information, such as by showing a 3-D model that can be rotated and viewed from different angles. Some learning augmentation systems use the metaphor of building a 3-D model of a car, where various parts have to be correctly assembled. The use of artificial intelligence for course design and recommendation of learning paths and content can also be seen as a form of learning to engineer. This article discusses how the next-generation technologies using machine learning, user modeling, and genetic algorithms are being developed to support personalized learning as one the key technologies for learning engineering. Adaptive hypermedia, human–machine interaction, augmented reality, and computer-assisted instruction enhance instructional delivery or instructor performance.

## 1. Introduction

Learning engineering is designing and developing a learning experience that aligns with the learner's needs. The future of education will be centered on learning engineering. Learning engineering is a process that considers what learners need and wants to achieve their desired outcomes. It also considers the technologies available to support learners in various ways (Guglielman et al., 2018). The approach to designing learning materials, courses, and programs intend to effectively teach a particular skill or body of knowledge. This has undergone significant changes over the last few decades and will continue to do so. The rapid emergence of new technologies such as virtual reality, augmented reality, artificial intelligence, and machine learning will profoundly impact instructional design. Emerging technologies and learning theories shape the future of education. The new-gen learning technologies will reshape teaching and learning engineering. New-generation learning technologies have the potential to significantly transform the way the subjects are taught and learned. These technologies can enable more interactive and personalized learning experiences, provide access to real-time data and simulations, and facilitate collaboration and communication among students and teachers. For example, machine learning algorithms can be used to

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personalize learning for each student, adapting the content and pace of instruction to the individual's needs and abilities. And online learning platforms can enable students to access course materials and collaborate with their peers from anywhere in the world.

Emerging technologies are revolutionizing education by providing new tools and platforms for teachers and learners to engage with educational content and each other. These technologies have the potential to enhance the effectiveness and efficiency of education by providing more interactive and personalized learning experiences, increasing access to educational resources, and facilitating collaboration and communication. For teachers, emerging technologies can provide powerful tools to design and deliver instruction, assess student learning, and engage with students in new ways. For example, virtual and augmented reality can be used to create immersive learning environments that allow students to visualize and manipulate complex concepts, and machine learning algorithms can be used to personalize learning for each student, adapting the content and pace of instruction to the individual's needs and abilities. Similarly, for learners, emerging technologies can provide new ways to access and engage with educational content, as well as new opportunities for collaboration and communication with peers. For example, online learning platforms can enable students to access course materials and collaborate with their peers from anywhere in the world, and mobile devices can provide access to a wealth of educational resources and tools.

There are critical trends in the use of next-gen technologies for learning engineering (Sherwin, 2015). The use of technology to access information and the Internet has increased drastically. Technology in the classroom is facilitating collaboration and interaction among students. It is accelerating and supporting learning at a much deeper level. It has made it possible for students to become more self-directed in the learning process; and for teachers to be much more data driven. Three trends in educational technology are pretty notable. One is using technology to offer more relevant content and learning strategies, and how we can use technology to create engaging, collaborative environments for students (Truman, 2019). The second is the use of technology to provide unprecedented communication and connectivity between students, teachers, and parents. The third trend is using technology to create remarkable data and information that allows teachers to make much more informed decisions about how they can do their jobs more effectively and help students learn. Therefore, we need to address issues in adopting next-gen technologies for education. Some of the emerging technologies that are revolutionizing education are:

## 2. Augmented Reality

Augmented reality is the new buzzword that is being heard and seen everywhere (Hugues et al., 2011). Augmented reality provides learners with an immersive and interactive experience in a virtual environment (Azuma, 1997; Chicchi Giglioli et al., 2015). Augmented reality (AR) is a technology that superimposes digital content onto the real world, allowing users to interact with the physical environment in a more immersive way. AR technology can be accessed through a variety of devices, including smartphones, tablets, and specialized AR headsets. According to a recent report by the research firm MarketsandMarkets (n.d.), the augmented reality market is expected to reach $90.7 billion by 2024, growing at a compound annual growth rate of 49.5% from 2019 to 2024. The report cites the increasing adoption of AR in various industries, including education, healthcare, and retail, as a major driver of this growth. For its potential in education, AR can be used to create immersive learning environments that allow students to visualize and manipulate complex concepts, such as in anatomy or physics. In healthcare, AR can be used to assist with surgery or training, by providing real-time information and guidance to surgeons. And in retail, AR can be used to enhance the shopping experience, by allowing customers to visualize products in their homes or try on clothes virtually. It is no wonder educational institutes have taken it up to give the best to their students. However, with all the hype around it, there are certain challenges that it has to face on its way to the top. A look at some of the difficulties that AR has to overcome if it has to be a successful educational tool, enables teachers to create relevant learning experiences. Azuma et al. (2001) reported the technical challenges of implementing AR, including issues related to tracking, registration, and display. He discusses the various AR systems that had been developed at the time and describes the key components of an AR system, including sensors, displays, and computer hardware and software.. Augmented reality for learning through creation is not just an app or technology. It's a way of teaching. Squiggle Park (https://www.squigglepark.com/) is an augmented reality sandbox that allows students to create instant landscapes. It's a good foundation tool for the future of creation and learning through

AR. Augmented reality works on the concepts of the existing geometry. While learning a new ideas, abstract concepts may become difficult to understand if these are not related to the current concepts.

Augmented reality has the potential to enhance the effectiveness and efficiency of education by providing more interactive and personalized learning experiences. Some specific benefits of AR for education include creating immersive learning environments. It can be used to create immersive learning environments that allow students to visualize and manipulate complex concepts, such as in anatomy or physics. This can help students understand and retain information more effectively. AR enables teachers to create personalized learning experiences for each student, adapting the content and pace of instruction to the individual's needs and abilities. This can help students learn at their own pace and improve their learning outcomes. AR can provide access to real-time data and simulations, allowing students to interact with and analyze data in a more meaningful way. This can help students develop critical thinking skills and gain a deeper understanding of complex concepts. It can provide more engaging and interactive learning experiences, which can help increase student motivation and engagement. There are some challenges for augmented reality (AR) applications in e-learning environments , like most AR devices are expensive, and the user may not be able to afford them. Moreover, most AR devices are mobile devices. If the learner does not have a smartphone or a tablet, they may not be able to use the AR applications. Learners may be hesitant to provide personal data or be uncomfortable wearing a head-mounted display (HMD) or handheld device (e.g., a smartphone) on their head or carrying it in their hands. Further, they may need to spend a lot of time getting used to the system.

## 3. Virtual Reality (VR)

Virtual reality allows learners to be immersed in a 3D world they can explore, manipulate, and interact with (Sharma & Sharma, 2021). Virtual reality (VR) has been developing for many years. In fact, the origins of VR can be traced back to the 1960s when Morton Heilig designed the Sensorama simulator, which was a VR device that would immerse a person in an environment. These days, VR is continuing to grow and develop. Many VR devices are available on the market, such as the Oculus Rift and Microsoft HoloLens. Some of the best academic institutions in the world, especially in the STEM (Science, Technology, Engineering, and Mathematics) fields, are now using VR to teach various subjects (Sala, 2021). In the STEM fields (Lamb, 2021), VR has been used to teach students about the human brain and how neurons interact and how to build circuits and replicate real-world scenarios. However, VR is not only used in the STEM fields. VR can also teach any subject, including history, literature, and even art. VR can be used to create immersive learning environments that allow students to experience and explore complex concepts and environments in a more engaging and interactive way. For example, VR can be used to simulate historical events, scientific experiments, and complex systems, such as the human body or the solar system. This can help students understand and retain information more effectively.

The Virtual reality (VR) applications –currently may be prohibitive as the hardware cost is very high. The user must wear a headset and some may feel motion sickness for prolonged use.

## 4. Artificial Intelligence (AI)

AI generates personalized content for students based on their needs and interests. Artificial intelligence (AI) is the capability of a machine to imitate intelligent human behaviour (Saghiri et al., 2022). But it’s not as simple as that. There’s a whole host of different types of artificial intelligence. And while some types of AI are already a reality, others are coming in the not-too-distant future (Management Association, 2017).

The three main types of artificial intelligence are:
- Artificial Narrow Intelligence (ANI)
- Artificial General Intelligence (AGI)
- Artificial Super Intelligence (ASI)

### 4.1. Artificial Narrow Intelligence (ANI)

ANI is the most basic form of AI. It can only do one thing at a time and has difficulty changing that function for another task. Artificial narrow intelligence (ANI), also known as weak AI or specialized AI, is a type of artificial intelligence that is designed to perform a specific task or tasks. An example of ANI in daily life is seen in the form of personal assistants. Many people use personal assistants, such as Amazon's Alexa or Apple's Siri, to perform a

variety of tasks, such as setting alarms, playing music, or answering questions. These personal assistants are examples of ANI, as they are designed to perform specific tasks related to voice recognition, language processing, and information retrieval. These are also used as spam filters. Most email providers use ANI algorithms to filter out spam messages and prevent them from reaching users' inboxes. These algorithms are trained to identify patterns in the content and sender of email messages that are indicative of spam, and they are able to accurately identify and filter out a large percentage of spam messages. Many financial institutions use ANI algorithms to detect fraudulent activity in real-time. These algorithms are trained to identify patterns in financial transactions that are indicative of fraud, and they can alert human analysts to investigate further when they detect potentially fraudulent activity.

### 4.2. Artificial General Intelligence (AGI)

AGI is a huge step up from ANI. It is the ability to perform basic tasks such as human speech recognition, interpretation, and text translation. AGI is what we have in Google Translate today. Artificial General Intelligence (AGI) refers to the ability of artificial intelligence (AI) systems to perform tasks and exhibit intelligent behavior that is equivalent to that of humans (Tripathi, 2021). In the context of education, AGI could potentially be used to create personalized learning experiences for students, adapt teaching methods to individual learning styles, and even grade assignments and assessments. However, the use of AGI in education also raises ethical concerns (Arora, 2021), such as the potential for AI systems to replace human teachers and the potential for biased algorithms to perpetuate inequalities in education.

### 4.3. Artificial Super Intelligence (ASI)

Artificial Super Intelligence (ASI) is the highest level of AI. It refers to the hypothetical future development of artificial intelligence (AI) that surpasses the cognitive abilities of humans in all domains. In the context of education, ASI could potentially revolutionize the way we learn and teach, providing access to vast amounts of knowledge and the ability to analyze and understand complex concepts at a speed and depth beyond human capabilities (Kaplan 2021). However, the development and use of ASI also raises significant ethical concerns, including the potential for ASI to surpass human control and potentially pose a threat to the survival of humanity (Uğur & Kurubacak, 2019). It is important to consider these ethical implications when discussing the potential use of ASI in education (Pană, 2014 and Guerreiro, 2020). ASI isn't just capable of performing general tasks; it is capable of doing everything a human being can do, even exceeding that. It can read, write, talk, program, and even converse.

Self-driving cars on the road today are an example of the early stages of artificial super intelligence (ASI), which has garnered a lot of attention in popular media. While AI in education can be beneficial, it is important to consider the potential dangers and limitations of this technology. However, AI has the potential to improve learning experiences by suggesting content that helps deepen understanding and by analyzing learner behavior to design more effective training. By leveraging the power of AI and combining it with data, we can enhance the effectiveness of our training efforts. Nguyen et al. (2022) talk about the ethical principles for artificial intelligence in education. Responsible AI refers to the ethical and accountable development and use of artificial intelligence (AI) systems. It involves considering the potential impacts and consequences of AI on various stakeholders, such as individuals, organizations, and society, and taking steps to mitigate any negative effects. Responsible AI involves a number of key principles and practices, such as transparency, equity, inclusivity, privacy, governance, and accountability. These principles and practices help ensure that AI is developed and used in a way that is ethical, transparent, and accountable, and that it does not perpetuate or amplify biases or disadvantages for certain groups.

## 5. Machine Learning (ML)

Machine learning is a subset of artificial intelligence (AI) that involves the use of algorithms and statistical models to enable computers to learn and improve their performance on a specific task without being explicitly programmed (Liu & Ardakani, 2022). Machine learning algorithms are trained using large amounts of data and can make predictions or decisions based on patterns and trends identified in the data. Machine learning can be used in a variety of fields, including education, to analyze student data and provide personalized recommendations for learning and teaching (Khanal et al., 2020). Machine learning helps teachers analyze data sets from student's interactions with course materials to make better decisions about instruction for future lessons or assessments (Khadimally, 2022). At the moment, it is still rudimentary. Machine learning algorithms are used to analyse learner behaviour and filter and modify the content they receive in response (Gulzar & Leema, 2021). For example, suppose

a learner struggles with a particular part of the content. In that case, the algorithm might recognise this and suggest an alternative learning path, tailoring the experience to the learner's needs.

## 6. Adaptive Learning Systems (ALS)

Adaptive learning systems adapt to learner's pace, progress, preferences, or other factors so learners can learn at their own pace without getting bored or frustrated with their lack of progress (Harrigan et al., 2009). This is another area in which AI is making inroads is in the creation of adaptive learning environments (Harati 2020). Rather than making one learning experience for all, adaptive learning creates personalised programmes that are based on how effective a learner is, and what learners have managed to achieve. A recent survey by the Association of Talent Development (https://www.td.org/about) found that around 75% of talent development professionals are already personalising learning programmes, with 25% of these saying that they are already highly customised.

Adaptive learning works by following a learner's progress through an eLearning course, dynamically altering the modules and content they are presented with so they are challenged without frustration (Liu, & Cercone, 2016). At the same time, the learning path can be optimised to ensure that learners are only being presented with material they have already mastered (Janati & Maach, 2017).

The adaptive learning model is used in all learning environments, from educational institutions to the corporate sector. For example, RoadmapU is an app that provides training for first-year college students, determining exactly what each student needs to learn and when they need to learn it. It does this by using a recommender system that analyses the learner's performance, comparing it with the performance of their peers. Likewise, companies like Axonify Axonify. (n.d.) (https://axonify.com/) and Grovo Cornerstone OnDemand. (n.d.) (https://www.cornerstoneondemand.com/solutions/content/grovo/) are also using adaptive learning in the corporate setting, for everything from onboarding new employees to training front-line staff. It's becoming increasingly clear that the pedagogy of the future will be a highly personalised one. The rise of adaptive learning and the greater impact of AI in the learning environment makes this abundantly clear.

## 7. Questions related to reshaping teaching and learning engineering we need to seek answers to!

There is a lot of discussion about how next-gen technologies will shape the future of education (Trede, 2009). How can the learning environments be made more interactive? Some people think they are not suitable for learning, and some think they are good for learning. The truth is, there is no clear answer to this question. They can be used both for good and bad purposes. If learning was an experience, it would be akin to a game. That's because we are wired to want to play when it comes to learning. Learning designers can utilize next-generation technologies such as artificial intelligence and virtual reality to create more engaging and personalized learning experiences for students. For example, AI can be used to analyze student data and provide tailored recommendations for learning materials and activities. Virtual reality can be used to create immersive, interactive learning environments that allow students to explore and experience concepts in a more hands-on way. These technologies can also be used to create adaptive learning systems that can adjust to the needs and progress of individual students, providing a more customized and efficient learning experience.

There are crucial questions before learning designers to ponder over how next-gen technologies will shape the future of education (Sharma, Yildirim, & Kurubacak, 2020). Which emerging technologies will be most impactful in the next 5-10 years? Which next-gen technologies will lead to the biggest disruption? How will next-gen technologies address the new challenges associated with education in the 21st century? What are the new opportunities that next-gen technologies offer? What are the barriers to using next-gen technologies in education? How do we ensure that next-gen technologies are inclusive of all students?

Technologies that have the potential to significantly disrupt various industries and sectors include artificial intelligence, virtual reality, blockchain, and the Internet of Things (IoT). These technologies can revolutionize industries such as education, healthcare, finance, and transportation, among others. These can help address the new challenges associated with education in the 21st century by providing more personalized, accessible, engaging, and efficient learning experiences. Learning designers can analyze student data and provide personalized recommendations for learning materials and activities, helping to tailor education to the needs and interests of individual students. By designing engaging and interactive learning experiences the students can be kept motivated. Learning designers can use next-gen technologies for increasing efficiency. Efficiency: Technologies such as

automation and machine learning can help to streamline various aspects of education, such as grading and assessment, freeing up time and resources for more valuable learning activities.

## 8. Conclusions

Next-gen technologies are the enabler. The technology used well is not about technology; it's about people. If you look at teachers or principals, they teach kids, manage their classrooms, and learn about new technologies. They're the ones who need to be the drivers of technology in their classrooms. The prominent issue of next-gen technologies for education is the use of data and how we aggregate, analyze and use that data to make better decisions about education (Barrera-Cámara et al., 2021). Increasingly, next-gen technologies will play a role in K-12 and post-secondary education. We're going to see a lot more analytics and dashboards to help school districts make better decisions, principals provide better resources to teachers and parents, and students can see the results of their actions. Another important thing about using technology for education is how it is used and for what purpose. If technology is used to replace the old way of doing business, it is not being used to its fullest. One of the crucial challenges is the cost and provisioning of the technology. As the price of technology goes down, the cost of bandwidth, security, and connectivity goes up. A common mistake institutions commit is spending a lot of money on technology but not buying the right solution for the right reason.

Next-generation technologies have transformed the traditional education model by empowering students to take a more active role in their learning (Mandala et al., 2022). A shift towards a new era of education has resulted in the convergence of technology and education trends. This convergence is enabling students to access and interact with learning materials in new and innovative ways, using a variety of technologies such as artificial intelligence and virtual reality. This shift towards active learning and technology-enhanced education has the potential to revolutionize the way we learn and teach in the 21st century. The question now is, as we see the education system that we have is not going to take us into the future, how do we best take advantage of technology to make education relevant? One of the roles of next-gen technologies in education is to create more relevant learning in a safe environment. Now, students can go on the Internet and look at whatever they want. We want to allow them to use the Internet and technology to learn in a way that's relevant and meaningful for them.

The traditional education model, which typically involves a teacher delivering information to a group of students who are expected to passively absorb that information, may not be effective in meeting the needs and expectations of 21st century learners. This is due, in part, to the rapid pace of technological advancement and the increasing demand for more personalized, interactive, and experiential learning opportunities. As a result, there is a growing trend towards more active, student-centered learning models that utilize technology to facilitate collaboration, interaction, and experiential learning. While the traditional education model may still have value in certain contexts, it is important for educators to consider alternative approaches that are more adaptable and responsive to the changing needs and expectations of modern learners.The more we can integrate technology in a meaningful way, the better (Li et al., 2021). We must help educators become much more comfortable with these technologies. There has to be enough focus on the professional development of administrators and teachers.

We need to be mindful of education and technology because these next-gen technologies give students access to incredible amounts of information and help them be more innovative, creative, and independent (Bertolone-Smith & Spagna, 2019). For reshaping the teaching and learning engineering, the learning designers need to ensure that learners have access to a range of technology tools and resources that are appropriate for their age and learning needs. Learning experiences need to include the opportunities to use technology to explore, create, and solve problems, rather than simply consuming information. Adequate and suitable guidance and support be ascertained to help learners develop critical thinking and problem-solving skills, as well as the ability to effectively use and evaluate technology. Learners should be encouraged to use technology responsibly and ethically, including respecting the privacy and security of others. It is important to ensure that the use of these technologies does not compromise the overall goal of education, which is to teach students the skills and knowledge they will need to succeed in the future.

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