VET2Sustain

PROMOTING SUSTAINABLE, INCLUSIVE AND DIGITAL VOCATIONAL EDUCATION AND TRAINING

Report: T5.2. Recommendations for AI in Personalized Learning

VET2Sustain – Promoting sustainable, inclusive and digital Vocational Education and Training

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1. REPORT SUMMARY

This report compiles the current understanding, research foundations, and practical findings that guide the development of personalised, AI-supported study paths within the VET2Sustain project. It synthesises the pedagogical frameworks, technological trends, generational characteristics, and survey insights generated in WP5 and translates them into actionable recommendations for partners.

The document's purpose is to consolidate the work done so far, clarify conceptual foundations, and support the design of pilots and resources in the next tasks (WP5.3–WP5.6). The report illustrates how AI, XR technologies, and data-driven methods can enhance personalised learning in VET while ensuring ethical, inclusive, and student-centred approaches aligned with European and national regulations.

The report highlights three key insights:

1. **Personalisation through AI is pedagogically justified**, but must be implemented in alignment with established theories, such as constructivism, UDL, and self-regulated learning.
2. **Generational change—especially the rise of Generation Alpha—requires more adaptive, visual, and hybrid learning approaches**, where AI and XR play a central role.
3. **Survey results across partner institutions indicate uneven readiness**, with strong enthusiasm but varying levels of infrastructure, teacher competence, and policy frameworks.

The document concludes by offering recommendations and a roadmap for developing personalised AI learning environments, emphasising human-centred design, safe and ethical AI usage, and sustained collaboration among European VET providers.

2. INTRODUCTION

Work Package 5 (WP5) focuses on utilising artificial intelligence and other virtual opportunities to support inclusive and personalised learning in VET. This report (T5.2) builds on the findings from Task 5.1 (survey on the use of AI and virtual tools), the earlier desk research of WP5, and the D5.1 recommendation document. Its purpose is to provide a shared conceptual, pedagogical, and strategic basis for the forthcoming tasks — particularly pilots (WP5.3), evaluation of XR environments (WP5.4), and the creation of open educational resources and learning pathways (WP5.5–5.6).

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The document does not attempt to introduce AI in isolation but positions it within the broader pedagogical transformations taking place in European VET. By combining theory, technology trends, generational insights, and practical survey findings, the report aims to support partners in aligning their work and ensuring coherence in future activities.

2.1 Purpose and position of the document in the broader VET2Sustain project

The purpose of this document is to consolidate and explain the work already carried out in Work Package 5 (WP5) and to show how these insights will support the next stages of the project. It does not act as a starting point but as a **synthesis of earlier results and theoretical foundations** that create continuity towards the upcoming tasks.

The document builds directly on the findings of WP5.1, where a survey mapped the current use of AI and virtual tools in VET across partner institutions. By combining these findings with pedagogical theories and definitions of personalized learning and AI, the document provides a **shared framework** for how partners can approach the remaining WP5 activities.

Its position in the project is therefore supportive and guiding:

- It makes earlier work more concrete and accessible.
- It translates results and theories into a usable form for partners.
- It ensures that the **pilots (WP5.3)**, the evaluation of XR environments (WP5.4), and the creation of resources and learning pathways (WP5.5–5.6) are designed and implemented consistently across the consortium.

In summary, the document **opens up the work already done and connects it to what lies ahead**. Its role is to act as a reference point and practical aid in planning, testing, and drawing conclusions in the later stages of WP5.

3. THEORETICAL AND PEDAGOGICAL BACKGROUND

3.1 Definitions of personalized learning and AI in education

Personalized learning (PL) refers to approaches in which the learning process is adapted to the individual learner’s needs, prior knowledge, pace, and goals, rather than applying a one-size-fits-all model. Contemporary research emphasizes that personalization can be viewed as a continuum: at one end lies basic differentiation, and at the other, highly adaptive systems supported by artificial intelligence (AI) (Pane et al., 2020; Vorobyeva et al., 2025).

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Key dimensions of personalized learning include content adaptation, pace adjustment, scaffolding and support, learner agency, continuous formative assessment, and contextual adaptation (Rose & Meyer, 2020; Tomlinson, 2017). These elements align with the idea that learners progress at different rates and benefit from tailored resources and feedback.

Artificial Intelligence in education is commonly defined as computational systems that analyze learner data—such as performance records, behavioral logs, and interaction histories—and make decisions or recommendations in an intelligent manner (Merino-Campos et al., 2025). AI-driven personalization can manifest through adaptive learning engines, recommender systems, intelligent tutoring systems, natural language processing–based chatbots, and generative content tools (Sajja et al., 2023).

For the purpose of this project, we define:

Personalized learning as an instructional approach in which learning trajectories (content, pacing, supports) are adapted to individual learners' needs and preferences, while preserving opportunities for learner agency and reflection.

AI-supported personalized learning as systems in which artificial intelligence methods (e.g., machine learning, natural language processing, predictive analytics, generative models) are used to analyze learner data and make adaptive pedagogical decisions in real or near real time, thereby scaling personalization beyond what human teachers alone can provide.

This definition forms the conceptual foundation for further exploration of pedagogical theories that justify the use of AI in supporting personalized study paths.

3.2 Pedagogical theories supporting personalised study paths

The integration of AI into personalized learning must be grounded in established and emerging pedagogical frameworks. Several theories provide justification and guidance for the design of personalized study paths in vocational education and training (VET).

Constructivism and Social Constructivism.
Constructivist theories view learning as an active process in which learners build new knowledge by connecting it with prior understanding. Social constructivism, following Vygotsky, stresses the importance of interaction, scaffolding, and the Zone of Proximal Development (ZPD). Personalized learning, supported by AI, can provide adaptive scaffolding that adjusts to each learner's performance and gradually fades as competence increases (Siemens, 2019; Vorobyeva et al., 2025).

Self-Regulated Learning and Metacognition.
Personalized pathways require learners to plan, monitor, and reflect on their own progress. Theories of self-regulated learning emphasize metacognitive awareness as a prerequisite for

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effective personalization. AI can provide prompts, progress visualizations, and reflective questions to strengthen learners' ability to self-regulate (Zimmerman, as discussed in OECD, 2021).

Differentiated Instruction and Universal Design for Learning (UDL).
Differentiated instruction argues for offering multiple pathways (content, process, product) to meet the needs of diverse learners (Tomlinson, 2017). UDL provides a framework for designing learning environments with multiple means of engagement, representation, and expression from the outset (Rose & Meyer, 2020). AI systems can operationalize these principles by dynamically recommending alternative resources and learning modalities.

Connectivism.
In digital and networked contexts, learning is often distributed across resources and communities. Connectivism highlights the importance of navigating knowledge networks and recognizing patterns. AI can assist learners by recommending relevant nodes—peers, communities, or digital resources—thus strengthening personalized learning networks (Siemens, 2019).

Complexity Theory and Adaptive Systems.
Educational systems can be conceptualized as complex adaptive systems where feedback loops and emergent patterns matter more than linear instruction. Personalized AI systems must therefore be designed to respond flexibly to unpredictable learner behavior (Gunawardena, 2024).

Learning Analytics and Data-Driven Pedagogy.
Learning analytics theories highlight the use of data to guide pedagogical decision-making. AI can support educators and learners by providing real-time insights into learner progress and suggesting adaptive interventions (Sajja et al., 2023).

Emerging Perspectives: Pedagogical Alignment and Ethics.
Recent advances emphasize aligning AI systems with pedagogical principles and ethical standards. Projects such as EduAlign demonstrate how large language models can be trained to act in accordance with educational values such as scaffolding, reflection, and creativity, rather than simply providing answers (EduAlign, 2025).

Implications

These theoretical perspectives underline that AI-supported personalized learning environments in VET should:

1. Provide adaptive scaffolding and fade support as competence grows.
2. Strengthen learners' metacognitive and self-regulation skills.
3. Offer multiple pathways and modalities for inclusivity.
4. Connect learners with networks of knowledge and communities.
5. Operate as adaptive, feedback-driven systems.

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6. Use analytics responsibly to inform pedagogical choices.
7. Ensure transparency, fairness, and pedagogical alignment in AI decisions.

3.3 Conceptual link between AI, guidance, and student autonomy

1. AI as Support for Learning – Not a Replacement for Teachers

AI can offer quick feedback, hints, and progress insights, helping learners move at their own pace. It supports routine tasks, but the teacher remains responsible for motivation, wellbeing, and educational decisions. AI assists learning — it does not replace professional judgement.

2. Strengthening Student Autonomy

AI tools can help students plan their work, monitor progress, and identify skill gaps. This supports self-regulated learning: learners understand where they are, what they need next, and how to move forward. Autonomy increases when students receive personalised, timely feedback.

3. Transparency and Human Oversight

AI must be used transparently. Students should know when AI is involved and how recommendations are created. Teachers always supervise and validate AI outputs, ensuring fairness, context understanding, and emotional support.

4. GENERATIONAL DEVELOPMENT AND THE LEARNER OF THE FUTURE

4.1 Overview of generational models

The concept of *generation* refers to cohorts of people born within a certain timeframe who share similar historical, cultural, and technological influences. Generational models are often used as heuristic tools to highlight differences in attitudes, communication styles, media usage, and learning preferences across age groups (OECD, 2018).

In education, the idea of “generations” helps us make sense of how young people shape their ways of learning and thinking. Of course, people are far more complex than the year they were born and learning style can’t be defined only by their birth year. However, these patterns give teachers and trainers helpful insights on how different learners approach education and recognizing them helps to anticipate learners’ expectations and design relevant and engaging experiences.

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Each generation has grown up surrounded by different technologies and social realities which influence their attitudes and approaches towards learning.

We can roughly distinguish three generations that are particularly relevant for today’s (and tomorrow’s) classrooms:

Millennials

Born between 1981 and 1996, they witnessed the arrival of the internet, the spread of mobile phones and the first global job markets. They learned to balance analog and digital tools and often seek meaning and purpose in their work and studies.

Generation Z

“Generation Z” typically refers to individuals born between the mid-1990s and around 2010, the so called “digital natives”. They have grown up in a world where the internet, smartphones, and social media are omnipresent (Chan & Lee, 2023). They value speed, transparency and connection. Their worldview is shaped by online culture, environmental concerns and social justice movements. They expect education to be relevant, interactive and technology-enhanced. Research shows that this generation is open to AI-powered tools, but simultaneously holds high expectations regarding transparency, ethics and personalization (Deloitte, 2024; ResearchGate, 2023).

Generation Alpha

“Generation Alpha” encompasses those born since roughly 2010. It represents the first cohort raised entirely in an AI-driven and platformed environment. Tablets, voice assistants and personalised content are part of daily life, shaping expectations for adaptive, visual and gamified learning (Comparative Analysis of the Alpha and Z Generations, 2022). Gen Alpha is characterized by early media literacy, intuitive use of digital devices, and a playful, immersive learning style (Nestr Blog, 2023).

Research from the Stanford Accelerator for Learning (2025) shows that this generation will likely benefit from systems capable of personalisation and inclusion through ethical AI design. OECD projections suggest that many of Alpha’s future jobs do not yet exist, making flexibility, creativity and social-emotional competence crucial foundations.

While these “labels” are helpful, we must remember that there’s no single “Gen Z learner” or “Alpha student.” Social and economic factors, family background and access to technology often matter just as much as age. What’s clear, though, is that the speed of change has accelerated both in society and in how young people learn. In VET, we see this every day.

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As underlined by the OECD (*Trends Shaping Education 2022*) and UNESCO (*Reimagining Our Futures Together*), younger generations are entering a world of constant change, digital saturation, and environmental urgency—conditions that are redefining what it means to be an active learner and citizen.

European education strategies acknowledge this shift. The **Digital Education Action Plan (2021–2027)** emphasize the importance of digital literacy, inclusion, and lifelong learning. They encourage schools and training centers to integrate technology meaningfully, as a way to support creativity, problem-solving and equity. These frameworks also remind us to keep learning human-centered, ensuring that technology serves education, not the other way around.
For us in the VET field, understanding these generational patterns is not about stereotypes — it's about preparation. If we want to keep our training relevant, we must connect with how learners think, communicate, and build knowledge in a connected world. That means designing flexible, inclusive, and engaging pathways that meet digital-native learners where they are, while still providing space for reflection, craftsmanship, and the deeper learning that no app can replace.

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4.2 Characteristics of Generation Z and Alpha and expected learning needs

Generation Z and Generation Alpha represent the most digitally immersed cohorts currently within the education system, or soon to enter it. Generation Z largely comprises today's upper-secondary and VET students, while Generation Alpha is growing through primary and early secondary schooling—and will feed into VET and higher education in the coming years.

Both cohorts have grown up with constant connectivity, large volumes of digital information and rapid technological change. Technology for them is not just a tool but a context of life, identity and social engagement.

They share a number of characteristic features: they are used to rapid adaptation, they navigate multiple media channels simultaneously, their attention spans tend to be shorter and they show a strong preference for highly visual, interactive, and multimodal learning formats rather than text-only, static instruction.

Even if they show a strong affinity for digital media, their modes of engagement differ:

- Gen Z are highly active on social media and prefer short, visual information formats.
- Gen Alpha is growing up with interactive, immersive technologies such as VR and AI-supported learning environments.

For both cohorts, technological competence goes hand in hand with a heightened awareness of values, sustainability, and personal purpose in learning and professional contexts (Deloitte, 2024; OECD, 2018).

Given these features, the learning needs of these generations must be finely tuned.

Generations Z and Alpha expectations push VET (and also general) education systems to evolve toward personalization, creativity and lifelong adaptability. Artificial Intelligence, XR and data-driven feedback systems can become enablers of this transformation if they are used in line with EU policy frameworks that ensure access equity, and data protection.

Below we address key learning-needs areas.

1) Personalized, adaptive learning tools

They expect learning to reflect the customization they experience in digital life (in streaming services, social media, games and other digital platforms). Learning systems therefore must become more adaptive: using analytics and AI to respond to individual pace, preferred modality, prior knowledge and evolving interests. Research on Generation Alpha education emphasises the importance of "teaching tools" among the major themes. Adaptive learning tools can provide immediate feedback, scaffold learning paths, and allow learners to progress according to their own rhythm rather than a one-size-fits-all pace. In a VET environment, this means enabling

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learners to identify gaps, choose pathways coherent with their future employability, and self-regulate their learning.

These tools enable teachers to shift from standardized instruction to data-informed guidance, enhancing both motivation and autonomy (European Commission, Artificial Intelligence in Education: Challenges and Opportunities, 2022).

2) Blended online/offline methods

The learning environments for these generations need to span both digital (online) and physical (offline) contexts in a seamless way. Generation Alpha shows a strong preference for learning environments that incorporate gamification, virtual reality (VR), and augmented reality (AR). These technologies engage students actively, making learning more dynamic and aligned with their digital experiences.

Blended approaches allow learners to apply theoretical knowledge in immersive or simulated contexts. Within VET, Extended Reality (XR) and virtual environments can simulate authentic work settings, reinforcing competence-based learning and inclusion

3) Emphasis on creativity, problem-solving and critical thinking

Future employability increasingly depends on transversal skills such as creativity, adaptability and problem-solving. Educational systems must therefore foster learning experiences that encourage curiosity, resilience, and design thinking which are essential for navigating complex, technology-driven workplaces (OECD, Future of Education and Skills 2030). Project-based learning, interdisciplinary approaches, and community engagement are methods that can foster critical thinking and teamwork, skills essential for future success.

4) Lifelong learning mindset

Given that jobs, skills and work contexts will continue to evolve rapidly (driven by automation, AI, green transition, globalisation), learners from Gen Z and Gen Alpha will need to engage in continuous up-skilling, reskilling and self-directed learning beyond initial formal education. The young generations must develop a mindset of lifelong learning: being curious, self-regulated, able to learn how to learn, comfortable with change and disruption. The “systematic review” of Gen Alpha education emphasises that despite their digital fluency, there is risk of decreased opportunities for social-emotional development and other negative effects of digital immersion—thus the educational ecosystem must support not only digital skills but also metacognitive, reflective and motivational capacities. For VET programmes, this could mean creating modular credentials, micro-learning options, career pathways that allow movement, and embedding reflection, self-assessment, meta-skills as part of the curriculum. Educators become lifelong learning facilitators rather than just content deliverers.

5) Focus on Sustainability and Ethical Awareness

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These generations are growing up amid global discussions on climate change, sustainability, and ethical considerations in technology. Generation Z and Alpha are anticipated to prioritize environmental and social issues, influencing their learning preferences and career aspirations. Educational programs that incorporate sustainability themes and ethical discussions can resonate more effectively with this cohort.

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4.3 Learning behaviors, digital expectations, and challenges

In today's classrooms, Generation Z and Generation Alpha bring a new learning rhythm. They are used to being connected at all times. Their learning behaviors show a clear preference for interactive, visual, and gamified approaches, where participation feels more like playing than studying. They enjoy short, focused learning moments — microlearning videos, simulations, or collaborative tasks — that give them instant feedback and a sense of progress.

These generations expect technology to work smoothly and to be part of the learning process, not an extra. A study found that 65% of Gen Alpha students are already engaging with AI tools like

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ChatGPT and express strong excitement about AI's role in learning appsanywhere.com. Platforms that remind them of YouTube, TikTok, or gaming environments are their natural territory. They expect immediate answers and access to materials on any device. In vocational education, this means we must rethink how we design digital content: it needs to be practical, hands-on, and engaging, while also connected to real-world work tasks.

However, these new expectations bring significant challenges for teachers and schools. Constant exposure to digital media can fragment attention and reduce the ability to focus deeply on complex tasks. Furthermore, the rapid pace of technological advancement presents challenges in curriculum design and teacher preparedness. Educators must adapt to new teaching methods and tools to meet the evolving needs of Generation Alpha students. Research from CEDEFOP and UNESCO-UNEVOC warns that while digital engagement increases motivation, it can also lead to "digital overload" and weaker critical thinking if not balanced with reflective learning practices. In VET, where safety, accuracy, and teamwork are vital, helping students slow down, reflect, and collaborate in person remains essential.

Another concern is the digital divide. Not all learners have the same access to high-quality devices, stable internet, or family support in using technology. The EU Digital Education Action Plan (2021–2027) highlights that inclusion and equal opportunities are crucial to ensure no student is left behind in the digital transition. For us in VET, this means checking not only if students can connect, but whether they feel confident and supported when using new tools.

Mental health is also part of the digital equation. Many young people experience stress and comparison through social media, which can lead to anxiety or disengagement. Increased screen time has been linked to behavioral issues and symptoms of ADHD, depression, and anxiety, which can disrupt classroom dynamics and affect learning outcomes The Emory Wheel.

Finally, to keep up with these learners, teachers need continuous professional support. The EU DigCompEdu Framework gives a good structure for developing digital pedagogy, helping teachers use technology in meaningful and ethical ways. It's not just about learning new apps — it's about understanding when and why digital tools make sense. As AI and virtual assistants become more common in learning, educators also need to be aware of data privacy, bias, and transparency, ensuring that technology remains a tool for inclusion and empowerment, not exclusion.

In short, the learning behaviors of Gen Z and Alpha call for a balanced approach: mixing interactive digital learning with reflective, project-based, and social learning. Technology should help connect better, not replace the connection itself. The challenge for the next decade in VET is to create digital environments that are inclusive, ethical and emotionally supportive, helping every learner grow both in skills and in confidence.

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4.4 How generational change shapes future education models

Education is changing rapidly as new generations enter schools and training centres. The advent of Generation Alpha heralds a transformative shift in educational paradigms. As the first cohort to be fully immersed in a digital environment from birth, their unique characteristics and expectations necessitate a reimagining of educational models to ensure relevance and efficacy in the coming decades.

1. Integration of Digital and Social-Emotional Learning

Digital tools are now a normal part of this transformation. Artificial Intelligence, Virtual Reality, and Augmented Reality are powerful tools. These technologies make it possible to simulate authentic work situations safely, allowing students to practise and make mistakes without real-world risks. This hands-on digital training increases confidence and builds professional competences that match what companies need.

However, this immersion has also raised concerns regarding the development of social-emotional skills. Research indicates that increased screen time may limit opportunities for face-to-face interactions, potentially hindering the development of empathy and emotional intelligence SpringerLink.

To address this, future educational models must integrate digital literacy with social-emotional learning (SEL). The OECD's framework emphasizes the importance of fostering competencies such as self-awareness, empathy, and interpersonal skills alongside traditional academic knowledge OECD. This holistic approach ensures that students are not only technologically proficient but also emotionally intelligent and socially responsible.

2. Personalization Through Artificial Intelligence

Generation Alpha's familiarity with personalized digital experiences sets the stage for the integration of Artificial Intelligence (AI) in education. AI can facilitate adaptive learning

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environments that cater to individual learning paces and styles, providing customized educational experiences that enhance engagement and efficacy.

The OECD highlights the potential of AI to transform education by offering personalized learning pathways, thereby accommodating diverse learner needs and promoting equity in educational outcomes One MP. However, the implementation of AI in education must be approached with caution, ensuring that ethical considerations such as data privacy and algorithmic bias are addressed.

3. Emphasis on Lifelong Learning and Skill Development

Education systems now need to focus more strongly on key 21st-century competences such as adaptability, teamwork, problem-solving, and critical thinking. Generation Alpha will require continuous opportunities to acquire and refine such skills to navigate an ever-evolving job market.

The OECD's Education 2030 project underscores the necessity of fostering these competencies through curricula that emphasize inquiry-based learning, collaboration, and real-world problem-solving OECD. Educational systems must evolve to support continuous learning beyond traditional schooling, incorporating flexible learning pathways and credentials that recognize diverse learning experiences.

4. Global Citizenship and Ethical Awareness

Generation Alpha is growing up in an interconnected world where global challenges such as climate change, inequality, and geopolitical tensions are prevalent. At the same time, new ethical questions are emerging. The use of AI in education raises issues of privacy, transparency and fairness. The EU Artificial Intelligence Act highlights the need for technology that remains human-centred and accountable. Teachers and institutions have a key role in ensuring that learners not only use digital tools effectively but also understand their ethical and social impact.

This global context necessitates the cultivation of global citizenship and ethical awareness in education.

Future education models must incorporate curricula that promote understanding of global issues, cultural diversity, and ethical decision-making. The OECD's Learning Compass 2030 envisions education systems that prepare students to act as informed and responsible global citizens, equipped to contribute positively to society OECD.

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Overall, generational change represents more than a shift in age groups; it is a complete rethinking of education. Vocational schools and training centres must stay flexible, strengthen cooperation with companies and communities, and design learning experiences that prepare students for professions that are still taking shape.

Characteristic	Millennials	Generation Z	Generation Alpha
Digital Exposure	Transition from analog to digital	Constant internet access, smartphones	Fully AI immersed, platform native
Work/Study Values	Meaning, purpose, and value	Speed, transparency, and connection	Highly visual, gamified, adaptive
Education Preferences	Balancing traditional and digital	Interactive, relevant, tech-supported	Strengthen creativity, flexibility
Key Influences	Global job markets	Environmental concerns, social justice	Future jobs do not yet exist

Figure 1. Comparison of generational characteristics for Millennials, Generation Z and Generation Alpha across digital exposure, work and study values, education preferences and key influences.

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5. TECHNOLOGICAL DEVELOPMENT AND AI TRENDS IN EDUCATION

Artificial Intelligence (AI) and Extended Reality (XR) technologies are rapidly transforming vocational education and training (VET) by enabling new forms of teaching, learning, and assessment. This Section explores current capabilities (see Section 5.1), emerging trends (see Section 5.2), future projections (see Section 5.3), and the evolving role of XR (see Section 5.4), offering a comprehensive view of the changing technological landscape in educational settings.

5.1 Overview of current AI tools and capabilities

Today's AI tools in education range from simple rule-based systems to advanced generative models that support complex interactions, personalized learning, and automated assessment. Their capabilities can be grouped into four main categories:

- **Content Generation and Enhancement:** Tools such as ChatGPT, Copilot, and Diffit allow educators and learners to generate summaries, create quizzes, simplify texts, or translate materials. These tools reduce preparation time and make content more accessible.
- **Personalized Support:** AI-driven platforms adapt to learners' skill levels and progress, offering tailored feedback, hints, or next steps. Examples include adaptive learning systems and writing assistants that support idea development and grammar correction.
- **Assessment and Feedback:** AI is increasingly used in formative and summative assessment processes. It provides automated grading, language support, error detection, and even real-time speech or image analysis in performance-based tasks.
- **Planning and Tutoring:** Large Language Models (LLMs) can be used to scaffold learning journeys by helping students set goals, plan tasks, and monitor progress. Teachers also use AI for curriculum mapping, lesson planning, and administrative support.

Despite these advancements, most tools remain general-purpose and not tailored for vocational contexts. Educators often adopt these tools experimentally, with limited pedagogical or ethical guidelines in place. Integration into formal VET systems is still in early stages, particularly for domain-specific or multilingual use cases.

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5.2 Emerging trends and innovations in educational AI

The field of educational AI is evolving along several key dimensions that are likely to shape the future of VET:

- **Multimodal and Multilingual Capabilities:** New AI systems increasingly support multimodal input and output – processing not only text but also voice, images, video, and sensor data. This expands accessibility, especially for learners with reading difficulties or language barriers. Tools can now generate instructional videos, describe 3D objects, or offer voice-based interactions in multiple languages, supporting inclusive and immersive learning.
- **Embedded and Context-Aware Systems:** AI is becoming more context-sensitive, capable of operating within specific environments, such as simulators, digital twins, or augmented reality interfaces. These embedded systems provide on-the-spot feedback during hands-on tasks, enhancing safety, competence acquisition, and real-world relevance in vocational learning.
- **Generative and Co-Creative AI:** AI is shifting from passive information delivery to active co-creation. Learners are increasingly using AI to brainstorm, prototype, or iterate their ideas. This positions AI as a creative partner in project-based learning, design thinking, and entrepreneurial education – if supported with proper scaffolding and ethical safeguards.
- **Learning Analytics and Predictive Modelling:** Institutions are experimenting with data dashboards, early warning systems, and learner engagement analytics powered by AI. These tools support personalized interventions, dropout prevention, and strategic planning. However, they also raise concerns around bias, surveillance, and student autonomy.
- **Human-AI Collaboration in Vocational Tasks:** In some sectors, such as healthcare, manufacturing, and logistics, AI is already integrated into the workplace. Preparing students to work alongside AI – understanding its limitations, auditing its outputs, and exercising oversight – is becoming an educational goal in itself. This highlights the importance of AI literacy in VET.

5.3 Projections: How AI might evolve in the next 5–10 years

Although future developments are inherently uncertain, several projections can be made based on current trajectories:

- **More Specialized Tools for VET:** Domain-specific AI solutions will emerge, aligned with industry standards and certification requirements. These may include intelligent tutors for welding, diagnostic assistants for mechanics, or virtual patients for healthcare training.
- **Greater Integration into LMS and Platforms:** AI features will be embedded directly into learning management systems, reducing the need for separate tools and improving workflow efficiency for educators.

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- **Increased Emphasis on Trustworthy AI:** As regulatory frameworks like the EU AI Act take effect, educational institutions will need to demonstrate that AI systems are transparent, explainable, and fair. Trust will become a prerequisite for adoption.
- **Rise of Hybrid Human-AI Instruction Models:** Teachers will increasingly operate as orchestrators of hybrid learning environments, balancing human judgement with AI recommendations. This will require new professional skills, pedagogical strategies, and support systems.
- **Progress Toward AI Companions and Lifelong Learning Agents:** Within the next decade, AI could evolve into persistent learning companions – systems that accompany individuals across different learning stages and environments, supporting lifelong learning pathways in both formal and informal contexts.

However, responsible development must keep pace with innovation. Risks related to bias, misinformation, over-reliance, and erosion of critical thinking remain high if educational use is not framed within strong pedagogical and ethical boundaries.

5.4 Role of XR and hybrid environments alongside AI

XR – including Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) – plays a complementary and often synergistic role in the digital transformation of VET. When combined with AI, XR enables hybrid environments that blend real-world practice with immersive simulations and intelligent feedback loops:

- **Enhancing Practical Skills Training:** In fields where hands-on training is essential, XR can simulate tools, environments, and procedures safely and repeatedly. When AI is added – e.g., to detect errors, guide users, or adapt scenarios – the result is a powerful, self-directed learning experience.
- **Supporting Remote and Distributed Learning:** XR enables remote learners to access practical training that would otherwise require expensive equipment or physical presence. AI can further optimize this by adjusting difficulty levels or offering translation and accessibility support, making hybrid learning more inclusive.
- **Promoting Motivation and Engagement:** Gamified XR environments supported by AI storytelling and adaptive feedback mechanisms significantly increase learner motivation and engagement. This is particularly valuable in preventing dropout and supporting re-skilling among adult learners.
- **Challenges in Adoption and Integration:** Despite their potential, XR and AI remain underused in formal VET curricula. Barriers include high costs, limited infrastructure, insufficient educator training, and lack of clear pedagogical models. Addressing these challenges requires coordinated investment and policy alignment.

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5.5 Conclusion

The technological landscape in VET is undergoing a profound transformation. AI and XR are no longer speculative tools of the future – they are rapidly becoming integral components of educational ecosystems across Europe. Their capacity to enhance interactivity, personalize learning experiences, and support the development of practical skills is increasingly evident across pilot projects, institutional strategies, and policy-level discussions.

However, meaningful and sustainable implementation of AI and XR in VET is not solely a matter of adopting the latest technologies. It requires a systemic approach that aligns pedagogical innovation with ethical and inclusive design, supports educators through training and co-creation, and embeds experimentation within robust frameworks of governance and evaluation. Section 5 has shown that when designed thoughtfully, these technologies can support more engaging, equitable, and effective learning experiences, especially for learners who have previously been underserved by traditional methods.

The most promising outcomes emerge from contexts where technological deployment is coupled with strong collaboration among learners, teachers, developers, and institutional leaders. Co-creation practices, ethical impact assessments, and pedagogical adaptation are not optional – they are prerequisites for building trust, relevance, and long-term value. Furthermore, equitable access to infrastructure and digital skills remains essential to ensure that technological transformation does not deepen existing divides.

Looking ahead, VET institutions must stay attuned to emerging trends, such as generative AI, adaptive XR simulations, and the increasing use of real-time learner analytics. They must also anticipate the evolving regulatory landscape, particularly the implementation of the EU AI Act and related national frameworks that will shape what is permissible and responsible in educational AI use.

In summary, Section 5 has demonstrated that AI and XR can support VET learners in developing future-proof competences – when their integration is guided by pedagogical intent, ethical foresight, and systemic inclusiveness. By recognizing what is already possible, embracing experimentation, and fostering collaboration at all levels, vocational education can proactively shape a digital transformation that is innovative, human-centered, and resilient.

6. POLICY CONSIDERATIONS AND ETHICAL ASPECTS

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6.1 European-level frameworks and AI strategy

AI technologies are reshaping education, also offering a tool for growing need for more personalized learning. AI technologies are seen as a supporting tool for teachers, and as personalised study paths, helping with automated grading of students' work and administrative support. However, concerns of ethical use of AI in education arises from privacy of students, fairness, and biases of these technologies.

In 2024, the European Artificial Intelligence Act[1] was adopted—the first of its kind in the World. It establishes the regulatory framework for the use of AI across the EU, including in the education sector. AI systems used in education are classified as "high-risk," meaning they are subject to strict requirements related to transparency, safety, non-discrimination, and human oversight. These AI systems must be ethically sound and fair, supervised by humans, and non-discriminatory, for example with regard to gender, age, or ethnicity.[1]

Emotion inference technology, which recognizes emotional states of students, could enhance learning, as emotions are critical to it, but there are several ethical and practical problems related to this technology. Accuracies of these technologies are not sound and misinterpretation is likely. As education is categorized as high risk the EU AI act forbids the use of these technologies. [2]

The AI Act requires educational institutions to clearly inform students and guardians about the use of AI. AI must not be solely responsible for student assessment—a human – teacher, must always retain ultimate responsibility. Incorrect or biased outputs from AI could result in unfair treatment or discrimination. For example, some AI tools may underestimate the abilities of students with disabilities. Although AI systems must comply with defined standards and evaluation criteria, users need to understand their limitations, including possible errors and embedded biases.[3]

Data misuse or security breaches are additional concerns. These could result in violations of the General Data Protection Regulation (GDPR)[2] and may have long-term consequences for students. High-risk AI systems must undergo risk assessment and mitigation both before and during their use. The GDPR plays a critical role in ensuring that students' data and rights are protected. To use and process students' personal data, a school or service provider must have a valid legal basis. When working with minors or young learners, additional safeguards must be in place. Since children may not fully understand how AI works, obtaining informed consent is more complex and requires extra care.[4]

In addition to regulatory requirements, the European Commission's Digital Education Action Plan 2021–2027 (DEAP) provides strategic direction for the safe and effective use of digital

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technologies in education. The DEAP emphasises the development of high-quality digital learning environments, the promotion of AI literacy for both learners and teachers, and the need for accessible and inclusive digital tools. It stresses that AI systems used in education must be human-centred, transparent, and aligned with EU ethical and data-protection principles. These priorities reinforce the importance of responsible AI use in personalised learning pathways and support institutions in developing trustworthy digital practices.

The most common legal bases in education are consent and legal obligation. Consent must be freely given, specific, informed, and reversible, meaning it can be withdrawn at any time. In some cases, schools may process data as part of their legal duty, for example to fulfil national curriculum requirements or to ensure equal access to education.

Some types of personal data are considered special category data under GDPR and are subject to stricter protections. These include health information such as medical conditions, learning difficulties or disabilities, ethnic origin, and religious beliefs. Such data cannot be processed without explicit consent. This means the purpose must be clearly explained, and consent must be freely and actively given. The processing must be necessary for providing educational support or accommodations, and appropriate safeguards must be in place, such as data minimization and encryption.

AI Application Area	Legal Considerations
Personalized learning support	GDPR: data minimization, consent required
Assessment tools	AI Act: high-risk systems – requires human oversight
Content generation (e.g., ChatGPT)	Clear usage policies + obligation to inform users
Identifying special education needs	Sensitive data – requires a strong legal basis
Learning analytics	Requires transparent privacy policies and specific purpose

Responsibility of assessing the use of AI applications in education remains with education and training providers. Data security, protection, intellectual property rights, as well as the students and teachers right to their own data and privacy. (EU AI Act)

The European Digital Education Hub[5] organised two expert workshops in June 2025 to revise EU guidelines on disinformation and on the ethical use of AI and data in education, so that

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educators across Europe receive practical, current, and inclusive support. Working groups of teachers, researchers, policymakers, and media professionals are updating the 2022 documents by refining their structure, adding new emphasis such as emotional awareness, the role of generative AI, and social media—and embedding concrete classroom tools like gamified learning, role-play, fact-checking, and reflective activities. They are also aligning the texts with national policy frameworks and preparing accurate translations into all 24 EU languages to maximize accessibility for teachers and school leaders. In parallel, AI specialists are reworking the ethical guidelines to reflect rapid advances in generative technologies, offering educators actionable guidance on responsible classroom use, data privacy and academic integrity, and strategies to build learners' AI literacy, supported by an updated glossary. This joint effort serves teachers, school leaders, and decision-makers across Europe, aiming to strengthen resilience against disinformation, promote ethical, transparent and inclusive AI practices, and build a digitally competent educational community. The revised guidelines, part of the Commission's 2021–2027 Digital Education Action Plan, will inform the forthcoming Digital Education Action Plan 2030 Roadmap and are expected later this year.

[1] Aslama, M. et al. (2025) Tekoälyopas opettajille, Faktabaari, Helsinki

[2] Saarela et al., The EU AI Act: Implications for Ethical AI in Education, DOI:10.007/978-3-031-93979-2_3

[3]Aslama, M. et al. (2025) Tekoälyopas opettajille, Faktabaari, Helsinki

[4]Aslama, M. et al. (2025) Tekoälyopas opettajille, Faktabaari, Helsinki

[5] https://education.ec.europa.eu/news/revising-guidelines-on-disinformation-and-ai-ethics-workshops-insights , accessed 29.9.2025

6.2 National policy Finland

Finland's guidelines for AI in education are part of the national Digital Compass and have been developed collaboratively by the Ministry of Education and Culture and the Finnish National Agency for Education. In this context, "AI system" refers to any system, application,

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or service utilizing AI in educational operations, while "generative AI" specifically means AI that creates content (e.g., text, images, audio). The guidelines are divided into legal responsibilities and recommendations, with clear distinctions between the roles of education providers and teachers/trainers. The full text (in Finnish) is available on the OHP website.

Legal Responsibilities of Education Providers

Education providers are required to define clear policies for the use of AI in teaching, learning, student services, and administration. They must ensure staff training and internal guidance, and guarantee that AI systems comply with relevant legislation, including:

- **EU AI Act**
- **GDPR and Finnish data protection law**
- **Copyright legislation**
- **Act on Information Management in Public Administration**
- **Act on Public Procurement**
- **Non-discrimination and Equality Acts**
- **Relevant education-specific laws** (e.g., Vocational Education Act, Basic Education Act, Early Childhood Education Act)

Additionally, AI systems must align with curricula and qualifications, and statutory duties must be respected. Learners must not be exposed to advertising, ideological manipulation, or harmful content via AI systems, and any legal age limits must be observed.

A risk assessment is required to determine if an AI system falls under the EU AI Act and to address obligations such as transparency and human oversight. This includes the education provider's duty to conduct a Data Protection Impact Assessment (DPIA) and, when necessary, consult the data protection authority. Staff must be sufficiently AI-literate and instructed not to input personal or sensitive data into AI systems unless legal requirements are met. Learners and staff should be clearly informed about personal data processing in an age-appropriate manner.

AI systems must not be trained on copyrighted material without explicit permission from the rights holder. The use of public domain or openly licensed content (e.g., CC0) is strongly encouraged. Content generated by AI typically does not qualify for copyright protection, as it lacks human creative input.

Recommendations for Education Providers

AI systems should be evaluated for legal compliance and pedagogical relevance. Education providers should ensure both staff and learners receive adequate training on responsible AI

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use. Transparency is essential: users must always be informed when AI is used in educational settings, fostering trust and ethical implementation.

Other recommendations include:

- Considering energy consumption and sustainability when adopting AI systems
- Requiring AI vendors to provide documented analyses of algorithmic bias and potential errors, with regular reviews
- Following national frameworks for learning analytics
- Integrating copyright principles into all internal AI policies and guidance

Legal Responsibilities and Recommendations for Teachers and Educational Staff

Teachers must use only AI tools provided or approved by the education provider. Learners cannot be required to register for or purchase access to external AI tools. While AI may support assessment, the teacher remains solely responsible for final decisions. If AI-assisted assessment is classified as high-risk, additional obligations apply. Personal or confidential data must never be provided to AI systems without verifying legal requirements.

Teachers and staff should:

- Use only approved AI tools, ensuring consistency with institutional policies
- Ensure AI use has a clear pedagogical purpose
- Communicate openly with learners about AI use, agree on principles, set boundaries, and discuss misuse consequences
- Support learners in developing critical skills to interpret and evaluate AI-generated content
- Discuss potential biases and errors in AI systems to foster digital literacy
- Use AI only if it adds value to teaching and learning

Sources:

- Finnish National Agency for Education (OHP): AI recommendations and obligations in education
- EU AI Act, GDPR, Finnish data protection law, copyright legislation, and other relevant acts

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Survey on the use of artificial intelligence in teaching and guidance work at vocational colleges KAO, Brahe, Luovi and Vamia.

The staff of the educational institutions answered the following questions:

1. Have you used artificial intelligence in guidance or to support students? (Artificial intelligence, or AI, can also be tools that are not immediately recognizable as AI, such as automatic feedback, progress tracking, or chatbots.)
2. If you have used, how?
3. What are the biggest barriers to using AI in control?
4. Briefly describe how you may have used AI in guidance or to support students, or what ideas you have about using it. (Examples: automatic feedback, learning path personalization, virtual exercises, chatbots to support new students, Copilot in creating exercise materials, learning tracking in Teams)

The number of respondents was 42 people: Kao: 18 respondents (teachers providing guidance), Brahe: 7 persons working as guidance counsellors (study and career counsellors, vocational teachers, special education teachers), Luovi: 4 guidance counsellors, Vamia: 13 respondents, teachers.

In most educational institutions, artificial intelligence is already used in a variety of ways to support teaching and guidance, but the ways of using it and the challenges vary somewhat.

Use cases:

- Artificial intelligence is most commonly used to tailor learning materials according to the needs of students (Kao, Luovi, Brahe, Vamia). For example, ChatGPT and Copilot are used to create training materials and monitor learning.
- Virtual learning environments and immersive materials (e.g. Thinglink, chatbots) are used especially in the guidance of new students (Luovi, Vamia).
- Artificial intelligence also supports the planning of personal learning paths, career counselling and the intensification of guidance discussions (Brahe, Luovi).
- Teachers utilise artificial intelligence in lesson planning, preparation of materials and exercises, and information retrieval (Brahe, Vamia).
- In some educational institutions, artificial intelligence is also used to automatically check assignments and give feedback (Kao, Brahe, Vamia).
- A special feature of Vamia is the piloting of the Annie chatbot to support students' study paths.

Major obstacles and challenges:

- The most common obstacle to the use of artificial intelligence is the lack of familiarity with the tools and the lack of time for their developmental use (Kao, Luovi, Vamia).

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- Many people are concerned about information security and privacy (Kao, Luovi, Vamia).
- Some educational institutions feel that artificial intelligence does not yet work smoothly or reliably, and more training and resources are needed for the introduction of artificial intelligence (Kao, Brahe, Vamia).
- Vamia's and Brahe's responses also highlight the lack of institutional policy and clear guidelines in the use of artificial intelligence and XR technologies.

Development needs and wishes:

- All educational institutions are hoping for more training and support for the use of artificial intelligence (Kao, Brahe, Luovi, Vamia).
- Educational institutions have organised several AI-related trainings for their staff, but development is still needed, especially to ensure ethical issues, competence and human-centredness. Users also want AI training for certain teams on their own topics. (Luovi, Brahe)
- Vamia's responses highlight the need for clear institutional policies and ethical frameworks, as well as the desire for more extensive use of XR technologies.

Artificial intelligence is mainly seen as a useful tool that facilitates teaching and guidance work, especially in the production of materials and the monitoring of learning. The biggest challenges are related to competence, resources and information security. The focus of the development is on training, clear guidelines and taking ethical issues into account.

7. SYNTHESIS AND ANALYSIS

7.1 How Generation Alpha's traits align with AI's educational potential

Generation Alpha represents the first cohort to grow up fully immersed in AI-enabled environments. Their learning expectations are shaped by constant interaction with adaptive, responsive, and personalised digital systems. Findings from WP5.1 and the broader pedagogical and generational analysis show a strong alignment between Generation Alpha's traits and the educational potential of AI in vocational education and training (VET).

Generation Alpha expects personalisation as a default. AI-supported systems that enable adaptive pacing, differentiated tasks, and continuous feedback directly respond to this expectation and reinforce learner agency within competence-based VET models [1][2].

AI also aligns with Generation Alpha's preference for immediacy and interaction. Formative feedback, on-demand guidance, and reflective prompts provided by AI tools mirror everyday

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digital experiences while supporting self-regulated learning without replacing the pedagogical role of teachers [3].

When combined with XR technologies, AI enables immersive and contextual learning environments that support safe skills rehearsal, reflection, and progression. This is particularly relevant in VET, where practical competence and safety are central [4].

Finally, alignment must be balanced with ethical governance. Trust in AI-supported learning depends on human oversight, transparency, and compliance with the EU AI Act and GDPR. AI must remain a supportive tool within clearly defined institutional and pedagogical frameworks [5].

7.2 Institutional readiness: what gaps exist and where support is needed

This summary presents how artificial intelligence is currently used to support teaching and guidance in Finnish vocational colleges. The responses highlight both the opportunities and challenges experienced by staff across different institutions. Also the use of XR is noted.

Current Use of AI and XR: At Vamia, only one teacher reported using both XR and AI in teaching, with AI being more commonly adopted among staff. AI is primarily leveraged for lesson planning, creating exercises, and structuring course content, serving as a productivity tool for teachers rather than as an interactive learning experience for students. There is some use of AI for generating model answers and example sentences, especially in language subjects, and limited interactive use for student conversations. XR, on the other hand, is still in an exploratory phase, with existing environments (e.g., for excavation and earthmoving machines) not yet widely implemented in teaching.

Challenges and Barriers

- **Lack of Time:** Across institutions, a major barrier is the lack of time for staff to explore, develop, and integrate AI tools into guidance and teaching processes (Brahe, Luovi, Kao).
- **Data Security and Privacy:** There are concerns about data security and student privacy when using AI solutions (Brahe, Luovi). Valmia also mentioned concerns about data security in the use of XR.
- **Uncertainty About AI Reliability:** Staff are uncertain about the reliability of AI and its ability to handle complex, subject-specific tasks (Brahe).
- **Human-Centered Guidance:** Some feel that the inherently human nature of guidance work may not align well with AI-driven solutions, emphasizing that guidance should remain human-driven (Brahe).

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- **Limited Understanding of AI and Ethics:** There is a limited understanding of prompt engineering and the ethical use of AI (Brahe).
- **Lack of Knowledge of AI Tools:** Especially in Luovi, there is a noted lack of knowledge about available AI tools (Luovi, Kao).
- **Lack of Time for Testing:** Luovi specifically highlights the lack of time for proper AI testing and use (Luovi).
- **Lack of clear policies:** a lack of clear institutional stance or communicated policies regarding AI and XR. Some staff are new and unfamiliar with the organization's vision, suggesting that policies and best practices are not yet formalized or widely shared. (Vamia)

Capabilities and Opportunities

- **Personalized Learning:** AI is seen as having potential to personalize study paths and support flexible progression
- **Chatbots for Routine Guidance:** The use of chatbots to supplement guidance, especially for routine matters, is suggested
- **Support for Differentiated Learning:** AI tools could support teachers and counsellors in planning differentiated learning opportunities

Support Needs and Recommendations

- **Clear Guidelines and Best Practices:** There is a need for clear guidelines and best practices for the ethical and pedagogical use of AI
- **Access to AI Tools:** Respondents recommend broader access to AI tools and licenses
- **Continuous Training:** Ongoing training for staff is needed for AI an XR use
- **Sharing of Use Cases:** Encouraging the sharing of successful AI use cases among educators is recommended
- **Alignment with EU Recommendations:** Practices should align with EU recommendations on transparency, reliability, and data protection
- **Targeted Training:** In Luovi, training is offered but is more beneficial when targeted to specific user groups rather than as general AI training
- **Clearer Instructions for Teachers:** Vamia highlights the need for clearer instructions and more education on the responsible use of AI for staff

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8. RECOMMENDATIONS

Recommendation 1: Human-centred AI for personalised learning pathways

AI should be used to support personalised learning paths, formative feedback, and guidance, while all educational decisions and assessments remain under human responsibility. This ensures pedagogical integrity, fairness, and regulatory compliance, while responding to Generation Alpha's expectations of adaptive learning.

Recommendation 2: Systematic investment in teacher competence and institutional readiness

VET providers should invest in continuous professional development aligned with DigCompEdu and establish clear institutional AI policies. Survey results show that without structured support, AI adoption remains fragmented and dependent on individual initiative rather than strategic planning.

Recommendation 3: AI as an enhancer of immersive and practice-based learning

AI should complement hands-on vocational training by supporting preparation, simulation, reflection, and individual feedback, particularly in XR-supported environments. This preserves the core strengths of VET while enabling innovative and engaging learning experiences.

9.ROADMAP AND FUTURE VISION

This chapter outlines the shared direction for how personalised, digitally supported learning environments can be developed within VET over the coming decade. The earlier sections of this report have shown that vocational education faces both rapid changes and clear opportunities. Learners expect flexibility, relevance and engaging formats, while labour market requires constantly updated skills and the ability to adapt. At the same time, the consortium's earlier research in WP2 confirms that the attractiveness of VET relies on strong ties to workplaces, high quality teaching, practical learning experiences, adequate resources and clear pathways toward further studies.

The purpose of the roadmap is to bring these elements together and present a long-term view of how AI and XR technologies can support personalised learning in ways that strengthen the quality and appeal of VET. The vision that follows does not focus on technologies alone, but on the conditions that allow them to support learning, inclusion and student wellbeing. Section 10.1 presents the detailed roadmap and describes the phases that institutions can follow as they build responsible, pedagogically aligned and future-oriented learning environments.

9.1 Long-term roadmap for personalised AI learning environments

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9.1.1 Context and justifications

Based on earlier project findings, this roadmap provides concrete recommendations for how AI can support personalised learning in VET in a responsible and pedagogically meaningful way. The development of personalised AI supported learning environments is grounded the understanding that future VET learners will expect flexible, engaging and visually rich learning opportunities. Generations Z and Alpha are accustomed to adaptive digital services in their daily lives and benefit from learning approaches that respond to their pace and preferences. At the same time, the findings from earlier work in this project show that high quality teaching, close connections with workplaces and practical learning experiences remain essential for the long term attractiveness of VET.

The roadmap builds on these insights and outlines how personalised AI-supported learning can strengthen inclusion, student motivation and the relevance of vocational education, while ensuring that ethical and pedagogical foundations remain clear. Recent EU guidance highlights that AI-supported learning requires strong digital literacy, critical thinking and awareness of how algorithms shape information, so that learners can navigate digital environments safely.

9.1.2 Guiding principles for AI supported personalisation

To ensure that the long-term development of VET environments remains sustainable and ethical, this roadmap is underpinned by a set of core guiding principles. These principles serve as a checklist to guarantee that technology enhances, rather than dilutes, the educational experience:

- Learning remains human-centred and pedagogically driven
- AI functions as a supportive tool to augment professional judgement, not to replace it.
- Personalisation should not just feed content to students; it must actively strengthen their self-regulation, metacognitive skills, and ability to learn independently.
- Technologies must promote inclusion, accessibility and equal opportunities
- Transparency and responsible data use are essential for trust
- Learning environments remain anchored in real work practices
- AI-supported practices must be used to reinforce students’ digital literacy, improving their ability to evaluate sources and resist misinformation.
- Teachers must retain full oversight of the learning process

These principles ensure that the technological innovation remains aligned with the strengths of VET.

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9.1.3 Personalised learning path model

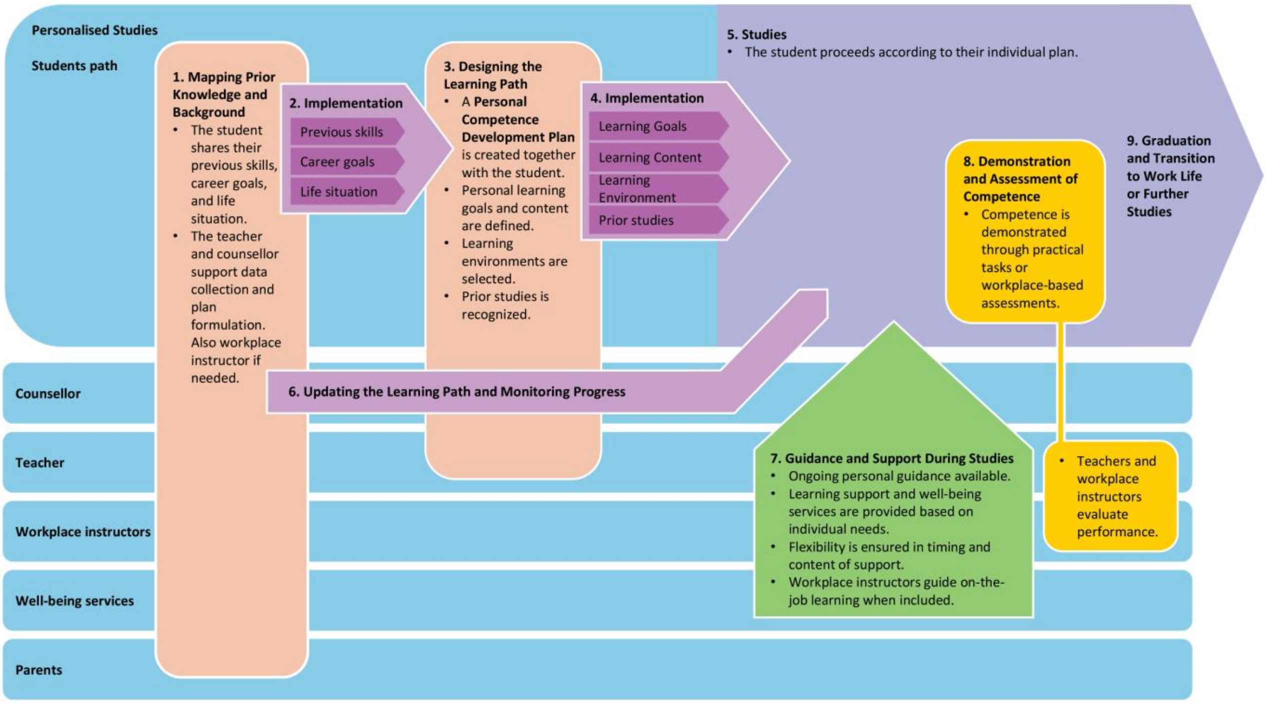

Figure 2. Phases of a personalised learning path in VET.

The personalised learning path model provides a clear structure for understanding how vocational learning progresses from initial mapping of skills to graduation and transition to work. It also helps identify where AI can meaningfully support students and teachers across the different phases.

This model consists of nine phases that describe the full progression of personalised learning, from the initial mapping of prior competence to the final transition towards work or further studies. It offers a consistent structure that can be used to analyse how different forms of support operate at each stage. In this roadmap, the nine phase model functions as the foundation for identifying where AI can provide added value, where particular risks may emerge and which pedagogical considerations require attention. The expanded version presented later in this section builds directly on this model and makes these elements explicit.

9.1.4 DEVELOPMENT PHASES OF THE LONG TERM ROADMAP

Phase 1. Foundations for development

In the initial phase, institutions focus on creating the conditions that allow AI-supported personalisation to grow responsibly.

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- Build shared understanding of how AI supports each of the nine phases in the personalised learning path
- Establish clear ethical and pedagogical principles for AI use
- Strengthen teachers' basic AI literacy and their ability to guide students in responsible use
- Strengthen students' digital literacy, including source evaluation, understanding algorithmic influence and recognising manipulative digital content.
- Ensure that students learn to question AI-generated suggestions and reflect on the reliability and origin of digital content
- Begin small scale pilots with selected groups and simple tools
- Develop institutional policies addressing data protection, accessibility and inclusion
- Ensure strict safeguards when processing sensitive data related to learning difficulties or wellbeing
- Identify how AI-based solutions can support labour market needs, strengthen teachers' skills and reinforce the quality factors identified earlier in the project

This phase ensures that the foundations remain stable before technology is scaled further.

Phase 2. Pedagogical adoption and integration

In the second phase, AI becomes part of everyday pedagogical practice and supports the structuring of personalised learning paths. The following actions describe this development:

- Teachers use AI-based insights to adapt instruction, personalise guidance and plan study paths together with students
- AI tools help identify learners' prior competence and suggest materials and tasks suited to their level
- Students receive support in planning, monitoring and reflecting on their own learning
- Initial AI-enhanced XR environments are introduced to support practical training and learning by doing
- Guidance staff experiment with chatbots or virtual assistants for routine support tasks
- Collaboration with workplaces expands, helping ensure that personalised learning remains aligned with real work practices
- Teachers maintain oversight and remain responsible for final decisions regarding assessment and guidance

This phase increases motivation and helps ensure that learning paths are meaningful for different learners.

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Phase 3. AI supported hybrid learning ecosystems

At this stage, personalisation becomes more comprehensive across learning environments and study paths.

- AI-supported XR simulations are used for practising technical tasks in safe and repeatable environments
- Learning analytics provide early signals of support needs, helping guide interventions before problems escalate
- Students gain a clearer understanding of their progress through visual feedback tools that strengthen metacognitive skills
- AI helps create accessible, multimodal learning materials that meet the needs of diverse learners
- Digital learning environments and physical training integrate more closely, forming hybrid ecosystems
- Workplaces contribute to the design of shared learning content so that materials remain up-to-date
- Teachers maintain oversight and remain responsible for final decisions regarding assessment and guidance

These developments support the long term quality and relevance of VET and create more engaging learning opportunities.

Phase 4. Integrated ecosystems and lifelong learning support

In the long term, AI-supported personalisation becomes part of a broader learning ecosystem that supports learners throughout their educational and professional paths.

- AI agents help learners recognise their skills, update competence profiles and explore new study or career opportunities
- Recognition of prior learning becomes faster and more consistent, supporting flexible transitions between programmes
- XR environments replicate authentic work situations and evolve with industry needs
- Students’ personalised competence profiles help match them with further study options or employment opportunities.
- Teachers focus increasingly on guidance, creativity, ethics and supporting learners’ wellbeing, while maintaining full responsibility for final decisions regarding assessment and guidance
- Institutions offer flexible pathways that allow movement toward higher education or new professions

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This phase reflects a future where personalised learning is continuous, inclusive and closely linked with professional development.

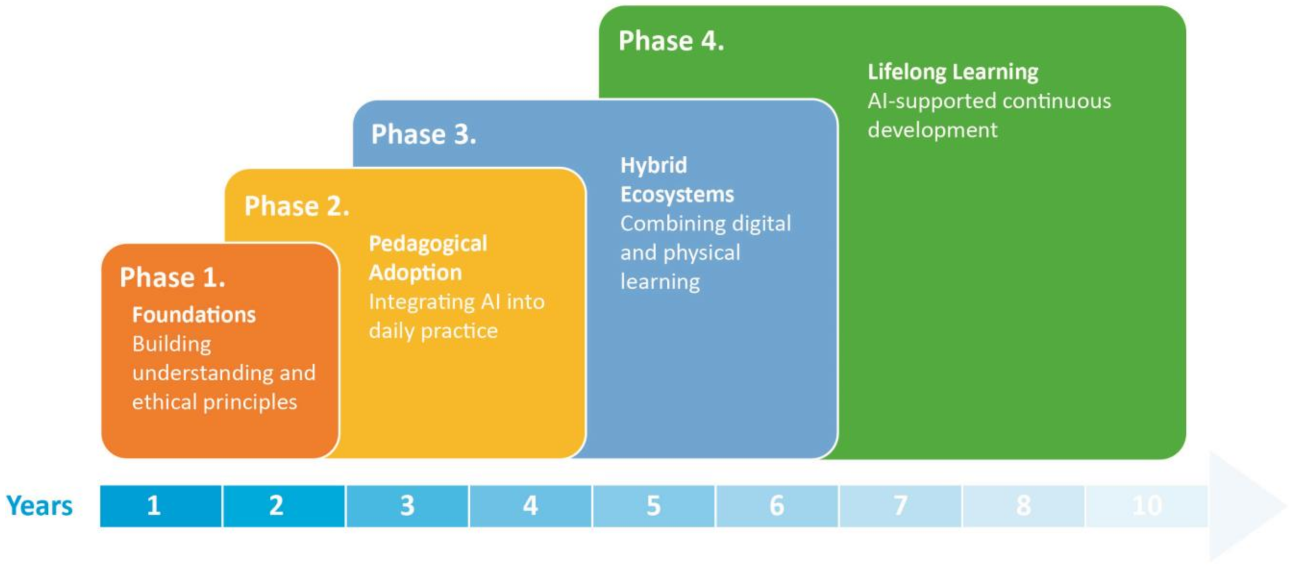

Figure 3. Four phase roadmap illustrating the gradual integration of AI supported personalisation from foundational principles toward fully developed hybrid and lifelong learning ecosystems.

9.1.5 EXPANDED PERSONALISED LEARNING MODEL WITH AI SUPPORT, RISKS AND LEARNER NEEDS

Below is the phase by phase summary that accompanies the expanded diagram.
Each phase highlights three perspectives: how AI can support learning, which risks must be managed and which pedagogical considerations are central to learners' needs.

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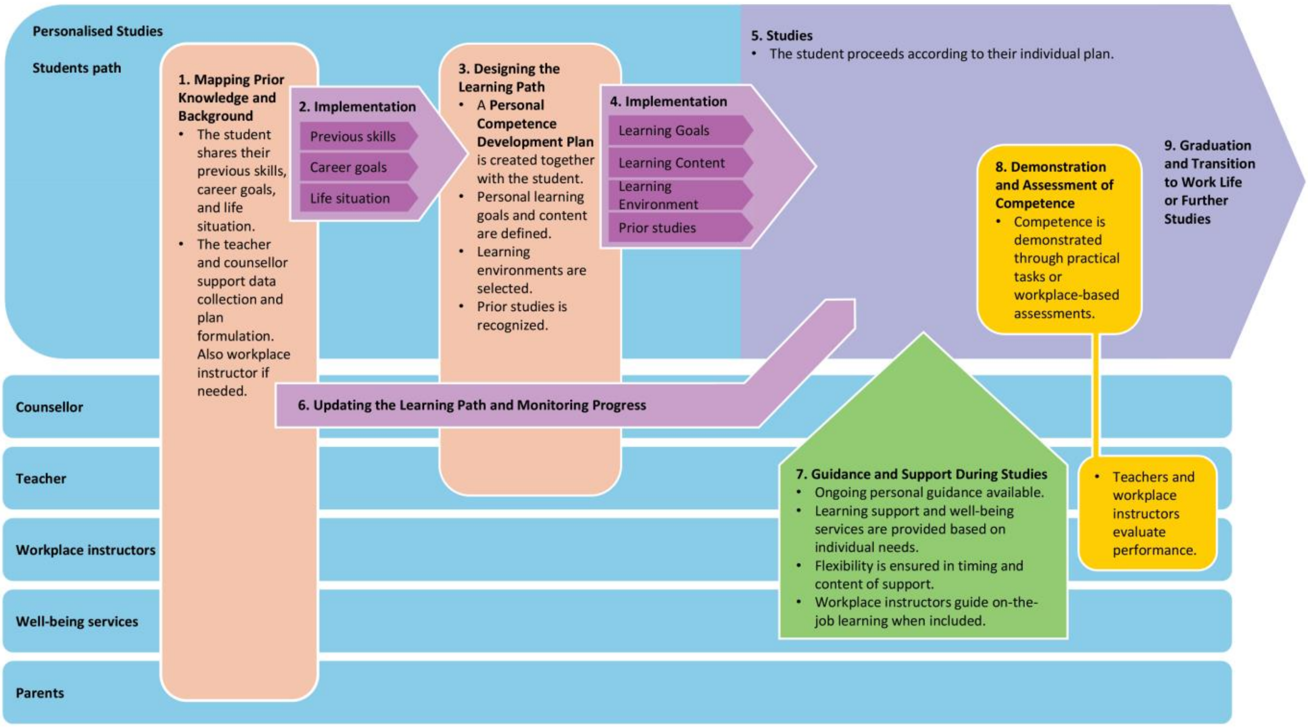

Figure 4. Phases of a personalised learning path in VET.

1. Mapping prior competence and background

AI support: Organises prior skills and goals, identifies missing information.
Risks: Sensitive data, possible incorrect assumptions, requires human verification.
Pedagogical considerations: Safe process, multimodal expression of competence.

2. Implementation of information

AI support: Suggests initial steps and pathway options.
Risks: Algorithmic bias, narrow recommendations, teacher review required.
Pedagogical considerations: Learners need clarity and control over their choices.

3. Designing the learning path

AI support: Recommends courses and modules, checks path feasibility.
Risks: Incomplete data, learner disengagement in planning.
Pedagogical considerations: Learners remain active decision makers; visual overview supports regulation.

4. Implementation of learning path in studies

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AI support: Adapts tasks and provides timely support.
Risks: Over reliance on AI, low quality or manipulative content.
Pedagogical considerations: Maintain learner agency and strengthen metacognition.

5. Studies

AI support: Personalises content and structures complex information.
Risks: Misinformation, unreliable sources, requires teacher oversight.
Pedagogical considerations: Support source evaluation and digital resilience.

6. Updating the learning path and monitoring progress

AI support: Detects challenges early and suggests adjustments.
Risks: False alerts or reinforced incorrect assumptions.
Pedagogical considerations: Teachers make final decisions; progress should be visualised clearly.

7. Guidance and support during studies

AI support: Answers routine questions and provides reminders.
Risks: Cannot detect emotional needs, inaccurate advice possible.
Pedagogical considerations: Human guidance remains essential, especially for vulnerable learners.

8. Demonstration and assessment of competence

AI support: Suggests task types and analyses technical performance.
Risks: AI cannot perform summative assessment, risk of misclassification, emotional data prohibited.
Pedagogical considerations: Teachers lead assessment; criteria must be clear and diverse.

9. Graduation and transition to work or further studies

AI support: Creates competence summaries and suggests progression options.
Risks: Narrow recommendations, strict data protection requirements.
Pedagogical considerations: Learners need help understanding strengths and making informed choices.

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9.1.6 RISKS AND SAFEGUARDS

Personalised learning supported by AI requires continuous attention to the following areas:

- Responsible data use and transparent practices
- Fairness and avoidance of bias in algorithms
- Accessibility and equal opportunities for all learners
- Avoiding overreliance on automated suggestions
- Supporting teachers as practices evolve
- Ensuring that emotional support, decision making and assessment remain human led
- Protection of sensitive and special category data, especially health information or learning difficulties, which may not be processed by AI without explicit safeguards
- Preventing the spread of misinformation, deepfakes or emotionally manipulative content through AI supported recommendations
- Avoiding reinforcement of confirmation bias or filter bubbles in personalised learning environments

Clear institutional policies and open communication help maintain trust.

9.1.7 FUTURE VISION

The roadmap outlines a pathway toward a VET system that is more personalised, inclusive and responsive to learners' needs. AI and XR technologies help create flexible study paths and engaging learning environments, but their value depends on strong pedagogy, ethical awareness and close cooperation with workplaces. By moving forward in stages and maintaining human centred guidance, institutions can support student wellbeing and create meaningful opportunities for progression to work and further studies.

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9.2 Recommendations for further research and piloting

The rapid evolution of AI and XR technologies presents a unique challenge for vocational education. Unlike previous technological shifts, the current pace of development is exponential; tools and capabilities available today may be obsolete or radically transformed within months. Consequently, researching these technologies cannot be limited to analyzing what is currently available on the market. Instead, it requires a forward-looking approach that anticipates emerging trends and capabilities before they fully mature.

This necessitates a shift toward a concept of "living research." In the context of VET, living research implies that innovation is not a periodic event but a continuous state of inquiry. It acknowledges that we are no longer preparing learners for a static future, but for an environment defined by rapid and continuous change.

Traditionally, education systems have functioned as providers of certainty, designing curricula based on established facts to offer learners a clear and predictable path to their future professions. This mandate often makes institutions hesitant to adopt experimental technologies or explore unproven methods. However, in an era of AI acceleration, holding on to static certainties risks obsolescence. To remain relevant, innovation in VET must from now on be inextricably linked with continuous applied research. This approach allows institutions to explore the potential of new technologies safely, testing their pedagogical value in real-time while maintaining the stability required for student well-being.

9.2.1 Addressing open challenges in personalised AI-supported learning

One of the most persistent challenges identified by the project is the assumption that younger learners—often labelled "digital natives"—are instinctively prepared to navigate advanced digital, AI-driven, or XR-based learning environments. Research increasingly demonstrates that this assumption is misleading. While many young people possess a high degree of confidence in using social and entertainment technologies, this superficial fluency does not necessarily translate into the critical, reflective, and purposeful skills required for deep learning.

Consequently, future inquiries must move beyond this generalization to map the real level of AI literacy and data awareness among VET learners. There is a pressing need to investigate the gap between everyday digital habits and the complex competencies needed to interact with algorithmic systems. This involves not just technical skill, but the ability to understand how these systems shape information and influence decision-making.

This research must be viewed through the lens of equity. Without targeted investigation, there is a risk that personalised technologies could inadvertently deepen existing inequalities. We must identify the specific support mechanisms required by vulnerable groups—including learners with

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learning difficulties, low digital confidence, or migrant backgrounds—to ensure they are not left behind by the very tools designed to help them.

The scope of research must expand to include the psychological dimension of learning. We need to better understand the emotional, motivational, and cognitive impact of highly adaptive and immersive environments. It is not yet clear how different learner profiles react to constant algorithmic monitoring or automated guidance. Addressing these questions is essential to ensuring that personalisation becomes a genuine tool for inclusion rather than a source of technological alienation.

In short, by focusing on key concepts, future research must pivot around four strategic priorities:

- establishing an evidence-based understanding of AI literacy that replaces generational myths;
- bridging the functional gap between recreational and educational digital fluency;
- designing specific interventions for targeted inclusion to protect vulnerable learners;
- and rigorously monitoring the psycho-emotional impact of adaptive systems.

Only by addressing these foundational elements can we ensure that the transition to AI-supported learning is both effective and equitable.

9.2.2 Recognising the non-linearity of human learning and development

A central hypothesis for future research is that human learning is rarely as linear, predictable, or purely rational as algorithms might presume. Motivation, self-confidence, mental health, and personal circumstances create a complex reality that rigid technological systems may struggle to accommodate. Consequently, a highly personalised, AI-driven environment that empowers one learner might inadvertently overwhelm another, depending on their psychological state and background.

Therefore, applied research must extend beyond cognitive metrics to investigate the friction points between human non-linearity and algorithmic structure. We need to understand how AI environments can adapt to fluctuating emotional and motivational states, rather than just academic performance. This includes identifying the specific thresholds at which personalisation becomes counterproductive—where helpful guidance crosses the line into fostering dependency, isolation, or an over-reliance on automated feedback.

Technical models must be developed to better integrate non-linear learning trajectories. Real-world study paths often involve pauses, regressions, radical changes in direction, and re-entry into education.

Systems must be designed to accommodate these realities without penalising the learner. Equally important is the need to preserve space for "unoptimised" learning: ensuring that efficiency does not eliminate the necessary room for experimentation, productive failure, peer interaction, and unstructured exploration. To validate these concepts, pilots should explicitly test scenarios where

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the learner's path is discontinuous or redefined, examining how both the system and the teacher can respond with flexibility rather than rigidity.

In short, by focusing on key concepts, future inquiry must center on four strategic priorities:

- developing holistic adaptability that responds to emotional states;
- determining the autonomy thresholds to prevent algorithmic dependency;
- engineering structural flexibility to accommodate discontinuous study paths;
- and safeguarding productive friction, ensuring that the efficiency of AI does not crowd out the essential human need for experimentation and social learning.

9.2.3 Ethical, pedagogical and organisational risks to be tested in pilots

While AI and XR technologies offer powerful educational opportunities, they simultaneously introduce complex risks that theoretical policy cannot fully predict. To truly understand these challenges, they must be observed and stress-tested within real educational environments through controlled, iterative pilot projects.

A critical area for inquiry is the integrity of the underlying systems. Pilots must rigorously examine data governance models, moving beyond compliance to ensure that transparency, consent, and learner control over personal data are practical realities. Simultaneously, these live environments are necessary to detect and mitigate algorithmic bias in adaptive systems, particularly within high-stakes areas like assessment, guidance, and progression recommendations, where automated logic can inadvertently reinforce existing disadvantages.

Beyond the technical architecture, pilots must assess the human impact of these tools. This involves scrutinizing the cognitive load and potential alienation effects of immersive XR environments to ensure they are pedagogically justified rather than merely impressive. Furthermore, the risk of "atomisation" must be addressed; if personalisation becomes excessively individualised, there is a danger of eroding the social interaction and collaborative learning that define the VET experience. Finally, the evolving role of the teacher requires careful observation to prevent professional deskilling, ensuring that human judgement is augmented, not replaced, by automated systems.

In short, by focusing on key concepts, pilot programs must target four strategic priorities:

- validating operational ethics to ensure data control and algorithmic fairness;
- assessing psychological ergonomics to prevent cognitive overload and alienation in XR;
- preserving professional agency to ensure teachers remain central to decision-making;
- and maintaining social cohesion, ensuring that the pursuit of individualised learning paths does not dismantle the collaborative fabric of the classroom.

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9.2.4 Recommendations for pilot models in VET contexts

To effectively respond to the uncertainties of rapid technological change, the project advocates moving away from rigid, large-scale implementations. Instead, the focus should shift toward modular, context-sensitive pilot models. These initiatives should be embedded directly into real VET programmes but constrained in scale and duration. This targeted approach allows for systematic evaluation and comparison, effectively turning the educational environment into a laboratory for active inquiry rather than a testing ground for finished products.

The design of these pilots requires a collaborative and multi-dimensional mindset. Rather than attempting to overhaul the entire curriculum, each pilot should zoom in on one or two specific phases of the personalised learning path model to allow for deep analysis. Fundamentally, this process must be participatory; teachers, learners, and industry mentors should serve not merely as test subjects, but as co-designers and co-evaluators. The integration of AI and XR tools must always be paired with strong human facilitation and reflection activities, ensuring that technology supports rather than dictates the pedagogical process.

To validate these experiments, the evaluation framework must be rigorous and holistic. This involves collecting both quantitative performance metrics and qualitative insights into learner well-being, engagement, and self-efficacy. Ethical safeguards are also paramount, requiring clear exit criteria to halt testing if negative impacts arise. Finally, special priority should be given to hybrid approaches where digital tools are tested alongside direct workplace experiences. This ensures that innovation reinforces, rather than dilutes, the core identity of VET as a practice-based learning system.

In short, by focusing on key concepts, the design of effective pilot models must pivot around four strategic priorities:

- adopting a modular precision that targets specific learning phases rather than systemic overhauls;
- fostering participatory co-design that unites teachers, learners, and mentors as architects of the solution;
- implementing holistic metrics that balance performance data with ethical safeguards and well-being;
- and ensuring hybrid authenticity, where digital innovation is deeply integrated with the practical realities of workplace training.

10.2.5 Long-term research directions

The concept of "living research" necessitates a commitment to horizon scanning—looking beyond immediate implementation hurdles to anticipate broader shifts in the educational landscape. As AI tools increasingly assist with content generation, traditional testing methods risk becoming obsolete. Therefore, future inquiry must explore new models of assessment that focus on process, critical application, and creativity rather than simple knowledge retention. In parallel, this shift

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requires a rethink of how progress is recognised; research should investigate the integration of micro-credentials and digital badges to validate the non-linear, personalised learning trajectories that standard degrees may fail to capture.

Beyond the classroom, we must track the long-term impact of these technologies on the learners themselves. It is vital to understand how early exposure to AI-supported environments influences a student's lifelong career adaptability and their behavior as continuous learners. Equally significant is the evolution of the teaching profession; we must continuously map the new competences required by VET trainers as they transition from content deliverers to architects of AI-rich learning ecosystems. Ultimately, these technical advancements must be contained within robust governance models, ensuring that the integration of AI in education remains strictly aligned with European values of inclusion, democracy, and social responsibility.

In short, by focusing on key concepts, the long-term research agenda must pivot around four strategic priorities:

- constructing dynamic assessment frameworks that value process over output;
- validating agile recognition systems like microcredentials for non-linear paths;
- monitoring the long-tail impact on career adaptability and teacher competence;
- and enforcing value-driven governance to ensure technology strengthens, rather than undermines, democratic and inclusive principles.

Fundamentally, the transition to "living research" represents more than a methodological shift; it constitutes a profound reorientation of how vocational education interacts with the future. By embracing uncertainty as a space for inquiry rather than a source of anxiety, VET institutions can reclaim their agency in a rapidly evolving world. This roadmap invites educators and policymakers to move beyond the passive adoption of tools and instead become active architects of their own technological reality. In doing so, we ensure that innovation remains a means to an end, serving not the speed of the algorithm, but the depth, dignity, and potential of the human learner.

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