Catalyzing Curriculum Transformation to Advance Industry 5.0 Engineering Education

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***Abstract*—Graduates who can solve problems and make an impact on society, in a volatile and uncertain world, are required. In this changing world, there are constant drivers and challenges, which lead to new requirements for Higher Educational Institutions (HEIs) curricula and pedagogies. HEIs are changing at a rapid pace, with strong disturbance, and operate in volatility, uncertainty, complexity and ambiguity (VUCA). The main aim of the study was to explore how to guide HEI academics and programme leaders to catalyze curriculum transformation to advance engineering education. Using a qualitative research approach, participants from partner universities (in France, Germany, Iceland, Indonesia, Lithuania and South Africa) were selected using purposive sampling. Data were collected from an interactive virtual workshop conducted in May 2024 to explore diverse understandings of curriculum transformation, and disruptions experienced in the HEIs with respect to curriculum transformation. Thematic analysis was used to generate five themes. The results highlight that the process of curriculum transformation can be enhanced by encouraging flexibility at HEIs, facilitating cooperation and teamwork, improving the collective capacity to change the curriculum, and ensuring the involvement of diverse stakeholders. The findings provide valuable insights for programme designers tasked with leading curriculum transformation and sustenance of engineering education.**

Keywords—Higher Education, transformation, curriculum, VUCA, disruptions

I. INTRODUCTION

Curriculum transformation in Higher Education (HE) is essential to advancing Science and Technology education in a rapidly changing world**.** Currently, Science and Technology education navigates in a rapidly advancing world and must respond to and engage with stakeholders within the social, political and increased tensions, in the global environment. Higher Educational Institutions (HEIs) operate in a volatile, uncertain, complex and ambiguous (VUCA) context, and societies are under pressure from disruptions. The HE system is being impacted and may impede responsiveness because of the complexities of reform, and sometimes its inertia. These complex challenges call for transformation, and the necessity for institutions and their stakeholders to adapt quickly. In HEIs, there is a compelling need for new strategies, learning and teaching methods that reflect changes in society, and its needs.

In such a context, the international 2022-25 European DECART (Designing higher Education Curricula for Agility, Resilience & Transformation) project proposes a framework and tools to guide Science, Technology, Engineering and Mathematics (STEM) and management educational leaders in curriculum design and programme transformation, according to unpredictable VUCA contexts. As such, the project aims to identify and share innovative curricula among international partners (France, Germany, Iceland, Indonesia, Lithuania and South Africa) with different VUCA characteristics specific to their countries and economies, to propose models and processes for curriculum change and transformation and improve interoperability and resilience of curricula. The project reflects on original curriculum structures and properties, with a shared understanding of curriculum in partner countries, as well as their drivers and triggers of change. VUCA scenario impacting HEIs help to anticipate and assess the agility and resilience of the curriculum. An international Body of Knowledge scoped in this project, including change and transformation processes and serious games for transformation management of curriculum are to help and inspire programme leaders.

The main aim of the study was to explore how to guide HEI academics and programme leaders to catalyze curriculum transformation, to advance engineering education, by gaining insights into what curriculum transformation entails, and identifying the disruptions that affect curriculum in HEIs.

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II. LITERATURE REVIEW

A. Engineering Education and Emerging Challenges

Curriculum reform in HE has been around for a long time. Ministries at national level, inter-regional policies, such as the Bologna reform in Europe and new institutional strategies, are guiding the revision of training programmes. Accreditation systems, which are cyclical, are also an excellent lever for stimulating curriculum transformation. HE, and engineering training in particular, is closely linked to the needs of national industries and economic development. The drivers for curriculum change are varied and linked to social and societal issues; they can be pedagogical. For example, engineering courses have followed the trend towards active teaching in HE, initiated by the McMaster University model in the mid-1960s [1], in Canadian medicine courses. Problem-based learning, which was later adopted in HE in Europe, has also been linked to project-based learning, which is very popular in integrated engineering curricula. It should also be noted that the philosopher Dewey, in his principles of education through experience [2], laid the foundations of the learner experience and its continuum, which is beginning to be felt in today's competency-based approaches.

The challenges for engineering students and academics are in terms of management and decision-making capacities that go beyond the classical approach of risk management, which requires abilities, such as risk assessment, risk planning and prevention tools in a VUCA world [3]. For example, future engineering managers face the challenge of dealing with a form of radical uncertainty linked to unforeseen and unforeseeable events [4] with, as a corollary, a resilience management perspective linked either to a defensive approach with preventative control capacities [5] connected to distinct temporal phases related to the pre, in and post-crisis event [6]or to a more progressive approach [5] seeking to meet the emergence of innovation opportunities driving radical changes. The fundamental aspect of making curriculum transformation happen or happen more quickly and start being successful is understanding what it means.

B. Interface of University and Industry

We are living in an age where change in science, technology and society is not constant, but accelerating at a pace humankind has never seen before. Rapidly evolving markets, changing regulations, breakthroughs in technologies and political instabilities make it hard to look too far into the future, especially in Industry 5.0. Universities are institutions that look for innovation and advanced knowledge, and in that respect, they are at the forefront of society. At the same time, however, they are also filled with traditions and conservatism. In fact, it would be regrettable if the gap between teaching and technological monitoring grew between the strategy of visionaries and leaders, and teachers and university staff. The university of the future will “derive its right to exist primarily from being active in the world and by producing knowledge for the world” (Quote by Bert van der Zwaan in his book “Higher Education in 2040”). Engineering is oriented towards a practice-based profession. Engineering students must prepare for this future by meeting their role models in academia and industry. They must realize that universities and businesses have very different temporalities. Universities need to address how technological change and innovation shape industries.

Companies need engineers who go beyond disciplinary and digital skills. They want young graduates to understand customer needs, product costing, manufacturability, project management, strategic planning and industry-specific knowledge. Enhanced cooperation with companies in engineering business could render university systems dynamic and needs-oriented and better align curriculum with their needs. The involvement of industry professionals is crucial. For example, at Airbus, according to M. Collins [7], “professionals wish to use equipment and experiment to make the concepts conveyed during courses more tangible”. In the era of acceleration and digitalization, a strong and sustainable partnership between industry and academia is more essential than ever.

The imperative for curriculum transformation in engineering education is driven by the evolving demands of the 5.0 era, characterized by a paradigm shift from technology-centered efficiency to a human-centric, sustainable, and adaptable approach. Curriculum transformation must incorporate flexibility, resilience, and a collaborative ethos to address both internal and external pressures. Disruptions such as technological advancements (e.g., artificial intelligence), global crises (e.g., COVID-19), and shifts in societal expectations significantly influence HEIs structure and delivery content [8].

C. VUCA as backdrop and skillset

VUCA provides a critical lens for curriculum developers and HEI leaders to navigate today’s rapidly changing and unpredictable world. By understanding VUCA, academics can develop the skills and mindset students need to handle the complexities and disruptions shaping both higher education and the workplace. Integrating VUCA context and skill sets helps build resilient curricula: the VUCA framework clarifies the dimensions of a shifting environment, and VUCA-aligned competencies (e.g., adaptability, resilience, and innovation) guide how educators and students can respond effectively.

In the HEI, the VUCA framework serves as both a contextual backdrop and a skillset imperative in curriculum transformation efforts. Ramsaroop [9] acknowledges that the role of universities in preparing students for a VUCA world is relevant to scholars and policymakers in different parts of the world. The acronym VUCA for volatility, uncertainty, complexity, and ambiguity is traceable to students in the U.S. Army War College in the late 1990s after the end of the Cold War [10]. Subsequently, VUCA has been widely adopted in business and education to frame the unpredictability and complexity of modern contexts [11].

VUCA, by its nature, makes it more difficult for one to make decisions without the pursuit of understanding where there is uncertainty, seeking clarity, turning plans into reality in a complex situation, and being agile in the face of ambiguity. According to Taskan et al. [10], volatility is about rapid, constant and dynamic change often associated with no predictable trend or repeatable pattern. The pace of any change in terms of varying speeds and magnitudes may create instability, disruption of trends and unexpected occurrences. Focusing on performance measurement and workflow in a manufacturing organization [12] adds that a volatile context is also typified by extreme and rapid fluctuations.

Uncertainty, which is the second construct in the acronym VUCA, stands for the inability to predict situations and incidents due to lack of knowledge (e.g. about the outcomes,

cause-effect relationship, the mechanisms of change), unpredictability and unknown factors.

The third construct in the acronym is complexity. This characterizes a situation where there are many interconnected parts, which are unidentifiable or contradictory, making it difficult to understand the reasons and factors behind a problem. (12) Andrade et al. [12] specify that the combination of the quantity of factors involved and multiple interconnections and interrelationships between the factors are fundamental elements of complexity.

Lastly, ambiguity refers to a situation or condition in which the causes and the "who, what, where, when, how and why" behind the causes and events are unclear and difficult to ascertain [10]. It, therefore, is not only the accuracy but also the recognition that components of the VUCA acronym may sometimes overlap. This is critical for categorizing and interpreting information from the environment. The conceptual map of VUCA is also useful to inform on adaptive decisions and actions when it comes to the strategic and operational levels for curriculum transformation. Fig. 1 depicts the conceptual map of VUCA, the necessary actions in volatile conditions, pursuit of understanding when faced with uncertainty, agility in ambiguous conditions and clarity in complex environments.

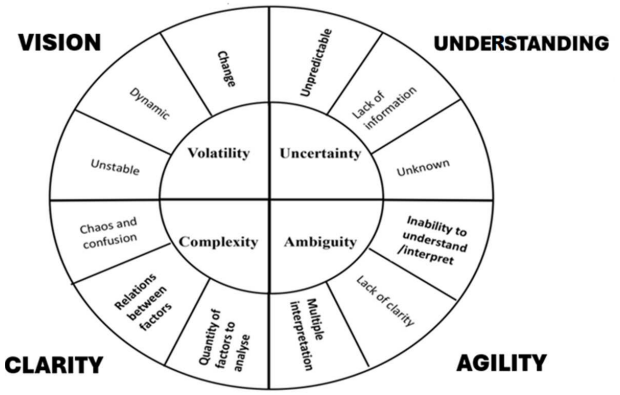

Fig. 1. Conceptual map of the acronym VUCA, adapted from [10].

The pressing demand for versatile skills in modern organizations mirrors the challenges posed by VUCA environments. In these environments, traditional competencies often prove to be insufficient. When incorporated as content in a curriculum, the VUCA framework informs the development of vision-led thinking and focuses on volatile times, critical thinking, flexibility, and resilience among students. Integrating a "VUCA skills approach" ensures that curriculum transformation aligns educational objectives with industry demands, equipping students with competencies essential for success in environments where ambiguity and complexity are routine. More important, VUCA skills are insightful to the design of a transformed curriculum, manifesting a shift to substantively new components of the curriculum in response to changes affecting different stakeholders and society, involving priorities different to the status quo, and leading to changes across multiple elements of the curriculum.

Below is a quick link of VUCA to some of the demands for Industry 5.0, which not only builds on the digitization and automation of Industry 4.0 but also emphasizes the harmonization of human-centric values with technological advancements. In integrating VUCA, it is important to initially bear in mind that the six main themes of Industry 5.0 are human-centricity (prioritizing human needs and well-being in the production process), sustainability (ensuring environmentally friendly practices and resource efficiency), resilience (building robust systems that can withstand external shocks and challenges), collaboration (enhancing cooperation between humans and machines to improve productivity), customization (focusing on personalized products to meet individual customer needs) and integration of Advanced Technologies (utilizing technologies like IoT, AI, and digital twins for smarter manufacturing). The shift from Industry 4.0 to Industry 5.0 underscores the importance of VUCA skills - volatility, uncertainty, complexity, and ambiguity - in preparing graduates for an interconnected and rapidly evolving industrial landscape [13].

- Volatility: Professionals in Industry 5.0 are expected to adapt to constant technological innovations and disruptive shifts in both market and environmental conditions, requiring agility and rapid decision-making skills [11].
- Uncertainty: Unpredictable advances in AI and robotics raise new ethical, societal, and occupational uncertainties. Graduates equipped with strong critical thinking and self-regulation skills are better prepared to navigate these ambiguities [14].
- Complexity: Industry 5.0 workplaces demand proficiency in managing complex, multi-layered systems involving human-AI interactions across global markets. Systems thinking is crucial for understanding these interactions and addressing challenges associated with human-machine collaboration and sustainability.
- Ambiguity: The emphasis on human-centred approaches requires adaptability, creativity, and the capacity for ethical reasoning. Professionals must navigate diverse perspectives and make informed decisions amid conflicting demands [15].

VUCA is also linked to adaptability and computational skills. Adaptability, defined as the capacity to modify thoughts and behaviors in response to changing conditions, enhances resilience and stress management. Rooted in cognitive adaptation theories, adaptability involves both assimilation and accommodation processes [16]. In VUCA contexts, adaptability fosters resilience, equipping individuals to recalibrate strategies and respond effectively to emerging disruptions [14]. Programs that cultivate adaptability prepare individuals for VUCA challenges, transforming uncertainty into opportunities for growth and innovation [17]. Adaptability has emerged as a fundamental competency within Industry 5.0, facilitating a responsive mindset that embraces both human and machine collaboration. Curriculum transformation that fosters adaptability prepares students to adopt new technologies, reconfigure skill sets, and address sustainability goals within complex environments [9]. Experiential learning and project-based assignments are essential for nurturing such adaptability, as they provide students with the tools to manage socio-technological shifts effectively [16]. Consequently, fostering adaptability has become essential for educational and professional

development, equipping individuals to navigate disruptions effectively.

Computational thinking, originally from computer science, has gained cross-disciplinary relevance for its structured approach to problem-solving. Core elements of computational thinking include decomposition, pattern recognition, abstraction, and algorithmic thinking [18]. These components support effective responses in VUCA contexts. Computational thinking is recognized as a core skill for engaging with Industry 5.0's advanced technological landscape. By promoting a structured, analytical approach to problem-solving, computational thinking enables future professionals to optimize human-AI collaboration, drive digital transformation, and innovate in addressing broader societal challenges [18]. This foundation supports the development of resilient, adaptable systems aligned with the human and environmental priorities of Industry 5.0 [19].

- Educational institutions equip students with a robust problem-solving toolkit, preparing them for rapid environmental shift, by embedding computational thinking in curricula [20].
- Integrating adaptability and computational thinking into educational and workplace programs equips individuals to navigate VUCA environments effectively (see Tab. I). Key applications include:
- Educational Programs: Project-based learning within simulated VUCA contexts helps students develop adaptability and computational thinking, preparing them for complex real-world challenges [19].
- Workplace Training: Workshops focused on adaptive thinking and structured problem-solving enhance employee readiness to tackle VUCA challenges confidently [21].

TABLE I. FRAMEWORK FOR INTEGRATING COMPUTATIONAL THINKING AND ADAPTABILITY SKILLS IN ENGINEERING CURRICULUM TRANSFORMATION

Industry 5.0	**VUCA Comp.**	**Computational Thinking (CT) Skills**	**Adaptability Skills**	**HE Engineering Curriculum Transformation**
Human-Centric Design	Volatility	Decomposition: Breaking down complex changes into manageable parts for analysis.	Resilience: Staying prepared and robust in the face of rapid technological and social shifts.	Integrate project-based learning that simulates real-world changes, enabling students to apply decomposition and resilience in dynamic scenarios.
Sustain. & Social Resp.	Uncertainty	Pattern Recognition: Identifying recurring patterns to inform responses in uncertain contexts.	Flexibility: Adapting approaches based on evolving data and environmental conditions.	Embed sustainability case studies to teach students flexible thinking and pattern recognition, emphasizing adaptability to global sustainability trends.
Complex Human-AI Collab.	Complexity	Algorithmic Thinking: Creating structured, step-by-step processes to address multi-layered issues.	Strategy Reconfiguration: Adjusting strategies as complex systems and AI tools evolve.	Emphasize systems engineering and AI in the curriculum, focusing on managing complexity through algorithmic thinking and strategy reconfiguration.
Innov & Ethical Decision-Making	Ambiguity	Abstraction: Focusing on essential components while disregarding irrelevant details in unclear situations.	Creativity & Ethical Reasoning: Generating innovative, ethically sound solutions amidst ambiguous demands.	Incorporate ethics and innovation modules that encourage abstraction and ethical reasoning, preparing students to navigate ambiguous, value-driven challenges.

By embedding these competencies, institutions develop a resilient, innovative workforce aligned with Industry 5.0's goals of sustainability and human-centric progress [22].

III. METHODOLOGY

The interpretive paradigm was adopted to gather multiple perspectives on curriculum transformation and how it can be catalyzed in HEIs. A qualitative research approach was used to explore the in-depth views and opinions of participants. Purposive sampling was used to identify participants who are academics and programme leaders at partner universities (France, Germany, Iceland, Indonesia, Lithuania and South Africa), involved in the international project.

An interactive virtual workshop was held on 13 May 2024, with 13 participants from the partner universities, as listed above. The workshop lasted three hours. Data were collected using Mentimeter and Jamboard, as well as group discussions in Zoom breakout rooms, and shared discussions with the large group (collective). The purpose of data gathering was to explore understanding of curriculum transformation and how to catalyze it. The key questions in the workshop focused on what curriculum transformation means and the disruptions experienced in HEIs with respect to curriculum. These questions were critical to understanding the nature of curriculum transformation and disruptions that may impede the process of catalyzing curriculum transformation. Data was analyzed using thematic analysis.

This study offers rich, in-depth qualitative insights into catalysing curriculum transformation. It did not however include quantitative measures (e.g., comparative performance metrics or surveys) to further validate these findings. Future research could adopt mixed-methods approaches to systematically evaluate the impact of the strategies identified, thereby providing more robust, data-driven guidance for advancing engineering education in an Industry 5.0 context. The study only draws on data from the interactive workshop with participants from the project partner universities. The study results can thus not be generalized.

IV. RESULTS

Using Mentimeter as an interactive, real-time polling digital tool, presented an opportunity for participants to share their views (up to three responses could be added per participant), and to see what other participants thought. Using

Mentimeter, diverse participant understandings of curriculum transformation were thus elicited from the question: "What does curriculum transformation mean to you?" Fig. 2 depicts the various responses.

Fig. 2. Diverse understandings of curriculum transformation.

The responses centered on innovation, adaptation, and flexibility. Also, improvement, adaptation to change, and development were stated. Participants also noted that it entails a process of change, and a new structure, which involves technology integration, and pedagogical innovation. It is key that various parties are involved, and that there be managerial effort, especially considering that there may be challenges involved in change. Flexibility is thus critical.

The following participant quotations illustrate the diverse views shared:

> *"What I want to say in the curriculum transformation, it's a process."*
>
> *"...it refers to a certain kind of process that includes amending, revising, reviewing. Reviewing is also part of a change process of a curriculum into modifying or updating content, also updating the structure and in the delivery of the curriculum or the curricula."*
>
> *"So, what it is an innovation with seeing the future and setting new goals. And I think also, we have. Yeah, adapt, adaptation as one word."*
>
> *"... a complete reimagination of the curriculum context, the content in terms like that. Transformation should result in an educational approach that's different from its original form."*
>
> *"Also, it's important that curriculum transformation involves a lot of stakeholders or a lot of parties. So, it's good to discuss the involvement component when we are doing curriculum transformation, such as with stakeholders and students, or maybe industry leaders, alumni and all other parties."*

As highlighted in Fig. 3, participants outlined the following in response to disruptions: natural hazards, pandemics, crisis and emergency, and lack of energy. The issue of generative AI, digitalization, technology trends, ensuring relevance, and pedagogical innovations, also featured. Other aspects, such as regulatory issues, policy, strategy, and competition, also disrupted the curriculum.

Fig. 3. Disruptions experienced in Higher Educational Institutions with respect to curriculum.

Participants highlighted:

- *"Disruption in education... challenges the status quo."*
- *"In my mind, positive change. I think new methods of teaching are learning through innovation, through AI. I think that that is positive. It's just something that is changing and pushes us to think differently"*
- *"So that was very interesting, and another aspect that was very interesting to me was the Industry 4.0, which speaks more to the direction of where curriculum needs to go to meet society's requirements"*
- *"We mentioned artificial intelligence. How can we incorporate it into our teaching?"*

Having gained an understanding of the perceived disruptions, participants worked in groups to identify the pressing challenges that required attention.

Participants noted the following:

- Disruptions due to AI, natural hazards, and the preparation of students impact the curriculum and HE as a whole, perhaps resulting in teaching and learning not happening,
- Crisis and emergency situations like the COVID-19 pandemic create sudden disruptions, for example, leading to a swift transition to online teaching and learning.
- Globalization and internationalization require HEIs to meet international standards.
- Technological changes result in rapid advancements, which can make the curriculum outdated.
- New regulations / regulatory changes in accreditation standards that necessitate curriculum adjustment.
- Market demand and job market changes require curriculum changes.
- Relevance to link industry and business and integrate theory and practice.
- Societal and cultural shifts whereby there is increased awareness of social justice issues, environmental concerns, or shifts in values, which drive curriculum changes.

- Policy where there is no consideration of the time frames for curriculum development, and where it is top down and does not consider the diversity of ideas.
- Financial pressure, for example, budget cuts, leads to HEIs having to make decisions about which programs to maintain, expand or cut.
- Strategy changes and direction.
- Pedagogical innovations lead to new teaching methods and learning models, such as flipped classrooms or online learning, which disrupt the curriculum.
- Mismatch about training programme objectives (mismatch between students and teachers).
- Staff do not understand, and lack advanced knowledge and skills required for the new curriculum.
- Continuous adaptation of students and staff.
- Changes between face-to-face and online teaching.
- Increased student workload.

The following quotations from the participants emphasize their views.

- *"And we all know how overloaded we are with teaching, and so on. Do we want something that really requires us to think deeply and put in a lot of effort to do this disruption?"*
- *"So, disruption in education is about challenging the status quo, the established norms, practices, and assumptions that have become so ingrained, we rarely question them. It's about recognizing that our current educational systems may no longer be serving our students or society effectively."*
- *"... another aspect that was very interesting to me was Industry 4.0. Which… speaks more to the direction of where the curriculum needs to go to meet society's requirements because… the curriculum… not being done for the sake of the university. That curriculum when transforming, needs to take into account."*
- *"...this disruption… because it pushes them out of their comfort zones and challenges their authority or expertise? You just have to speak to parents on a daily basis to hear their concerns about social media, and where… their children are learning from, they're concerned that they're not learning things at school or at university but in spaces that that we have no control over. So how are we going to cope with the onslaught of AI, generative AI and all the technology that's coming. Will we have a hold?"*

V. Discussion

Based on a thematic analysis of the data, five key themes emerge:

1. Curriculum transformation is an ongoing and dynamic process
2. Curriculum transformation involves multi-stakeholder engagement
3. Curriculum transformation involves a regulated process of change
4. Curriculum transformation involves innovation and requires innovative thinking in curriculum design
5. Curriculum transformation involves disruption to the existing curriculum

Fig. 4 was developed based on the analysis of the data to provide a model for catalyzing curriculum transformation.

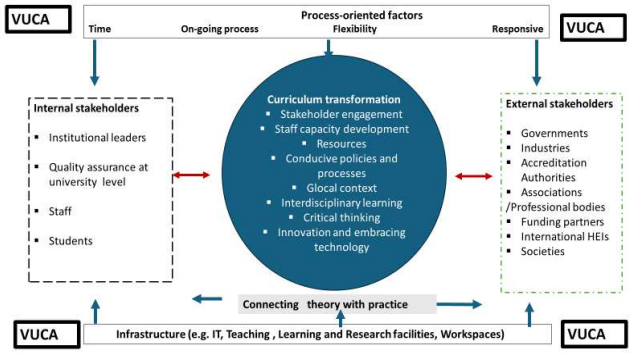

Fig. 4. Catalyzing curriculum transformation, source: constructed by the authors.

The analysis reveals that curriculum transformation is viewed as a complex, multi-dimensional process that requires time to integrate innovation, stakeholder engagement, and future-focused learning. The distinction between change and transformation is significant, with participants acknowledging the need for both in different contexts. External factors such as regulatory frameworks and societal shifts also play a key role, with curricula needing to adapt in response to these forces in a VUCA context. This holistic view of curriculum development underscores the need for ongoing review, inclusive participation of internal and external stakeholders, and proactive planning to prepare students for a rapidly changing world.

The theme of mismatch reveals the complexities of curriculum transformation. As educational systems evolve, misalignments between student expectations, faculty preparedness, and institutional goals become more apparent. These discrepancies can undermine the effectiveness of curriculum changes, particularly if students feel overwhelmed by new demands or if faculty are not adequately prepared to implement innovative teaching practices. The challenge is to ensure that all stakeholders—leadership, students, teachers, and administrators—are aligned in their understanding and expectations of curriculum changes. This requires clear communication, ongoing professional development, and a collaborative approach to curriculum design.

The results highlight that curriculum transformation can be enhanced through encouraging flexibility, where a repertoire of existing alternatives is sought and evaluated for possible switching as appropriate at HEIs, facilitating cooperation and teamwork, enhancing the collective capacity to change the curriculum, and ensuring involvement of diverse stakeholders. It is also critical that there is enthusiasm and academic strength of faculty, support from leadership, theory and practice, along with a VUCA skills approach be integrated, industry needs be aligned, and that the curriculum emphasizes lifelong learning and critical thinking.

VI. Conclusion

This research has demonstrated that curriculum transformation is a complex process. Diverse understandings of curriculum transformation exist, and multiple diverse

stakeholders should be involved. The research has highlighted that HEIs face multiple challenges, such as new technologies, e.g., AI, change, and strategy, which significantly impact the curriculum, and teaching and learning. Agile, innovative processes are required. It is important to plan for the negatives and adapt to external and internal needs.

Systemic transformations of society are essential if we are to respond to the current crises, which are intensifying both nationally and internationally. HE must anticipate future transformations. Interaction between educational ecosystems, industry and civil society is key. All these aspects call on the academic world to question, (re-)think and support the transformation of HE and STEM training in the future.

By implementing and sustaining curriculum changes, STEM and engineering education can better prepare graduates to address new challenges, like contemporary and future sustainability, key social aspects of Industry 5.0, including its focus on human-centricity, and societal impact, making them graduates future agents of positive change in society.

A curriculum that considers the VUCA skillsets and context of society helps develop students for nomadic careers. Indeed, the considerable challenge for careers and learning is no longer provided by the company within internal labour markets but by individual initiative. These new careers, described by some as "nomadic" [22, 23] or the current of "boundaryless careers" [24] are an important dimension of the New Knowledge Economy. Revising the curriculum makes it possible to develop a new, more agile and flexible career orientation.

Below are five key guidelines for embedding VUCA principles into curriculum transformation:

1. **Maintain a Relentless Focus on Purpose.** Rapid changes and disruptions can derail educational goals if not continuously aligned with institutional purpose. Ensure that new activities and curriculum adjustments serve, rather than distract from, the core objectives of the HEI.
2. **Embrace Agility and Innovation.** Swiftly adapt to market, legal, and technological shifts. Foster a culture that encourages experimentation and creative problem-solving, enabling curriculum to remain relevant and forward-looking.
3. **Develop Resilience.** Build anticipatory (before), coping (during), and adaptive (after) capacities into curricula and institutional processes. This strengthens the ability of students, faculty, and programs to recover quickly from disruptive events.
4. **Encourage Adaptability and Flexibility.** Anticipate disruptions by planning for contingencies and promoting readiness to pivot. Cultivate an environment where students and staff can seamlessly adjust to new challenges and opportunities.
5. **Cultivate Systemic Thinking.** Retain a long-term strategic view by managing the vertical and horizontal interdependencies within and beyond the institution. Collaborative networks, shared resources, and synergy across disciplines help HEIs thrive amid ongoing volatility.

By embedding these VUCA-oriented strategies, HEIs can better prepare students for the realities of a constantly evolving global landscape, ensuring that graduates possess the resilience, adaptability, and critical thinking skills needed to excel in Industry 5.0 and beyond [25, 26].

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