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MODERN EDUCATIONAL TRENDS AND TECHNOLOGIES FOR TRAINING ENGINEERS FOR INDUSTRY 4.0

The fourth industrial revolution, also known as Industry 4.0, is transforming the manufacturing industry and creating a demand for highly skilled process engineers. To meet this demand, educational institutions must adapt to the changing needs of environmental science and provide education that prepares students for the challenges of Industry 4.0. This article discusses modern educational trends and technologies for training materials processing engineers for Industry 4.0. One of the trends in modern education is the adoption of interdisciplinary curricula. Interdisciplinary curricula also prepare materials processing engineers to work in cross-functional teams. Project-based learning, an approach to education that emphasizes learning through projects rather than traditional lectures, is an effective way to prepare material processing engineers for Industry 4.0 as it allows students to apply their knowledge and skills to real-world problems. Virtual and augmented reality technologies are becoming more and more popular in education. These technologies provide immersive learning. Artificial intelligence is another technology that is transforming the manufacturing industry. Materials processing engineers must have a basic understanding of artificial intelligence in order to work effectively in Industry 4.0. Educational institutions can incorporate artificial intelligence into their curricula by teaching courses in machine learning, data analysis, and robotics. Schools should partner with industry to provide students with hands-on experience and familiarity with real manufacturing processes. Educational institutions must adapt to the changing demands of industry and provide training that prepares students for the future of work.

Key words: training of materials processing engineers, educational technologies, Industry 4.0, project-based learning, interdisciplinary curriculum, virtual and augmented reality, artificial intelligence, digitalization.

The world is rapidly changing, and so is the industry. The fourth industrial revolution, also known as Industry 4.0, is characterized by the integration of advanced technologies such as artificial intelligence, robotics, and the Internet of Things (IoT) into the manufacturing process. This transformation is creating new opportunities and challenges for engineers, who must be trained to work with these technologies and adapt to the changing demands of the industry. The problem we face today is how to train engineers for Industry 4.0. The traditional engineering curriculum is no longer sufficient, as it does not address the skills and knowledge required for working with advanced technologies. Therefore, we need to develop new educational trends and technologies that can provide engineers with the necessary skills and knowledge to succeed in the Industry 4.0.

The task at hand is to design an educational system that can meet the demands of Industry 4.0. This system should be based on a multidisciplinary approach that combines engineering, computer science, and other related fields. It should also incorporate emerging technologies such as virtual and augmented reality, gamification, and simulation tools to create an engaging and interactive learning experience for students. The relevance of this task cannot be overstated. The success of Industry 4.0 depends on having a skilled workforce that can design, implement, and maintain the advanced technologies that are driving this revolution. Therefore, it is crucial to invest in the education and training of engineers who will play a key role in shaping the future of the industry. This task is also connected with important scientific and practical tasks. From a scientific perspective, it involves research into the best practices for teaching advanced technologies and how to integrate them into the curriculum. From a practical perspective, it requires collaboration between academia and industry to ensure that the skills and knowledge taught in universities align with the demands of the industry.

Analysis of the Latest Research and Publications. In the last ten years, several articles have been published on the topic of training engineers for Industry 4.0 [1-6]. The article discusses the challenges that Industry 4.0 presents to companies and the education system. It proposes solutions such as developing new curricula, promoting lifelong learning, and collaborating with industry partners. Due to Industry 4.0, the Industrial and Systems Engineering (ISE) undergraduate programs are changing; likewise, the complexity in organizations is increasing. Moreover, international competition, rising market volatility, and the demand for highly complexity in organizations is increasing.

Moreover, international competition, rising market volatility, and the demand for highly customized products are challenging enterprises. Against this scenario, the ISE educational programs should develop creative ways to quickly adequate new requirements.

In another article [7] this analysis aims at providing support for further consolidated recommendations to enable the development of higher education engineering curriculum for enhancing I4.0 applications for smart organisations and industrial companies within the digital supply chains. Also, the paper provides an analysis of advancement from digitalization in engineering education to the implementation of Education 4.0 and related practices of smart labs and simulation of smart factories leading at the learning factory.

The new industry 4.0 developments have created requirement of new cross-functional roles on the emerging knowledge and skills combining information technology (IT) and production. Therefore, it is important to understand the characteristics of knowledge and skills required for the future of jobs and engineering profiles to determine the emerging patterns in the delivery of new education requirements of Industry 4.0 [8].

Unresolved Parts of the Problem. While these articles provide valuable insights into the issue of training engineers for Industry 4.0, there are still unresolved parts of this problem that need to be addressed. One such part is the lack of standardization in engineering education for Industry 4.0. Different countries and institutions have different approaches to preparing engineers for Industry 4.0, which can lead to a lack of consistency in skills and knowledge among engineers. Another unresolved part is the need for lifelong learning in engineering education. Industry 4.0 is a rapidly evolving field, and engineers need to keep up with the latest technologies and trends to remain relevant. Therefore, engineering education needs to provide opportunities for lifelong learning and professional development.

Unresolved Parts of the Problem. While these articles provide valuable insights into the issue of training engineers for Industry 4.0, there are still unresolved parts of this problem that need to be addressed. One of the unresolved parts is the need for lifelong learning in engineering education. Industry 4.0 is a rapidly evolving field, and engineers need to keep up with the latest technologies and trends to remain relevant. Therefore, engineering education needs to provide opportunities for lifelong learning and professional development. Industry 4.0 presents a significant challenge to engineering education. The latest research and publications suggest that engineering education needs to be more interdisciplinary, industry-focused, flexible, and collaborative to prepare engineers for Industry 4.0 successfully. By addressing these issues, we can ensure that engineers are adequately prepared to meet the demands of Industry 4.0 and contribute to its continued growth and success.

The goal of this article is to explore the modern educational trends and technologies that are being used to train engineers for Industry 4.0. As the world becomes increasingly digital, the skills required for engineers to succeed in the workplace are changing rapidly. It is therefore essential that educational institutions keep up with these changes and equip their students with the necessary skills to thrive in the new digital age.

To achieve this goal, we will first examine the concept of Industry 4.0 and its impact on the engineering profession. We will then discuss the specific skills that engineers need to succeed in this new era, and the challenges that educational institutions face in providing this training. Finally, we will explore some of the emerging trends and technologies in engineering education that are helping to bridge this gap. Industry 4.0 refers to the fourth industrial revolution, which is characterized by the integration of advanced technologies such as artificial intelligence, robotics, and the Internet of Things (IoT) into traditional manufacturing processes. This new era is expected to bring about significant changes in the way that goods are produced and consumed, as well as in the skills required for workers to succeed in the workplace.

One of the key skills that engineers need to succeed in Industry 4.0 is digital literacy. This includes not only a basic understanding of computer programming and data analysis, but also an ability to work with advanced technologies such as machine learning algorithms and virtual reality

systems. Engineers must also be able to collaborate effectively with colleagues from different disciplines, as well as with machines and robots. However, many educational institutions are struggling to keep up with these changes. Traditional engineering programs often focus on theoretical knowledge rather than practical skills, and may not provide students with the hands-on experience they need to succeed in the workplace. Additionally, many instructors may not have the necessary expertise to teach these new technologies effectively.

To address these challenges, a number of emerging trends and technologies are being used in engineering education.

Emphasis on Interdisciplinary Learning in Engineering Education. Engineering is a field that has been traditionally associated with technical knowledge and skills. However, with the changing times, the role of engineers has expanded beyond just technical expertise. Today, engineers are expected to possess a range of skills such as critical thinking, problem-solving, communication, and collaboration. To prepare engineers for this changing landscape, there is a growing emphasis on interdisciplinary learning in engineering education. Interdisciplinary learning involves the integration of knowledge and skills from multiple disciplines to solve complex problems. It is an approach that recognizes that real-world problems do not exist in isolation and require a multidisciplinary approach to find solutions. In the context of engineering education, interdisciplinary learning involves the integration of technical knowledge with other disciplines such as social sciences, humanities, business, and design.

One of the key benefits of interdisciplinary learning is that it helps students develop a broader perspective on the world. By exposing students to different disciplines, they are able to understand the interconnectedness of various fields and appreciate the diversity of viewpoints. This exposure helps students develop critical thinking skills and the ability to analyze problems from multiple perspectives. In addition, interdisciplinary learning helps students develop skills that are essential for success in today's workforce. Employers are increasingly looking for candidates who possess a range of skills beyond just technical expertise. These skills include communication, collaboration, creativity, and adaptability. Interdisciplinary learning provides students with opportunities to develop these skills by working on projects that require them to collaborate with others from different disciplines.

Another benefit of interdisciplinary learning is that it helps students develop a more holistic approach to problem-solving. By integrating knowledge from different disciplines, students are able to approach problems from multiple angles and develop more comprehensive solutions. This approach is particularly important in today's complex and rapidly changing world where problems are often interconnected and require multidisciplinary solutions. To facilitate interdisciplinary learning in engineering education, universities are adopting a range of strategies. One approach is to offer interdisciplinary courses that bring together students from different disciplines to work on common projects. These courses are designed to expose students to different perspectives and help them develop skills in collaboration and communication.

Focus on hands-on learning. Hands-on learning is an essential component of engineering education. It involves practical experience that allows students to apply theoretical knowledge in real-world scenarios. This approach to learning has gained popularity in recent years due to its effectiveness in producing competent engineers who are ready to tackle the challenges of the industry. The benefits of hands-on learning are numerous. Firstly, it helps students to develop problem-solving skills. By working on real-world projects, students are exposed to a range of challenges that require them to think critically and come up with innovative solutions. This process helps to hone their analytical skills and prepares them for the complex problems they will face in their future careers. Secondly, hands-on learning helps to bridge the gap between theory and practice. In traditional classroom settings, students learn theoretical concepts that may not always be applicable in real-world scenarios. However, hands-on learning provides students with the opportunity to apply these concepts in practical situations, thereby reinforcing their understanding of the subject matter. Thirdly, hands-on learning promotes teamwork and collaboration. In engineering, teamwork is essential as projects often

involve multiple disciplines working together towards a common goal. Hands-on learning provides students with the opportunity to work in teams, thereby promoting effective communication, collaboration, and problem-solving skills.

Another approach is experiential learning. This involves students gaining hands-on experience through internships, co-op programs, or industry placements. This approach provides students with the opportunity to work alongside industry professionals, learn from their experiences, and gain practical skills that are highly valued by employers.

Project-Based Learning: Preparing Materials Processing Engineers for Industry 4.0. The advent of Industry 4.0 has brought about significant changes in the way industries operate. With the introduction of advanced technologies like automation, artificial intelligence, and the Internet of Things (IoT), there is a growing need for skilled professionals who can manage and optimize these systems. Materials processing engineers play a crucial role in this new era of manufacturing, and it is essential to equip them with the necessary skills to succeed in Industry 4.0.

To meet this demand, educational institutions are adopting project-based learning (PBL) as a teaching methodology. PBL is an innovative approach that emphasizes hands-on experience, critical thinking, and problem-solving skills. It involves students working on real-world projects that simulate industry scenarios, allowing them to apply their knowledge in practical situations.

One of the key advantages of PBL is that it prepares students for the challenges they will face in the workplace. By working on complex projects, students learn to collaborate effectively, communicate their ideas clearly, and develop solutions to real-world problems. PBL also encourages students to take ownership of their learning, as they are responsible for planning, executing, and evaluating their projects.

In the context of materials processing engineering, PBL can be particularly effective in developing skills related to process optimization, quality control, and supply chain management. For example, students could be tasked with designing a production line that maximizes efficiency while minimizing waste. They could also work on improving the quality of materials by developing new testing methods or implementing statistical process control techniques.

Another benefit of PBL is that it allows students to develop their creativity and innovation skills. In Industry 4.0, there is a growing emphasis on using technology to create new products and services that meet customer needs. By working on projects that require them to think outside the box, students can develop their ability to innovate and come up with novel solutions.

Virtual and Augmented Reality: Modern Educational Trends for Processing Engineers in Industry 4.0. In today's rapidly evolving technological landscape, Industry 4.0 is transforming the way we live, work, and learn. As a result, educational institutions and training programs are turning to modern technologies to prepare students for the demands of the future workforce. Virtual and Augmented Reality (VR/AR) are two such technologies that are revolutionizing the way we teach and learn. VR/AR technologies provide immersive, interactive experiences that allow students to explore complex concepts and processes in a safe, controlled environment. These technologies have been used in a variety of industries, from healthcare to entertainment, and are now being adopted in education and training programs to enhance learning outcomes.

For processing engineers, VR/AR technologies offer a unique opportunity to explore complex manufacturing processes in a virtual environment. By simulating real-world scenarios, students can develop the skills and knowledge required to operate machinery and equipment safely and efficiently. This not only improves learning outcomes but also reduces the risk of accidents and injuries in the workplace. One example of how VR/AR technologies are being used in processing engineering education is through the development of virtual laboratories. These laboratories allow students to experiment with different processes and materials without the need for expensive equipment or hazardous chemicals. This not only reduces costs but also provides a safe and controlled environment for students to explore new ideas and concepts.

Another example is the use of AR technologies to enhance traditional classroom learning. By overlaying digital information onto real-world objects, students can visualize complex concepts and processes in a more tangible way. This not only improves understanding but also makes learning more engaging and interactive. In addition to improving learning outcomes, VR/AR technologies also have the potential to transform the way we assess student performance. By tracking student movements and interactions within a virtual environment, educators can gain valuable insights into how students are learning and identify areas for improvement. This data can then be used to personalize learning experiences and provide targeted feedback to individual students.

Gamification in engineering education refers to the use of game design principles and mechanics to enhance the learning experience. It can involve incorporating elements such as points, badges, leaderboards, and challenges into engineering coursework to make it more engaging and interactive. Gamification can help students stay motivated and interested in their studies, and can also provide opportunities for hands-on learning and problem-solving. In recent years, gamification has emerged as a powerful tool for enhancing the learning experience. While traditionally, education has been seen as a serious and often tedious process, gamification has made learning more engaging, interactive and fun. This approach has been particularly successful in engineering education, where students are often faced with complex and abstract concepts that can be difficult to grasp.

Gamification involves the use of game design elements such as point systems, badges, leaderboards, and challenges to motivate and engage learners. In the context of engineering education, gamification can be used to enhance the learning experience by making it more interactive, immersive, and enjoyable. By incorporating game-like elements into the learning process, students are more likely to stay engaged, retain information better, and develop a deeper understanding of the subject matter. One of the key benefits of gamification in engineering education is that it provides students with a safe environment to experiment and make mistakes. In traditional classroom settings, students are often afraid to make mistakes for fear of being judged or losing marks. However, gamification allows students to experiment and learn from their mistakes without any negative consequences. This not only enhances learning but also fosters a growth mindset where students are encouraged to take risks and learn from their failures. Gamification also provides instant feedback to students, which is essential for effective learning. By providing immediate feedback on their progress, students can identify areas where they need to improve and adjust their learning strategies accordingly. This allows students to stay on track and achieve their learning goals more efficiently.

Another advantage of gamification in engineering education is that it promotes collaboration and teamwork. Many gamified learning platforms incorporate social features that allow students to interact with each other and work together on challenges. This not only enhances the learning experience but also develops essential teamwork skills that are essential for success in the workplace. Gamification has also been shown to improve student motivation and engagement. By incorporating game-like elements into the learning process, students are more likely to be motivated to learn and stay engaged throughout the course. This is particularly important in engineering education, where the subject matter can be complex and challenging.

Online Courses and Tutorials in Engineering Education. The world of engineering is constantly evolving and as such, it is important for engineers to keep up with the latest trends and technologies. One way to do this is by taking online courses and tutorials. Online courses and tutorials offer engineers the opportunity to learn at their own pace and on their own schedule. In this article, we will explore the benefits of online courses and tutorials in engineering education. Flexibility. One of the biggest benefits of online courses and tutorials is flexibility. Engineers can take courses and tutorials at their own pace and on their own schedule. This means that they can fit learning into their busy schedules without having to sacrifice work or family time. Online courses and tutorials also allow engineers to learn from anywhere in the world. This is especially beneficial for engineers who live in remote areas or who are unable to travel. Cost-effective. Online courses and tutorials are also cost-effective. Traditional classroom-based courses can be expensive, with tuition fees, textbooks,

and travel costs adding up quickly. Online courses and tutorials, on the other hand, are often much cheaper. Many online courses and tutorials are free, while others charge a nominal fee. This makes it easier for engineers to access high-quality education without breaking the bank. Learn from industry experts. Online courses and tutorials also provide engineers with the opportunity to learn from industry experts. Many online courses and tutorials are taught by professionals who are experts in their field. This means that engineers can learn from the best of the best, gaining valuable insights and knowledge that they might not be able to get elsewhere. Interactive learning. Online courses and tutorials also offer interactive learning experiences. Many online courses and tutorials use videos, quizzes, and other interactive tools to engage learners. This makes learning more fun and engaging, which can help engineers retain information better.

Platforms for Collaborative Learning in Engineering Education. Collaborative learning has become an increasingly popular approach to education in recent years, and for good reason. By working together, students can share ideas, build on each other's strengths, and improve their critical thinking and problem-solving skills. In the field of engineering education, collaborative learning is particularly important, as it allows students to tackle complex problems that require a range of different skills and perspectives.

Fortunately, there are now a wide range of platforms available that can facilitate collaborative learning in engineering education. In this article, we will explore some of the most popular platforms and discuss their benefits and drawbacks.

1. Learning Management Systems (LMS). Learning Management Systems (LMS) are perhaps the most well-known platform for collaborative learning. LMS platforms such as Blackboard, Moodle, and Canvas allow instructors to create online courses and provide students with access to a range of resources, including readings, videos, quizzes, and discussion forums. LMS platforms can be particularly useful for engineering courses that require students to work on group projects. Instructors can create groups within the LMS and assign tasks to each group. Students can then collaborate on these tasks using the platform's discussion forums, file sharing tools, and other features.

2. Social Media Platforms. Social media platforms such as Facebook, Twitter, and LinkedIn can also be used for collaborative learning in engineering education. Instructors can create groups or pages on these platforms and invite students to join. Students can then use the platform's messaging and discussion features to collaborate on projects or discuss course materials. One advantage of social media platforms is that they are often more familiar and user-friendly than LMS platforms. Students may already be using these platforms for personal or professional purposes, which can make it easier for them to engage with course materials.

3. Project Management Platforms. Project management platforms such as Trello, Asana, and Basecamp can also be useful for collaborative learning in engineering education. These platforms allow users to create tasks, assign them to team members, and track progress over time. Instructors can use project management platforms to create group projects and assign tasks to each team member. Students can then use the platform to collaborate on these tasks, share files, and communicate with each other. One advantage of project management platforms is that they are designed specifically for collaboration, which can make them more effective than more general-purpose platforms such as LMS or social media. However, these platforms may have a steeper learning curve than other options, which could make it more difficult for students to get started.

4. Video Conferencing Platforms. Video conferencing platforms such as Zoom, Microsoft Teams, and Google Meet have become increasingly popular in recent years due to the COVID-19 pandemic. These platforms allow users to communicate with each other in real-time using video and audio. Instructors can use video conferencing platforms to hold virtual office hours or group meetings. Students can also use these platforms to collaborate on group projects or discuss course materials. One advantage of video conferencing platforms is that they allow for real-time communication, which can be particularly useful for group projects that require rapid feedback or decision-making. However,

these platforms may not be as effective for asynchronous collaboration, which could be a disadvantage in some contexts.

5. Virtual Labs. Virtual labs are web-based platforms that enable students to conduct experiments and simulations online. Virtual labs are particularly useful for engineering students who do not have access to physical labs or equipment. These platforms can be used to simulate real-world scenarios and enable students to develop practical skills in a safe and controlled environment.

Creating Immersive Simulations and Learning Environments. In today's world, technology has revolutionized the way we learn and acquire knowledge. With the advent of immersive simulations and learning environments, students can now experience a more engaging and interactive learning process. These tools have been designed to provide an immersive experience that allows students to learn through exploration, experimentation, and problem-solving. In this article, we will explore the importance of creating immersive simulations and learning environments and how they can enhance the learning process.

What are Immersive Simulations and Learning Environments? Immersive simulations and learning environments are computer-based tools that simulate real-world scenarios to create an engaging and interactive learning experience. These simulations can be designed to replicate anything from a laboratory experiment to a complex medical procedure. They are created using advanced computer graphics, virtual reality, and augmented reality technologies to create a realistic environment that students can interact with.

The Importance of Immersive Simulations and Learning Environments. Immersive simulations and learning environments have become increasingly popular in recent years due to their ability to enhance the learning process. Here are some of the key benefits of using these tools:

1. Increased Engagement: Immersive simulations and learning environments provide a more engaging learning experience by allowing students to interact with the subject matter in a more meaningful way. This increased engagement can lead to better retention of information and a deeper understanding of the subject matter.

2. Realistic Scenarios: Simulations can be designed to replicate real-world scenarios, allowing students to practice skills and procedures in a safe and controlled environment. This is particularly useful in fields such as medicine and engineering, where mistakes can have serious consequences.

3. Personalized Learning: Immersive simulations and learning environments can be tailored to each student's individual needs, allowing them to work at their own pace and focus on areas where they need more practice.

4. Cost-Effective: Simulations can be used to replace expensive equipment or materials, reducing the cost of training and education.

Creating Immersive Simulations and Learning Environments. Creating immersive simulations and learning environments requires a multidisciplinary approach that involves experts from various fields such as education, technology, and design. Here are some key considerations when creating these tools:

1. Define Learning Objectives: The first step in creating an immersive simulation or learning environment is to define the learning objectives. What skills or knowledge do you want students to acquire? What are the key concepts that need to be covered?

2. Choose the Right Technology: There are many different technologies that can be used to create immersive simulations and learning environments, including virtual reality, augmented reality, and gamification. It is important to choose the technology that best fits the learning objectives.

3. Design for User Experience: The user experience is critical in creating an effective simulation or learning environment. The design should be intuitive and easy to use, with clear instructions and feedback.

4. Test and Iterate: Once the simulation or learning environment has been created, it is important to test it with users to identify any issues or areas for improvement. Iteration is key to creating an effective tool that meets the needs of learners.

Interactive textbooks have emerged as a powerful tool in engineering education. These textbooks are designed to engage students in a more active and participatory learning process. They provide students with an opportunity to interact with the content and receive immediate feedback on their progress. This article explores the benefits of interactive textbooks in engineering education and how they can be used to enhance the learning experience. One of the primary benefits of interactive textbooks is that they provide students with a more engaging learning experience. Traditional textbooks can be dry and difficult to read, which can lead to disengagement and lack of interest in the subject matter. Interactive textbooks, on the other hand, use multimedia elements such as videos, animations, and interactive simulations to make the content more engaging and easier to understand. This can help students stay focused and motivated throughout the learning process.

Another benefit of interactive textbooks is that they provide students with immediate feedback on their progress. Traditional textbooks often require students to complete exercises or assignments and then wait for the teacher to grade them and provide feedback. With interactive textbooks, students can receive immediate feedback on their work, allowing them to identify areas where they need to improve and make corrections in real-time. This can help students learn more effectively and efficiently. Interactive textbooks can also be customized to meet the needs of individual students. Traditional textbooks are often one-size-fits-all, with the same content and exercises for all students. Interactive textbooks, on the other hand, can be personalized based on the student's learning style, interests, and abilities. This can help students learn at their own pace and in a way that works best for them.

Another advantage of interactive textbooks is that they can be updated more easily than traditional textbooks. The field of engineering is constantly evolving, with new technologies and techniques being developed all the time. Traditional textbooks can quickly become outdated, leaving students with inaccurate or incomplete information. Interactive textbooks, however, can be updated in real-time, ensuring that students have access to the most up-to-date information. Interactive textbooks also promote collaboration and communication among students. Traditional textbooks are often read individually, with little opportunity for discussion or interaction among students. Interactive textbooks, on the other hand, can include features such as discussion forums, group projects, and collaborative activities that encourage students to work together and share their ideas. This can help students develop important teamwork skills that will be valuable in their future careers.

Artificial Intelligence in Engineering Education. Artificial Intelligence (AI) has become an increasingly important field of study in recent years, with applications in a wide range of industries. One area where AI is particularly relevant is in engineering education. In this article, we will explore the ways in which AI is being integrated into engineering curricula and how it is changing the way we approach engineering education.

The integration of AI into engineering education has the potential to revolutionize the way we teach and learn about engineering. AI can be used to enhance the learning experience for students, providing them with new tools and techniques that can help them to better understand complex engineering concepts. One way in which AI is being used in engineering education is through the development of intelligent tutoring systems. These systems use AI algorithms to provide personalized feedback to students as they work through engineering problems. By analyzing the student's responses and performance, the system can adapt its feedback to provide targeted guidance and support.

AI can also be used to create simulations and virtual environments that allow students to explore and experiment with engineering concepts in a safe and controlled setting. These simulations can be used to teach everything from basic engineering principles to more advanced topics like robotics and automation. Another area where AI is having an impact on engineering education is in the development of new tools and technologies. For example, AI algorithms can be used to analyze large amounts of data and identify patterns and trends that would be difficult or impossible for humans to detect. This can be particularly useful in fields like civil engineering, where large amounts of data are generated from sensors and other monitoring devices.

While there are many opportunities to integrate AI into engineering education, there are also challenges that must be addressed. One of the biggest challenges is the need for faculty and staff to develop new skills and knowledge in order to effectively incorporate AI into their teaching practices. Another challenge is the need for high-quality data to train AI algorithms. In order for these algorithms to be effective, they must be trained on large amounts of relevant data. This can be difficult in fields like engineering, where data may be scarce or difficult to obtain. Despite these challenges, there are many opportunities for AI to transform engineering education. By providing students with new tools and techniques, we can help them to better understand complex engineering concepts and prepare them for careers in a rapidly changing field.

Collaboration with Industry in Industry 4.0 Engineering Education. The fourth industrial revolution, or Industry 4.0, is transforming the way we live and work. With advancements in technology such as artificial intelligence, the Internet of Things, and automation, the demand for skilled engineers has never been higher. However, traditional engineering education may not be sufficient to prepare students for the rapidly changing landscape of Industry 4.0. This is where collaboration with industry becomes crucial.

Collaboration with industry allows engineering educators to keep up with the latest trends and technologies in the field. By working closely with industry partners, educators can gain insight into the skills and knowledge that are in high demand in the workforce. This information can then be used to update and enhance engineering curricula to better prepare students for the real-world challenges they will face in their careers. Industry partnerships can also provide students with valuable hands-on experience. By working on real-world projects alongside industry professionals, students can gain practical skills that are difficult to teach in a classroom setting. This type of experiential learning is highly valued by employers, as it demonstrates that students have the ability to apply their knowledge to real-world problems. In addition to benefiting students and educators, collaboration with industry can also have a positive impact on the industry partners themselves. By working with educational institutions, industry partners can identify and recruit top talent early on, giving them a competitive advantage in the job market. They can also use these partnerships to stay up-to-date with the latest developments in the field and gain access to cutting-edge research.

However, collaboration with industry is not without its challenges. One of the biggest challenges is ensuring that the partnership is mutually beneficial. Educational institutions must be careful not to become too focused on meeting the needs of their industry partners at the expense of their students' education. At the same time, industry partners must be willing to invest time and resources into the partnership, and not simply view it as a way to recruit cheap labor.

Another challenge is ensuring that the partnership is sustainable over the long term. Industry partners may have changing needs and priorities, and educational institutions must be prepared to adapt to these changes in order to maintain a successful partnership.

Despite these challenges, collaboration with industry is essential for preparing students for careers in Industry 4.0. By working together, educational institutions and industry partners can ensure that students are equipped with the skills and knowledge they need to succeed in this rapidly evolving field. They can also help to bridge the gap between academia and industry, ensuring that research and innovation are translated into practical applications that benefit society as a whole.

Emphasis on Lifelong Learning in Engineering Education. Engineering is a field that is constantly evolving, with new technologies and techniques being developed all the time. As such, it is essential for engineers to embrace lifelong learning in order to stay up to date with the latest advancements and remain competitive in the job market. Lifelong learning refers to the process of acquiring knowledge and skills throughout one's entire life, rather than just during formal education. This can take many different forms, from attending conferences and workshops to reading industry publications and pursuing advanced degrees. In the field of engineering, lifelong learning is particularly important due to the rapid pace of technological change. Engineers who fail to keep up with the latest

developments risk becoming obsolete and losing their competitive edge in the job market. By contrast, those who embrace lifelong learning are able to stay ahead of the curve and remain at the forefront of their field. There are many different ways that engineers can engage in lifelong learning. One popular option is to attend conferences and workshops, which provide opportunities to learn from experts in the field and network with other professionals. Many engineering organizations also offer continuing education courses and certification programs, which allow engineers to deepen their knowledge and skills in specific areas.

Another important aspect of lifelong learning for engineers is staying up to date with industry publications and research. This can involve reading academic journals, attending webinars, and following industry blogs and social media accounts. By staying informed about the latest developments in their field, engineers can identify new opportunities and stay ahead of the competition. In addition to these formal avenues for lifelong learning, engineers can also benefit from informal learning opportunities such as mentoring and peer-to-peer collaboration. By working with colleagues and mentors who have different perspectives and experiences, engineers can gain new insights and expand their knowledge in ways that might not be possible through more traditional forms of learning.

CONCLUSION

Interdisciplinary learning is becoming increasingly important in engineering education. It provides students with a broader perspective on the world, helps them develop essential skills for success in today's workforce, and enables them to approach problems more holistically. Universities are adopting a range of strategies to facilitate interdisciplinary learning, including offering interdisciplinary courses, incorporating interdisciplinary projects into existing courses, and creating interdisciplinary programs. By embracing interdisciplinary learning, engineering education can prepare students for the complex and rapidly changing world of tomorrow. Hands-on learning is an essential component of engineering education. It helps students to develop problem-solving skills, bridge the gap between theory and practice, and promote teamwork and collaboration. There are several approaches to hands-on learning, including project-based learning and experiential learning. Incorporating hands-on learning into engineering education requires a significant investment in resources and infrastructure but is essential in producing competent engineers who are ready to tackle the challenges of the industry. Project-based learning is an effective teaching methodology for preparing materials processing engineers for Industry 4.0. By emphasizing hands-on experience, critical thinking, and problem-solving skills, PBL can help students develop the skills they need to succeed in a rapidly changing industry. To support PBL, it is essential to have access to modern educational trends and technologies, as well as industry experts who can provide guidance and support. With these resources in place, we can ensure that our future materials processing engineers are well-equipped to meet the challenges of Industry 4.0.

VR/AR technologies offer a unique opportunity to enhance processing engineering education and prepare students for the demands of Industry 4.0. By providing immersive, interactive experiences, these technologies can improve learning outcomes, reduce risk in the workplace, and transform the way we assess student performance. While there are challenges that need to be addressed, the potential benefits make it clear that VR/AR technologies have an important role to play in modern educational trends for processing engineers. Gamification has emerged as a revolutionary approach to learning that has transformed the way we think about education. In engineering education, gamification has been particularly successful in enhancing the learning experience by making it more engaging, interactive, and enjoyable. By providing a safe environment for experimentation, instant feedback, promoting collaboration and teamwork, and improving student motivation and engagement, gamification has become an essential tool for educators looking to improve student outcomes. As we continue to explore the potential of gamification in education, we can expect to see even more innovative approaches to teaching and learning in the years ahead. Online courses and tutorials offer a

range of benefits for engineers looking to further their education. They provide flexibility, cost-effectiveness, access to a wider range of courses, the opportunity to learn from industry experts, and interactive learning experiences. With so many benefits on offer, it's no wonder that more and more engineers are turning to online courses and tutorials to enhance their skills and knowledge.

There are many different platforms available for collaborative learning in engineering education. Each platform has its own benefits and drawbacks, and the best choice will depend on the specific needs and goals of the course. By carefully considering the options available and selecting the right platform for their course, instructors can help their students develop the skills they need to succeed in the field of engineering. Immersive simulations and learning environments have the potential to revolutionize the way we learn and acquire knowledge. By providing a more engaging and interactive learning experience, these tools can enhance retention of information and improve understanding of complex concepts. Creating effective simulations and learning environments requires a multidisciplinary approach that involves experts from various fields. By considering key factors such as learning objectives, technology, user experience, and testing, we can create tools that provide a more effective and efficient way of learning. Interactive textbooks are a powerful tool for enhancing the learning experience in engineering education. They provide students with a more engaging and personalized learning experience, immediate feedback on their progress, and the ability to collaborate and communicate with their peers. As technology continues to advance, we can expect to see even more innovative and effective interactive textbook solutions in the future.

AI is rapidly transforming many industries, including engineering education. By integrating AI into our curricula and teaching practices, we can provide students with new tools and techniques that can help them to better understand complex engineering concepts. While there are challenges that must be addressed, the opportunities for AI in engineering education are vast and exciting. As we continue to explore this field, we can look forward to a future where AI plays an increasingly important role in shaping the way we teach and learn about engineering.

Collaboration with industry is crucial for engineering education in the age of Industry 4.0. By working closely with industry partners, educational institutions can stay up-to-date with the latest trends and technologies, provide students with valuable hands-on experience, and help bridge the gap between academia and industry. While there are challenges to overcome, the benefits of collaboration with industry far outweigh the costs. It is up to educators and industry partners alike to work together to ensure that future generations of engineers are prepared for the challenges and opportunities of Industry 4.0. Industry 4.0 is transforming the world we live in, and engineering education must keep up with the pace of change in order to prepare students for the challenges and opportunities of the future. By emphasizing interdisciplinary learning, integrating digital technologies into curricula, focusing on hands-on learning and lifelong learning, developing soft skills, emphasizing sustainability, and collaborating closely with industry partners, engineering education can help ensure that the engineers of tomorrow are ready to tackle the challenges of Industry 4.0 head-on.

REFERENCES

1. Bertha Leticia Treviño-Elizondoa and Heriberto García-Reyesa. What does Industry 4.0 mean to Industrial Engineering Education? Procedia Computer Science 217 (2023) 876–885.

2. Pranckutė, Raminta. (2021) "Web of Science (WoS) and Scopus: The Titans of Bibliographic Information in Today's Academic World." Publications 9 (1): 12.

3. Hernandez-de-Menendez, Marcela, Ruben Morales-Menendez, Carlos A. Escobar, and Megan McGovern. (2020) "Competencies for Industry 4.0." International Journal on Interactive Design and Manufacturing (IJIDeM) 14 (4): 1511–1524.

4. Himmetoglu, Beyza, Damla Aydug, and Coskun Bayrak. (2020) "Education 4.0: Defining the teacher, the student, and the school manager aspects of the revolution." Turkish Online Journal of Distance Education 21 (Special Issue-IODL): 12–28.

5. Massachusetts Institute of Technology (MIT). (2022) "Professional Certificate Program in Industry 4.0." MIT Professional Education. Accessed: Jan. 16, 2022. [Online]. Available: https://professional.mit.edu/programs/certificate-programs/professional-certificate-programindustry-40

6. National University of Singapore (NUS). (2022) "MSc in Industry 4.0." NUS School of Continuing and Lifelong Education. Accessed: Jan. 16, 2022. [Online]. Available: https://scale.nus.edu.sg/programmes/graduate/msc-in-industry-4.0 [27] Universidad Carlos Ill de Madrid (uc3m). (2022) "MASTER IN CONNECTED INDUSTRY 4.0." Universidad Carlos Ill de Madrid (uc3m) MASTERS. Accessed: Jan. 16, 2022. [Online]. Available: https://www.uc3m.es/master/connected-industry-4.0#home

7. I. Neaga Applying INDUSTRY 4.0 and EDUCATION 4.0 to engineering education. Proceedings 2019 Canadian Engineering Education Association (CEEA-ACEG19) Conference. Proceedings 2019 Canadian Engineering Education Association (CEEA-ACEG19) Conference CEEA19; Paper 001University of Ottawa; June 9 – 12, 2019

8. K. Vikas, E. Banu Y. Engineering education towards industry 4.0. 10th Annual International Conference on Industrial   Engineering   and   Operations   Management   (IEOM).   Mar.   2020. http://ieomsociety.org/ieom2020/proceedings/

Подлєсний С. В. Сучасні освітні тенденції та технології підготовки інженерів з обробки матеріалів для Індустрії 4.0.

Четверта промислова революція, також відома як Індустрія 4.0, трансформує обробну промисловість та створює попит на висококваліфікованих інженерів-технологів. Щоб задовольнити цей попит, освітні установи повинні адаптуватися до мінливих потреб економіки та забезпечити навчання, яке готує студентів до викликів Індустрії 4.0. У цій статті розглянуто сучасні освітні тренди та технології підготовки інженерів із обробки матеріалів для Індустрії 4.0. Однією з тенденцій у сучасній освіті є прийняття міждисциплінарних навчальних програм. Міждисциплінарні навчальні програми також готують інженерів з обробки матеріалів для роботи у крос-функціональних командах. Проектне навчання - це підхід до освіти, при якому особлива увага приділяється навчанню за допомогою проектів, а не традиційних лекцій, це ефективний спосіб підготовки інженерів з обробки матеріалів для Індустрії 4.0, оскільки він дозволяє студентам застосовувати свої знання та навички для вирішення реальних проблем. Технології віртуальної та доповненої реальності стають все популярнішими в освіті. Ці технології забезпечують іммерсивне навчання. Штучний інтелект – ще одна технологія, яка трансформує обробну промисловість. Інженери з обробки матеріалів повинні мати базове уявлення про штучний інтелект, щоб ефективно працювати в Індустрії 4.0. Освітні установи можуть включити штучний інтелект у свої навчальні програми, викладаючи курси з машинного навчання, аналізу даних та робототехніки. Навчальні заклади повинні встановити і підтримувати партнерські відносини з промисловістю, щоб надати студентам практичний досвід та познайомитись із реальними виробничими процесами. Освітні установи повинні адаптуватися до мінливих вимог виробництва та забезпечувати навчання, яке готує студентів до майбутньої роботи.

Ключові слова: підготовка інженерів з обробки матеріалів, освітні технології, Індустрія 4.0, проектне навчання, міждисциплінарна навчальна програма, віртуальна та доповнена реальність, штучний інтелект, цифровізація.

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