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M-STEM

CURRICULUM AND TRAINING CONTENTS

METAVERSE-BASED STEM EDUCATION FOR A SUSTAINABLE AND RESILIENT FUTURE

2023-1-FR01-KA220-SCH-000151516

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M-STEM Curriculum and Training Contents

Introduction

The M-STEM curriculum is designed to support STEM teachers in integrating Metaverse technologies into teaching and learning through a structured and pedagogically grounded approach. Its main focus is to provide educators with the knowledge, skills, and practical tools needed to design, deliver, and evaluate STEM learning experiences in immersive virtual environments. By combining STEM content with digital innovation, the curriculum promotes active learning, experimentation, collaboration, and the development of key STEM skills in a Metaverse context.

This is a comprehensive curriculum and training contents that guide teachers on how to teach STEM subjects in the Metaverse. The materials address both theoretical and practical dimensions of teaching, including the use of virtual simulations, interactive environments, and digital tools to support learning in subjects such as computer science, mathematics, physics, engineering, and biology. The curriculum also emphasizes the development of critical and creative thinking skills, interdisciplinary collaboration, and effective pedagogical strategies adapted to virtual learning environments.

The curriculum is structured into interconnected chapters that gradually guide educators from foundational concepts to applied practice. It begins with an introduction to STEM education and the Metaverse, followed by a focus on digital STEM literacy and the development of creative and critical thinking skills. The curriculum then moves into hands-on activities and projects, where teachers apply concepts through practical Metaverse-based STEM experiences. This is complemented by chapters on assessment and evaluation in virtual environments, career pathways in STEM, and ethical considerations related to the use of immersive technologies. Together, these chapters form a coherent training pathway that supports teachers in confidently implementing STEM education in the Metaverse.

INTRODUCTION TO STEM AND THE METAVERSE

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CHAPTER 1

METAVERSE-BASED STEM EDUCATION FOR A SUSTAINABLE AND RESILIENT FUTURE

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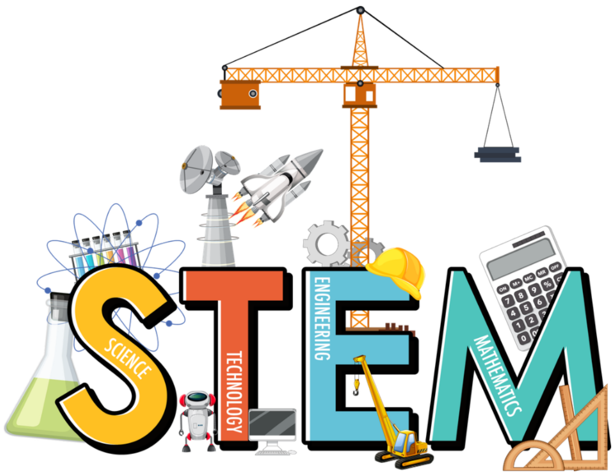
The Changing Landscape of Education in the 21st Century

Introducing STEM education and the metaverse

In today's rapidly evolving world, priorities shift to keep pace with these changes, and education is no exception. The 21st century has witnessed a massive surge in digital technologies, revolutionizing how we approach learning. Education is no longer just about acquiring knowledge; it's now focused on equipping students with the skills to navigate complex, technology-driven environments.

An emerging education force is STEM: Science, Technology, Engineering & Mathematics. STEM education is defined as an interdisciplinary approach to learning, integrating subjects of science, technology, engineering, and mathematics, focusing on real-world applications and problem-solving. Even though these subjects, for example mathematics, can be taught alone, the difference is that STEM education altogether encourages applying the knowledge, therefore increasing the student abilities when it comes to critical thinking, creativity, and innovation.

Today's world is very well interconnected and technology-driven, for this reason, the vitality of STEM education, cannot be denied.



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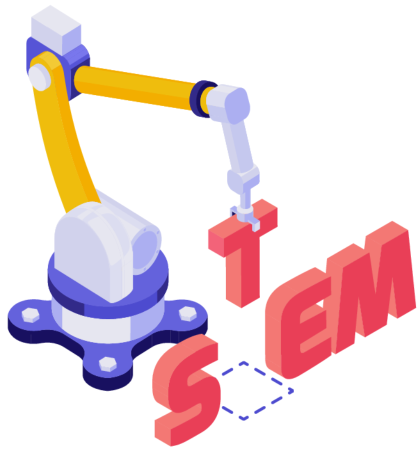
Industries all around the globe continue to evolve on a daily basis and therefore we're forced to adapt to these new technologies. As our adaption is a must, the demand for skilled professionals with a strong foundation in STEM subjects continues to grow, subjects ranging from climate change to healthcare advancement all

require solutions that are not only innovative but also multidisciplinary, that is the reason why STEM education is very important for all students all around the world. The metaverse is a virtual space, blending physical and digital reality offering interactive experiences. Metaverse is initially known to be in the entertainment

industry and the gaming industry, however, its rapid increase of popularity has helped it gain traction in education. Integration of STEM education and metaverse means to corporate STEM concepts into a virtual world of Metaverse where learners can

explore scientific models, collaborate in real time with an engaging 3D environment and simulate engineering problems. This interconnectedness of both STEM and metaverse opens up a world of possibilities with the promise of interactive and accessible learning experiences.

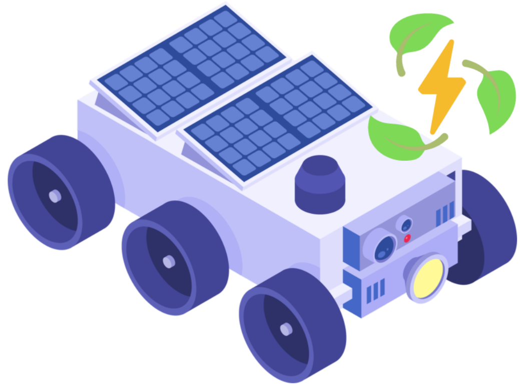


In this chapter, we're going to dive into the importance of STEM education and its benefits. We will also be discussing the Metaverse concept, its importance, and how it's linked to STEM education.

Benefits of STEM Education

Real World Applications & Hands on Learning

STEM education includes showing how taught material can be applied in real life situations. For example, in a class learning about renewable energy, students may end up designing their own solar-powered devices under the teacher's supervision. This application of solar-panel helps



students to experience firsthand on how science and engineering can solve environmental problems, and how these solutions are realistically applied in the real-world. Furthermore, hands-on learning refers to engaging students to actively participate while learning.

For example, instead of reading about electricity from the book, students are in a laboratory, reading from their book as well as building their own circuits and experimenting through the process. This does not only help students to understand vigorous concepts, but it also allows students to be personally engaged with the matter, enabling them to apply their theoretical knowledge into practical applications. In such hands on learning, as students build circuits, they are able to detect their mistakes and therefore fixing it, giving them a sense of accomplishment.

Equality in Education through STEM Education

STEM education plays a crucial role in promoting equality in education by providing inclusive opportunities for all students, regardless of their backgrounds. In many traditional educational settings, certain groups may face barriers to accessing advanced courses or resources.

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However, STEM initiatives actively work to remove these gaps by offering specific programs which are designed to support disadvantaged groups. For example, after-school coding camps aimed at girls or students from low-income families can open doors to careers in technology. Implementing STEM education in school curricula means having hands-on, project-based learning, which levels the playing field for students with diverse learning styles. For instance, a project on building a robot allows students to contribute based on their strengths so some students may find themselves excelling in coding,

while other students find out they enjoy design, while some find they shine in teamwork. In the long run, this helps students to find out more about their learning patterns and their interests, which makes them more knowledgeable about what they want to end up doing when they become working adults. Such an environment, with wide collaboration,

promotes a sense of belonging and encourages the students to realize their valuable skills. Having inclusivity and accessibility through STEM education created equitable learning environments, this enriches educational experiences and prepares a group of educated students in diverse sectors capable of tackling multifaceted challenges.

Critical Thinking & Creativity in STEM Education

STEM education boosts students' critical thinking and creativity by immersing them in hands-on projects, as we've discussed earlier in this chapter. When students dive into these projects, they analyze information, evaluate evidence, and come up with solutions to the problems they encounter. This process encourages collaboration, allowing students to brainstorm together and share their ideas, which helps them blend their diverse perspectives into a cohesive solution.

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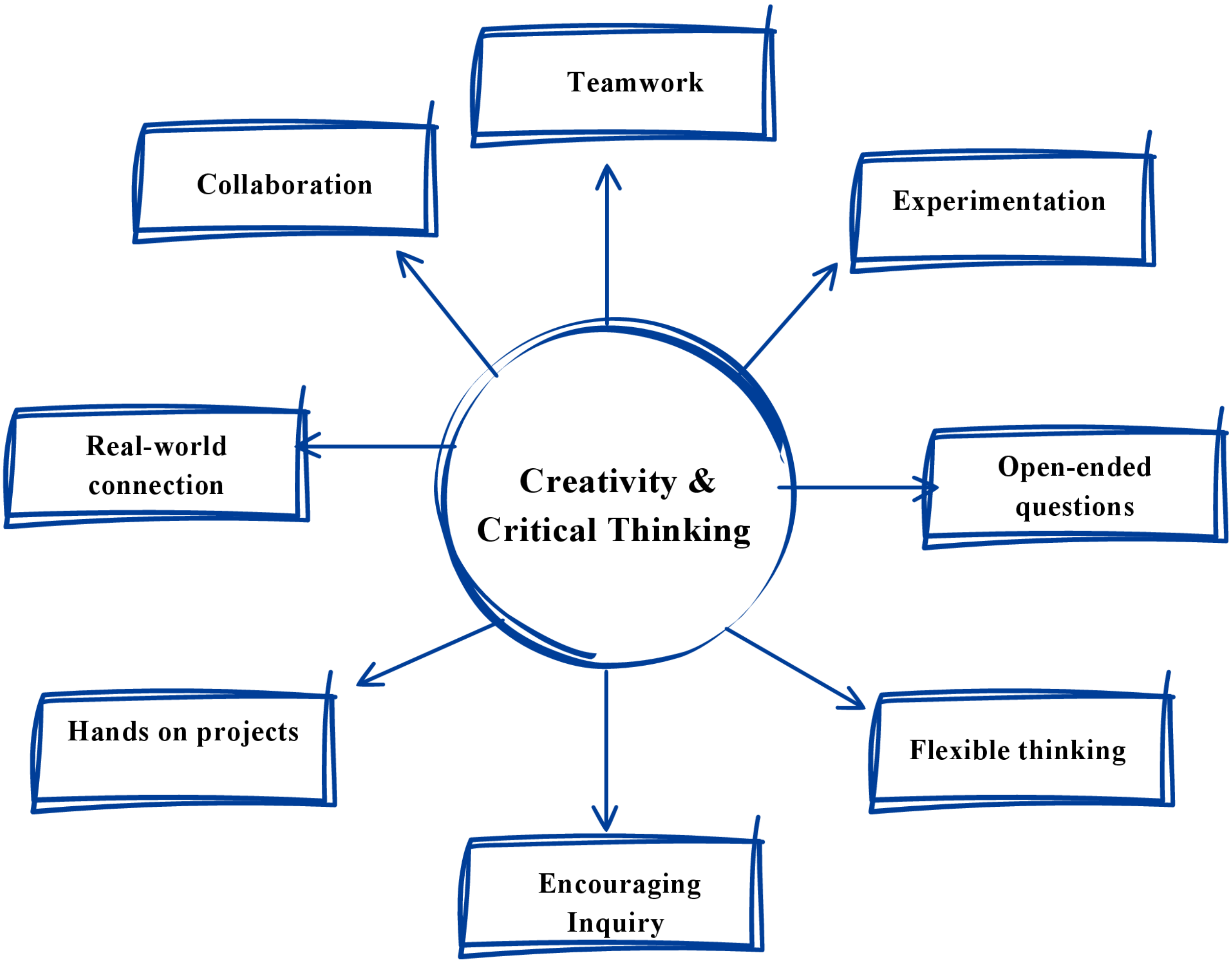
Moreover, STEM education incorporates various learning methods—like experimentation, open-ended questions, teamwork, and real-world connections—enabling students to think critically and express their creativity as they explore how what they're learning applies to real-life situations.



Other benefits of STEM education include motivating the students to explore a specific subject without supervision, on their own initiative, sparking curiosity and interest. STEM education encourages independent exploration by motivating students to dive deeper into subjects. For example, a student taking a class about astronomy may begin building models of planets or may begin to research space topics without any prompt from their teacher. Another benefit is the enhancement of teamwork as STEM projects in school require pupils to collaborate in teams, for instance in a robotics class, students may apply teamwork by focusing on different sections of their task. One student might focus on coding while another designs the hardware, teaching them the importance of working together.

The Metaverse: Overview and Potential in Education

Metaverse is defined as a virtual-reality space in which users can interact with a computer-generated environment and other users. Metaverse is rapidly progressing and developing throughout the years, as a technology that involves immersive, interactive and 3D digital environments where users are able to interact with one another and virtual objects as well in a virtual hypothetical reality. Metaverse blends both the physical world as well as the digital world

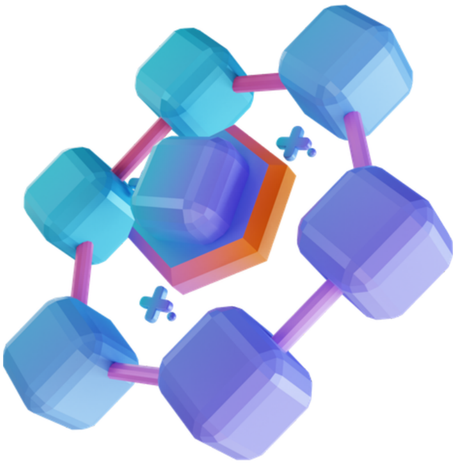
together, offering an experience where people don't just view it but also are able to participate in it. When it comes down to the context of

education, the blending of metaverse technology and education is a breakthrough; new horizon of education which enables new, refreshing ways of both teaching and learning, breaking any limitation that physical classroom may have. In order to understand how metaverse can be blended in education,

It's vital to understand that metaverse offers a variety of technologies making a digital environment possible such as:

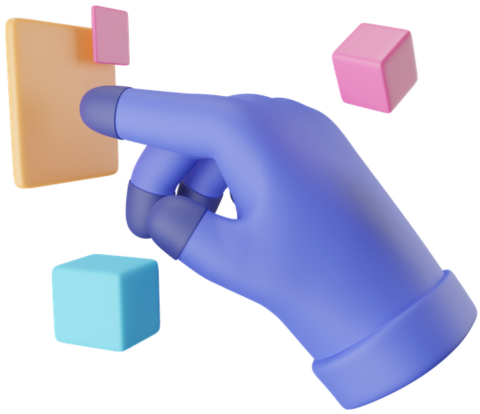
- **Virtual Reality (VR)**: the computer-generated simulation of a 3D image or environment that can be interacted in a seemingly real or physical way by a person using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors.
- **Augmented Reality (AR)**: Augmented reality is an interactive experience that enhances the real world with computer-generated perceptual information. Using software, apps, and hardware such as AR glasses, augmented reality overlays digital content onto real-life environments and objects.

- **Artificial Intelligence (AI)**: Artificial Intelligence (AI) is an evolving technology that tries to simulate human intelligence using machines. AI encompasses various subfields, including machine learning and deep learning, which allow systems to learn and adapt in novel ways from training data.



- **Chain technology**: The chain technology is a decentralized, distributed and public digital ledger that is used to record transactions across many computers so that the record cannot be altered retroactively without the alteration of all subsequent blocks (elements of the chain) and the consensus of the network.

Virtual Reality (VR) creates interactive digital worlds which may be explored by students allowing them to experience circumstances that may be impractical in the real world. An example is students studying ancient civilizations may be able to have a walk in VR through a reconstruction of ancient Rome. Other students who study



oceanography may have a dive into different depths of the ocean through VR technology, without having the need to physically leave the classroom. Now, let's imagine an oceanography class where students use AR glasses to explore a 3D model of the ocean floor. They can zoom in to observe underwater topography, label different types of marine ecosystems, and interact with virtual marine species, studying how they adapt to their environment. In that case,

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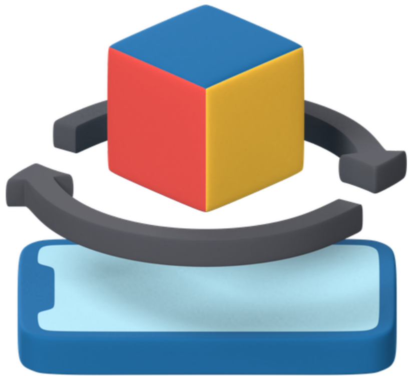
Augmented reality (AR) is what enables this, overlaying digital elements onto the real world, creating a better real-life environment through interactive information. Furthermore, artificial intelligence is another main essential component which would be helpful in creating virtual tutors, adaptive learning platforms and automatic assessment tools. Lastly, Decentralized technology



helps make sure digital identities such as usernames and important documents like certificates and transcripts are safe and can't be faked or changed. Think of it like a super secure digital locker that keeps track of everything and makes sure no one can tamper with it.

For example, if a student earns a diploma in an online course, the chain technology stores the diploma in a way that anyone can verify it's real, but no one can change or delete it without permission.

Metaverse is starting to make its way into education, changing how teachers teach and how students learn. There are platforms like virtual classrooms, immersive simulations, and game-like learning spaces that are helping to reach this change. For instance, Engage VR, a free application, which provides various tools for collaboration, such as immersive white boards, screen streaming, 3D virtual pens and spatial VoIP communication, allowing students join classes in a fully immersive setting where they can interact with their classmates and teachers as avatars. Other platforms, like AltspaceVR and Mozilla Hubs, are used for virtual events and group discussions, creating opportunities for students to learn together. These mentioned platforms, are digital spaces using the technology mentioned above, they don't just replace traditional classrooms but also they allow realistic simulations of complex processes such as science experiments which may be expensive or not doable in real life.

Learning with Metaverse VS Traditional Learning

It is essential to analyze and compare traditional learning and Metaverse learning methodologies to gain a deeper understanding of their distinct effects on student outcomes. Key factors to consider in this comparison include the learning environments they provide, the levels of interaction and engagement, opportunities for personalization and flexibility, the nature of collaboration, and issues related to accessibility and inclusivity. Additionally, cost and resource efficiency, as well as the impact on social and emotional development, are critical components that influence how each approach shapes the educational experience.

By examining these factors, educators and policymakers can make informed decisions regarding the integration of new technologies in educational settings, ultimately enhancing the learning experience for students.

Learning environment
Traditional Learning: Physical classrooms with face-to-face interactions between teachers and students. Desks, books, whiteboards, and lectures are common tools used in this setting. Students are typically passive recipients of information. **Metaverse learning:** Occurs in virtual environments. With tools like VR and AR, students can explore 3D simulations, interact with avatars, and engage in hands-on virtual experiments.

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Interaction and Engagement

Traditional Learning: Mainly focused on teacher-led instruction. While group work and discussions exist, fewer interactive elements exist when compared to digital environments.

Metaverse Learning: Highly interactive and allows students to actively engage with the content. Students can manipulate virtual objects, explore simulations, and participate in immersive experiences.

Personalization and Flexibility

Traditional learning: Has a one-size-fits-all approach, with set curriculums that may not accommodate to individual learning speeds or styles.

Metaverse learning: Offers personalized learning experiences. Students can learn at their own pace, repeat difficult concepts, or explore topics in more depth. There's capability of using AI-powered platforms can track progress and provide tailored recommendations to enhance learning.

Collaboration

Traditional Learning: Students collaborate in person through group work, presentations, and discussions. All of these include face-to-face interactions which help students develop their social skills, but they are fixed to the students found in the classroom.

Metaverse learning: Enables global collaboration. Students can work with peers from different parts of the world, engaging in virtual group projects or attending international seminars. This opens opportunities for global learning experiences that would be difficult in a traditional classroom setting

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Accessibility and Inclusivity

Traditional Learning: Limited by location and resources. Schools in rural or underfunded areas may not have access to advanced materials, laboratories, or diverse learning opportunities.

Metaverse learning: Can overcome geographic barriers, making quality education accessible to students from different locations.

Cost and Resource Efficiency

Traditional learning: Requires significant investment in physical infrastructure, textbooks, and other materials.

Metaverse learning: Can reduce the need for physical resources by using virtual environments. Virtual labs and field trips can replace costly real-life counterparts.

Social and Emotional Development

Traditional learning: Emphasizes real-world social interaction, which is essential for developing communication skills, teamwork, and emotional intelligence.

Metaverse learning: offers virtual collaboration, however the concern is reliance on digital environments might limit real-world social skills and face-to-face interactions.

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Self Assessment: Understanding STEM Education and the Metaverse

Purpose: To help teachers consolidate their understanding of the key concepts introduced in this chapter, including STEM education, its benefits, and the role of the Metaverse in transforming learning environments.

Teachers review the statements and select True (T) or False (F) based on the chapter content:

1. STEM education focuses on teaching science, technology, engineering, and mathematics as isolated subjects. T/ F
2. A key goal of STEM education is to connect learning to real-world applications and problem-solving. T/F
3. Hands-on learning allows students to apply theoretical knowledge through active participation. T/F
4. The Metaverse combines physical and digital realities to create interactive learning experiences. T/ F
5. Virtual and augmented reality can enable learning experiences that may be difficult or impossible in traditional classrooms. T /F

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Self Assessment: Understanding STEM Education and the Metaverse: Answer Sheet:

1. False
2. True
3. True
4. True
5. True

DIGITAL LITERACY USING METAVERSE: ESSENTIAL SKILLS FOR THE FUTURE

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CHAPTER 2

METAVERSE-BASED STEM EDUCATION FOR A SUSTAINABLE AND RESILIENT FUTURE

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Digital literacy using metaverse: Essential skills for the future

Introduction

As digital technologies rapidly evolve, STEM education faces both unprecedented challenges and opportunities. Today's STEM teachers are expected not only to master subject-specific content but also to navigate a digital landscape that includesvirtual environments, interactive simulations, and online collaborative tools. The incorporation of metaverse; a vast network of 3D virtual spaces where users can interact with a computer-generated environment and other users in real-time, further pushes the boundaries of traditional teaching, demanding new skills and strategies from educators. As metaverse is in an ongoing development, the importance of digital literacy becomes increasingly apparent. Navigating virtual environments requires a unique set of skills that go beyond traditional digital literacy. Frazier (2022) "Digital literacy is critical in picking through this mass of information and finding useful information that meets our needs. It's about finding the best matches out of all the possibilities that are out there on the internet."

Definition of STEM careers

Digital literacy is a critical competency for STEM educators, equipping them to meet the demands of an ever-expanding digital ecosystem. At its core, digital literacy for STEM educators goes beyond technical know-how and involves a foundational understanding of how to meaningfully integrate technology to enhance learning and create engaging, student-centred experiences. Educators must be able to evaluate and use digital tools and resources in ways that complement the curriculum, foster critical thinking, and support students in applying theoretical knowledge to real-world problems.

Equality in Education through STEM Education

STEM education plays a crucial role in promoting equality in education by providing inclusive opportunities for all students, regardless of their backgrounds. In many traditional educational settings, certain groups may face barriers to accessing advanced courses or resources.

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Importance of STEM in today's society

In this chapter, the aim is to outline the essential digital literacy skills required by STEM educators and to provide a practical roadmap for navigating the digital environments that are integral to modern STEM teaching. The chapter addresses the effective use of digital resources and tools, the development of technical proficiency to overcome challenges in virtual and digital teaching spaces, and the collaborative skills needed to work efficiently in virtual or hybrid environments. It also emphasizes critical thinking and problem-solving skills for analyzing information and applying logical reasoning to complex problems, while introducing ethical awareness and digital citizenship, which are explored in greater depth in Chapter 7. Overall, the chapter empowers STEM educators to bridge the gap between conventional classroom teaching and the immersive, technology-driven possibilities of the Metaverse and other digital platforms, supporting the transformation of learning spaces into environments that foster digital fluency, collaboration, creativity, and real-world problem-solving in STEM education.

General context of Digital Literacy

Digital literacy encompasses the ability to effectively use technology to communicate, access information, and create content, and in the Metaverse this includes understanding how to interact within virtual spaces, manage digital identities, and engage with immersive technologies. In the context of STEM education, digital literacy represents a combination of technical, cognitive, and critical skills that enable educators to confidently integrate digital tools into their teaching in ways that deepen students' understanding of STEM concepts and support interactive, student-centred learning. As educators navigate innovative digital platforms in the Metaverse, information literacy becomes particularly important, as it involves the ability to locate, evaluate, and use information effectively and ethically. STEM educators play a key role in guiding students to distinguish reliable sources from misinformation, especially when working with scientific data, simulations, or emerging technologies, where virtual experiences may blur the boundary between digital and real-world contexts, particularly for younger learners.

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By modelling critical analysis, questioning the credibility of digital content, and encouraging the use of trustworthy academic and educational sources, educators help students develop a critical mindset toward information consumption that is applicable both within virtual environments and across a wide range of learning contexts.

Technical Proficiency in STEM & the Metaverse

Aspect	Key Idea
What it is	Technical proficiency refers to the ability to confidently use digital devices, software, and online platforms.
Common Misconception	Students are often assumed to naturally possess these skills without guidance.
Reality	Both educators and students need structured support to develop meaningful digital skills.
Role in STEM	Educators must use tools such as coding platforms (Scratch, Python), data visualisation software, and simulations.
Role in Metaverse	Familiarity with virtual worlds, VR/AR technologies, and basic 3D modelling is required.
How it should be developed	Start with accessible platforms and gradually move to more complex technologies.
Educational Value	When combined with analogue methods and pedagogy, technical proficiency enables lifelong learning and co-creation.

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Collaborative skills

How collaboration happens	Tools that support collaboration	Learning through collaboration	Learning Outcomes & Readiness
• Physical & digital environments • Virtual and hybrid communication	• Digital communication platforms • Shared workspaces & co-editing tools	• Problem-solving & projects • Confidence in immersive environments	• Problem-solving and co-creation • Confidence in academic and professional STEM contexts

It is important to emphasise the role of guided practice in developing collaborative skills. Students often need explicit support to select appropriate digital collaboration tools and make informed choices independently. In STEM education, educators facilitate collaboration by designing activities that reflect real-world scientific and technological practices, including teamwork in virtual and immersive environments. Regular collaborative work across classroom and Metaverse settings helps students build confidence, responsibility, and effectiveness in digitally mediated teams.

Critical Thinking and Problem-Solving in STEM Digital Learning

Critical thinking and problem-solving skills are essential for preparing students to become active and responsible global citizens. These competencies involve the ability to analyse information critically, apply logical reasoning, and develop solutions to complex problems, and they require sustained development through early introduction and continuous practice. In STEM education, digital literacy goes beyond the technical use of tools to include understanding when, why, and how digital technologies should be applied to address challenges effectively. Educators therefore play a central role in guiding students to approach digital and immersive environments with a problem-solving mindset, encouraging them to analyse scenarios, make informed decisions, and evaluate outcomes.

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Analyse Information

- Logical reasoning
- Evidence-based thinking

Identify the Problem

- Understanding STEM challenges
- Interpreting virtual scenarios

Test & Revise Solutions

- Hypotheses & experimentation
- Learning from feedback

Evaluate Outcomes

- Reflecting on results
- Communicating solutions

Ethical Awareness and Digital Citizenship

Definition

- Ethical awareness and digital citizenship are essential competencies that support responsible participation in digital environments.
- In digital literacy, ethical awareness includes: Respect for intellectual property, protection of privacy and lastly responsible behaviour in digital spaces
- Developing these skills enables students to make informed decisions, contribute positively to digital communities, and model ethical digital practices.

Relevance in STEM

- Ethical considerations in STEM education are closely linked to digital citizenship, particularly in:

  Data privacy, Responsible research practices, Respect for others' work
- In immersive and collaborative environments such as the Metaverse, educators guide students to:
  a. Act respectfully in digital interactions
  b. Understand the consequences of their digital actions
- Collaboration and discussion help students value diverse perspectives and improve collective outcomes.

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Practical Application

- Ethical awareness and digital citizenship should be embedded across all STEM activities rather than addressed as standalone topics.
- Educators can support ethical understanding by:
  a. Discussing real-world digital scenarios (e.g. source attribution, data use)
  b. Encouraging ethical decision-making in virtual experiments
  c. Establishing clear guidelines for virtual interaction
- Integrating digital ethics into subject-specific activities promotes responsible and reflective use of digital tools in both physical and virtual learning environments.

Conclusion

These key components of digital literacy, when combined, enhance students' understanding of digital learning and enable STEM educators to become more effective facilitators of technology-rich learning environments. To achieve the greatest impact, these skills must be integrated across subjects rather than taught in isolation, allowing educators to move beyond the basic use of digital tools toward creating deeper, more interactive learning experiences that place content within a broader context. A digitally literate educator not only supports the development of technical competence but also empowers students to think critically, collaborate effectively, and act ethically in an increasingly digital world, skills that are essential for becoming active and responsible global citizens.

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Key Skills for Digital Literacy in the Metaverse for STEM Educators

STEM educators need to feel confident in their own digital literacy in order to effectively support students in developing these skills themselves. Students rely on educators to guide them through digital environments and to help them identify tools that best support their learning needs. Digital literacy in the Metaverse goes beyond basic technical competence and requires a broader understanding of how immersive virtual environments can be purposefully used to enhance STEM teaching and learning. The following key skills are essential for educators to successfully implement Metaverse technologies in the classroom.

Spatial Awareness and Virtual Navigation Literacy

Skill Definition

- The ability to orient and move confidently within three-dimensional digital environments.
- Essential for educators, as poor navigation can reduce student engagement and learning effectiveness.

Relevance in the Metaverse

- Educators need to navigate virtual spaces confidently and demonstrate navigation strategies to students.
- Understanding spatial design (e.g. interactive zones and learning areas) helps create a clear and logical learning flow.
- Well-structured virtual environments support motivation and sustained engagement.

Application in STEM

- Educators guide students through complex 3D representations, such as molecular or anatomical models.
- Immersive interaction supports understanding of abstract concepts and encourages curiosity and continued exploration.

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Digital Content Literacy for Virtual Worlds and the Metaverse

- ***Skill definition:*** Digital content literacy involves the ability to select, combine, create, and organize digital resources to support meaningful learning experiences. In the Metaverse, this includes working with 3D models, simulations, and other digital assets within a coherent educational context that helps students understand connections between concepts.
- ***Relevance in the Metaverse:*** Educators need to be digitally competent in choosing, adapting, or creating content suitable for virtual learning environments. Understanding which types of digital assets are compatible with Metaverse platforms and how to source or develop them is essential for creating engaging and effective lessons. When educators possess these skills, they can also involve students in content creation, further deepening learning and ownership.
- ***Application in STEM:*** In practice, educators may integrate existing digital resources, such as interactive biology or physics simulations, and enrich them with customized content aligned to specific STEM objectives. This approach supports immersive, goal-oriented learning experiences that connect theory with practice in virtual environments.

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Digital Communication and Collaboration Literacy

Digital communication and collaboration literacy involve the effective use of communication tools within the Metaverse to manage learning activities, provide instructions, and support collaboration among students. This skill also includes the ability of educators to collaborate with one another, share virtual learning environments, and learn from each other's practices to continuously improve teaching quality.

In immersive virtual settings, educators must adapt their communication methods by using avatars, chat functions, voice tools, and shared workspaces to guide interactions and encourage collaborative problem-solving. Mastery of these tools enables educators not only to support student learning more effectively but also to assess student engagement and progress with greater accuracy.

In STEM group projects, educators can assign tasks, facilitate discussions, and monitor teamwork in real time within the Metaverse. For example, students may collaborate on a virtual chemistry experiment, while the teacher uses communication tools to provide guidance, answer questions, and assess learning outcomes throughout the activity.

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Ethical and Responsible Use of Digital Spaces

Ethical and responsible use of digital spaces encompasses digital ethics, privacy awareness, and responsible behavior within virtual environments. Without confidence in this area, educators may become overly restrictive; instead, ethical competence enables educators to guide students toward responsible and informed digital participation. In immersive virtual environments, educators must establish clear standards for respectful behavior, including protection of personal data, respect for intellectual property, and positive interaction with others. Involving students in defining these standards increases awareness, responsibility, and shared ownership of ethical digital practices. Educators can collaboratively develop ethical guidelines with students, addressing topics such as respect for virtual avatars, responsible use of digital assets, and intellectual property rights. This approach helps students understand the real impact of their actions in digital environments and supports ethical decision-making across STEM activities.

Adaptability and Technical Troubleshooting

Adaptability and technical troubleshooting refer to the ability to quickly identify and resolve technical issues that may disrupt learning. This skill enhances educators' confidence and efficiency when working in dynamic digital environments.

Virtual environments can present unique technical challenges, such as system errors or connectivity issues. Educators must be prepared to adapt, troubleshoot, and guide students through these challenges to ensure continuity of learning and maintain engagement.

For example, if a virtual physics experiment is interrupted due to technical issues, an educator may redirect students to an alternative platform or a 2D simulation while addressing the problem. Developing troubleshooting skills collaboratively with other educators and involving students in problem-solving helps distribute knowledge and strengthens collective digital resilience.

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Digital Assessment and Feedback Skills

- **Definition:** Digital assessment and feedback skills involve using virtual tools and analytics within the Metaverse to evaluate student progress, engagement, and understanding, and to provide meaningful feedback based on digital interactions.
- **Relevance in the Metaverse:** Assessing learning in virtual environments requires educators to interpret new forms of evidence, particularly when traditional physical cues are limited. The Metaverse enables innovative learning experiences that require adapted assessment strategies aligned with immersive and experiential learning.
- **Application in STEM:** Educators may use interactive checkpoints in virtual labs, analytics tools to track engagement, or digital portfolios to assess student learning. Feedback can be provided in real time within the virtual environment or through complementary digital platforms, allowing educators to tailor assessment methods to specific learning objectives.

By developing these key digital literacy skills, STEM educators can confidently navigate the Metaverse and design engaging, ethical, and effective learning experiences. These competencies enable educators to use virtual environments as powerful teaching tools that enhance students’ understanding of complex STEM concepts, strengthen digital literacy, and support meaningful, future-oriented learning across disciplines.

Conclusion

Digital assessment and feedback skills are presented last because they complete the cycle of digital literacy by enabling educators to measure student progress and provide targeted, meaningful feedback based on virtual interactions, ensuring that engagement in the Metaverse leads to real learning outcomes and skill development. Digital literacy is therefore foundational for successful participation in immersive environments, and as technology continues to advance, these skills empower educators and students to thrive responsibly in virtual spaces. As STEM educators enter the Metaverse, developing a flexible and nuanced set of digital literacy competencies becomes essential to transforming traditional STEM education into immersive, interactive learning experiences that deepen understanding of complex scientific and mathematical concepts. Collectively, the competencies outlined form a comprehensive framework for effectively navigating and leveraging the Metaverse as a transformative educational platform rather than a technological novelty. By mastering these skills, educators can inspire curiosity, foster ethical engagement, and prepare students for a future in which digital literacy is paramount. These skills are deeply interwoven between educators and students, creating a symbiotic relationship in which educators must first build their own competencies and then actively involve students in the process. As educators guide students in critical thinking, collaboration, and ethical digital citizenship, their own skills are continuously reinforced and refined, while students' progress challenges educators to remain adaptive and innovative. This ongoing feedback loop fosters a dynamic and sustainable learning ecosystem in the Metaverse, where educators and learners grow together and succeed in an interconnected digital world.

Self Assessment: Digital Literacy Competencies in the Metaverse

The following True/False statements are designed to support teachers in reviewing and consolidating the key ideas presented in Chapter 2. This self-assessment focuses on the role of digital literacy competencies in enabling meaningful learning within Metaverse environments, the interconnected nature of these skills, and the importance of assessment, feedback, and ethical engagement.

1. Digital assessment and feedback skills are positioned last because they help complete the digital literacy cycle. T/ F
2. Engagement in the Metaverse automatically guarantees meaningful learning outcomes without assessment or feedback. T/F
3. Digital literacy is described as a foundational requirement for effective participation in immersive learning environments. T/F
4. The development of digital literacy competencies allows educators and students to use the Metaverse responsibly and purposefully. T /F
5. Digital literacy competencies are presented as isolated skills rather than an interconnected framework. T/F
6. Mastery of digital literacy skills helps transform the Metaverse from a technological novelty into a meaningful educational platform. T/ F
7. Educators must first develop their own digital competencies before effectively guiding students in immersive environments. T /F
8. The relationship between educators' and students' digital literacy development is described as one-directional. T /F
9. Continuous interaction between educators and students creates a feedback loop that strengthens skills on both sides. T /F
10. The chapter concludes that digital literacy competencies support curiosity, ethical engagement, and readiness for a digital future. T /F

Self Assessment: Digital Literacy Competencies in the Metaverse Answer Sheet:

1. True
2. False
3. True
4. True
5. False
6. True
7. True
8. False
9. True
10. True

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CREATIVE AND CRITICAL THINKING SKILLS

MSTEM

CHAPTER 3

METAVERSE-BASED STEM EDUCATION FOR A SUSTAINABLE AND RESILIENT FUTURE

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Introduction

In a constantly changing world, developing creativity and critical thinking is an educational priority so that everyone can analyse and act with discernment. Far from being a skill reserved for adults, critical thinking begins to be developed from early childhood, when the child explores, questions and tries to understand the world around them.

This process of intellectual awakening, guided by appropriate interactions, is essential for the development of autonomous individuals, capable of discernment and able to act on the world
At different levels, these two skills are synonymous with well-being for the individual: 'One of the main attractions and interests of creativity lies in the feeling of anchoring and well-being it provides, according to positive psychology. (OECD p22). Critical thinking also plays a role in individual well-being, but is more often seen as one of the main pillars of a well-functioning modern democracy.' (OECD, p22)

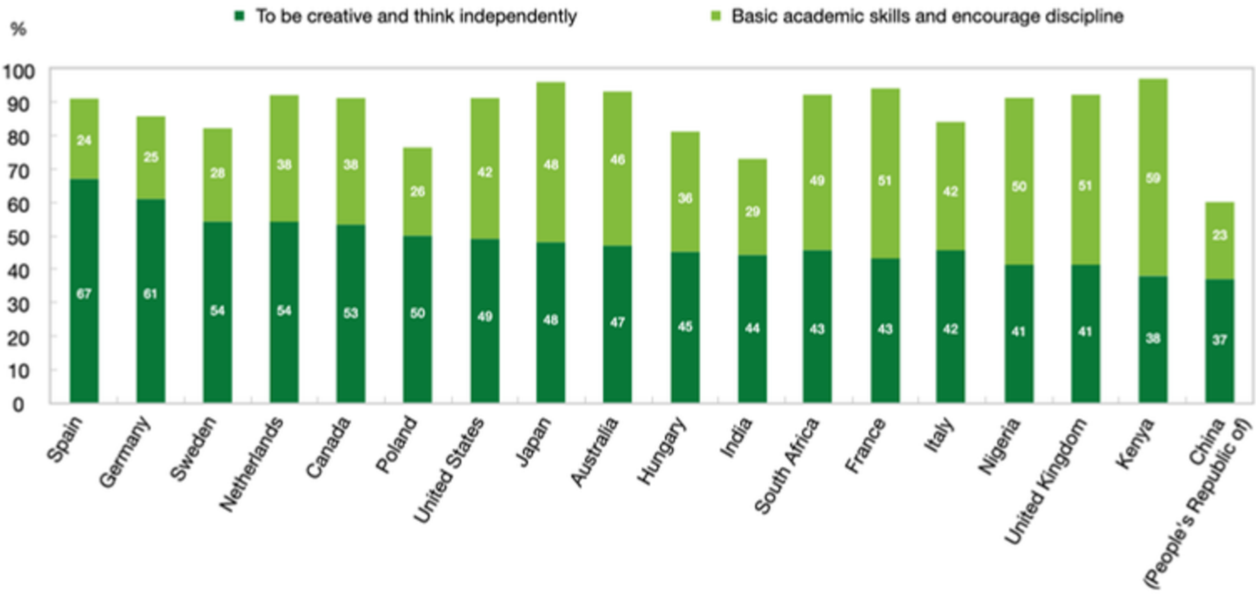
Creativity is often associated with the arts, and critical thinking with the analysis of discourse or media output. Yet all areas of thought require creativity and critical thinking. Similarly, one might think that creativity is a gift and critical thinking a particularly strong personality trait. Yet both skills are present very early on and naturally in all individuals. 'Like other skills (at least most of them), creativity is not binary, but a continuum that can operate at different levels of mastery. It is not only artists or 'visionaries' or those presented as such who are capable of it.' (OECD). Similarly, critical thinking, given the biases in reasoning induced by the functioning of the human brain and the variety of situations in which it must be exercised also requires different levels of mastery.

It is therefore possible to develop levels of mastery in creativity and critical thinking. Most societies also believe (survey conducted by the OECD, chapter 2, p52) that it is important for these two skills to be taught at school.

It is therefore possible to develop levels of mastery in creativity and critical thinking. Moreover, most societies believe (survey conducted by the OECD, chapter 2, p52) that it is important for these two skills to be taught at school.

Figure 2.2. Most societies support the fostering of creativity and critical thinking in education

It is more important that schools in our country teach...



Source: Pew Research Centre, Spring 2016 Global Attitudes Survey.

The chart shows how people in different countries view the main purpose of education, comparing the importance of creativity and independent thinking with basic academic skills and discipline. In most countries, a higher proportion of respondents believe schools should prioritise creativity and critical thinking. However, preferences vary across contexts, with some countries placing greater emphasis on foundational skills and discipline. Overall, the chart highlights a global shift toward valuing higher-order thinking skills in education.

Learning models and education in creativity and critical thinking

Creativity and critical thinking cannot be developed without a certain amount of knowledge. But the reverse is also true. It is in this tension between the contribution of knowledge and creativity on the one hand and knowledge and critical thinking on the other that the learning situations devised by teachers must take place.

Creativity can be defined as the ability to ‘come up with new ideas and solutions’ (OECD, p32). Critical thinking as the ability to ‘question and evaluate ideas and solutions’ (OECD, p32).

In view of these definitions, it is clear that not all learning situations are equal when it comes to fostering creativity and critical thinking. Learning models that leave room for students to represent their everyday lives, in which they can try, make mistakes and start over are conducive to the development of creativity and critical thinking. Learning through research and problem solving and project-based learning are conducive to the development of creativity and critical thinking in pupils. These two teaching methods, which are inspired by the scientific approach of researchers, are therefore easily practicable with pupils in the context of MSTEM learning.

On the other hand, ‘When education is seen as the simple transmission of socially accepted knowledge, there is little room for creativity and critical thinking. On the other hand, like most skills, creativity and critical thinking should only be exercised at certain times: assuming it is really possible, a world where people are creative or critical all the time would be unbearable.’ (OECD, p53)

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In 'Defining and Educating Critical Thinking', Pasquinelli et al emphasise that the learning times for critical thinking must be explicit for the pupils. The teacher and the pupils must know that in this situation, each will improve their creative and critical skills. It is therefore important to define and explain the criteria that correspond to these two skills and to specify the levels of mastery. In their OECD report (p32), the teachers who took part in the study propose these evaluation criteria for pupils.

Easily transferable to the classroom, these criteria are a guide for evaluation.

Table 1.2. OECD rubric on creativity and critical thinking (domain-general, class-friendly)

	CREATIVITY Coming up with new ideas and solutions	**CRITICAL THINKING** Questioning and evaluating ideas and solutions
INQUIRING	Make connections to other concepts and knowledge from the same or from other disciplines	Identify and question assumptions and generally accepted ideas or practices
IMAGINING	Generate and play with unusual and radical ideas	Consider several perspectives on a problem based on different assumptions
DOING	Produce, perform or envision a meaningful output that is personally novel	Explain both strengths and limitations of a product, a solution or a theory justified on logical, ethical or aesthetic criteria
REFLECTING	Reflect on the novelty of the solution and of its possible consequences	Reflect on the chosen solution/position relative to possible alternatives

Note: This rubric is meant for teachers/faculty to identify the student skills related to creativity and to critical thinking that they have to foster in their teaching and learning, not for assessment.

We will use the 4 actions: research, imagine, do and reflect to identify the added value of the metaverse for educating creativity and critical thinking in the context of STEM.

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Contributions of the Metaverse to Education in Creativity and Critical thinking with M-STEM

The metaverse enables people who are physically distant to meet and interact, and provides access to a very wide variety of content, both interactive and non-interactive.

The metaverse is therefore suitable for the collective resolution of problems or scientific questions or for the realisation of collective projects. The virtual laboratory also makes it possible to carry out manipulations that are impossible in real life due to lack of equipment or because they are too dangerous.

Drawing inspiration from the work of colleagues who wrote the OECD report, here are a few examples of scientific activities that are suitable for developing creativity and critical thinking skills. These activities have in common that they are open-ended, related to the pupils' daily lives and linked to MSTEM content.

Explaining a phenomenon

- Evaporation cooling
- Gas exchange between the chlorophyll plant and its environment

Solving an environmental problem

- Reducing the heat in the playground
- Promoting biodiversity in the school
- Reducing traffic in a street to avoid traffic jams

Designing a production

- Designing a structure to provide shelter from the sun and collect rainwater for the garden or to feed a pond.
- Building a pontoon to facilitate the observation of life in the pond

Imagine hypothetical scientific scenarios

- What would the Earth be like if plate tectonics did not exist?
- If photosynthesis did not exist, what would ecosystems be like?

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For each area of creativity and critical thinking assessment, we present some of the possibilities offered by the metaverse

Rubrics	Examples of activities available in the metaverse for education in creativity and critical thinking
Inquiring	• Explore virtual environments to find project-related information and data • Use data-visualisation tools to analyse problems and identify knowledge gaps
Imagining	• Participate in immersive brainstorming sessions to generate and share ideas • Use simulations or virtual models to explore scenarios and outcomes
Doing	• Design and prototype virtual objects or environments using 3D tools • Experiment in virtual labs • Co-create digital artworks or interactive installations
Reflecting	• Join virtual discussions or debates to critically evaluate ideas • Use digital portfolios to reflect on learning progress and skill development

Conclusion

To conclude, the metaverse is a useful resource for working on creativity and critical thinking, provided that the pedagogical situation proposed by the teacher is a sufficiently open situation in which the pupils have a problem to solve. They will be able to compare their ideas with those of pupils who are not in the class and produce together or in parallel productions that can be discussed.

The use of AI present in the metaverse will also be an opportunity for students to exercise their critical thinking in the face of the proposed results, which are only the result of a statistical use of the data to which the AI has access.

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Self-Assessment: Creative and Critical Thinking Skills

The following True/False statements are designed to help teachers review and consolidate the key concepts presented in Chapter 3. This self-assessment focuses on the nature of creativity and critical thinking, their development across different levels of mastery, the role of appropriate learning models, and the added value of Metaverse-based STEM activities in fostering these skills.

Mark each statement as True (T) or False (F) based on the content of Chapter 3

1. Creativity and critical thinking are skills that only develop during adulthood. T/F
2. Both creativity and critical thinking exist naturally in all individuals and can be developed at different levels of mastery. T /F
3. Creativity is limited to artistic subjects, while critical thinking applies only to media or discourse analysis. T/F
4. The development of creativity and critical thinking requires a balance between knowledge acquisition and opportunities for exploration. T / F
5. Learning models that allow students to try, make mistakes, and start again are conducive to creativity and critical thinking. T / F
6. Project-based learning and problem-solving approaches are aligned with the development of creativity and critical thinking in STEM education. T /F
7. The chapter presents creativity as the ability to question and evaluate ideas, while critical thinking is defined as producing new ideas and solutions. T /F
8. The four key actions used to analyse creativity and critical thinking in the Metaverse are researching, imagining, doing, and reflecting. T /F
9. Metaverse environments support creativity and critical thinking by enabling collaboration, open-ended exploration, and experimentation that may not be possible in real-life settings. T /F
10. The use of artificial intelligence in the Metaverse requires students to exercise critical thinking when interpreting AI-generated results. T /F

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Self-Assessment: Creative and Critical Thinking Skills

Answer Sheet:

1. False
2. True
3. False
4. True
5. True
6. True
7. False
8. True
9. True
10. True

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INTRODUCTION TO METAVERSE HANDS-ON STEM ACTIVITIES

MSTEM

CHAPTER 4

METAVERSE-BASED STEM EDUCATION FOR A SUSTAINABLE AND RESILIENT FUTURE
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Introduction

This chapter presents a set of hands-on STEM learning activities implemented in the Metaverse. The activities are designed to support students in exploring scientific concepts through interactive experimentation, simulation, and problem-solving in a virtual environment.

Using immersive digital tools, students actively engage with abstract and complex topics by observing, manipulating variables, testing hypotheses, and analyzing results. The Metaverse allows learners to experience phenomena that may be difficult, dangerous, expensive, or impossible to explore in a traditional classroom or laboratory setting.

Each activity follows a similar structure and is aligned with STEM principles, encouraging the integration of science, technology, engineering, and mathematics. Students work individually or collaboratively to complete tasks, collect data, and reflect on outcomes, strengthening both conceptual understanding and digital competence.

The following topics are implemented as hands-on Metaverse activities in this chapter:

- Properties and behavior of solids
- Rocket simulation lab and motion principles
- Chemical reactions and observable changes
- Renewable energy systems, including solar panels and wind turbines
- Photosynthesis and energy transformation in plants
- Lenses and image formation in optics
- Human digestion system and biological processes

Through these activities, students develop critical thinking, scientific inquiry, and engineering design skills, while gaining experience with innovative learning technologies. The Metaverse serves as a safe, engaging, and flexible environment that enhances experiential STEM learning and supports diverse learning styles.

By engaging with these Metaverse-based activities, students are encouraged to take an active role in their learning process, moving beyond passive observation toward exploration and experimentation. The immersive nature of the virtual environment supports deeper understanding, increases motivation, and allows learners to learn from trial and error. These activities are designed to be adaptable across different educational contexts, ensuring accessibility and flexibility while promoting meaningful, hands-on STEM learning experiences.

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Virtual Chemistry Lab: Exploring Chemical Reactions in the Metaverse

Project Overview

This project brings chemistry to life in the Metaverse by allowing students to conduct experiments in a virtual lab. Instead of working with real chemicals, students will interact with digital substances, mix compounds, observe reactions, and analyze results—all within a safe and controlled environment. This eliminates the risks associated with real-world chemical experiments while making learning more interactive and engaging. By using immersive technology, students will be able to explore different types of reactions, change variables, and understand how different factors influence outcomes. The project is designed to introduce key chemistry concepts such as chemical reactions, reaction rates, and lab safety. Students will learn how substances interact, what causes certain reactions to speed up or slow down, and how scientists conduct controlled experiments. By adjusting variables like temperature and concentration, they will see firsthand how different conditions affect a reaction. This will help them develop a deeper understanding of scientific principles and improve their analytical thinking skills. This virtual lab is ideal for students aged 12 to 18 who are at a beginner to intermediate level in chemistry. It provides an accessible and engaging way for students to explore STEM subjects, even if they don't have access to physical lab equipment. The interactive nature of the Metaverse allows for experimentation without limits—students can repeat reactions, test different scenarios, and even collaborate with classmates in shared virtual spaces. The project aims to make chemistry more exciting, encourage curiosity, and give students the confidence to explore scientific concepts in a fun and meaningful way.

Learning Objectives

This project aims to help students understand fundamental chemistry concepts through interactive, hands-on experiments in the Metaverse. They will explore different types of chemical reactions, analyze how variables like temperature and concentration affect reaction rates, and develop a deeper understanding of reaction mechanisms. Beyond chemistry knowledge, students will enhance their scientific reasoning, critical thinking, and data analysis skills. They will practice formulating hypotheses, recording observations, and drawing conclusions based on their virtual experiments. The interactive nature of the project will encourage problem-solving and experimentation. Additionally, students will develop digital literacy and collaboration skills by using Metaverse tools to conduct experiments, compare results, and discuss findings with peers. By the end of the project, they will have a strong foundation in chemistry, improved analytical thinking, and a greater appreciation for STEM subjects.

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Hands-On Activity in the Metaverse

Students will engage in immersive, hands-on chemistry experiments within a virtual laboratory in the Metaverse. This interactive environment will allow them to safely conduct experiments that would otherwise require specialized equipment or pose safety risks in a physical lab. To begin, students will create their own virtual chemistry workspace, where they will access digital lab equipment such as beakers, test tubes, and Bunsen burners. Guided by interactive tutorials, they will mix different chemicals to observe and analyze reactions like synthesis, decomposition, combustion, and displacement. They will adjust variables such as temperature and concentration, monitoring how these changes affect reaction rates in real time. The Metaverse environment will provide instant feedback, allowing students to see molecular structures and reaction progress through visual simulations.

Example Experiments:

1.Hydrogen and Oxygen Reaction:

Students will mix hydrogen (H_2) and oxygen (O_2) in a controlled virtual environment.
Using a virtual spark, they will initiate the reaction to produce water (H_2O) while observing the energy release and molecular transformation. This experiment demonstrates the concept of combustion and energy changes in chemical reactions.

2.Acid-Base Neutralization:

Students will combine hydrochloric acid (HCl) with sodium hydroxide (NaOH) to observe neutralization. They will use pH indicators to track the color change as the reaction progresses to form water (H_2O) and salt (NaCl). This experiment reinforces acid-base interactions and real-world applications like antacid medications.

3.Electrolysis of Water:

Using a virtual power source, students will separate water (H_2O) into hydrogen and oxygen gas through electrolysis. They will analyze gas collection in test tubes and measure reaction efficiency based on voltage changes. This experiment highlights redox reactions and the principles of electrochemistry.

4.Precipitation Reaction:

Students will mix silver nitrate ($AgNO_3$) with sodium chloride (NaCl) to form silver chloride (AgCl) as a solid precipitate. They will adjust concentrations to analyze solubility limits and factors affecting precipitation. This experiment demonstrates ionic reactions and solubility rules in chemistry.

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Students will also collaborate in teams, designing and conducting experiments together. They will document their observations and hypotheses using virtual lab notebooks and engage in discussions with peers to compare results. Additionally, they will test their understanding by completing challenge-based experiments, such as identifying unknown substances based on reaction behavior or optimizing conditions for a specific chemical process. To evaluate their findings, students will present their experiment results in a shared virtual space. They will participate in peer reviews, visiting other teams' digital labs to provide feedback and discuss their conclusions. The Metaverse will also allow for gamified elements, where students can take part in interactive quizzes or challenges that reinforce key chemistry concepts.

Required Tools and Software

To participate in this project, students will need access to:

- VR Headset (e.g., Oculus Quest, HTC Vive) or a mobile phone with Google Cardboard for an immersive virtual lab experience.
- A Metaverse platform (such as Mozilla Hubs or Spatial) to create and interact in virtual chemistry labs.
- A virtual chemistry simulation tool (such as Labster or PhET Interactive Simulations) to conduct experiments and visualize chemical reactions.
- Collaboration tools like Google Docs or Miro for documenting observations, analyzing results, and sharing findings with peers. Stable internet connection to ensure smooth access to the virtual environment.

Extensions and Future Exploration

After completing the project, students can extend their learning by exploring more complex chemical reactions, such as redox reactions or electrolysis, and their real-world applications. They could also investigate environmental chemistry, designing eco-friendly processes or studying sustainability. Cross-disciplinary projects could allow students to apply chemistry in fields like material science or robotics. Collaborating with real-world scientists or joining virtual science communities can provide further insights, while virtual chemistry competitions offer opportunities to showcase and compare results. These extensions will encourage students to apply their knowledge in innovative ways and deepen their STEM skills.

ROCKET MOTION SIMULATOR: A VIRTUAL PHYSICS LAB

Project Overview

Rocket Motion Simulator: A Virtual Physics Lab project is a project that allows students to explore rocket science fundamentals in an interactive virtual environment. More specifically, it allows students to use a physics lab in the metaverse to experiment with crucial variables that are critical for rocket launchingand therefore they can learn from the results. Variablesthat the studentscan experiment with are such as thrust, fuel type, mass, aerodynamics, with the ability to directly observe how these adjustments influence the rocket's motion, altitude, and trajectory.
The purpose of the projectis to provide students with hands-on learningabout physics principles and engineering concepts,allowing students to witness firsthand how different forces choicesimpact rocket behavior.This interactive experience connects theoretical physics to real-world applications, giving students a deeper understanding of STEM fields while at the same time using critical thinking to apply different solutions.

This project focuses on several core concepts that students can explore as they learn about rocket science. First, they will study thrust and Newton’s Third Law to understand how rockets gain momentum through the force of thrust and how this is balanced by opposing forces. By experimenting with velocity and acceleration, students can see how changes in speed and direction are influenced by variations in thrust and the rocket’s mass.

Students will also look at gravity and air resistance, analyzing how gravitational pull and drag impact the rocket’s stability, ascent, and maximum altitude. Exploring fuel efficiency allows them to experiment with different types of fuel and consumption rates to find a balance between energy use and performance. Testing aerodynamics shows how the rocket’s shape and materialshelp reduce drag, increase speed, and keep it stable.Through iterative testing, students engage in the engineering design process, refining their rocket’s design to meet specific flight objectives.

This project is designed for students aged 12-18, with intermediate skill levels. It’s suited for middle and high school students who have a basic understanding of algebra and physics and are interested in space science. By combining science, technology, engineering, and math, this projectprovides a hands-on,interactive learning experience in the Metaverse that brings STEM concepts to life.

Learning Objectives

Through this project,students will gain a varietyof valuable skills and knowledge. They'll develop an understanding of physics and motion by exploring core concepts like Newton's Laws of Motion and learninghow rockets move through thrust and force. Bycalculating factors like force, speed, and trajectory using math formulas,students will connect math to real-world situations, practicing basic algebra and physics equations to predict rocket movement. The engineering process comes into play as students design, test, and improve their rockets, learning to identify issues, make adjustments, and find solutions, just like professional engineers. In addition, through experimentation, students will make predictions, test ideas, and analyze data, gaining hands-on experience with recording and understanding data and seeing how variables like fuel type and launch angle affect results.They will also develop digitalskills by working in a Metaverse lab, navigating virtual environments, and using digital tools— critical skills in tech-focused careers. Furthermore, students will strengthen their communication and teamwork skills as they collaborate in a virtualspace, sharing ideas, designingtogether, and discussing outcomes. By connecting science, technology, engineering, and math, this project offers an engaging, hands-on way to practice essential STEM skills in an immersive, virtual environment.

Hands-On Activity in the Metaverse

Students will take part in interactive activities within a virtual lab in the Metaverse, where they can test how different variables affect a rocket's launch. To start, students will enter a digital lab where they will see a rocket and a control panel with settings they can adjust. They won't design rockets but will play with variables like thrust, fuel type, mass, and aerodynamics. They'll begin by watching a default rocket launch to see how it behaves before making any changes. Once they are familiar with the setup, students will experiment by adjusting one variable at a time like changing the thrust or altering the fuel type and then launch the rocket to see how each change affects its speed, altitude, and trajectory. They can run multiple tests, making different adjustments each time, and observe how the rocket's behavior changes. As they adjust, they'll record the results, noting how each change impacts the rocket's flight. After running severaltests, students will evaluate the data they collected in comparison to the hypothesis that they have had to see if the rocket performed as expected. They will then analyze how different variables influenced the rocket's performance, helping them understand the science behind the changes they made. Students will then compare their results with classmates by visiting each other's virtual spaces, where they can see what others tested and discuss their findings.

Finally, students will present their results to the class, sharing the adjustments they made, how the rocket performed, and what they learned. This collaborative approachwill allow them to learn from each other and provide feedback, deepening their understanding of the physics involved.

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Required Tools and Software

VR Headset and a smartphone with Google Cardboard application.

Extensions and Future Explorations

After applying this project, students can extend their learning in several ways. They could experiment with more advanced variables, such as combining different factors like fuel type and mass,to create the most efficient rocket. Another idea for students to understand how gravity and atmospheric conditions affect the rocket's performance, is to simulate rocket launches in different environments, like on the Moon or Mars. Students could also dive deeper into the math behind rocket launches,using more complex calculations to predict flight paths or optimal launch angles. Furthermore, they might create a mission plan for a rocket launch, testing different configurations to achieve specific goals. Collaborative space exploration projects could also allow students to work togetheron larger challenges, where each student focuses on a different aspect of the rocket. They could even connect their virtual experiments with real-world space exploration by researching current missions and rocket technologies. Students could build a portfolio of their experiments, documenting their process and results, helping them reflect on what they've learned and how their virtual work ties into real-world science. These activities would help students keep building on their knowledge and apply what they've learned in new and exciting ways.

EXPLORING SOLIDS IN A VR ENVIRONMENT

Project Overview

This project proposes creating an engaging and educational VR activity about solids in a classroom. It is an excellent way to help students better understand the properties and qualities of various types of solids. The students can visualize and interact with 3D shapes and concepts.

This project is designed for students aged 12-18, with intermediate skill levels. It's suited for middle and high school students who have a basic understanding of geometry and mathematics in the area of solids and polygons.

Learning Objectives

One of the main objectives of the lesson will be for students to understand that there are different types of solids. All with different properties and shapes, and through this virtual environment they will be able to manipulate, compare and distinguish the different types of solids.

It begins with a brief theoretical introduction about solids using a whiteboard or projector to show images of various solids (cube, sphere, pyramid, cone and cylinder) and explain their properties: Faces, edges and vertices, showing at the end some examples of application of solids in the real world. Then, in a second part of the activity, we will try to familiarize students with the use of virtual reality glasses, with their commands and controls to manipulate, move and rotate objects. Demonstrate how to use the VR headset and controllers to move, scale, and rotate objects in the VR environment. Remind students to stay aware of their surroundings when using the VR headsets. Them the Students will enter the VR environment where they will interact with 3D models of solids. They have chance to Explore: Students will see various geometric solids in 3D. They will be able to rotate, scale, and manipulate these shapes to understand their structure. Manipulate: the students change the size of the solids, count faces, edges, and vertices.

They should identify each solid and categorize them based on their properties (e.g., how many faces a cube has versus a sphere). The Students compare different solids side-by-side to identify the differences and similarities in their geometries.

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Hands-On Activity in the Metaverse

Them the Students will enter the VR environment where they will interact with 3D models of solids. They have chance to Explore: Students will see various geometric solids in 3D. They will be able to rotate, scale, and manipulate these shapes to understand their structure. Manipulate: the students change the size of the solids, count faces, edges, and vertices.
They should identify each solid and categorize them based on their properties (e.g., how many faces a cube has versus a sphere). The Students compare different solids side-by-side to identify the differences and similarities in their geometries. At the end we can ask students to use guided activities in the to build a structure using a combination of solids. or to solve somme challenges like - "Create a building using a cube and a cone".

Required Tools and Software

To participate in this project, students will need:
Educational Metaverse Platform; This will be the main environment in which the practical activities will take place. It is essential that it is accessible, intuitive and compatible with school devices (laptops, tablets or VR glasses).

Extensions and Future Explorations

This VR activity will allow students to experience a deeper, interactive understanding of solids, engaging them visually, mentally, and physically in the learning process. At the end of the activity we can ask students to take off their headsets and reflect on how the activity might change their perspective on geometry. Ask them for feedback about the VR experience how they felt about the learning environment and what they found most engaging. We can then issue them a challenge: to design a structure or object in the VR world using a combination of solids. For example, they can build a geometric city or a pyramid using only cubes and cylinders.

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Exploring Pollen in the Metaverse

Project Overview

The aim of the project is to highlight the exchanges that chlorophyll plants have with their environment. The key concepts are biological: photosynthesis and energy transfer in ecosystems, but also physical and chemical, as concepts such as dissolved gases, the identification of oxygen gas and the wavelengths of light are used. Once they have identified the gaseous exchanges that plants have with their environment, students can continue their investigation by looking for the wavelengths of light that are effective for photosynthesis. This virtual laboratory is designed for students with a beginner to advanced level of science. The equipment used is simple and the results easy to interpret. In addition to exploring the process of photosynthesis, this activity places a strong emphasis on pollen and its role in plant reproduction. Within the Metaverse, students observe pollen grains at a microscopic level, examine their structure, and follow their movement from the anther to the stigma during pollination. Through interactive simulations, learners can manipulate variables such as wind, insects, and environmental conditions to understand how pollen is transferred and how successful pollination supports plant growth and reproduction. This immersive approach allows students to visualize processes that are normally invisible to the naked eye and strengthens their understanding of plant life cycles.

Learning Objectives

The scientific skills worked on by the pupils are experimental:
Devising and implementing a protocol, Vary a parameter so that a comparison can be made (control experiment),Communicate and interpret results.Working in groups will help develop the skills of cooperation and sharing results.

Hands-On Activity in the Metaverse

In the Metaverse, students enter a virtual plant environment where pollen can be observed and explored at different scales. Students begin by examining pollen grains closely, observing their shape, size, and surface structure, which are normally invisible to the naked eye.
Students can interact with pollen by:

- Identifying where pollen is produced in the plant (anther)
- Moving pollen grains to the stigma to simulate pollination
- Observing how pollen travels through wind or insects
- Comparing successful and unsuccessful pollination scenarios
- Through these simple interactions, students understand the role of pollen in plant reproduction and how pollen transfer is essential for plant development.

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Part 2: Investigating Photosynthesis in a Virtual Laboratory

Students often hear the expression “forests are the lungs of the planet.” In this activity, students explore what this statement means by testing their own ideas in a virtual laboratory.

Before starting the experiment, students discuss their initial ideas, which usually fall into two main hypotheses:

Plants consume oxygen and release carbon dioxide
Plants consume carbon dioxide and release oxygen

Virtual Laboratory Setup:

- In the Metaverse laboratory, students are provided with virtual materials, including:
- A basin filled with water (boiled water without gas, tap water, or water enriched with CO_2)
- Beakers, funnels, and test tubes
- Fragments of aquatic plants

Additional unnecessary materials to encourage critical thinking and decision-making

Students work in groups to design an experimental setup that allows them to test their hypotheses. Each group records its proposed setup in a shared virtual space, where other groups can review and comment on the design. After discussion and feedback, the teacher approves the final experimental setups.

Required Tools and Software

To participate in this project, students will need access to:

- VR Headset or a mobile phone with Google Cardboard for an immersive virtual lab experience.
- A Metaverse platform

Extensions and Future Explorations

Once the students have demonstrated the consumption of CO2 and the release of oxygen into the light by the plant, they can continue their reasoning by looking for the most effective wavelengths of light for photosynthesis. New experimental set-ups will then have to be devised by varying the wavelengths of the light source. A chlorophyll absorption spectrum can be created in the virtual laboratory: Spinach leaves ground in a mortar with ethanol, Absorption spectrum of the suspension obtained in a spectroscope. A comparison of the results with the effective wavelengths for photosynthesis obtained previously will show how well the wavelengths absorbed by the chlorophyll match the effective wavelengths for photosynthesis.

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Virtual Laboratory for the Study of Lenses and Image Formation through Lenses

Project Overview

This project allows students to explore fundamental concepts of optics in an interactive virtual environment. Specifically, the project allows students to use a virtual laboratory in the METAVERSE, to experiment with the variables that influence image formation through lenses, so they can directly observe how adjustments to various parameters affect the type, clarity, and size of the image. The goal of the project is to provide students with a hands-on experience in understanding essential optical principles, such as refraction and image formation through converging and diverging lenses. The project helps students understand how changes in position, focus and lens type affect the behavior of light and images, providing them with a deep understanding of optical phenomena, through an interactive and easy-to-understand application.

Learning Objectives

Understanding the basic principles of:

- Optics – Students will explore how converging and diverging lenses work and how they form images through the refraction of light.
- Practical applications of optical formulas – Students will apply mathematical formulas to calculate focal lengths, the size and type of image formed, experimenting with parameters such as object distance and the lens used.
- Experimenting with different types of lenses – Students will explore the behavior of different lenses (convex and concave), observing how these lenses influence the path of light and form real or virtual, enlarged or reduced images.
- Stimulating critical thinking and problem solving – Students will use the principles of physics to create experimental scenarios and adjust parameters to observe different effects and validate hypotheses based on the data obtained.
- Familiarization with scientific and technological applications of optics – Students will understand real-world applications of optics in various fields, such as optical instruments (microscopes, telescopes, eyeglasses), through an interactive approach.

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Key concepts studied:

- Converging and Diverging Lenses – Students will explore the differences between lenses that converge light (converging lenses) and those that disperse it (diverging lenses), learning how real and virtual images are formed.
- Refraction of Light – The concept of refraction will be studied through lenses, observing how changes in angle and material influence the direction and trajectory of light.
- Focal Length – Students will learn how to calculate the focal length of lenses and observe how it influences the size and clarity of the image formed.

Hands-On Activity in the Metaverse

Students will participate in interactive activities in a virtual lab in Metaverse, where they will explore how different variables influence the formation of images through lenses. At first, students will enter a digital lab where they will find a set of converging and diverging lenses, along with a virtual object whose image will be observed. They will adjust variables such as focal length, lens type and object position to observe the effects on the formed image.

To begin, students will observe how an image is formed in a default situation, using the standard settings of the virtual lab. They will analyze the resulting image and observe how it behaves in relation to the position of the object and the distance from the lens. Once they become familiar with this process, students will experiment by adjusting one variable at a time. For example, they will change the distance of the object from the lens or change the type of lens (converging or diverging) to observe how this influences the sharpness and type of image (real or virtual, inverted or upright). Students will run several tests, making adjustments and observing the changes in image behavior. They will also be able to experiment with lenses of different focal lengths to understand how they affect the size and shape of the image. They will record the results and analyze how each change in variables (object distance from the lens, lens type, lens focal length) influences image formation.

After running several tests, students will evaluate the data obtained and compare it with the hypotheses formulated at the beginning, to verify whether the image matches their expectations. They will discuss how the variables studied influenced the type and clarity of the image and explore the connections between these concepts and their applications in real optical devices, such as microscopes, telescopes, cameras.

Students will have the opportunity to collaborate, visiting their peers' virtual labs to see what others have tested and to discuss their findings. This interaction will allow them to share their observations and learn from each other. Finally, students will present their conclusions to the class, detailing the adjustments they made, how the image evolved, and what they learned about lens optics. This collaborative and hands-on approach will allow for deeper knowledge of light refraction and image formation, developing both critical thinking skills and a better understanding of the principles of physics applied to optics.

Required Tools and Software

To participate in this project, students will need access to:

- VR Headset (e.g., Oculus Quest, HTC Vive) or a mobile phone with Google Cardboard for an immersive virtual lab experience.
- A Metaverse platform

Extensions and Future Explorations

After implementing this project, students can extend their learning in many ways. They could experiment with more advanced variables, such as combining different types of lenses and positioning them to create complex optical systems such as microscopes or telescopes. Another idea to deepen the concepts is to simulate image formation in different environments, such as underwater, to understand how the refractive index influences the trajectory of light rays.

Students could also explore the mathematical formulas that describe image formation, using lens equations to calculate the position and size of images formed in different configurations. In addition, they could design experiments to determine the optimal parameters of a lens for the desired application, testing different combinations to achieve maximum image clarity.

Students could build a portfolio of their experiments, documenting their observations and conclusions to reflect on their progress and to make connections between the theory studied and practical applications. These activities would help them consolidate their knowledge and apply what they have learned in new and exciting ways.

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Exploring RenewableEnergy through Immersive STEM Learning

Project Overview

This project enables students to explore renewable energy systems through interactive, hands-on activities in the Metaverse. By entering virtual environments designed for energy production and sustainability, students investigate how solar panels, wind turbines, and other renewable technologies generate electricity and support modern societies.In the Metaverse, students actively build, place, test, and improve renewable energy systems, such as installing solar panels on buildings or positioning windmills in suitable locations. Through experimentation and problem-solving, learners gain a practical understanding of how renewable energy works, how energy efficiency can be improved, and how engineering decisions affect energy output.The project focuses on STEM-based learning, combining science, technology, engineering, and mathematics to help students understand real-world energy challenges and solutions using immersive digital tools.

Learning Objectives

Through this activity, students develop an understanding of how renewable energy systems, such as solar panels and wind turbines, produce electricity. They apply STEM knowledge to design, test, and optimize renewable energy solutions within a virtual Metaverse environment, using digital tools to measure energy output and efficiency. By adjusting variables that influence energy production, students learn to identify key factors affecting system performance, collect and interpret data related to energy efficiency, and evaluate the effectiveness of their designs. The activity also supports the development of communication skills, as students clearly present and justify their design choices and results based on evidence from their virtual experiments.

Hands-On Activity in the Metaverse

Each group documents their energy output results, design choices, and the changes that improved or reduced system efficiency, and then presents their findings to the class. This is followed by a Renewable Energy Planning Meeting, where students take part in a city-planning scenario in which they must decide how to power a city using solar panels and wind turbines. During the discussion, students evaluate where solar panels should be placed, where windmills are most effective, how to balance energy production with available space, and which renewable energy system generates the highest energy output based on their collected data. In the metaverse, students will be able to experience doing this first hand, for example they will be able to select solar panels and put them in the right place.

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Required tools and Software

- Computers or tablets
- Access to the Metaverse platform
- VR Headsets
- Paper and Pen for writing notes

Extensions and Future Explorations

Future exploration of this activity could include the integration of additional renewable energy sources such as hydro or geothermal power, as well as energy storage systems and smart grids to better reflect real-world energy infrastructure. More advanced scenarios may also introduce real-world constraints such as weather conditions, population needs, land availability, and budget limitations, enabling students to design more realistic and sustainable city energy plans while further developing their critical thinking, data analysis, and decision-making skills.

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Human Digestion: Virtual Exploration

Project Overview

This activity allows students to explore the human digestion system through an interactive simulation in the Metaverse. By following the journey of food and liquids through the body, students observe how digestion occurs step by step, from ingestion to absorption and elimination. The virtual environment enables learners to visualize internal organs and processes that are difficult to observe in real life, supporting a clearer understanding of human biology through immersive, hands-on learning.

Learning Objectives

Through this activity, students develop an understanding of the structure and function of the digestive system and how food and drinks are processed in the human body. They explore the role of different digestive organs, identify how nutrients are absorbed, and use digital tools in the Metaverse to observe, analyze, and explain the digestion process, while strengthening scientific inquiry, observation, and communication skills.

Hands-On Activity in the Metaverse

In this hands-on activity, students enter a virtual human body in the Metaverse and explore the digestion process in an interactive and guided way. The activity begins in the mouth, where students observe how food is mechanically broken down by chewing and mixed with saliva. Students can select different types of food and drinks (e.g. solid food, liquids, healthy and less healthy options) and observe how these choices affect the digestion process. Students then follow the movement of food through the esophagus into the stomach, where they observe chemical digestion and the role of gastric juices. By interacting with the simulation, students can see how food is transformed into a semi-liquid substance and how digestion time varies depending on the type of food consumed. Next, students explore the small intestine, where nutrient absorption takes place. The Metaverse allows learners to zoom in and observe how nutrients pass through the intestinal walls into the bloodstream. Students identify which nutrients are absorbed and discuss why this stage is essential for providing energy and supporting body functions.

The activity continues in the large intestine, where students observe water absorption and the formation of waste. Students can track what remains undigested and understand the final stages of digestion before elimination.

Throughout the activity, students complete guided tasks such as:

- Identifying the function of each digestive organ
- Tracking the path of food and drinks through the body
- Comparing digestion processes for different food types
- Documenting observations using digital worksheets

At the end of the activity, students summarize their findings and reflect on how the digestive system works as a connected system, linking structure and function through interactive exploration in the Metaverse.

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Required Tools and Software

- Computers or tablets
- Access to the Metaverse platform
- VR Headsets
- Paper and Pen for writing notes

Extensions and Future Explorations

The digestion scenario can be expanded in future versions of the Metaverse to include nutrient tracking, comparisons between healthy and unhealthy diets, and the impact of hydration on digestion. Additional features could allow students to explore digestive disorders or simulate how lifestyle choices influence digestive health, supporting deeper learning and real-world connections.

ASSESSMENT AND EVALUATION

MSTEM

CHAPTER 5

METAVERSE-BASED STEM EDUCATION FOR A SUSTAINABLE AND RESILIENT FUTURE

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Co-funded by the European Union

Introduction: Assessment and Evaluation

This chapter provides STEM educators with guidance on assessing and evaluating student learning within the dynamic and interactive environment of the metaverse. With the growing presence of virtual and immersive technologies in education, effective assessment methods are critical to capturing a comprehensive picture of student achievement and progress. The chapter covers both formative and summative assessment and grading strategies tailored for the unique opportunities and challenges that metaverse presents. By integrating traditional assessment approaches with advanced virtual tools, educators can track engagement, problem-solving skills, collaboration, technical proficiency, and practical application of knowledge in real time. Through evidence- based methods and practical examples, this chapter aims to equip both STEM educators and educators teaching other subjects with the skills and insights needed to measure student success effectively, ensuring that evaluations are accurate, engaging, and aligned with educational goals in STEM and other subjects.

> ***"Assessments in the metaverse can potentially transform how we evaluate learning. They can be more engaging and interactive than traditional assessments and can provide educators with detailed information about a student's understanding of a subject."***
> **Joies, S (2024)**

The techniques and best practices shared in this chapter aims to offer a balanced framework to foster active learning, support meaningful feedback, and help accessing the strengths of metaverse-based learning environments for educators. It is aiming to make planning for assessment easier for educators. It is important to understand that this is a new way of teaching and that metaverse will rapidly evolve and expand the more educators not only are getting used to assessing the students work in metaverse but also the more educators share, collaborate and learn together they will explore and develop more methods. This new landscape presents both unique opportunities but also challenges for educators.

This is a combined work among all educators wanting to use the metaverse as regular teaching. In order to assess the students, educators need to use metaverse as a common tool among others in the classroom and not make it an astonishing event where students are more explorative than learning.

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Assessment in the Metaverse

Assessment in the metaverse involves evaluating student performance and learning outcomes in a dynamic, interactive setting in a way that has not been done before. Unlike conventional assessments, which often rely on standardized tests, metaverse assessments can enhance the understanding of both the student and the educator. For the student, enhancing the learning experience and providing a context that is not possible in education today. For the teacher it enhances the understanding of different learning environments and how we can use them as tools for our students to reach higher in their learning but also learning about and refining the methods for assessment and evaluation while working with immersive experiences.

The objectives below have been gathered by different educators who want to share their ideas regarding ways of assessing students while working in the metaverse. It is important that the objectives are both measurable and meaningful.

Assess the integration of core STEM skills

One objective is to evaluate students' development and application of core STEM skills such as critical thinking, problem-solving, creativity, and analytical reasoning;through interactive and practical assessments. These core skills often go by 21st century skills and they are identified by several learning organisations and accepted all over the world as the core skills to implement in all learning contexts for students. By using simulations, problem scenarios, and virtual labs, assessments aim to measure how effectively students can apply theoretical knowledge to practical situations, mirroring real-world STEM challenges.

Measure student engagement and active learning

Another key objective is to assess the level of student engagement in learning activities within the metaverse. This includes evaluating indicators like time spent on tasks, participation in discussions, and collaboration in virtual projects. By tracking engagement metrics, assessments help educators understand how actively students are involved in their learning and enable them to make adjustments to maintain high levels of interest and motivation. This opens up for a deeper understanding from the educator towards each student's unique learning abilities and will support the educator in adjusting and creating environments that suit every single student in their class.

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Evaluate the application of knowledge and practical skills

This objective is about assessing students' ability to apply learned knowledge in hands-on, practical settings. Through virtual experiments, collaborative projects, and simulations, assessments are designed to determine students' proficiency in translating theoretical understanding into applied skills, a crucial aspect of STEM education. This objective supports the development of practical, problem-solving abilities relevant to future STEM careers. Furthermore this objective opens up for brand new ways of testing the students theoretical and practical combined skills like it has never been possible to do before.

Encourage self-reflection and peer evaluation

An important objective is to foster student self-reflection and peer assessment. This is an objective where it is important to involve the students early on and make them part of how this could and should be done, what to think of and make them aware of their own learning but also how others learn. By integrating tools for self- evaluation and peer feedback, assessments help students develop self-awareness, set personal learning goals, and practice evaluating their own and others' work constructively. This objective promotes lifelong learning skills, enhances collaboration, and empowers students to take ownership of their educational journey. "Peer assessment serves as a powerful motivator, fostering a sense of ownership and accountability among students for their learning". Ephraim, N (2024)

Provide actionable insights for educators and stakeholders

Assessment in metaverse is designed to produce valuable data that offers insights into student progress for educators, school administrators, and parents. This objective ensures that assessments give a clear picture of student achievements and areas needing improvement, helping all stakeholders to support students more effectively and evaluate the impact of virtual learning tools on educational outcomes. This also benefits in the discussions at student-parent meetings with the educator, then everyone already has a deeper understanding.

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Evaluate instructional effectiveness and support continuous improvement

A final objective is to use assessment outcomes to inform and improve teaching strategies. This objective is more directly aimed at the educators and how they can enhance and improve their planning and create the most efficient use of metaverse to most benefit the learning of the students. By analyzing assessment data, educators can identify which instructional methods are most effective and adjust their approaches accordingly. This creates a continuous feedback loop, allowing for responsive teaching that adapts to students' needs and enhances the quality of STEM education within a metaverse environment.

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Assessment in the Metaverse: Self-assessment and Peer Assessment

Aspect	Portfolio & Project-Based Assessment	Self- & Peer Assessment
Description	Students create a collection of work over time or complete complex, multi-stage projects. Formative feedback is provided during the process, followed by a summative grade.	Students reflect on their own work and evaluate peers' contributions, providing constructive and formative feedback.
How it works in Metaverse	Virtual portfolios may include screenshots, recordings, completed tasks, and collaborative projects such as 3D models or simulated engineering solutions, often using a cross-curricular approach.	Students use digital journals, feedback forms, and collaborative spaces within the Metaverse to reflect on and discuss their work and that of peers.
Benefits	Emphasises cumulative learning, allowing students to demonstrate skill progression, creativity, and deeper understanding.	Promotes self-awareness, critical thinking, and collaboration, helping students better understand both their own work and others'.
Usage	Suitable for long-term evaluation and showcasing student development, but requires clear structure and can be resource-intensive. Best implemented through collaboration between educators from multiple subjects.	Supports reflective learning and peer collaboration while providing educators insight into student perspectives. More challenging for younger students but adaptable through simplified reflection activities.

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Gamified Assessment Method

Description: Gamified assessment uses game-like elements—such as points, levels, or badges to motivate students and track their progress. Most of all it's core is to give immediate feedback to the students in order for them to continue forward.

How it works in the metaverse:

- Students earn rewards, complete quests, and unlock new levels
- Mastery of STEM topics is demonstrated through interactive challenges
- Badges are awarded for milestones in virtual physics labs
- High performance is recognized in coding or problem-solving tasks

Benefits:

- Enhances motivation and student engagement
- Makes assessment more interactive and rewarding
- Familiar game structures increase student acceptance
- Supports continuous feedback and learning progression

Motivation to use this method: Gamified assessment methods use game elements to boost motivation, making learning more enjoyable and engaging for students. This method benefits students by providing an appealing way to approach assessments. However, for educators, it is crucial to ensure that game elements genuinely support learning rather than merely becoming competitive. To accommodate educators without advanced technology, simpler gamification elements, such as levels or rewards in the form of stars or badges, can be used in the classroom as a start for using this method.

"The metaverse learning based on gamification techniques has five steps: motivation and setting goals, constructing content, discussion and interaction, practice and mission, and summarizing and feedback. The measurement process has a post-test element. The evaluation has one component – the evaluation of the student total experience. Feedback has two components: feedback to the inputs and feedback to the learning process." Srisawat, S & Piriyasurawong, P. (2022)

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Simulation-based Assessment

Simulation-based Assessment

Description: Simulation-based assessment places students in realistic, virtual scenarios where they must apply STEM knowledge to make decisions and solve problems in order to complete tasks and challenges created by the educator.

How It Works in the Metaverse

- *Virtual chemistry experiments with compounds and reactions*
- *Troubleshooting robotic systems*
- *Solving issues in simulated satellites or technical environments*

Benefits

- *Safe environment for complex problem-solving*
- *Encourages experimentation and learning from mistakes*
- *Enables assessment of skills difficult to measure in traditional classrooms*
- *Requires assessment planning during simulation design*

Motivation to Use This Method

- *Realistic application of STEM knowledge*
- *Deeper insight into students' problem-solving abilities*
- *Supports both students and educators*
- *Technically demanding*
- *Recommended to start with simple simulations (e.g., role-playing, practical exercises.*

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Scenario-based Assessments with Branching Choices

Description: Scenario-based assessments present students with situational challenges that require decision-making and have multiple outcomes based on their choices.

How it works in the metaverse:

- Students are placed in realistic scenarios within a virtual environment
- In environmental science, students make decisions to address ecosystem challenges
- Each decision leads to different consequences and future outcomes
- Educators prepare multiple branching scenarios based on possible student choices

Benefits:

- Emphasizes critical thinking and decision-making
- Develops adaptive problem-solving skills
- Reflects real-world complexity and uncertainty
- Prepares students for STEM careers and active global citizenship

Motivation to use this method:

- Allows students to demonstrate decision-making and adaptability
- Focuses on student-centered problem-solving in complex situations
- Can be challenging for educators without advanced digital tools
- Can begin with simplified written scenarios or multiple-choice pathways before full metaverse implementation

These approaches aim to make the most of metaverse's immersive and interactive potential, allowing STEM (all)- educators to assess not only knowledge acquisition but also applied skills, engagement, collaboration, and critical thinking. Each approach also provides students with varied, meaningful ways to demonstrate their learning, ultimately supporting a more dynamic and student-centered assessment process.

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Conclusion

Assessing student learning in the metaverse requires a shift in both mindset and methodology, offering educators the opportunity to move beyond traditional assessment toward more holistic, student-centered approaches. The methods explored in this chapter demonstrate how immersive environments can provide a broader and more meaningful picture of students' knowledge, skills, and learning progress through performance-based tasks, simulations, and interactive feedback. Rather than relying on a single solution, effective assessment in the metaverse depends on thoughtful planning, adaptability, and collaboration among educators.

The metaverse enables assessments that emphasize learner growth, practical application, and engagement, supported by real-time feedback and learning analytics. These approaches not only benefit students by offering diverse and meaningful ways to demonstrate learning, but also support educators and institutions by providing transparent and actionable insights into student progress. Ultimately, by embracing innovative assessment practices in the metaverse, educators can better prepare learners to become adaptable, collaborative, and active world citizens in an increasingly complex and technology-driven world.

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Self-Assessment: Assessment & Evaluation

The following True/False statements are designed to help teachers review and consolidate the key concepts presented in Chapter 5.

Mark each statement as True (T) or False (F) based on the content of Chapter 5

1. The metaverse enables assessment methods that focus only on summative evaluation rather than formative feedback. T/F
2. Simulation-based assessments provide a safe environment for students to experiment and learn from mistakes. T/F
3. Gamified assessment relies on competition alone and does not support learning progression or feedback. T/F
4. Scenario-based assessments with branching choices help develop students' decision-making and adaptability. T/F
5. Effective assessment in the metaverse requires educators to adapt methods to their students' needs and technological context. T/F
6. True and False assessments are best used as a standalone method for measuring complex problem-solving skills. T/F
7. Learning analytics and real-time feedback can support a more comprehensive understanding of student progress. T/F

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Self-Assessment: Assessment & Evaluation
Answer Sheet

Answer Key

1. False
2. True
3. False
4. True
5. True
6. False
7. True

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CAREER PATHWAYS IN STEM

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CHAPTER 6

METAVERSE-BASED STEM EDUCATION FOR A SUSTAINABLE AND RESILIENT FUTURE

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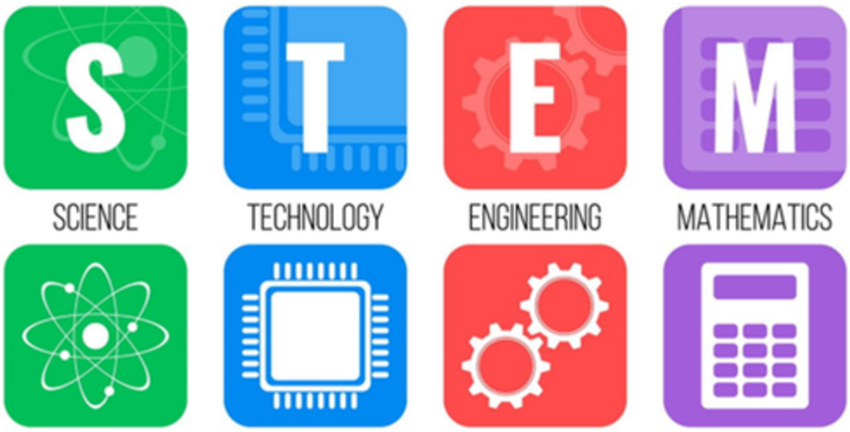
Introduction: Defining STEM careers

Deciding on a future career is not easy. There is a wide variety of degrees and career opportunities, which makes it difficult to choose. However, STEM careers can offer high employability, good conditions and development opportunities. According to the World Economic Forum's Future of Jobs Report 2023, 25% of current jobs will change in the next five years, largely due to technological transformation. Hence, studies linked to Science, Technology, Engineering and Mathematics are gaining prominence and are becoming the professions of the future. When people talk about STEM careers, they are referring to the acronym for Science, Technology, Engineering, and Mathematics (STEM). Therefore, this growing sector encompasses studies that include skills and knowledge in one of these disciplines.

By subject area, some of the most popular STEM careers are:

- Sciences: Physics, Chemistry, Biology, Biotechnology, Astrophysics, Medicine, Dentistry, etc.
- Technology: Computer Science, Telecommunications, Systems Analysis, Robotics, Web Development, etc.
- Engineering: Electronics, Electrical, Mechanical, Architecture, etc.
- Mathematics: Mathematics, Economics, Statistics, etc.

However, in the labour market, there is a constant need for professionals. As a result, new STEM careers are appearing every year in addition to the classic ones. These are programmes related to data processing (Big Data), cybersecurity, nanoscience, virtual and augmented reality, the Internet of Things (IoT), bioinformatics, genetics, food science, environmental sciences and astronomy, among others. And, according to the U.S. Bureau of Labor Statistics, in the field of Data Science alone, the number of jobs will increase by 35% between 2022 and 2032.



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Importance of STEM in today's society

STEM education is essential for several reasons. Firstly, STEM careers are some of the highest paid and most in-demand professions worldwide. Currently, jobs in these fields are growing at a faster rate than the average rate of employment growth, a trend that will undoubtedly continue over the next few years. This means that there is a high demand for skilled workers in these fields, and students who pursue STEM studies are more likely to find satisfying and, above all, well-paid jobs.

Secondly, STEM education also aims to address the long-standing gender gap in these fields. At present, the representation of women in STEM careers is low, but gradually increasing quotas are being achieved. in this regard, there are numerous campaigns actively encouraging girls from an early age to pursue STEM studies, with the aim of encouraging them to choose careers in these fields in the future, thereby increasing gender diversity within these sectors.

Finally, STEM education equips students with skills that are transferable to other areas of life. The problem solving, critical thinking and analytical skills that students learn in STEM education can be applied to many other contexts and situations, including non-STEM fields. These skills prepare students for lifelong learning and success, regardless of the career they choose.

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General Context of STEM Careers

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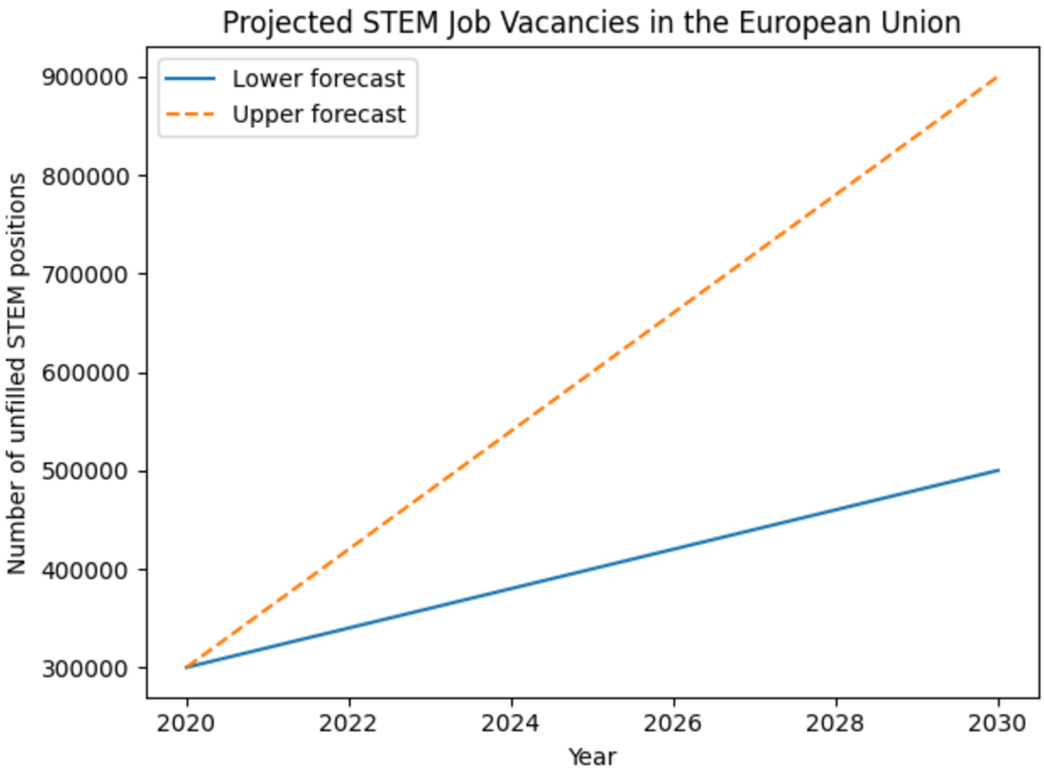
Evolution and relevance

Studies and forecasts are unanimous: in the European Union, the demand for professionals in technical and scientific careers exceeds the supply. And this gap is expected to widen substantially in the coming years. On the other hand, the vocation of teenagers for STEM subjects (science, technology, engineering and mathematics) is decreasing. This means that the problem of labour demand will only get worse in the future. But this is not the only difficulty. The basis for economic, industrial, technological and social development depends on the breakthroughs discovered by future STEM graduates. It is necessary to study the starting point situation and look for causes and solutions to solve the problem posed by the STEM paradox: why there is a constant drop in interest in STEM studies among teenagers, if the future employment of these careers is one of the most promising and is expected to improve.

The need for these careers in the Global and Local Market

Europe is in the midst of a labour market paradigm shift. The globalisation of markets is taking hold and requires new labour skills. Automation, Industry 4.0, the development of telecommunications, big data, the shift to clean energy, among others, are realities of today's society, on which the well-being of modern society depends. But they are also the trends that will underpin economic growth in the future. All this must come hand in hand with STEM workers.

The greatest employment opportunities for recent graduates are among those with a higher education degree1 . This is a trend that has continued over the last decade and is expected to continue in the medium to long term future. The more educated the population is, the higher the employability and activity rate and the lower the unemployment rate. This happens regardless of the age and gender of the person and it is in the STEM professions where the employment rate is highest.



The European Commission has warned of the huge demand for job vacancies in science and technology. The forecast ranges from 300,000 unfilled positions in 2020 to 500,000 or even 900,000 in ten years, where the main reason is the change in the production model. The intensification of automation, the European Union's "reindustrialisation" strategy, the retirement of the "baby boom" generation and the great difficulty European companies have in attracting talent are some of the reasons for this.

The main challenge facing the EU is the shortage of professionals in this sector. Students' loss of vocation for STEM subjects is causing them not to decide to study or to drop out of such careers.

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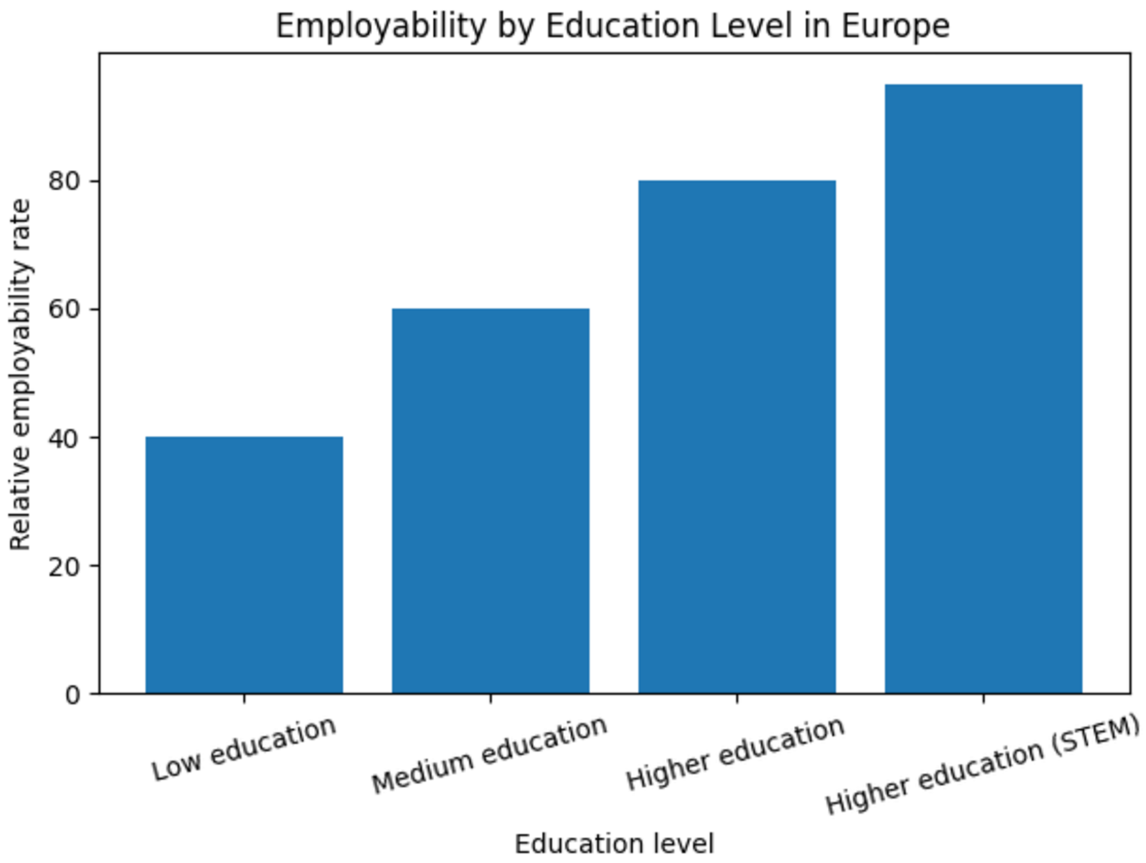

Projected Growth in STEM Sectors

In recent years, society has entered a new Age of Digitalisation marked by profound changes in how people live, work, and interact. The Fourth Industrial Revolution (Industry 4.0), highlighted at the 2016 Davos Forum, is driven by digitalisation and the convergence of physical, digital, and biological technologies, including artificial intelligence, robotics, biotechnology, nanotechnology, and 3D printing. These developments are reshaping economies, business models, healthcare, and daily life, requiring societies to become more adaptable and flexible.

Scholars argue that these technological shifts are redefining what it means to be human, influencing how individuals relate to technology, each other, and themselves. Digital devices have become ubiquitous, transforming social interaction and reducing traditional notions of privacy, with digital engagement beginning at increasingly younger ages.

Despite concerns about automation, technological advancement is expected to create new jobs focused on human–machine interaction, even as existing roles evolve or disappear. Robotics and artificial intelligence are already transforming fields such as medicine and logistics, replacing not only low-skilled tasks but also highly specialized professions. As work continues to change, the demand for advanced technological skills will increase, highlighting the need for education systems that prepare individuals for a rapidly evolving digital future.

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Academic Outlets in STEM

Specialisation options

STEM (Science, Technology, Engineering and Mathematics) degrees offer multiple academic opportunities for those who wish to deepen their knowledge or specialise in emerging areas. These options allow professionals to keep up to date, advance their careers and contribute significantly to scientific and technological development. The main specialisation options and the most relevant emerging areas are listed below.

Postgraduate and Master's degrees

Postgraduate and Master's programmes are a common way to specialise after obtaining a university degree in STEM. These programmes allow:

- Broaden knowledge in specific areas such as advanced engineering, computer science or applied mathematics.
- Access highly skilled roles in industry or academia.
- Develop practical skills through projects and collaborations with companies.

In Europe, programmes such as the master's degrees in Biomedical Engineering, Data Science and Robotics stand out. In addition, international scholarships, such as Erasmus Mundus, facilitate the mobility of students interested in programmes of excellence.

Academic Research

For those who wish to contribute to global knowledge, academic research is a crucial outlet.

- Doctorates: These are the gateway to research, allowing students to work on cutting-edge projects funded by universities, governments or private institutions.
- International projects: Initiatives such as the Horizon Europe programme promote collaboration in areas such as quantum physics and biotechnology.

The impact of this specialisation is visible in innovations such as messenger RNA vaccines or advances in sustainable materials.

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Advanced Courses and Specific Certifications

The rapid evolution of STEM technologies has driven the demand for specific technical courses and certifications.

- Short courses and bootcamps: In fields such as programming, cybersecurity or data analysis, they offer intensive training.
- Recognised certifications: e.g. AWS Certified Solutions Architect (cloud technology) or Microsoft Certified: Data Analyst (data analytics).
- Advantages: They allow for rapid integration into the labour market or the updating of knowledge in a constantly changing environment.

Emerging Areas

Emerging areas in STEM represent the future of innovation and sustainable development. Among the most prominent are:

Artificial Intelligence and Big Data: Artificial intelligence (AI) and big data analytics are revolutionising entire industries.

- Key applications: process automation, personalisation in marketing, epidemic prediction and autonomous driving.
- Academic opportunities: Master's degrees and certifications in Machine Learning, predictive analytics and AI ethics are in high demand.

Biotechnology: Biotechnology combines biology, chemistry and technology to create innovative solutions in health, agriculture and the environment.

- Key developments: Genetic treatments, bioplastics and bio-manufacturing.
- Academic specialisation: Masters in molecular biotechnology, bioinformatics or biomedicine offer advanced training in these disciplines.

Renewable Energies: With the global transition to a sustainable future, renewable energies are a key pillar.

- Growing fields: wind power engineering, solar photovoltaics and energy storage.
- Training programmes: Masters in renewable energy and environmental sustainability are designed to prepare experts to lead this change.

Academic outlets in STEM not only offer a wide range of opportunities for specialisation, but also equip professionals to tackle the most pressing global challenges. Whether through postgraduate degrees, research or technical courses, these options are key to staying ahead in an ever-changing world.

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Career opportunities in STEM: Main sectors of employment:

STEM (Science, Technology, Engineering and Mathematics) degrees offer a wide range of career opportunities thanks to their relevance in digital transformation, sustainability and technological advances. Graduates from these fields find job opportunities in strategic sectors, highly sought-after professions and opportunities for global entrepreneurship.

Technology & Software: Drives the digital economy through programming, AI, cybersecurity, data analytics, cloud services, and app development, with strong demand across industries.

Health & Biotechnology: Focuses on biomedical research, medical technologies, genetics, and data analysis to improve healthcare and global wellbeing.

Energy & Environment: Supports the clean energy transition through renewable technologies, energy storage, climate action, and sustainable resource management.

Engineering: Covers fields such as civil, industrial, aerospace, and robotics engineering, enabling infrastructure development, manufacturing, automation, and transport.

Science Education & Outreach: Promotes STEM literacy by teaching and communicating science through schools, universities, and digital platforms.

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Most in-demand Professions in STEM World

Data Scientist	Data scientists are essential for analysing large volumes of information and extracting insights applicable to business, science and public policy. According to the World Economic Forum's The Future of Jobs 2023 report, this profession is leading job demands in technology and financial sectors.
Software Engineer	Software development and optimisation are critical skills in technology companies and traditional sectors undergoing digitalisation. From software architects to full-stack developers, this profession stands out for its flexibility and high remuneration.
Bioinformatics	The intersection between biology and technology has given rise to the bioinformatician, who analyses genomic data and designs algorithms for medical research. This profile is essential for areas such as biotechnology and pharmacology.

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Global opportunities

The global STEM market is large, with high demand in countries such as the United States, Germany and Japan, where the technology and industrial sectors face a shortage of skilled professionals. Programmes such as STEM visas and international collaborations open doors for professionals interested in working abroad.

Entrepreneurship in STEM

Entrepreneurship is another key career path. Many STEM graduates found start-ups in areas such as artificial intelligence, biotechnology and renewable energy. Technology incubators and accelerators, such as Y Combinator or Techstars, provide financial and strategic support to these projects.

Key Competencies for STEM Success

The STEM (Science, Technology, Engineering and Mathematics) field is characterised by constant evolution, driven by technological and scientific advances. To succeed in this field, professionals must cultivate a combination of technical and soft skills, as well as an attitude of adaptability and continuous learning. These key competencies are detailed below.

Hard Skills:

Technical skills are specific and measurable competences that apply directly to the knowledge of tools, languages, technologies and processes within STEM disciplines. These skills are essential because they enable professionals to develop, implement and optimise practical solutions in a highly technical environment. Some of the most important include:

- ***Programming and software development:*** Knowledge of programming languages (such as Python, Java, or C++) is indispensable for professionals working in areas such as software development, artificial intelligence or data analysis.
- ***Data analytics:*** The ability to work with large volumes of data (big data), use it to create predictive models and draw relevant conclusions is crucial in areas such as data science, engineering and biotechnology.
- ***Knowledge of specialised technological tools:*** The mastery of specific software and tools for disciplines such as engineering (AutoCAD, MATLAB), or graphic design (Photoshop, Illustrator) is essential to be able to carry out complex technical tasks.

Soft Skills:

In addition to technical skills, soft skills are crucial for successful performance in the STEM field. These skills refer to the interpersonal and management skills that facilitate collaboration, effective communication and teamwork. Some key soft skills include:

- ***Teamwork:*** Most STEM projects involve collaboration between professionals from different disciplines. Knowing how to work as a team, share ideas and coordinate efforts is essential for innovation and progress.
- ***Effective communication:*** The ability to communicate complex ideas in a clear and understandable way is essential. This includes both written and verbal communication, to convey research results, technical reports or presentations.
- ***Critical thinking:*** The ability to analyse information, identify problems and propose logical solutions is fundamental to solving complex problems in science and engineering.
- ***Time management and leadership:*** STEM professionals must be able to manage their projects, resources and deadlines efficiently, as well as have the ability to lead teams and make important decisions under pressure.

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Adaptability and Continuous Learning

The STEM environment is marked by rapid technological evolution and constant changes in methodologies and tools. For this reason, adaptability and continuous learning are essential to keep up with innovations and changes in the sector. The ability to learn new skills, adapt to new environments and face unfamiliar challenges is critical to long-term success.

Ability to learn new technologies: STEM professionals must be willing to update their knowledge and skills as new technologies or methodologies emerge.

Flexibility to change: Adaptability refers not only to learning new tools, but also to the ability to adjust to changes in working environments, market demands or research methods.

Continuing professional development: Participating in courses, workshops, seminars and conferences is key to staying up-to-date in a dynamic field like STEM

The key competences for success in STEM are not limited to technical skills, but also include a set of soft skills, along with the ability to adapt and learn continuously. The combination of these competences is essential to address current and future challenges in the field, and to contribute significantly to innovation and technological progress. The constant evolution in STEM requires professionals not only to be experts in their technical area, but also to be able to collaborate, communicate and adapt to a constantly changing environment.

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Conclusion

The M-STEM curriculum provides a forward-thinking and pedagogically sound framework for STEM educators to effectively use Metaverse technology into teaching and learning. The curriculum provides instructors with the competencies they need to develop engaging, immersive, and student-centered STEM learning experiences by combining strong theoretical underpinnings with hands-on, practice-oriented training. The program helps instructors navigate the potential and challenges of teaching in virtual environments by progressing from basic concepts and digital STEM literacy to applied projects, evaluation methodologies, and ethical considerations.

Importantly, the M-STEM curriculum goes beyond technological adoption, encouraging critical and creative thinking, multidisciplinary collaboration, and reflective educational practice. It frames the Metaverse as a revolutionary learning place capable of increasing engagement, experimentation, and problem-solving across STEM disciplines. By addressing evaluation, career routes, and appropriate use of immersive technologies, the curriculum ensures a comprehensive and long-term approach to STEM education in digital and virtual environments.

Overall, the M-STEM curriculum provides a cohesive and adaptive training pathway that equips educators to confidently implement novel STEM teaching approaches that are matched with the changing demands of education and the future workforce. As immersive technologies advance, this curriculum provides a scalable strategy for incorporating developing digital worlds into STEM education, assisting teachers in designing inclusive, engaging, and future-ready learning experiences.

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Self-Assessment: Assessment & Evaluation

The following True/False statements are designed to help teachers review and consolidate the key concepts presented in Chapter 6. Mark each statement as True (T) or False (F) based on the content of Chapter 6

True / False Questions:

1. STEM careers include fields such as science, technology, engineering, and mathematics.T/F
2. According to reports, STEM jobs are growing at a slower rate than the average employment growth.T/F
3. One goal of STEM education is to reduce the gender gap in science and technology fields.T/F
4. STEM education only prepares students for careers strictly within scientific and technical fields.T/F
5. The European Union faces a shortage of professionals in STEM-related occupations.T/F
6. Automation and Industry 4.0 reduce the need for STEM professionals in the labour market.T/F
7. Postgraduate and master's programmes allow STEM graduates to specialise and access highly skilled roles.T/F
8. Soft skills such as teamwork and communication are considered unimportant in STEM careers.T/F
9. Continuous learning and adaptability are essential for long-term success in STEM professions.T/F

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Self-Assessment: Assessment & Evaluation Answer Sheet

Answer Key

1. True
2. False
3. True
4. False
5. True
6. False
7. True
8. False
9. True

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ETHICAL CONSIDERATIONS

MSTEM

CHAPTER 7

METAVERSE-BASED STEM EDUCATION FOR A SUSTAINABLE AND RESILIENT FUTURE

2023-1-FR01-KA220-SCH-000151516

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Introduction

The educational field is being overtaken by the metaverse, which will alter methods of human-computer interaction. Given the speed at which technology is advancing, prominent tech CEOs are coming up with creative methods to make the Metaverse a learning environment. People have become used to telemedicine, teleworking, and many other types of remote communication since the COVID-19 pandemic.

Many educators have been concentrating on the Metaverse lately. Following Facebook's announcement that it was renaming and marketing itself as Meta, moreover interest in computer science and education increased.Exciting new approaches to student engagement, collaborative learning, real-world simulation, and personalized experiences are provided via metaverse tools. However, there are a number of ethical issues that arise with increased immersion and data collecting that educators need to be aware of and deal with an emphasis on privacy, security, and responsible practice, We must also take into account a number of ethical concerns as the virtual environment grows more intricate and potentially intrusive, including data privacy and security, digital identity, equity and access, ownership, and control of the influence of immersive technology on intellectual property. This chapter examines the main ethical issues surrounding the use of technology and the Metaverse in education. Additionally, it offers instructors helpful advice on how to handle possible difficulties in the classroom, address inquiries from students, and include Metaverse experiences in ways that are respectful, safe, and consistent with educational ideals.

Importantly, the M-STEM curriculum goes beyond technological adoption, encouraging critical and creative thinking, multidisciplinary collaboration, and reflective educational practice. It frames the Metaverse as a revolutionary learning place capable of increasing engagement, experimentation, and problem-solving across STEM disciplines. By addressing evaluation, career routes, and appropriate use of immersive technologies, the curriculum ensures a comprehensive and long-term approach to STEM education in digital and virtual environments.

Overall, the M-STEM curriculum provides a cohesive and adaptive training pathway that equips educators to confidently implement novel STEM teaching approaches that are matched with the changing demands of education and the future workforce. As immersive technologies advance, this curriculum provides a scalable strategy for incorporating developing digital worlds into STEM education, assisting teachers in designing inclusive, engaging, and future-ready learning experiences.

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Ethical Considerations in the Metaverse

Privacy and Data Protection

The Metaverse and AI platforms relies on tracking a wide range of user information, including:

- Personal profile data - Name, email, social media accounts , pictures and video files

- Behavioral data - Interactions, choices, movement patterns, search history

- Biometric or sensor data - VR/AR equipment

Key Ethical Issues:

- Informed Consent: Learners must understand what data is being collected and how it will be used. This includes explicit permission from parents for minors.
- Data Minimisation: Only essential data should be collected and stored.
- Third-Party Sharing: Many Metaverse platforms share data with external partners. Schools and educators must be transparent about this and, where possible, choose platforms with strong privacy commitments.

Security in Virtual Environments

Major Security Concerns and Solutions

Security isn’t just about passwords it includes protecting users from digital harms that may arise in immersive spaces.

1) Malware (Viruses, Trojans, Ransomware)

Malware refers to malicious software designed to damage systems, steal data, or block access to devices. Ransomware, for example, locks files and demands payment for their release.

Solutions

- Install reliable antivirus and anti-malware software
- Keep operating systems and applications regularly updated
- Avoid downloading files from unknown or untrusted sources
- Perform regular data backups

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2) Phishing and Social Engineering Attacks

Phishing attacks trick users into revealing sensitive information (passwords, bank details) through fake emails, messages, or websites. Social engineering exploits human trust rather than technical flaws.

Solutions

- Educate users to recognize suspicious emails and links
- Verify sender identity before clicking or responding
- Use email filtering and spam protection
- Enable multi-factor authentication (MFA)

3) Data Breaches and Privacy Violations

Unauthorized access to personal, institutional, or financial data can result in identity theft, financial loss, and reputational damage.
Solutions

- Encrypt sensitive data (both in storage and during transmission)
- Limit data access based on user roles (least-privilege principle)
- Comply with data protection regulations (e.g., GDPR)
- Monitor systems for unusual activity

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Security Concern	Key Solution
Malware	Antivirus, updates, backups
Phishing	Awareness, MFA, email filters
Weak passwords	Strong passwords, password managers
Data breaches	Encryption, access control
Insecure networks	VPNs, secure Wi-Fi
Cyberbullying	Policies, moderation, education
Identity theft	Privacy controls, monitoring
Outdated software	Regular updates

Guidelines and Responsible Practices

Educators should be aware of laws that apply when students use digital platforms

- Establish community agreements on acceptable behaviour.
- Use strong authentication (complex passwords, multi-factor authentication).
- Ensure platforms support encrypted communication.
- Monitor "public area" interactions with trained moderators.
- Have classroom rules and escalation paths for unsafe behaviour.

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Relevant Questions

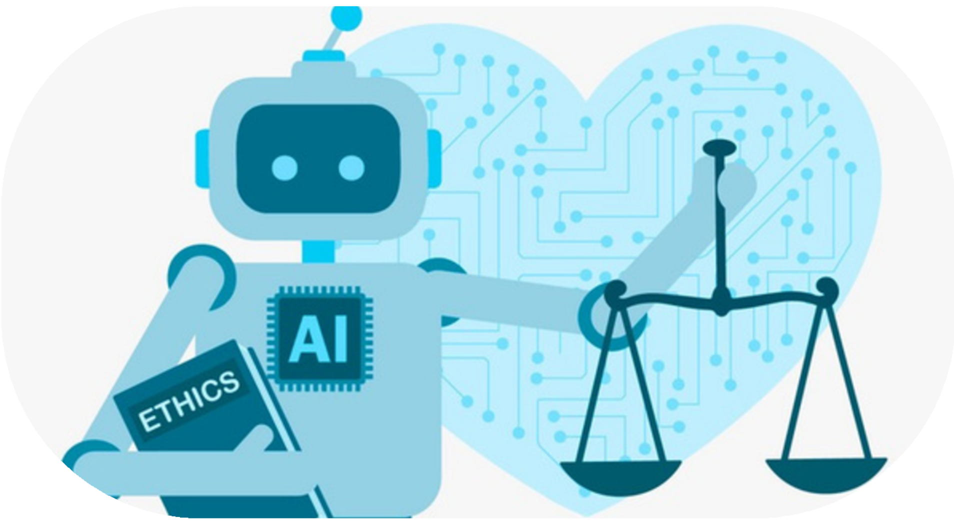
1) What data does this Metaverse platform collect, and who can see it?
is it possible to hack our class session in the Metaverse?

2) How can teachers protect students privacy when using Metaverse and immersive digital platforms in education?

3) How can teachers promote responsible and ethical behaviour among students in the Metaverse and other virtual environments?

Ethical Practices in the Metaverse and AI

- Collection of only necessary data
- Ensure informed consent, especially for minors
- Allow users to access, correct, or delete their data
- Transparency and Explainability
- Equality and non discrimination
- Human oversight



Conclusion

The Metaverse has the potential to revolutionize education through deeper simulations, more participation, and new forms of teamwork. However, this potential needs to be accompanied by a dedication to moral behavior. In order to safeguard digital interactions, promote respectful communities, and preserve privacy, responsible educators adopt preemptive measures. An essential component of responsible and successful learning design is the ethical use of technology and the Metaverse. As the educational landscape becomes more integrated with the Metaverse, a number of significant hazards and concerns become apparent. Data security and privacy are the main concerns. Sensitive student data is more likely to be compromised or exploited as educational interactions become more pervasive and integrated throughout the Metaverse.

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Self-Assessment: Assessment & Evaluation

The following True/False statements are designed to help teachers review and consolidate the key concepts presented in Chapter 7. Mark each statement as True (T) or False (F) based on the content of Chapter 7

True / False Questions:

1. The Metaverse is expected to change how humans interact with computers in education. T/F
2. Increased immersion in the Metaverse eliminates ethical concerns related to data collection.T/F
3. Metaverse platforms may collect personal, behavioral, and biometric data from users.T/F
4. Informed consent includes obtaining parental permission when learners are minors.T/F
5. Data minimisation means collecting as much user data as possible for future use.T/F
6. Phishing attacks rely mainly on technical system vulnerabilities rather than human trust.T/F
7. Malware can include viruses, trojans, and ransomware that may block access to files.T/F
8. Educators should establish clear community rules and escalation paths for unsafe behaviour.T/F
9. Ethical use of the Metaverse in education does not require attention to privacy or data security.T/F

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Self-Assessment: Assessment & Evaluation
Answer Sheet

Answer Key

1. True
2. False
3. True
4. True
5. False
6. False
7. True
8. True
9. False

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