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Digital services as catalysts for lifelong learning in Thai higher education institutions

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ABSTRACT

As lifelong learning gains increasing importance in higher education, this study explores the role of digital services in helping Thai universities establish effective learning environments and support systems for skill development. Using a quantitative research approach, data were collected through an online questionnaire targeting faculty members and program chairpersons, resulting in 224 valid responses for analysis. The findings reveal that respondents place high value on a wide range of library, educational, and IT/media services, especially those related to research support, digital resources, e-learning, and technology-enhanced learning, highlighting their essential contribution to cultivating lifelong learning skills. Key services such as wireless internet access, educational software, and collaborative learning spaces were particularly emphasized. While emerging technologies like virtual and augmented reality were seen as promising, their current usage remains limited. The study also notes strong support for integrating digital services into university curricula, with particular attention given to embedding these tools into learning strategies and management systems. Approaches such as collaboration with library staff and the use of e-portfolios were moderately endorsed, reflecting recognition of their value despite lower implementation levels. The results suggest that lecturers should embed digital services in their teaching and assessment practices to enhance learning outcomes. Students are likewise encouraged to actively engage with these technologies to boost their lifelong learning capacities, academic achievement, and personal growth. Meanwhile, universities are urged to play a proactive role by incorporating digital services into curriculum development and ensuring the availability of necessary resources to support continuous student learning.

Introduction

It can be seen that digital services involve the application of information technology to deliver services that depend on digitally connected physical products (Lerch & Gotsch, 2015; Rymaszewska et al., 2017; Schymanietz et al., 2022; Vendrell-Herrero et al., 2017). They are provided through digital platforms and are typically managed or controlled by the customer (Immonen et al., 2016). Thus, digital technologies enable transformative changes in how service value is created and delivered and significantly shape the relationship between providers and customers (Coreynen et al., 2017; Remane et al., 2017; Schymanietz et al., 2022).

Digital services are among universities' core academic supports for teaching and learning. When embedded across the curriculum, they enhance students' learning performance and 21st-century skills (Netwong, 2019; Tsang & Chiu, 2022). To cultivate lifelong learners, universities need a holistic approach that aligns teaching–learning management, infrastructure and facilities, and human-resource development (Closs et al., 2022; Håkansson Lindqvist et al., 2024; Tsang & Chiu, 2022; Van den Broeck et al., 2024). In practice, institutions should (a) purposefully support students' learning so they develop the knowledge, skills, and values required for lifelong learning (Lau, 2006; Weightman et al., 2017); (b) assure the quality of educational resources and services (Abumandour, 2020; Hu et al., 2024; Tsang & Chiu, 2022); and (c) integrate appropriate digital services into teaching to build students' digital-age competencies (Netwong, 2019). In addition, digital services should also motivate and prepare students for self-directed, and lifelong learning (Sivankalai, 2021).

Previous studies have indicated that Thai universities are increasingly implementing lifelong learning services to promote continuous

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education among students. According to Songsaen and Junlasuti (2024), a structured lifelong learning management system has been established, incorporating credit banking, credit transfer policies, and community-based courses. Their findings highlight the involvement of over 200 staff members and 260 community participants in pilot programs designed to integrate lifelong learning into the university system. Gerdruang (2022) emphasizes the critical role of learner motivation, digital literacy, and self-directed use of media, arguing that higher education institutions must cultivate these attributes to prepare students for evolving societal demands. These developments illustrate how Thai universities are building comprehensive digital and policy infrastructures, ranging from AI-driven platforms to credit systems and technology-enhanced teaching to create a strong lifelong learning environment aligned with national goals and the UN's SDG 4. Moreover, Phonthanukitithaworn et al. (2022) use structural equation modeling to examine how digital services, such as technical support, user-friendly e-learning systems, and inclusive tutorial content, affect perceived educational quality. Their research shows that effective digital services significantly boost student satisfaction and strengthen institutional loyalty. They recommend incorporating digital literacy programs and intercultural communication training to equip global learners with the skills necessary for sustained learning in an internationalized, and digital world.

Building on recent progress in Thai higher education, improving students' lifelong learning in the digital era needs coordinated work across teaching, infrastructure, and staff development, with digital services playing a key role. This study, therefore, examines how specific digital services can help Thai universities design teaching and learning activities, and invest necessary elements to improve students' lifelong learning skills. However, the present study does not estimate causal impacts on learning outcomes or lifelong learning, positioning these as promising avenues for future work. The findings of this study are useful for (1) lecturers to integrate the digital services in instruction and assessment, (2) students to leverage these services to develop their lifelong learning skills, learning performance and personal growth, and (3) universities to develop and integrate digital services to curriculum design and resources allocation to support students' lifelong learning skills and align with the national and SDG 4 goals.

This study answers two following questions:

(1) How important are university-provided digital services for developing students' lifelong learning skills in Thai universities?
(2) How important is the integration of digital services into curricula and courses for improving students' lifelong learning skills in Thai universities?

Literature review

Digital services in higher education

According to Salminen (2014), digital services blend characteristics of both goods and traditional services, defined by four key features: intangibility, technological foundation, consistency, and scalability. While lacking a physical form, digital services rely on environmental cues, such as website design, trust signals, and multimedia content to shape users' perceptions of quality. Unlike traditional services that depend heavily on human input, digital services offer standardization and repeatability, allowing for pre-testing and consistent performance across users. These high-tech, low-touch interactions typically occur through digital interfaces rather than direct human contact, making trust-building tools like live chat or feedback systems essential. Moreover, digital services are highly scalable, enabling organizations to serve increasing numbers of users with minimal additional cost, as service delivery is not constrained by physical infrastructure or human resource limitations.

Additionally, Williams et al. (2008) mentioned that digital service is defined as an activity or benefit delivered from one party to another via a digital transaction. The provider of the service is referred to as the digital service provider, while the recipient is the digital service user. Although a single transaction can constitute a digital service, these are often delivered as a series of or ongoing interactions. In some cases, such as in bartering, both parties may act as both providers and users. The complexity increases when a single provider offers multiple services, making it challenging to create a clear taxonomy of service types. However, efforts to classify digital services often evolve into categorizing the market presence of the providers themselves, based on the range of digital services they offer.

Other studies have highlighted that services are intangible solutions developed by providers using available resources to meet customer needs, with value co-created through user experience. In the digital era, services increasingly rely on digital technologies, often incorporating code-based modules and digital components embedded in physical products. These digital services are central to digital transformation, requiring the integration of products, software, and services to deliver value. Effective digital services are characterized by personalization, dynamism, and high quality, with a strong emphasis on connectivity and user-centric design (Ghazawneh, 2019; Linde et al., 2023; Sawung Murdha et al., 2023; Shen et al., 2021). The assessment of service quality has evolved to address the unique aspects of digital services, beginning with the SERVQUAL model (Parasuraman et al., 1985), which measures five dimensions: tangibles, reliability, responsiveness, assurance, and empathy. Recognizing the limitations of traditional models in online contexts, new frameworks such as WEBQUAL (Loiacono et al., 2002) and SITEQUAL (Yoo & Donthu, 2001) emerged, focusing on website design, trust, visual appeal, layout, and functionality. Later models further expanded e-service quality to include system availability, privacy, communication, and efficiency (Parasuraman et al., 2005; Rowley, 2006). Within this context, lifelong learning services are also evolving, shaped by three key elements: learning awareness, media and methods, and emotions and feelings (Dirin et al., 2020). These services leverage user experience design and connected technologies to offer dynamic, personalized, and emotionally engaging learning experiences. Learning awareness reflects the learner's motivations and strategies, effective media ensures content delivery, and positive emotions enhance engagement and retention, forming a technology-enabled model of lifelong learning.

Digital services and lifelong learning skills

Digital services play a significant role in promoting sustainable development and enhancing lifelong learning skills through multiple strategies (Chuenchom et al., 2021). These services ensure equitable access to information by offering resources in various formats: print, electronic, and digital, while supporting open access and open educational resources (OER) to advance teaching and research (Guo et al., 2021; Umukoro & Tiamiyu, 2017). They help reduce disparities in access to technology and information, promoting inclusive and equal educational opportunities for all learners (Atta-Obeng & Dadzie, 2020). Digital services also improve users' experiences by providing effective search tools and personalized support. Critically, they facilitate the teaching of information literacy, enabling individuals to locate, evaluate, manage, and apply information effectively. This process is often

integrated with the development of essential lifelong learning competencies such as digital literacy, critical thinking, problem-solving, and self-directed learning (Chuenchom et al., 2021; Guo et al., 2021; Sezer, 2020). Furthermore, the provision of ICT services broadens access to knowledge and communication channels, supporting continuous personal and professional growth (Umukoro & Tiamiyu, 2017). These functions demonstrate how digital services act as key enablers in building inclusive, skills-based, and sustainable lifelong learning environments.

Digital services have become a driving force in promoting lifelong learning skills in Thailand by expanding access, enhancing personalization, and supporting the development of essential competencies (Chunwijitra et al., 2020). The Thailand Cyber University's T-MOOCs platform, launched as part of the national ICT strategy, provides over 500 online courses that support formal, non-formal, and informal learning, enabling individuals to pursue education anytime and anywhere (Yoshida et al., 2021). Similarly, Kertpolsert (2022) highlights the importance of digital citizenship skills, including privacy awareness and secure online behavior, as core components of lifelong learning readiness. Yuangsoi and Wannakhao (2023) also highlight how digital literacy initiatives, focused on 3Rs and 7Cs competencies prepare learners for self-directed lifelong learning in the "new normal". It can be seen that these digital services illustrate how Thailand's educational system is using technology to build a dynamic, accessible, and skill-driven lifelong learning ecosystem aligned with national development goals and SDG 4.

Previous studies have highlighted the roles of academic libraries in providing information resources and services that foster higher-order thinking skills, creativity, and information competence, enabling learners to become independent and multiskilled lifelong learners (Leong, 2013; Malan, 2007; Nonthacumjane, 2011). University libraries also offer training and information literacy programs, electronic resources, reading clubs, and more to support lifelong learning (Atta-Obeng & Dadzie, 2020). To meet these needs, universities must serve as accessible and supportive learning environments by developing learning programs, extending ICT services, and assisting researchers in using information to create new knowledge and maintain continuous access to it (Atta-Obeng & Dadzie, 2020). In the context of Academic Library 4.0, Ocholla and Ocholla (2020) emphasized that smart users must possess technological literacy, adaptability, lifelong learning abilities, and ethical standards in using and sharing information.

Other research also underscore the critical role of integrating digital services into academic curricula to support lifelong learning. Embedding information literacy (IL) and digital literacy into course content equips students with essential skills for independent learning and adaptability in the digital age. For example, Webber and Johnston (2014) propose an educational framework positioning IL within higher education as a cornerstone for lifelong learning, emphasizing the need for curricula that adapt to the evolving information culture. Wang (2014) also discusses a model for curriculum integration of IL, advocating for its incorporation at various levels of higher education to enhance students' information capabilities. In addition, the integration of IL into Learning Management Systems (LMS) has been shown to create blended learning environments that facilitate access to digital tools and resources. Lockhart (2021) also presents a case study where an IL course was successfully embedded into an LMS, resulting in positive student evaluations and highlighting the importance of flexible, technology-enhanced learning designs. Furthermore, Rafi et al. (2019) found that technological involvement by libraries significantly improves students' technology-based learning skills, suggesting that library management should provide long-term strategies for digital literacy education. However, Haggerty (2021) finds that instructors generally support integrating information services, but they still face practical challenges, especially coordinating with faculties and implementing e-portfolios.

Research methodology

Sampling

This study aims to explore the importance of digital services and integration of them into Thai higher education institutions to develop lifelong learning skills for students, thus, it focuses on collecting data from program chairpersons and lecturers at 16 global and frontier research universities, as identified by the Ministry of Higher Education, Science, Research, and Innovation (MHESRI), Thailand. These institutions are recognized for their commitment to advancing research, fostering innovation, and promoting international collaboration (MHESRI, 2021). A purposive sampling technique was employed, involving the intentional selection of participants based on their relevance to the study's objectives.

The sample size was determined using Yamane's (1973) formula, with a margin of error set at 0.5. Based on this calculation, approximately 400 participants were identified as the target sample size. This number was considered adequate to ensure the reliability and validity of the study's findings, given the large population and the desired level of precision.

Research instrument

This study uses a questionnaire to collect data from participants, comprising three parts: (1) demographic information; (2) evaluation of the importance of specific services for developing lifelong learning skills; and (3) evaluation of the perceived importance of integrating digital services in Thai universities to enhance lifelong learning. In Part 2, we categorized the listed services into three function-based groups to reduce overlap, and align with campus management structures, thereby improving clarity, reliability, and analytical tractability. The groups reflect each service's primary intent: (a) Library services - information mediation and curated collections/training (e.g., reference, repositories, consulting, Library of Things); (b) IT & media services - enabling infrastructure and creative tools (e.g., networks, software, VR/AR, design/exhibition support); and (c) Educational services - pedagogy-facing production and delivery (e-learning support, online course production, AV/smart-classroom operations, lecture recording).

Using a five-point Likert scale - from 1 (Unimportant) to 5 (Very Important) - Sections 2 and 3 explore participant responses across 23 and 11 items, respectively.

This research tool was sent to three experts in universities to evaluate the appropriateness of questions, structure and language. Then, it was revised based on the experts' feedback.

Data collection and data analysis

The research instrument was distributed to participants via email between January and April 2025. In the email, we provided a clear explanation of the study's objectives, participation guidelines, and an assurance that no personally identifiable information would be collected. To protect participant confidentiality, we did not record their email addresses or any other identifying details. Participation was entirely voluntary, and individuals who agreed to take part were invited to complete and submit the questionnaire.

Upon completion of the data collection phase, we reviewed the

responses to identify and remove duplicate entries and incomplete questionnaires. As a result, a total of 224 valid responses (account for 56.0 % of the 400 participants described in the sampling section) were retained for further analysis. The data were then analyzed using SPSS, employing frequency and descriptive statistical methods to summarize and interpret the findings.

This research was conducted in accordance with the ethical standards approved by the Khon Kaen University Ethics Committee for Human Research (Approval No. HE683009).

Research results

The demographic data of the 224 respondents indicate that the majority were lecturers (79.5 %), with program chairpersons comprising 20.5 %. Most respondents held a Ph.D. (86.2 %), while smaller proportions had a master's degree (9.4 %) or a bachelor's degree (4.5 %). In terms of academic rank, associate professors made up the largest group (36.6 %), followed by assistant professors (33.5 %), lecturers (25.4 %), and professors (4.5 %), showing a relatively balanced distribution across academic levels.

The evaluation of the importance of digital services in developing lifelong learning skills

The findings of this section figure out three groups of digital services play important roles in developing lifelong learning skills for students in Thai higher education institutions based on the participant's opinions (Table 1):

Library services

Based on the data presented, respondents generally showed a high level of agreement regarding the importance of various library services, with all mean scores exceeding 4.14 on a 5-point scale. The highest-rated service was research support services ($\bar{x}$=4.36), reflecting strong recognition of the library's role in supporting academic and scholarly activities such as information retrieval, reference management, and journal access. This was followed closely by digital libraries and repositories service ($\bar{x}$=4.26) and collaborative spaces service ($\bar{x}$=4.21), highlighting the value placed on digital resources and spaces that promote community engagement and knowledge creation. Reference services also received a high rating with $\bar{x}$=4.20. Other services such as consulting service ($\bar{x}$=4.06), training service ($\bar{x}$=4.02), information exchange service ($\bar{x}$=4.01), and Library of Things/Library for All ($\bar{x}$=4.01) were also rated positively, though with slightly lower means. These results indicate that chairpersons and lecturers at universities perceived the important contributions of library services for developing lifelong learning skills for students.

Information technology and media services

The analysis highlights the perceived importance of information technology and media services in supporting the development of lifelong learning skills ($\bar{x}$=4.09). Among the services evaluated, wireless network service received the highest mean score ($\bar{x}$=4.35), underscoring its essential role in providing continuous and flexible access to online

Table 1
The importance of digital services for lifelong learning skills.

No.	Types of services	Mean	S.D.	Ranking
1. Library services		***4.14***	***0.738***	***High***
1.1	Research support services (i.e., information retrieval service, reference management, inter-library loan, journal publication, full text finder service, etc.)	4.36	0.851	Very high
1.2	Digital libraries and repositories, library databases and research tools	4.26	0.891	Very high
1.3	Collaborative spaces: encourage community engagement and shared learning experiences to explore ideas, solve problems, and create new knowledge	4.21	0.816	Very high
1.4	Reference services	4.20	0.912	High
1.5	Consulting services (i.e., research, projects, learning, assignment, etc.)	4.06	0.938	High
1.6	Training services (i.e., information literacy, digital literacy, library tour, library use instruction, etc.)	4.02	0.860	High
1.7	Library of Things, Library for All	4.01	0.923	High
1.8	Information exchange services (i.e., conference, workshop, seminar, exhibition, etc.)	4.01	0.868	High
2. Information technology and media services		***4.09***	***0.740***	***High***
2.1	Wireless network service	4.35	0.800	Very high
2.2	Educational software and simulations (i.e., Matlab, R program, Office 365, Email, etc.)	4.28	0.828	Very high
2.3	File retention and recovery: maintain secure backups of files held on information services' managed systems	4.12	0.953	High
2.4	Computer rooms: provide computers and printing facilities for registered users of university	4.10	0.905	High
2.5	Virtual meetings and events	3.97	0.880	High
2.6	Graphic design and exhibition service in several types of designing tasks to creatively enhance learning and teaching materials (i.e., create cartoons and illustrations for online lessons; design infographics for academic sources, and posters for presentation for each occasion; develop websites through various forms of graphic designs)	3.96	0.941	High
2.7	Virtual Reality (VR) and Augmented Reality (AR) tools for education	3.83	0.992	High
3. Educational services		***3.94***	***0.768***	***High***
3.1	E-learning services: provides advice, support and training in technology-enhanced learning for students	4.13	0.777	High
3.2	Online course production and library development services support online lessons for students in various forms	4.07	0.940	High
3.3	Audiovisual equipment services: facilitate and control media equipment used in classrooms following the conceptual smart classroom	4.03	0.908	High
3.4	Educational media services for teaching and learning approaches: visual aids proving photography services and video productions	3.96	0.913	High
3.5	Providing dedicated spaces for skill development, such as exhibition areas, training rooms, and presentation corners	3.95	0.921	High
3.6	Learning skills enhancing services encompass tailored activities focused on teaching and essential graduate qualities, offering training courses in digital media creation, marketing, design, and photography	3.87	0.892	High
3.7	Recording lectures, presentations and events: to record the audio and videos	3.80	0.926	High
3.8	Information monitors: used to display a rotating series of pages to advertise courses, services and news items	3.67	0.921	High

learning resources. Educational software and simulations such as Matlab, R, and Office 365 were also rated highly ($\bar{x}$=4.28), reflecting their value in enabling practical, application-based learning experiences. File retention and recovery ($\bar{x}$=4.12) and computer rooms ($\bar{x}$=4.10) were seen as important infrastructural supports that ensure data security and equitable access to technology. Services that support creativity and presentation, such as graphic design and exhibition ($\bar{x}$=3.96), and platforms for virtual meetings and events ($\bar{x}$=3.97), were also positively received, indicating their role in promoting digital communication and content creation. Virtual Reality (VR) and Augmented Reality (AR) tools received the lowest rating ($\bar{x}$=3.83), though still seen as important, suggesting potential for future growth as these technologies become more accessible. Thus, the findings demonstrate that IT and media services are considered vital for fostering the skills and flexibility required for lifelong learning in a digital age.

Educational services

The analysis of educational services aimed at developing lifelong learning skills reveals a generally positive perception among respondents, with all mean scores above 3.94. The highest-rated service was e-learning services ($\bar{x}$=4.13), indicating strong appreciation for support and training in technology-enhanced learning. This was closely followed by online course production and library development services ($\bar{x}$=4.07) and audiovisual equipment services ($\bar{x}$=4.03), which reflect the increasing need for digital tools and smart classroom integration. Educational media services ($\bar{x}$=3.96) and dedicated spaces for skill development ($\bar{x}$=3.95) were also well-regarded, highlighting the importance of hands-on, creative learning environments. Additionally, learning skills enhancing services ($\bar{x}$=3.87) and recording services for lectures and events ($\bar{x}$=3.80) were viewed as valuable components of modern education. The lowest-rated service, information monitors ($\bar{x}$=3.67), while still positively received, suggests that passive informational tools are seen as less impactful than interactive or skill-based offerings. These findings emphasize the growing importance of digital and experiential learning services in fostering lifelong learning competencies.

The integration of digital services in Thai universities to develop students' lifelong learning skills

The findings in Fig. 1 reveal that Thai universities are actively integrating various digital services to support the development of students' lifelong learning skills (see also Appendix A). The most frequently implemented strategies include offering step-by-step guidance on using academic tools and resources (73.2 %), hosting workshops and seminars focused on lifelong learning skills (71.0 %), and embedding information services into self-directed learning strategies (68.8 %). A significant majority also reported the integration of information literacy or digital literacy courses (67.4 %) and the use of project-based or collaborative learning that incorporates information services (67.4 %). These results suggest that universities are committed to equipping students with essential skills for independent and lifelong learning through both curricular and extracurricular support. However, some strategies show moderate to lower levels of implementation. Notably, only 46.4 % of respondents indicated that library staff are integrated into specific courses - a strategy with the lowest adoption rate. Additionally, initiatives such as promoting student e-portfolios (57.6 %) and including tasks that involve critical evaluation of information from diverse sources (58.9 %) were less commonly reported.

On the other hand, several items also had high 'Don't know' responses, particularly those involving library staff integration (24.1 %), integration with learning management systems (20.1 %), and the use of digital literacy courses (19.2 %), highlight a lack of awareness or visibility of these services. This indicates that even when information services are in place, their usage is hindered by poor communication or inadequate outreach. These areas represent opportunities for universities to enhance collaboration, promote reflective and portfolio-based learning, and improve awareness of existing services among stakeholders.

Additionally, the data from Table 2 reveals that integrating digital services into courses to support lifelong learning development is generally viewed as important, with most items receiving relatively high mean scores. The item with the highest mean value is 'Integrate digital services into learning and self-learning strategies' ($\bar{x}$=4.15), indicating strong support for embedding digital services in both structured and

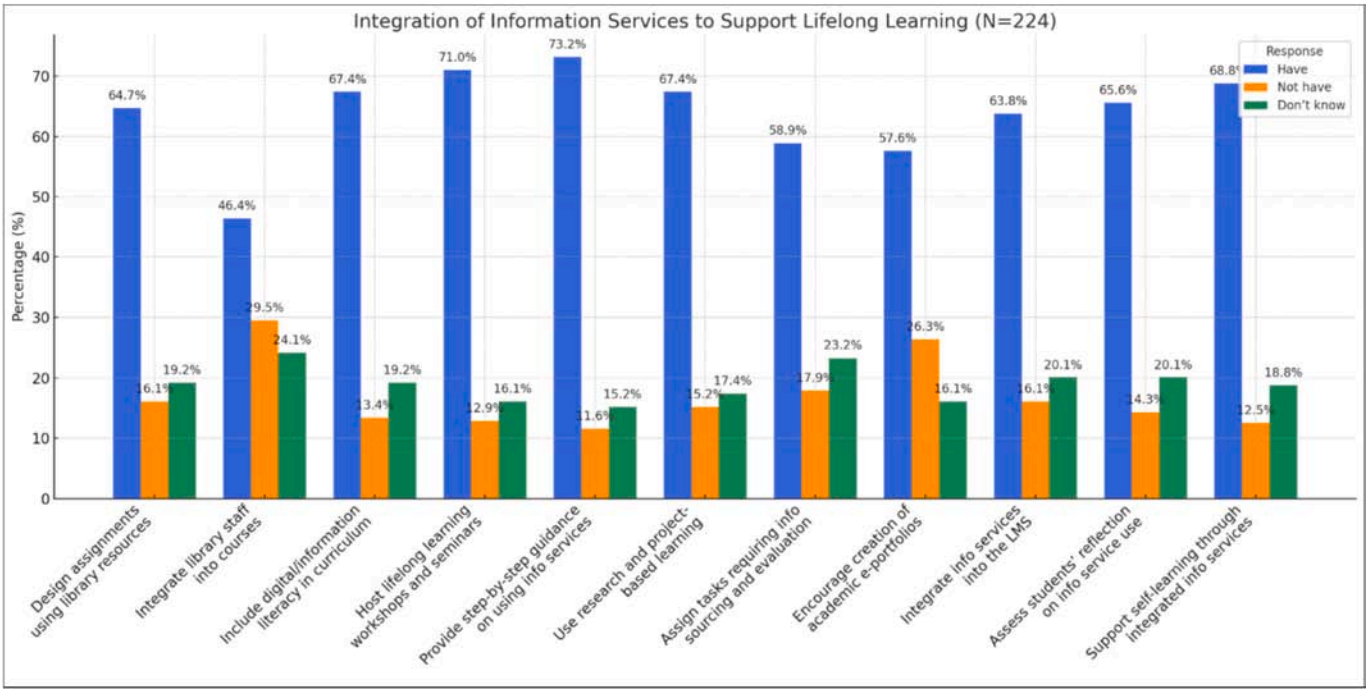

Fig. 1. Strategic integration of digital services to foster lifelong learning skills in universities.

Table 2
Importance of integrating digital services into courses for lifelong learning development.

No.	Item	Descriptive statistics (N = 224)	
		Mean	S.D.
1	Integrate digital services into learning and self-learning strategies to enhance students' lifelong learning skills (i.e., how to use learning platforms, information resources, technologies for learning, etc.)	4.15	0.984
2	Integrate information literacy/digital literacy courses into curriculum	4.05	0.939
3	Integrate digital services directly into the university's learning management system (LMS) to provide easy access to digital libraries, research tools, and databases through the LMS interface	4.04	1.015
4	Offer step-by-step instructions on how to access and use various information services, such as citation management tools, academic search engines, data repositories, academic resources, e-learning services, etc.	4.03	0.838
5	Incorporate research projects, project-based learning and collaborative learning projects into the curriculum that require students to work in teams and utilize information services extensively	3.99	0.918
6	Include assessments that require students to reflect on their use of digital services and how it has enhanced their learning	3.96	0.984
7	Include tasks that involve sourcing and critically evaluating information from various platforms	3.94	0.901
8	Host workshops, programs and seminars that enhance lifelong learning, including literacy classes, resume writing, job searching, interview skills, and career planning, technology training sessions, or subject-specific lectures and seminars, etc.	3.91	0.924
9	Encourage students to develop e-portfolios that showcase their research projects, papers, and other academic work	3.89	1.012
10	Collaborate with faculty members/service staff to design assignments that require the use of library resources and information services	3.84	0.960
11	Integrate library staff into specific courses to provide targeted research assistance and instruction	3.75	1.021

independent learning approaches. Close behind, 'Integrate digital services directly into the university's learning management system' ($\bar{x}$=4.04) and 'Offer step-by-step instructions on how to access and use various digital services' ($\bar{x}$=4.03) also scored highly, suggesting that ease of access and practical guidance for using digital tools are prioritized. Additionally, 'Integrate information literacy/digital literacy courses into the curriculum' ($\bar{x}$=4.05) shows strong endorsement for foundational skills development, crucial for lifelong learning.

On the other hand, while most items reflect positive attitudes toward integration, there is some variation in mean scores. Items such as 'Collaborate with faculty members/service staff to design assignments that require the use of library resources' ($\bar{x}$=3.84) and 'Encourage students to develop e-portfolios' ($\bar{x}$=3.89) received slightly lower mean scores, which may suggest these initiatives are considered important but are less frequently implemented or perhaps viewed as less immediate priorities. 'Integrate library staff into specific courses' ($\bar{x}$=3.75) had a slightly lower score, indicating that this strategy, while recognized, is less commonly practiced or might be more challenging to implement effectively.

Additionally, another suggestion from participants was to integrate digital services directly into the university's learning management system, enabling students to access reliable information sources.

Discussion

The research findings indicate that library services, educational services, and information technology and media services play complementary roles in supporting the development of lifelong learning skills. Library services emphasize access to academic resources, research support, and collaborative learning spaces, creating a foundation for self-directed and community-based learning. Educational services focus on enhancing learning through digital tools, hands-on training, and creative environments that build practical skills and digital literacy. Meanwhile, information technology and media services provide the essential infrastructure, such as connectivity, software, and digital tools that enable flexible, and technology-enhanced learning. While library services center on content and academic support, educational services highlight learning experiences, and IT services ensure accessibility and functionality. These service areas form an integrated ecosystem that empowers learners to continuously acquire and apply knowledge throughout their lives.

These results are consistent with Ormaree and Intanate (2020), who identified self-management, information literacy, critical thinking, goal setting, and motivation as foundational traits that enable university students to thrive as lifelong learners. Meanwhile, Chinabut (2021) and Sungsri (2023) emphasize the responsibility of universities to act as learning hubs, leveraging digital technology and academic resources to promote accessible, lifelong educational opportunities aligned with national development and SDG 4 - Quality Education. In specific disciplines, such as nursing, Navamindradhiraj University's findings highlight how lifelong learning attributes like motivation and computer literacy are crucial for ongoing professional competence (Pongsathonviboon et al., 2018). Further, Laohajaratsang (2019) underscores the integration of next-generation LMS features, including AI analytics, gamified rewards, social interactions, and mobile access to enhance self-regulated and socially-supported lifelong learning in university settings. These insights underscore that cultivating a culture of lifelong learning not only supports academic success but also prepares students for the demands of an evolving, knowledge-based society.

Additionally, Reamee et al. (2025) emphasize that digital library resources require clearly defined organizational policies, high-quality digital content, standardized storage systems, and well-structured service protocols to create learning environments that are scalable, accessible, and efficient - key to supporting lifelong learning. Complementing this, Abeyrathne and Ekanayake (2019) highlight the pivotal role of academic libraries in promoting self-directed learning by providing broad access to information resources and delivering targeted services that enhance students' information literacy. Horsfall et al. (2021) further illustrate how librarians enrich blended learning settings by curating and providing digital media such as podcasts, instructional videos, and multimedia tools that enhance teaching and research. These studies reflect the transformation of academic libraries into strategic partners that promote self-regulation, digital literacy, and the lifelong learning skills necessary for navigating today's dynamic educational landscape.

Another prominent finding underscores a strong commitment by Thai universities to foster students' lifelong learning skills through the integration of digital services. The widespread implementation of strategies, such as academic tool guidance, lifelong learning workshops, and self-directed learning support reflects a proactive approach in aligning educational services with the demands of an evolving knowledge society. The inclusion of information and digital literacy courses, as well as project-based and collaborative learning activities, further emphasizes the holistic efforts to build essential competencies for independent

learning. However, the relatively low adoption of strategies like integrating library staff into specific courses and promoting e-portfolios suggests gaps in the application of potentially impactful practices. Moreover, the high percentage of faculty members who are unaware of the integrative activities of information services for developing lifelong learning skills in various areas points to a communication disconnect between service providers and stakeholders. This lack of awareness can undermine the effectiveness of existing initiatives. To address this, universities should focus on enhancing visibility, fostering interdepartmental collaboration, and promoting user engagement with digital services. Then, they can create more cohesive and accessible support systems that not only develop but also sustain lifelong learning habits among students. Thus, Fallon and Breen (2012) suggested that managers must strive to facilitate access to information services for students, while service staff should assist learners in locating high-quality information resources to support their academic pursuits.

In addition, collaborative efforts between librarians and faculty are pivotal in designing assignments that effectively utilize library resources. For instance, Chan (2017) illustrates how librarian-faculty collaboration in developing e-portfolio exercises can enhance students' research skills and information literacy, although challenges remain in student engagement and technical support. George and Casey (2020) also highlight a case where collaboration between library staff and instructional designers led to increased use of OER in course development, benefiting students economically and academically. Furthermore, Sacchanand (2022) presents a development framework for information, media, and digital literacy tailored to distance learners, underscoring the importance of integrating these literacies to support self-directed learning. However, challenges remain in fully integrating library resources into LMS platforms. These findings suggest that while the value of information services is well recognized, further efforts are needed to promote and support deeper, more collaborative forms of integration.

Conclusion

This study highlights that digital services collectively form a vital, interconnected ecosystem that supports the cultivation of lifelong learning skills among students. Library services provide foundational academic resources and collaborative environments, educational services enhance learning experiences through digital tools and practical training, and IT and media services ensure the accessibility and functionality of these resources for flexible, technology-enhanced learning. Thai universities demonstrate a strong commitment to fostering lifelong learning by integrating digital services into academic programs, offering workshops, and promoting self-directed learning. However, gaps remain in fully leveraging strategies, such as embedding library staff in courses and encouraging e-portfolio use, compounded by a notable communication gap among faculty regarding information service initiatives. To maximize the impact of lifelong learning support, universities should improve awareness, strengthen cross-departmental collaboration, and enhance user engagement with information services. Emphasizing the integration of information literacy and digital literacy into curricula and embedding these services within learning management systems are crucial steps forward.

Although this study provides valuable insights, it also has several limitations. Firstly, it relies mainly on self-reported data from faculty members, which could be influenced by subjective viewpoints or differing levels of awareness about digital services and lifelong learning programs. Secondly, the focus on 16 global and frontier research universities in Thailand may limit the applicability of the results to other educational or cultural settings that have different institutional frameworks or resource capacities. Thirdly, some approaches, such as involving library staff in specific courses or utilizing e-portfolios were not widely adopted or well understood, leading to a scarcity of data on their execution and effects. Furthermore, the research may not have fully captured the variety of digital services and tools employed across all departments, possibly missing some innovative or emerging practices. Finally, the study prevents an examination of long-term impacts or trends in how digital services support the development of lifelong learning skills over time.

Future studies should focus on several important areas to expand upon the findings of this research. To reduce dependence on self-reported data and gain a clearer understanding of faculty experiences, employing mixed-methods and longitudinal approaches would be beneficial for capturing deeper insights and observing how digital services influence lifelong learning. Broadening the sample to include a wider variety of institutions beyond the 16 global and frontier research universities in Thailand, such as those from diverse cultural and educational backgrounds would improve the applicability of the results. Furthermore, more detailed research is needed on less commonly used strategies, like the involvement of library staff in courses and the implementation of e-portfolios, to better grasp their challenges and advantages. Future research should also strive to thoroughly map the digital services and tools utilized across different faculties and departments, paying particular attention to emerging technologies such as artificial intelligence, virtual reality, and mobile learning platforms, in order to identify innovative practices that promote lifelong learning. Additionally, investigating the direct impact of digital information services on student outcomes and lifelong learning skills through experimental or quasi-experimental methods would offer stronger evidence of their effectiveness. Lastly, examining how institutional policies and resource management affect the adoption and success of these digital services could guide more effective strategies to support lifelong learning.

CRediT authorship contribution statement

Lan Thi Nguyen: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Kulthida Tuamsuk:** Writing – original draft, Supervision, Methodology, Data curation, Conceptualization.

Author statement

All authors have read and approved the submitted manuscript. We affirm that no eligible contributors have been excluded and that the author's order has been collectively agreed upon.

Ethics declaration

This research complies with the ethical guidelines set forth by the Khon Kaen University Ethics Committee for Human Research, approval number HE683009.

Declaration of competing interest

Authors declare no competing interest.

Data availability

Data will be made available on request.

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Appendix A

Questionnaire

"Digital services model to enhance university students' lifelong learning skills in the digital age"

A. Information and Instruction

1. Definitions of the terms used:

- *Lifelong learning skills* are defined as the abilities and attributes that allow individuals to continue learning and developing throughout their lives. These skills can be developed through formal education, informal and non-normal learning opportunities. Lifelong learning skills include digital literacy, critical thinking, problem solving, and creative thinking, self-regulation, conscientiousness, mind-sets, and learning motivation, and social and emotional skills, etc.

- *Digital services* refer to a range of services that provide access to information resources and support users in finding, evaluating, and using information effectively to meet their information needs. There are some information services, including library services, information retrieval services, research support services, instructional technology services, information literacy programs, academic advising services, testing and assessment services, etc.

2. Please provide your responses to the following questions based on your personal experiences with lifelong learning skills and information services. Your answers will remain confidential and will only be used for the purposes of this research.

Part 1. Demographic information

- You are a: ☐ Program chairperson ☐ Lecturer
- Educational qualification: ☐ Bachelor's degree ☐ Master's degree ☐ Ph.D. degree
- Academic position: ☐ Professor ☐ Assoc. Prof. ☐ Asst. Prof. ☐ Lecturer
- Working experience: ☐ <=5 years ☐ 6-10 years ☐ 11-15 years ☐ >15 years
- Subject field: ☐ Humanities and Social sciences ☐ Science and Technology ☐ Health sciences ☐ Economics and Business Administration

Part 2. Digital services for developing lifelong learning skills

Please evaluate the importance of digital services by using the following scale:

1 - Very unimportant; 2 - Not important; 3 - Neutral; 4 - Important; 5 - Very important

No.	Types of services	Evaluation				
		1	2	3	4	5
2.1. Library services						
2.1.1	Reference services					
2.1.2	Information exchange services (i.e., conference, workshop, seminar, exhibition, etc.)					
2.1.3	Research support services (i.e., information retrieval service, reference management, inter-library loan, journal publication, full text finder service, etc.)					
2.1.4	Training services (i.e., information literacy, digital literacy, library tour, library use instruction, etc.)					
2.1.5	Library of Things, Library for All					
2.1.6	Digital libraries and repositories, library databases and research tools					
2.1.7	Collaborative spaces: encourage community engagement and shared learning experiences to explore ideas, solve problems, and create new knowledge					
2.1.8	Consulting services (i.e., research, projects, learning, assignment, etc.)					
2.2. Educational services						
2.2.1	E-learning services: provides advice, support and training in technology-enhanced learning for students					
2.2.2	Information monitors: used to display a rotating series of pages to advertise courses, services and news items					
2.2.3	Recording lectures, presentations and events: to record the audio and videos					
2.2.4	Learning skills enhancing services encompass tailored activities focused on teaching and essential graduate qualities, offering training courses in digital media creation, marketing, design, and photography					
2.2.5	Providing dedicated spaces for skill development, such as exhibition areas, training rooms, and presentation corners					
2.2.6	Educational media services for teaching and learning approaches: visual aids proving photography services and video productions					
2.2.7	Audiovisual equipment services: facilitate and control media equipment used in classrooms following the conceptual smart classroom					
2.2.8	Online course production and library development services support online lessons for students in various forms					
2.3. Information technology and media services						
2.3.1	Virtual meetings and events					
2.3.2	Wireless network service					
2.3.3	Computer rooms: provide computers and printing facilities for registered users of university					
2.3.4	File retention and recovery: maintain secure backups of files held on information services' managed systems					
2.3.5	Graphic design and exhibition service in several types of designing tasks to creatively enhance learning and teaching materials (i.e., create cartoons and illustrations for online lessons; design infographics for academic sources, and posters for presentation for each occasion; develop websites through various forms of graphic designs)					
2.3.6	Virtual Reality (VR) and Augmented Reality (AR) tools for education					
2.3.7	Educational software and simulations (i.e., Matlab, R program, Office 365, Email, etc.)					

Part 3. The integration of digital services in curricula and courses

3.1 What activities does your university integrate into in curricula and courses?

No.	Items	Have	Not have	Don't know
3.1.1	Collaborate with faculty members/ service staff to design assignments that require the use of library resources and information services			
3.1.2	Integrate library staff into specific courses to provide targeted research assistance and instruction			
3.1.3	Integrate information literacy/ digital literacy courses into curriculum			
3.1.4	Host workshops, programs and seminars that enhance lifelong learning, including literacy classes, resume writing, job searching, interview skills, and career planning, technology training sessions, or subject-specific lectures and seminars, etc.			
3.1.5	Offer step-by-step instructions on how to access and use various information services, such as citation management tools, academic search engines, data repositories, academic resources, e-learning services, etc.			
3.1.6	Incorporate research projects, project-based learning and collaborative learning projects into the curriculum that require students to work in teams and utilize information services extensively			
3.1.7	Include tasks that involve sourcing and critically evaluating information from various platforms			
3.1.8	Encourage students to develop e-portfolios that showcase their research projects, papers, and other academic work			
3.1.9	Integrate information services directly into the university's learning management system (LMS) to provide easy access to digital libraries, research tools, and databases through the LMS interface			
3.1.10	Include assessments that require students to reflect on their use of information services and how it has enhanced their learning			
3.1.11	Integrate information services into learning and self-learning strategies to enhance students' lifelong learning skills (i.e., how to use learning platforms, information resources, technologies for learning, etc.)			
3.1.12	Other:…….			

3.2 How important is the integration of digital services in curricula and courses for improving lifelong learning skills?

Please use the following Likert scale:

1 - Very unimportant; 2 - Not important; 3 - Neutral; 4 - Important; 5 - Very important

No.	Items	Opinion				
		1	2	3	4	5
3.2.1	Collaborate with faculty members/ service staff to design assignments that require the use of library resources and information services					
3.2.2	Integrate library staff into specific courses to provide targeted research assistance and instruction					
3.2.3	Integrate information literacy/ digital literacy courses into curriculum					
3.2.4	Host workshops, programs and seminars that enhance lifelong learning, including literacy classes, resume writing, job searching, interview skills, and career planning, technology training sessions, or subject-specific lectures and seminars, etc.					
3.2.5	Offer step-by-step instructions on how to access and use various information services, such as citation management tools, academic search engines, data repositories, academic resources, e-learning services, etc.					
3.2.6	Incorporate research projects, project-based learning and collaborative learning projects into the curriculum that require students to work in teams and utilize information services extensively					
3.2.7	Include tasks that involve sourcing and critically evaluating information from various platforms					
3.2.8	Encourage students to develop e-portfolios that showcase their research projects, papers, and other academic work					
3.2.9	Integrate information services directly into the university's learning management system (LMS) to provide easy access to digital libraries, research tools, and databases through the LMS interface					
3.2.10	Include assessments that require students to reflect on their use of information services and how it has enhanced their learning					
3.2.11	Integrate information services into learning and self-learning strategies to enhance students' lifelong learning skills (i.e., how to use learning platforms, information resources, technologies for learning, etc.)					
3.2.12	Other: …….					

Other suggestions for digital services to enhance university students' lifelong learning skills in your university: .....

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Entrepreneurial resilience learning in higher education: The role of metaverse-constructed ecosystems

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ABSTRACT

This study explores how a metaverse-constructed educational ecosystem, designed for higher education entrepreneurship instruction, supports the development of entrepreneurial resilience learning. Data were collected through a two-stage process involving 520 students from 68 instructional teams at Chinese universities. These teams had each piloted a metaverse entrepreneurship teaching platform and formed an ecosystem. The study employs Partial Least Squares Structural Equation Modeling and Necessary Condition Analysis to examine our conceptual model. The results reveal that metaverse-based entrepreneurial ecosystems cultivate entrepreneurial resilience through an instructional mechanism. Interactive engagement, contextualized knowledge integration, and mutual trust function as interdependent conditions that collectively shape an entrepreneurial knowledge field. This field enables students to apply knowledge in uncertain environments, reflect on challenges, and adapt constructively to failure and ambiguity. In addition, trust emerges as a central dynamic that fosters collaborative learning and psychological safety. The findings provide theoretical support for how metaverse-constructed ecosystems foster entrepreneurial resilience through structured engagement, knowledge contextualization, and trust-based collaboration. The study offers a transferable framework for designing mechanism-oriented entrepreneurship education tailored to the needs of higher education and lifelong learners.

1. Introduction

Entrepreneurship education is a core area within management education, playing a vital role in promoting economic growth, supporting innovation, and generating employment opportunities (Brant & Kilar, 2025). In fulfilling their social responsibility, many universities have established entrepreneurship programs to guide students in acquiring entrepreneurial competencies and ultimately cultivating successful entrepreneurs.

However, successful entrepreneurship depends not only on accumulating knowledge and skills but also on demonstrating entrepreneurial resilience in the face of risk and environmental uncertainty. Entrepreneurial resilience refers to the capability to maintain initiative, adjust strategies, and remain engaged when encountering challenges in the entrepreneurial process (Bhoyar et al., 2025; Ediagbonya et al., 2024; Jardas Antonić et al., 2024). In practice, however, educators often face a fundamental challenge in designing learning environments that effectively support the development of such resilience. Most existing entrepreneurship courses continue to focus on delivering entrepreneurial knowledge and technical skills, while pedagogical strategies and instructional support aimed explicitly at resilience development remain insufficient.

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More specifically, the cultivation of resilience depends on experiences with failure and pressure, as well as cross-boundary interactions. In response to such pedagogical needs, recent entrepreneurship education has seen the introduction of more interactive and practice-oriented approaches, including value-creation pedagogy (Lackéus, 2020) and challenge-based learning (Leijon et al., 2022; Van den Beemt et al., 2023). Despite these innovations, students are seldom exposed to the challenge of entrepreneurial failure or the psychological tension associated with risk-based decision making. As a result, the development of entrepreneurial resilience remains constrained. Therefore, creating a learning environment that effectively supports the development of entrepreneurial resilience remains a critical challenge in entrepreneurship education reform (Katsanakis, 2025; Lupini, 2024).

Therefore, the emergence of the metaverse presents a transformative opportunity for entrepreneurship education. Beyond enabling real-time interaction among students, educators, and industry professionals (Dwivedi et al., 2022), metaverse-based ecosystems, enabled by platform technologies, also allow the design of structured simulation tasks that immerse students in decision-making scenarios under uncertainty. These environments enable students not only to exchange knowledge and receive immediate feedback but also to experience the pressure of entrepreneurial choices, confront failure, and iterate solutions in a risk-free setting. Through these interactive and immersive dynamics, a shared educational context gradually takes shape, forming an interconnected ecosystem that supports knowledge co-creation and adaptive learning. Such conditions help bridge the gap between theoretical learning and real-world complexity, thereby enhancing students' entrepreneurial resilience learning (ER) (Haibin & Yunus, 2024; Nanda & Patnaik, 2023).

Although studies such as Dwivedi et al. (2022) have recognized the potential of the metaverse to support ER, few have examined why such outcomes occur. Existing research rarely explores the learning processes or structural conditions that enable students to develop resilience in virtual settings. In particular, how metaverse technologies are organized into educational ecosystems that facilitate such learning remains underexplored.

To address this gap, this study argues that the capacity of metaverse-based ecosystems to foster entrepreneurial resilience (ER) lies in their ability to generate an entrepreneurial knowledge field (EK). This field does not emerge in isolation but is rooted in three key features of the metaverse environment. First, real-time interaction and cross-boundary collaboration foster interactive engagement (IE), enabling students to encounter diverse perspectives that challenge and expand their thinking (Rahman et al., 2024). Second, immersive contexts allow students to apply and integrate knowledge within entrepreneurial scenarios that simulate real-world uncertainty and pressure, generating contextual knowledge integration (CK) that builds adaptive capacity (Kaigom, 2024). Third, as the platform continues to operate and participants engage in repeated collaboration, immersive trust dynamics (TD) gradually emerge, enhancing cooperation and deepening the application of knowledge. Evidence from Harvard and UC Berkeley shows that the accumulation of trust significantly improves collaborative effectiveness and applied learning in virtual settings (Lin, 2024; Sghaier et al., 2022). Taken together, the joint operation of IE and CK, facilitated by TD, constitutes an instructional mechanism that drives the development of EK, which in turn supports the cultivation of ER.

Building on this framing, Knowledge-Based View (KBV) and Resource-Based View (RBV) provide theoretical perspectives to explain how IE and CK foster the development of EK and why EK serves as a foundation for ER. From a KBV perspective, IE and CK broaden the acquisition, combination, and application of knowledge, helping students transform theoretical knowledge and lived experiences into situated understanding, thereby contributing to the development of EK and supporting adaptation under pressure (ER) (Feng et al., 2021). From an RBV perspective, IE and CK mobilize and coordinate internal and social resources, consolidating them within EK in ways that sustain capability development and provide a basis for persistent adaptive responses characteristic of ER. As for TD, it functions as a mediating condition that enhances the effectiveness of these processes by reducing risk perception and fostering trust.

While this study proposes that entrepreneurial resilience may be fostered through a specific instructional mechanism within metaverse-based ecosystems, it remains to be empirically validated whether the mechanism truly functions as expected. Based on this concern, the purpose of this study is to examine how the metaverse-constructed ecosystem can help students to learn entrepreneurial resilience. Based on the research purpose, the study investigates the following research questions:

1. How do interactive engagement and contextual knowledge integration contribute to the formation of an integrated entrepreneurial knowledge field within the metaverse ecosystem?
2. What role do immersive trust dynamics play in mediating the relationship between these elements and the creation of the entrepreneurial knowledge field?
3. Why does the integrated entrepreneurial knowledge field created within the metaverse ecosystem enhance entrepreneurial resilience learning?

This study will generate meaningful contributions at both theoretical and practical levels. Theoretically, it seeks to deepen the understanding of how metaverse-based learning environments can support entrepreneurial resilience by clarifying the underlying instructional mechanism that shapes knowledge construction, social engagement, and adaptive capability. In particular, the study offers a mechanism-based explanation for how metaverse ecosystems function, contributing to both instructional technology theory and design science by proposing a transferable framework that links platform dynamics with resilience outcomes. Practically, the study provides actionable guidance for educators, researchers, and system designers to create immersive learning ecosystems that transcend technological novelty and serve as effective pedagogical spaces for cultivating entrepreneurial capability in uncertain environments.

2. Metaverse ecosystem and entrepreneurial resilience learning

2.1. Functional perspective on the metaverse-constructed ecosystem in entrepreneurship education and learning resilience

The metaverse-constructed ecosystem has garnered increasing attention for its transformative potential in entrepreneurship education (Abaddi, 2024). Existing studies predominantly focus on the Metaverse's functional affordances and how these features contribute to enhanced learning outcomes, particularly the development of entrepreneurial resilience learning (Ronaghi & Forouharfar, 2024). From a functional perspective, the metaverse offers unique capabilities that traditional educational settings lack, providing immersive, interactive, and resource-rich environments that facilitate deeper engagement and applied learning.

One of the most widely recognized functional affordances is the immersive nature of the metaverse. Immersion allows learners to experience simulated entrepreneurial scenarios that closely replicate real-world complexities (Badiru & Aladelusi, 2023). This functional feature provides a heightened sense of presence, leading to increased cognitive engagement and emotional involvement. In entrepreneurship education, such immersive environments enable students to experiment with business strategies, confront challenges, and experience the consequences of their decisions in a risk-free context. In these settings, students are repeatedly exposed to failure and risk-taking without facing irreversible consequences. Such controlled experiences encourage reflection, adaptation, and persistence, which are central to entrepreneurial resilience learning (Virk & Gambhir, 2024).

Another key functional attribute is the scalability and accessibility of metaverse-enabled ecosystems. Unlike traditional classrooms, which are often constrained by physical and geographical limitations, the metaverse allows for widespread participation and inclusivity (Abaddi, 2024). Students can collaborate with educators, peers, industry experts, and mentors from around the world, broadening their exposure to diverse entrepreneurial perspectives. This accessibility enhances the richness of learning experiences, offering real-world insights and facilitating the development of critical entrepreneurial skills (Meepung, 2025).

Real-time collaboration and communication tools also play a pivotal role in the functional design of metaverse ecosystems (Monrattanachai et al., 2025). Features such as virtual meeting spaces, shared digital workspaces, and synchronous communication channels enable students to engage in dynamic, interactive learning activities. These collaborative opportunities mirror the complex, team-based nature of real-world entrepreneurial ventures, helping students develop essential skills such as negotiation, teamwork, and strategic decision-making. The presence of uncertainty in collaborative decision-making further reinforces resilience, as students must cope with setbacks and adjust their strategies in order to progress.

Metaverse platforms further distinguish themselves through the provision of resource-rich learning environments (Nanda & Patnaik, 2023). Virtual spaces often integrate various tools, including market simulations, data analytics, and scenario-based exercises, that support experiential learning. Students can test business models, analyze market trends, and simulate entrepreneurial decisions, bridging the gap between theoretical knowledge and practical application. When such experiments result in failure, students are encouraged to re-examine assumptions and attempt alternative solutions, reinforcing their ability to recover from mistakes.

Gamification elements embedded within metaverse ecosystems have also been recognized as functional features that enhance learner motivation and engagement. Components such as points, rewards, leaderboards, and challenges introduce competitive dynamics that encourage sustained participation. These gamified challenges often involve risks of losing progress or falling behind, which, although occurring in a low-stakes environment, push students to confront setbacks directly. By working through these failures, learners gradually strengthen the persistence and adaptability that define entrepreneurial resilience (Das et al., 2024).

Although recent studies have described the functional affordances within metaverse-constructed ecosystems, such as immersion, scalability, and collaboration, most of this literature focuses on surface-level outcomes such as increased engagement or motivation. For example, Guerra-Tamez (2023) examined how immersive virtual reality experiences influence learning in art and design education, emphasizing the mediating role of flow experience; however, the study did not address how such immersive engagement leads to sustained learning resilience or adaptive learning behavior. Similarly, in a recent systematic review, Haibin and Yunus (2024) concluded that although metaverse technologies are increasingly applied in entrepreneurship education, most research remains centered on technological implementations rather than on the cognitive or behavioral processes that link these features to long-term educational outcomes. These functional affordances are not ends in themselves; rather, they constitute the technological basis through which a metaverse-constructed ecosystem supports entrepreneurial resilience learning. This gap highlights the need to move beyond functional affordances alone and to investigate the instructional mechanisms through which metaverse environments transform these features into entrepreneurial resilience learning.

2.2. Research gaps and the need for mechanism-based studies

As above, despite the growing body of literature on the functional affordances of metaverse-constructed ecosystems in entrepreneurship education, a significant gap remains in understanding how these ecosystems actually enable the development of entrepreneurial resilience learning (Halberstadt et al., 2021). While existing studies often highlight the positive effects of features such as immersion, interactivity, and collaboration, they tend to focus on surface-level outcomes without exploring the underlying mechanisms that sustain these benefits (Morfaki & Morfaki, 2025). It is well-documented that immersive environments can boost engagement and that real-time collaboration fosters social learning, but few studies have investigated how these features specifically contribute to entrepreneurial resilience learning, a critical outcome in preparing students to adapt, innovate, and thrive in complex entrepreneurial environments (Morfaki & Morfaki, 2025; Pereira et al., 2024).

Without a clear understanding of the mechanism, it is challenging to establish comprehensive theoretical explanations of how learners, educators, and stakeholders interact within metaverse-constructed ecosystems to generate resilience (Haibin & Yunus, 2024).

Moreover, the lack of mechanism-based studies restricts the formation of effective management frameworks that could optimize metaverse-based educational practices.

This absence of mechanism-focused inquiry also creates practical challenges, since educators and system designers lack actionable guidance on how to structure and manage metaverse ecosystems to strengthen entrepreneurial resilience learning. While some studies note that controlled opportunities for failure and risk-taking may encourage reflection, adaptation, and persistence, these insights remain fragmented and speculative when disconnected from a broader mechanism-based explanation. In particular, few works have examined how interactive engagement (IE), contextual knowledge integration (CK), and trust dynamics (TD) operate together as an instructional mechanism that gives rise to an entrepreneurial knowledge field (EK), which in turn supports entrepreneurial resilience (ER).

This study directly addresses these gaps by clarifying how metaverse ecosystems foster resilience not simply through functional features in isolation, but through the combined operation of IE, CK, and TD as an instructional mechanism. By situating these dynamics within a structured framework, the study responds to the lack of mechanism-level explanations in existing research and provides a foundation for designing and managing metaverse-based ecosystems that more effectively support entrepreneurial resilience learning.

3. Conceptual model and hypotheses

3.1. Conceptual model

Cultivating students' entrepreneurial resilience has long been recognized as a critical outcome of entrepreneurship education. A high-quality entrepreneurial learning process should ultimately strengthen students' entrepreneurial resilience learning (ER). In this study, ER is defined as the capacity of students to adapt, recover, and persist when confronted with complex and uncertain entrepreneurial situations. It highlights both cognitive flexibility and behavioral strategies that enable learners to revise assumptions, adjust plans, and continue their engagement despite setbacks (Othman & Ab Wahid, 2014). Building on this perspective, the purpose of this study is to clarify how a metaverse-constructed ecosystem supports the development of entrepreneurial resilience (ER). As outlined in the introduction, the metaverse environment enables interactive engagement (IE) and contextual knowledge integration (CK). When these elements are reinforced by immersive trust dynamics (TD), they jointly give rise to an entrepreneurial knowledge field (EK). The emergence of EK then provides the foundation for ER. In this way, resilience in entrepreneurial learning is not promoted by isolated functional features but by the instructional mechanism formed through the interaction of IE, CK, and TD. Based on this framework, the conceptual model presented in Fig. 1 serves as the basis for developing the research hypotheses.

3.2. Relationship between interactive engagement and the entrepreneurial knowledge field

Interactive engagement (IE) in the context of the metaverse refers to the real-time, immersive interactions between students, educators, and external experts within a virtual learning environment (Wang et al., 2024). This engagement transcends passive learning by fostering active collaboration, knowledge sharing, and problem-solving in entrepreneurial scenarios (Suhail et al., 2024). Through this engagement, students gain a deeper understanding of entrepreneurship, bridging theoretical concepts with practical challenges in a dynamic and immersive virtual space (Chamola et al., 2025).

The entrepreneurial knowledge field (EK) refers to the integrated body of knowledge that emerges from continuous interactions and collaborations within the metaverse ecosystem (Belitski & Heron, 2017). It combines both theoretical knowledge and practical insights shared by mentors, industry professionals, and peers. This knowledge field thrives on sustained interactions within the learning ecosystem, where new ideas are generated, refined, and contextualized for real-world applications. As students engage with these diverse sources of knowledge, they create a more comprehensive and actionable understanding of entrepreneurship.

It can be inferred that the metaverse ecosystem plays a crucial role in promoting IE and thereby contributing to the development of the EK. The metaverse facilitates seamless connections between students and external resources such as industry experts, mentors, and real-time feedback mechanisms (Hewidy et al., 2024). Through such continuous interaction, students are no longer passive recipients

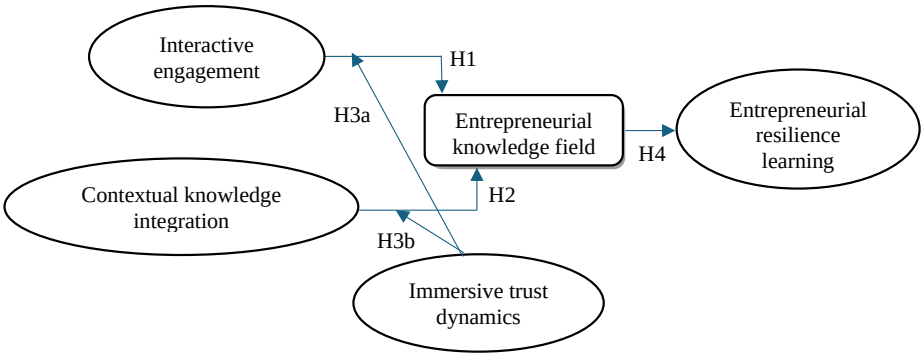

Fig. 1. Conceptual model.

of information but become active participants in meaning-making. These interactive conditions reproduce ambiguity, incomplete information, and emotional pressure commonly encountered in entrepreneurial practice, all of which are essential triggers for resilience development in learning contexts. According to Polat (2024), experiencing such conditions within safe yet challenging virtual environments supports the cultivation of adaptive coping strategies and iterative reflection, which are core components of entrepreneurial resilience learning. Under these circumstances, knowledge is not merely acquired but is tested, questioned, and reconstructed.

Existing studies further emphasize that meaningful knowledge construction in immersive environments requires more than exposure to content; it depends on learners' ability to engage in iterative interpretation, often prompted by disagreement, contradiction, or feedback within the learning process (Hajji, 2024; Polat, 2024). Through interactive engagement, students move from abstract understanding toward situated judgment. They encounter divergent perspectives, reflect on trade-offs, and reinterpret entrepreneurial principles within specific virtual contexts. These processes, particularly when embedded in task-based simulations or collaborative problem-solving under uncertainty, promote the development of resilient knowledge structures (Hajji, 2024). From the perspective of the KBV, this dynamic integration of external knowledge is essential for fostering innovation and adaptability (Feng et al., 2021), both of which are core dimensions of entrepreneurial resilience. Similarly, the RBV underscores that sustained access to valuable but non-imitable resources, such as expert mentorship and iterative feedback, can strengthen students' ability to recover from setbacks and adjust their learning strategies (Bobe & Kober, 2015). By ensuring continuous access to such resources and embedding them within socially grounded practices, the metaverse ecosystem advances the formation of EK as an integrated knowledge field. Therefore, it can be hypothesized that:

H1. Interactive engagement within the metaverse ecosystem positively contributes to the development of an integrated entrepreneurial knowledge field.

3.3. Relationship between contextual knowledge integration and the entrepreneurial knowledge field

Contextual knowledge integration (CK) refers to the process by which knowledge is not only shared but also applied and adapted within specific entrepreneurial contexts (Pillay & Barnard, 2019). It involves synthesizing external knowledge with existing mental frameworks to generate actionable insights. Unlike general knowledge sharing, CK stresses the practical application of knowledge in real environments (Pillay & Barnard, 2019). This dynamic process enables learners to adjust theoretical concepts to real-world challenges. In metaverse learning environments, CK appears in entrepreneurial simulations, mentorship sessions, and group problem-solving tasks (Daniela, 2020). Students apply theoretical frameworks and practical advice from peers and experts to tackle entrepreneurial problems in real time within a simulated space (Daniela, 2020).

CK plays a central role in the formation of the entrepreneurial knowledge field (EK). The metaverse ecosystem provides immersive, practice-oriented environments that enable students to integrate insights from mentors, peers, and industry professionals, thereby enhancing learning and improving decision-making in entrepreneurial contexts (Daniela, 2020). In these interactive processes, students are not merely recipients of knowledge but active participants who connect theoretical frameworks with practical experiences and apply them in simulated real-world settings. When students encounter uncertainty and pressure, this dynamic integration of knowledge becomes especially important, as it compels them to transform abstract theories into context-specific solutions. Recent empirical studies further support this point, showing that contextual learning through metaverse tools enhances opportunity recognition and entrepreneurial performance (Weking et al., 2023), while knowledge spillover theory suggests that incorporating underutilized university knowledge into entrepreneurial contexts generates practical innovation (Audretsch et al., 2025).

From a theoretical standpoint, the KBV argues that the integration of diverse knowledge sources is essential for fostering innovation and adaptability (Feng et al., 2021), both of which are also recognized as core dimensions of entrepreneurial resilience. metaverse platforms support CK by enabling students to combine explicit theoretical knowledge with tacit insights from mentors and peers, which strengthens the integrative and adaptive qualities of EK (Haibin & Yunus, 2024). Similarly, the RBV emphasizes that sustained access to valuable yet inimitable external resources, such as expert guidance and iterative feedback, enhances students' ability to recover from setbacks and adjust their strategies (Bobe & Kober, 2015). The metaverse ecosystem provides such continuous access and embeds these resources in socially interactive ways, thereby facilitating the development of EK through contextualized practice (An et al., 2024). Accordingly, CK not only promotes the practical application and integration of knowledge but, supported by KBV and RBV, also emerges as a key pathway for cultivating entrepreneurial resilience learning. Therefore, it can be hypothesized that:

H2. Contextual knowledge integration within the metaverse ecosystem positively contributes to the development of an integrated entrepreneurial knowledge field.

3.4. The mediating effect of the immersive trust dynamics

Immersive trust dynamics (TD) refer to a form of trust cultivated in immersive digital environments such as the metaverse. In these settings, trust is built through shared virtual experiences, real-time interaction, and active participation (Razalli et al., 2024). Unlike traditional trust rooted in face-to-face familiarity, TD evolves through continuous engagement among students, educators, mentors, and external experts. As participants collaborate in virtual simulations and mentorship sessions, trust gradually emerges through clear communication and aligned goals (Abaddi, 2024).

The immersive and transparent nature of metaverse-enabled ecosystems creates favorable conditions for the development of TD. Real-time interaction enables participants to connect on a more personal level, contributing to a sense of psychological safety. This

environment encourages students to openly express ideas and engage in exploratory learning, both of which are essential for meaningful knowledge exchange and innovation (Polychronaki et al., 2024).

TD is proposed to mediate the relationship between interactive engagement and the development of an entrepreneurial knowledge field (EK). When trust is present, students are more willing to contribute original ideas, challenge assumptions, and engage deeply with peers. These behaviors promote a dynamic learning atmosphere where collective knowledge is continuously generated and refined (Badiru & Aladelusi, 2023; Haibin & Yunus, 2024).

Furthermore, TD may also mediate the relationship between contextual knowledge integration (CK) and EK. When trust is established within the metaverse environment, participants are more likely to reveal their knowledge limitations and welcome external perspectives. This openness increases the diversity and richness of knowledge exchange (Boison & Burke, 2025), thereby enhancing the cognitive conditions for knowledge absorption, transformation, and application (Cabrera & Cabrera, 2005). In entrepreneurial education, psychological safety helps reduce defensiveness and facilitates deeper engagement with mentors or industry advisors. This enables students to incorporate heterogeneous knowledge into their entrepreneurial thinking and adapt it to specific problems (Hariani et al., 2021). In this way, TD supports not only the frequency of interaction but also the cognitive depth of knowledge integration.

Based on the above, immersive trust dynamics contribute not only to the depth of knowledge integration but also to the emotional stability and openness required for resilience learning. Trust enables students to face criticism constructively, navigate uncertainty with support, and develop the psychological flexibility necessary for entrepreneurial resilience in complex environments. Based on this reasoning, the following hypotheses are proposed:

H3a. Immersive trust dynamics mediate the relationship between interactive engagement and the development of an entrepreneurial knowledge field in the metaverse ecosystem.

H3b. Immersive trust dynamics mediate the relationship between contextual knowledge integration and the development of an entrepreneurial knowledge field in the metaverse ecosystem.

3.5. Relationship between the entrepreneurial knowledge field and entrepreneurial resilience learning

Building on the definition of entrepreneurial resilience learning (ER) introduced in Section 3.1, ER is further understood here as an outcome shaped by the structure and quality of the learning environment. Within the metaverse ecosystem, ER emerges not as an individual trait alone but as a learnable capability that develops through interactive processes, contextualized knowledge application, and trust-based collaboration. This perspective emphasizes that resilience is constructed in relation to the entrepreneurial knowledge field (EK), which provides students with repeated opportunities to adapt, recover, and persist under complex and uncertain conditions.

In this study, the EK is understood as the outcome of interactive engagement (H1), contextual knowledge integration (H2), and immersive trust dynamics (H3a, H3b) within the metaverse ecosystem. EK does not represent a fixed body of content but rather a dynamic and iterative construct shaped through simulations, feedback, expert input, and peer dialogue, which collectively form the foundation for resilience development.

EK emerges in challenge-based and task-oriented virtual environments. Students are frequently required to make decisions under pressure, revise business proposals in response to critical feedback, and navigate uncertainty. These experiences demand more than theoretical knowledge; they require judgment, iterative experimentation, and strategic flexibility. In this process, students are compelled to revisit assumptions and learn from failure, gradually constructing a dynamic and evolving knowledge field. From the perspective of the KBV, the ability to continually restructure knowledge through simulations and feedback provides the foundation for absorptive capacity, innovation, and adaptability (Feng et al., 2021), which are also recognized as core dimensions of entrepreneurial resilience. Correspondingly, the RBV regards EK as a valuable and non-imitable resource. When students leverage embedded knowledge from mentors, peers, and simulations, they gain an advantage that strengthens their ability to adapt to the volatility of entrepreneurial environments (Bobe & Kober, 2015; Nanda & Patnaik, 2023; Zhou et al., 2024).

Recent empirical studies support this view. Baah and Rambe (2024) found that students who engaged in multiple cycles of revision within simulation-based learning demonstrated stronger resilience and strategic adaptability. Similarly, Dzandu et al. (2025) argued that knowledge fields constructed under pressure and uncertainty foster deeper learning and greater flexibility in problem-solving. Based on this rationale, the following hypothesis is proposed:

H4. The development of an integrated entrepreneurial knowledge field within the metaverse ecosystem positively contributes to entrepreneurial resilience learning.

4. Empirical context, materials, and methods

To ensure that the analytical results of this study rest on a solid practical foundation, it was essential first to verify that the respondents had genuinely participated in relevant instructional experiments, rather than answering based on abstract or hypothetical assumptions. Accordingly, we began by distributing a preliminary questionnaire (outlined in Section 4.2) to identify university instructors in China who had expressed interest in metaverse-based entrepreneurship education. Through subsequent contact, we selected those who were willing to share their experiences with platform development and implementation. The details of these platforms and their instructional applications are presented in Section 4.1. Building on this foundation, we then designed a second-stage quantitative survey and collected data from these instructors and their teams to examine the proposed conceptual model.

Section 4.2 describes the design and administration of this questionnaire. Section 4.3 details the measurement procedures used to validate the constructs. Finally, Section 4.4 outlines the analytical strategies employed to test the model.

4.1. Empirical and observational context

This study examines ecosystems formed by metaverse-based entrepreneurship learning platforms independently developed by faculty teams at various Chinese universities. These platforms served as real-world experimental environments, offering conditions that facilitated close observation and empirical research. To locate these platforms, we first conducted a preliminary survey with 226 instructors involved in metaverse-based entrepreneurship education. We then invited them to participate in further interviews and documentation. A total of 68 instructors agreed, each representing a team that had developed and piloted a metaverse teaching platform. Through these interviews, we gathered insights into the platforms' operation and implementation, and synthesized their common features to reflect typical technological architectures and instructional design logic.

Although most platforms remained at the experimental stage and were not yet formally integrated into university curricula, their structure and recorded learning activities provided a sufficient foundation for systematic observation and analysis. The following sections present the integrated model, outlining its core technologies, functional modules, and how these systems support teaching and learning throughout the entrepreneurial process.

4.1.1. Platform architecture and functional modules

Metaverse systems can be classified by technical configurations and interaction modes into virtual, augmented, hybrid, and blockchain-based metaverses (Taçgin, 2022). This indicates that the virtual metaverse is not the only form (Ritterbusch & Teichmann, 2023). The platforms observed in this study largely reflected the characteristics of hybrid metaverse systems, combining immersive 3D simulation modules, web-based collaborative tools, AI integration, and blockchain storage technologies to build a blended learning environment for entrepreneurship education.

These platforms were not based on commercial systems, but were independently developed by university teaching teams through modular integration. Their core structures typically consisted of interconnected components serving both instructional and technological purposes. Based on our synthesis of 68 platforms, we identified seven major modules that support learning activities and system operations. Each module was developed using specific digital technologies and played a distinct role in guiding students through the entrepreneurial learning process.

1. **Student Login and Team Formation Module**: This module provides the foundational infrastructure for user registration, group formation, and task assignment. It operates in a 2D digital environment through a web interface, typically built with user authentication systems, relational databases, and customized dashboards. It plays a crucial role in onboarding students, familiarizing them with the platform, and organizing collaborative teams.
2. **Simulation Tasks and Scenario Module**: This module provides interactive startup simulations that allow students to experience early entrepreneurial decisions such as product design, market testing, and resource planning. It mainly operates in a 3D virtual environment, with content typically developed using game engines like Unity or Unreal Engine. While some features are still under development, this module serves as the core immersive element of the hybrid metaverse, allowing students to learn through virtual experience and reflection.
3. **AI-Assisted Module**: This module allows students to access real-time support based on their simulation experiences. Operating in a 2D environment, the system commonly adopts large language models such as ChatGPT or DeepSeek. Rather than replacing teacher feedback, the AI functions as a low-stakes thinking companion, supporting students' reflection and writing processes.
4. **Collaborative Editing and Discussion Module**: This module facilitates feedback exchange and communication among students, instructors, and internal or external mentors. It operates in a hybrid 2D/3D environment that includes shared documents, real-time messaging tools, and optional virtual spaces using avatars or immersive settings. Technically, it integrates online editing tools, communication platforms, and sometimes simulation-engine-based 2D/3D environments.
5. **External Consultation Module**: This module supports interactions between student teams and external stakeholders such as alumni mentors or industry advisors. It also functions in a hybrid format, via the collaborative module or within 3D virtual consultation spaces. Technical features include advisor portals and proposal viewing systems, with some platforms implementing immersive meeting rooms using simulation engines or digital twin technology. The hybrid design allows mentors to choose between formal online meetings and more contextualized consultation formats.
6. **Blockchain Storage Module**: This module operates in a 2D environment as a backend function rather than a user-facing interface. Most platforms adopt permissioned blockchain systems such as AntChain or Hyperchain to store timestamped versions of student proposals and key deliverables. These records serve as verifiable evidence of student progress and intellectual contribution, especially during assessment or external review.
7. **Investor Interface and Proposal Evaluation Module**: This module provides alumni investors or evaluators with dedicated access to student proposals and enables them to offer feedback. Operating in a 2D environment, it typically takes the form of web-based dashboards or investor portals. Some platforms include basic AI scoring tools to provide preliminary assessments of consistency, market logic, and language quality.

4.1.2. Instructional process and the formation of an ecosystem

The instructional process observed across the 68 platforms followed a six-stage sequence that was consistently supported by the

seven functional modules. Rather than treating the modules and stages as separate elements, the platforms embedded each module within the instructional flow, thereby forming an integrated ecosystem of teaching and learning.

Stage 1, student registration and team formation, was supported by the login and grouping module, which provided the basic infrastructure for onboarding and collaboration. Stage 2, engagement with simulation tasks, drew on the scenario simulation module, often complemented by AI-assisted reflection that helped students cope with uncertainty and time-constrained decision-making. Stage 3, team reflection and instructor feedback, relied on the collaborative editing module in combination with AI tools, which facilitated both peer exchange and structured feedback from instructors. Stage 4, external consultation and revision, was implemented through the consultation module, enabling interactions with alumni mentors who added practice-based insights. Stage 5, proposal refinement, combined AI assistance with blockchain storage, ensuring clarity in presentation and verifiable records of iterative development. Finally, Stage 6, final presentation and investor feedback, was conducted through the investor interface module, allowing alumni investors to review and evaluate proposals within a dedicated platform environment.

This alignment shows that the technological modules and the pedagogical stages jointly created a coherent learning pathway. Students were not simply completing isolated tasks, but were immersed in a structured process that mirrored the theoretical model of entrepreneurial resilience learning, where iterative engagement, contextual feedback, and trust-based consultation progressively shaped their capabilities.

Although these platforms were primarily implemented as small-scale pilots outside formal curricula, their modular and replicable design makes them well suited for integration into entrepreneurship education programs. Instructors noted that embedding the platforms within formal courses would allow broader participation beyond the small group of highly motivated students who currently opt in, thereby extending the benefits of iterative practice, external critique, and resilience-building to larger cohorts of learners.

4.1.3. Triadic instructional support and the formation of an integrated ecosystem

To support students in acquiring entrepreneurial knowledge and developing resilience, the metaverse-based learning ecosystem,

Table 1
Questionnaire content, variables for each construct, and their source.

Construct	Variables	Source
Interactive Engagement (IE)	IE1. In the metaverse teaching environment, I often engage in real-time discussions and collaboration with instructors. IE2. I participate in metaverse entrepreneurship learning activities that enable me to interact with external experts and receive immediate feedback. IE3. I actively participate in entrepreneurial simulations in the metaverse that encourage knowledge sharing and collaborative problem-solving. IE4. Through the metaverse, I can interact effectively with experts and peers in real time, which enhances my learning.	Wasim et al. (2024); Knox (2022)
Contextual Knowledge Integration (CK)	CK1.In the metaverse teaching process, I can integrate external expert advice with my entrepreneurial knowledge and apply it in real-world situations. CK2. Through metaverse-based learning, I participate in simulations that combine various entrepreneurial knowledge resources for me to apply and reflect on. CK3. In the metaverse, I effectively integrate insights from peers and external experts into my entrepreneurial learning process. CK4. In the metaverse, I frequently integrate knowledge from peers and experts with my own experience and apply it to real-world entrepreneurial contexts.	Secundo et al. (2017); Younis (2024)
Entrepreneurial Knowledge Field (EK)	EK1. In the metaverse, I have access to diverse entrepreneurial knowledge from industry experts and other scholars, which I incorporate into my entrepreneurial learning. EK2. Through metaverse-based instructional activities, I continually expand my entrepreneurial knowledge and diversify the ways I apply it in learning tasks. EK3. In the metaverse, the entrepreneurial knowledge I gain is continuously integrated into my learning, enriching my knowledge base. EK4. Through interactions within the metaverse ecosystem, I enhance my entrepreneurial knowledge by integrating academic theories with practical insights from the field.	Tresierra et al. (2021)
Immersive Trust Dynamics (TD)	TD1. In the metaverse entrepreneurial learning environment, I am able to build genuine trust relationships with my peers, which fosters knowledge sharing. TD2. The metaverse's immersive environment allows me to establish open and transparent communication with my peers, fostering trust. TD3. Through collaborative entrepreneurial challenges in the metaverse, I develop trust with my peers, which enhances cooperation and knowledge exchange. TD4. Through metaverse-based entrepreneurial activities, I experience trust-building with peers, which I believe is essential for supporting effective learning and fostering innovation.	Jones-Esan (2023); Green et al. (2014)
Entrepreneurial Resilience Learning (ER)	ER1. Through metaverse entrepreneurship education, I am able to adapt and address challenges in the entrepreneurial process quickly. ER2. Through metaverse-based instruction, I am able to respond to entrepreneurial uncertainties and develop innovative thinking. ER3. Through metaverse learning experiences, I strengthen my psychological resilience, helping me recover from setbacks and continue progressing in entrepreneurial settings. ER4. Through real-time feedback and entrepreneurial simulations in the metaverse, I become more adaptable to market changes and strengthen my learning resilience.	Migliano and Rao (2023); Lin (2023)

Note. All items were measured on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree).

enabled by modular platforms, fosters interaction among three types of guidance: instructors, AI tools, and alumni mentors. These roles are not intended to replace one another. Instead, each contributes uniquely to the learning process and provides complementary forms of support.

Instructors are responsible for designing the overall learning sequence. They determine the order of tasks, set the pace of progress, and clarify the learning goals at each stage. More than content providers, instructors serve as guides who help students break down complex problems, adjust underlying assumptions, and express their ideas with greater clarity.

AI tools are used more flexibly and informally. Students often turn to AI as a first point of consultation, especially when they feel uncertain about phrasing, logic, or organization. Rather than replacing human feedback, the AI offers a low-pressure and accessible way for students to reflect on their thoughts. When students ask well-defined questions based on their simulation experiences, the responses they receive tend to be more meaningful and can prompt deeper reflection and learning.

Alumni mentors, most of whom have launched their own ventures, are invited by instructors who have previously taught or advised them. This existing relationship makes them more willing to return and provide support. Their feedback is often grounded in real experience, expressed in straightforward language, and resonates with the student context. While mentors are not involved in daily instruction, they often focus on helping students assess the feasibility of their proposals, test the soundness of their assumptions, and consider whether their ideas make sense from an investor's perspective. Many students report that these interactions help them reflect more critically on their own thinking.

From the student's point of view, each form of guidance offers a different kind of value. AI tools help clarify structure and language. Instructors offer strategic direction and feedback on conceptual development. Alumni provide real-world perspectives that test the practical relevance of student ideas. These interactions also lead students to reconsider their own entrepreneurial readiness. Over time, they begin to let go of overly idealistic assumptions, which is an important step in developing entrepreneurial resilience.

Rather than being shaped by a single voice, the learning process emerges through layers of interaction. Each layer adds a different kind of insight, helping to create a learning environment that is both guided and open to exploration. In this way, students are not only learning content but also growing through continuous dialogue, reflection, and the practical demands of building something real.

4.2. Questionnaire development, data collection, and sample profile

4.2.1. Questionnaire design and pre-test

To test our research hypotheses and further examine the conceptual model, we employed survey-based empirical data collected from Chinese universities. As part of a broader research project, a questionnaire was developed. In alignment with the conceptual model outlined in Fig. 1, the questionnaire included five key constructs: IE, CK, EK, TD, and ER. We referred to prior studies and further operationalized each construct and its associated variables. These variables were then translated into specific items within the questionnaire, as presented in Table 1. Regarding the content validity of the questionnaire, it was confirmed through expert review. We conducted a pretest involving 31 domain experts, which demonstrated acceptable internal consistency, with Cronbach's alpha values exceeding 0.83 (Chang et al., 2011).

4.2.2. Sample profile and data collection

This study collected data from Chinese universities where faculty teams had independently initiated small-scale pilot projects in metaverse-based entrepreneurship education. To identify suitable participants, we first conducted a preliminary survey targeting faculty members who had publicly shared their experiences with metaverse-based instruction on platforms such as Red Book, Weibo, and BiliBili. Two rounds of questionnaires were distributed: the first from June 1 to July 31, 2024 (98 valid responses from 205 invitations), and the second from October 1 to December 31, 2024 (128 valid responses from 207 invitations). Together, these two stages yielded 226 valid responses, with an overall response rate of 54.85 %. An independent *t*-test indicated no significant difference between the two collection periods.

Following this initial stage, we recontacted the respondents and invited them to provide deeper information about their practices. A total of 68 instructors agreed, each representing a distinct teaching team that had independently developed and piloted metaverse-based platforms. These platforms, though still at trial stages, had already formed ecosystems that integrated technological modules with instructional design. Their structures and observed practices were synthesized in Section 4.1. Because metaverse-based entrepreneurship education in China remains in a formative stage, and many teams regarded one another as competitors for funding and

Table 2
Sample profiles.

Characteristic	Profiles
Regions	North China = 3.83 % Northeast China = 10.54 % East China = 71.07 % Central South China = 12.07 % Southwest China = 1.92 % Northwest China = 0.57 %
Entrepreneurial situations	Students who did not intend to start a business but found the system valuable = 34.48 % Students who had identified a business direction and were refining it = 37.36 % Students preparing to launch entrepreneurial activities = 28.16 %

innovation recognition, the participants requested strict anonymity. As a result, university affiliations and platform details are not disclosed; only aggregated descriptions are provided in Section 4.1.

While these instructor accounts provided important insight into platform development and teaching design, they were insufficient to determine whether entrepreneurial resilience learning was actually taking place. To address this limitation, the study extended its focus to students who had directly participated in the platforms. In consultation with the 68 teaching teams, we distributed a revised questionnaire to their entrepreneurial student teams. To maximize efficiency, data collection was conducted both online and through in-person visits, including occasions where students completed the survey on site. Between August 11 and August 31, 2025, this process yielded 520 valid student responses. Because many respondents were members of the same entrepreneurial teams, the data followed a nested structure, with multiple students clustered within each of the 68 teaching ecosystems.

The 520 student respondents represented varying levels of entrepreneurial intention. They were classified into three categories: (1) students who did not intend to start a business but found the system valuable, (2) students who had identified a business direction and were refining it, and (3) students preparing to launch entrepreneurial activities. A summary of this distribution is provided in Table 2.

4.2.3. Consistency analysis

In this study, the 520 participating students were not treated as isolated individuals; rather, many of them worked together in entrepreneurial partner groups, forming distinct teams. These teams were each trained within one of 68 metaverse-based entrepreneurial teaching platforms, which were designed to simulate collaborative processes of venture creation. To ensure that the outcomes from different platforms could be meaningfully compared, it was essential to evaluate whether members within the same team shared sufficiently consistent perceptions of the constructs related to resilience learning. Without such consistency, aggregating responses at the team level would not be justifiable. Therefore, we conducted a within-team agreement analysis using established approaches in organizational and educational research. We employed the $r_{-\omega g(j)}$ index (James et al., 1984), calculated as:

$$r_{\omega g(j)} = 1 - \left(\frac{S_x^2}{\sigma_E^2}\right),$$

where S_x^2 is the observed variance of team members' responses and σ_E^2 is the expected variance under a random response distribution ($\sigma_E^2 = 2.0$ for a five-point Likert scale). In addition, intraclass correlation coefficients ICC(1) and ICC(2) were derived from one-way random-effects ANOVA (Bliese, 2000) to determine whether individual responses could be reliably aggregated to represent team-level perceptions. Following conventional guidelines, $r_{-\omega g(j)}$ values greater than 0.5 indicate sufficient agreement for aggregation.

The analysis results, as shown in Table 3, indicate that across the five constructs, the average $r_{-\omega g(j)}$ values ranged from 0.618 to 0.724, with median values above 0.622. The majority of teams exceeded the 0.5 threshold, indicating that team members held consistent perceptions within their groups. Although ICC(1) and ICC(2) values were close to zero or negative, this outcome suggests that systematic differences across the 68 teams were minimal. In other words, students from different teaching platforms did not diverge substantially in how they interpreted the constructs, which supports the comparability of responses across teams.

Taken together, these findings demonstrate that the constructs were interpreted consistently within teams and showed minimal divergence across teams. This consistency provides assurance that students can be treated as the primary unit of analysis while maintaining comparability across the 68 instructional ecosystems.

4.3. Measurements

Following data collection, a series of analytical procedures were conducted to ensure the reliability and validity of the findings. These procedures included examinations of variable correlations, construct reliability, convergent validity, and discriminant validity.

First, Pearson correlation coefficients were calculated to assess the associations among variables, with statistical significance determined using p-values (Afzal et al., 2013; Udovičić et al., 2007). Second, reliability and validity were assessed to confirm the robustness of the measurement model. In addition to Cronbach's alpha, which is considered acceptable when above 0.7 (Sarstedt et al., 2022), we examined factor loadings, composite reliability (CR), and average variance extracted (AVE). Following Hair Jr et al., 2021, factor loadings above 0.5, CR values above 0.7, and AVE values above 0.5 indicate satisfactory reliability and convergent validity. Third, discriminant validity was evaluated using multiple approaches. According to the Fornell-Larcker criterion, the square root of AVE for each construct should exceed its correlations with other constructs. Cross-loadings were also inspected to verify that each item loaded more strongly on its intended construct than on others, with values above 0.5 indicating adequate distinctiveness. In addition, the heterotrait-monotrait (HTMT) ratio was adopted as a complementary measure, as recommended by Henseler et al. (2015), since it

Table 3
Team consistency results.

Constructs	Average $r_{-\omega g(j)}$	Median $r_{-\omega g(j)}$	ICC(1)	ICC(2)
IE	0.631	0.684	−0.014	−0.120
CK	0.675	0.712	−0.026	−0.245
EK	0.724	0.753	−0.038	−0.385
TD	0.618	0.622	−0.020	−0.175
ER	0.644	0.647	−0.031	−0.298

is considered a more reliable indicator when constructs are theoretically related.

These procedures represent the standard validity assessment approach in PLS-SEM, which does not require the application of traditional exploratory or confirmatory factor analysis, as construct validity is instead established through factor loadings, CR, AVE, and discriminant validity measures (Hair Jr et al., 2021; Sarstedt et al., 2022).

4.4. Methods and control variables

4.4.1. PLS-SEM

This study utilized Partial Least Squares Structural Equation Modeling (PLS-SEM) as the primary analytical method to assess the proposed conceptual model and hypotheses. PLS-SEM is a variance-based structural modeling technique that estimates model parameters through an iterative algorithm designed to maximize the explained variance of endogenous latent variables. The core principle involves two sub-models: the measurement model (outer model) and the structural model (inner model). In the measurement model, latent variables are estimated as weighted linear combinations of their observed indicators using a type of principal component analysis. In the structural model, path coefficients between latent constructs are estimated using ordinary least squares (OLS) regression (Hair Jr et al., 2021).

Unlike covariance-based SEM, which estimates parameters by minimizing the discrepancy between observed and model-implied covariances using maximum likelihood, PLS-SEM relies on a series of OLS regressions that prioritize prediction over model fit. To assess the significance and stability of the parameter estimates, the method uses non-parametric bootstrapping. In this study, bootstrapping with 5000 resamples was conducted to generate standard errors and confidence intervals for path coefficients. The iterative estimation process continues until convergence is achieved between the outer and inner model scores. All computations were performed using SmartPLS 4.0.

4.4.2. NCA

In addition to examining sufficient conditions through PLS-SEM, this study incorporated Necessary Condition Analysis (NCA) to identify conditions that are indispensable for the formation of key constructs. Unlike traditional variance-based methods, NCA focuses on "necessary but not sufficient" logic, where certain factors must be present for an outcome to occur. Combined with PLS-SEM, which captures "sufficient but not necessary" logic, this dual approach enables a comprehensive understanding of structural dynamics and potential bottlenecks in complex systems (Dul, 2016).

While the original plan involved using the non-parametric NCA Calculator developed by Erasmus University, this study adopted a more statistically rigorous and testable implementation based on Dul's recommendation: quantile regression at the 95th percentile ($\tau = 0.95$). According to Dul, this method, although not a formal ceiling envelopment technique, offers a more reproducible and testable approximation of necessity logic, especially when statistical significance and robustness are required.

The NCA analysis examined whether IE, CK, TD, and their interaction terms (IE × TD and CK × TD) are necessary conditions for the development of EK. This design reflects the theoretical premise that the instructional mechanism emerges through the interplay of IE, CK, and TD in shaping EK. By applying NCA, the study provides additional insight into how these factors jointly operate as critical components of the mechanism.

All quantile regression models followed the specification:

$$Y_i = \beta_0 + \beta_1 X_i + \varepsilon_i \text{ where } \tau = 0.95$$

A significantly positive β_1 under the 95 % indicates that the predictor functions as a necessary condition for achieving high levels of the outcome. Statistical significance was set at $p < 0.05$, and effect sizes were reported to interpret the magnitude of necessity.

This implementation maintains consistency with NCA's logic while providing statistical clarity and analytical transparency. It facilitates the identification of structural constraints and non-negotiable elements within the entrepreneurial learning process in metaverse-based educational systems.

4.4.3. Control variable

To address the concern that the sample was drawn from 68 teams, each operating its own metaverse-based entrepreneurship platform across 6 major regions, the region variable was included as a control in the PLS-SEM analysis. This allows the study to investigate whether regional differences consistently affect participants' perceptions and evaluations. By incorporating region as a control, the analysis can verify that the hypothesized relationships remain robust even when accounting for possible regional variation, ensuring that the findings reflect the theoretical model rather than contextual differences among the six regions.

4.5. Statistical analysis process

Based on the above, the statistical analysis proceeded in three stages. First, descriptive statistics and correlations were examined to provide an initial understanding of the relationships among constructs. Next, the measurement model was evaluated to ensure the quality of the latent constructs. Reliability was assessed using factor loadings, Cronbach's alpha, and CR. Convergent validity was verified through AVE, and discriminant validity was tested using the Fornell–Larcker criterion, HTMT, and cross-loadings.

In the second stage, the structural model was evaluated step by step through three progressively specified models. Model 1 included only the control variable and the direct path from EK to ER to establish the baseline effect. Model 2 added IE and CK to assess their

effects on EK and the explanatory power of the independent variables. Model 3 introduced TD as a mediating variable, allowing tests of the indirect effects from IE and CK through TD to EK. All path coefficients were estimated using PLS-SEM, and significance was assessed with 5000 bootstrap resamples. Indirect effects were evaluated using bootstrap confidence intervals and two-tailed tests of significance.

In the final stage, NCA was conducted to assess whether IE, CK, TD, and their interaction terms (IE × TD, CK × TD) were necessary conditions for the formation of EK. Quantile regression at the 95th percentile was used to estimate necessity effects, and the results were interpreted based on significance levels and necessity effect sizes.

5. Results

5.1. Measurement results

First, we analyzed the correlations among the study variables (Table 4). Most correlations are weak, indicating that the constructs are empirically distinct rather than redundant. TD shows a small but significant correlation with IE and with ER, while its correlations with CK and the EK are positive but not significant. This pattern aligns with the mechanism-oriented expectation that TD may operate as a mediator between learning activities (IE, CK) and EK, effects that bivariate correlations alone cannot reveal. Therefore, we assessed reliability and convergent validity and then conducted discriminant validity tests (Fornell-Larcker, HTMT, and cross-loadings; see Tables 6–8). Together, these results provide stronger evidence that the constructs are reliable and empirically distinct; subsequent structural modeling formally tests the hypothesized indirect effects.

In the second test, we analyze the reliability and validity of the constructs. As shown in Table 5, Cronbach's alpha for all five constructs exceeds 0.7, indicating acceptable internal consistency. Factor loadings are mostly $\geq$0.50 except for EK1. Given EK's adequate CR and marginal yet acceptable AVE, we retained EK in the measurement model, consistent with Fornell and Larcker (1981). Regarding CR and AVE, four constructs meet the recommended thresholds (Hair Jr et al., 2021). The AVE for EK is slightly below 0.5, but its CR is adequate; consistent with Fornell and Larcker (1981), when AVE is marginally below 0.5 but CR is satisfactory, convergent validity can still be considered acceptable. We therefore retain EK in the measurement model.

Finally, consistent with the predominantly small bivariate correlations in Table 4, we verified discriminant validity using three standard tests (Tables 6–8). First, the Fornell–Larcker criterion is satisfied because the square root of each construct's AVE exceeds its correlations with other constructs. Second, all HTMT ratios fall below conservative cutoffs, corroborating separation among constructs. Third, the cross-loading matrix shows a simple structure in which every item loads highest on its intended construct and lower on non-target constructs. Taken together with the weak correlations, these results confirm that IE, CK, TD, EK, and ER are empirically distinct yet theoretically related.

5.2. PLS and mediating effects results

Table 9 presents the results of the structural model analysis, which include the effects of the control variable and the outcomes of the research hypotheses. The results for each hypothesis are displayed with their corresponding β, t, and p values, providing a comprehensive understanding of the relationships within the model.

In Model 1, the analysis focuses on the relationship outlined in H4. For the relationship between EK and ER, which is significant, with $\beta = 0.128$, $t = 2.217$, and $p < 0.05$, suggesting that EK positively affects ER. Therefore, H4 is supported. Model 2 builds on Model 1 by incorporating the independent variables related to H1 and H2 alongside the continued validation of H4. The results for H1 indicate that IE positively affects EK, with $\beta = 0.216$, $t = 6.296$, and $p < 0.01$, supporting the hypothesis. For H2, the results indicate that CK does not have a significant effect on EK ($\beta = 0.125$, $t = 1.581$, and $p > 0.05$), suggesting that the hypothesis is not supported. However, this is not the final result, as the potential mediating effect still needs to be considered. Regarding H4, the relationship between EK and ER remains strong and positive, with $\beta = 0.108$, $t = 2.056$, and $p < 0.05$, providing further support.

Model 3 further expands the analysis by introducing the mediating effect of TD while further evaluating H1, H2, and H4. For H1, the results show $\beta = 0.203$, $t = 5.552$, and $p < 0.01$. For H2, the results indicate $\beta = 0.110$, $t = 2.013$, and $p < 0.05$. When the mediating effect is taken into account, CK exerts a direct influence on EK. This highlights the importance of the mediating variable. The relationship between EK and ER, as outlined in H4, remains significant, with $\beta = 0.117$, $t = 2.176$, and $p < 0.05$. These findings consistently support H1 and H4, while only the result for H2 has changed. The mediating effect of TD, as tested in H3a and H3b, is further examined. The analysis revealed that both IE and CK exert significant indirect effects on EK through TD. Specifically, the indirect effect

Table 4
Correlation matrices.

Constructs	Mean	SD	IE	CK	EK	TD
IE	3.500	0.852				
CK	3.455	0.803	0.018			
EK	3.531	0.730	0.105*	0.029		
TD	3.484	0.861	0.118**	0.073	0.049	
ER	3.480	0.846	0.121**	0.054	0.039	0.172**

** *p-value* ≦ 0.01, * *p-value* ≦ 0.05.

Table 5
Construct reliability and validity.

Constructs	Variables	Factor loading	Cronbach's Alpha	CR	AVE
Interactive Engagement (IE)	IE1	0.709	0.817	0.869	0.625
	IE2	0.835			
	IE3	0.809			
	IE4	0.802			
Contextual Knowledge Integration (CK)	CK1	0.562	0.795	0.829	0.553
	CK2	0.797			
	CK3	0.765			
	CK4	0.821			
Entrepreneurial Knowledge Field (EK)	EK1	0.489	0.759	0.792	0.495
	EK2	0.750			
	EK3	0.747			
	EK4	0.788			
Immersive Trust Dynamics (TD)	TD1	0.742	0.826	0.878	0.644
	TD2	0.844			
	TD3	0.821			
	TD4	0.798			
Entrepreneurial Resilience Learning (ER)	ER1	0.631	0.825	0.854	0.596
	ER2	0.775			
	ER3	0.829			
	ER4	0.836			

Table 6
Fornell-larcker criterion.

Constructs	IE	CK	EK	TD	ER
IE	0.790				
CK	0.094	0.743			
EK	0.233	0.156	0.704		
TD	0.167	0.177	0.198	0.802	
ER	0.187	0.179	0.149	0.250	0.772

Table 7
Analysis results of HTMT.

Constructs	IE	CK	EK	TD
CK	0.095			
EK	0.175	0.124		
TD	0.158	0.140	0.169	
ER	0.165	0.116	0.116	0.223

of IE on EK via TD was significant ($\beta = 0.023$, $p < 0.05$; 95 % CI [0.007, 0.045]), while the indirect effect of CK on EK through TD was also significant ($\beta = 0.025$, $p < 0.05$; 95 % CI [0.006, 0.047]). At the same time, the direct effects of IE ($\beta = 0.203$, $p < 0.01$) and CK ($\beta = 0.110$, $p < 0.05$) on EK remained significant. These results indicate partial mediation, demonstrating that both IE and CK influence EK directly and indirectly through TD. In other words, TD enhances, but does not fully replace, the direct contributions of IE and CK to EK, thereby providing strong support for H3a and H3b.

Regarding the control variable, across Models 1, 2, and 3, the region control was not significant for either EK or ER. With this control included, the direction and significance of the main paths remained unchanged, indicating that differences in team or platform origin do not drive the core conclusions. In other words, variation in source did not exert a systematic influence on the results, addressing the concern that teams may differ in their perspectives.

5.3. NCA analysis results

The NCA results (Table 10) indicate that IE functions as a necessary condition for shaping EK ($\beta = 0.143$, $p < 0.05$), underscoring that without sufficient interactive engagement, EK cannot be effectively developed. CK, by contrast, did not demonstrate a significant necessity effect when tested independently ($\beta = 0.000$, $p > 0.05$), suggesting that it is not an indispensable prerequisite on its own. Interestingly, TD, although conceptualized in this study as a mediating variable, also emerged as a significant necessary condition ($\beta = 0.143$, $p < 0.01$). This finding highlights that trust dynamics are not only part of the mediating process but also a structural foundation required for EK to emerge.

When interaction effects were tested, both IE and CK displayed significant necessity relationships in combination with TD (IE × TD → EK: $\beta = 0.028$, $p < 0.05$; CK × TD → EK: $\beta = 0.020$, $p < 0.05$). These results suggest that while IE is already necessary, its

Table 8
Analysis results of cross-loadings.

Constructs/Items	IE	CK	EK	TD	ER
IE1	***0.709***	−0.069	0.031	0.020	0.06
IE2	***0.835***	0.068	0.208	0.154	0.135
IE3	***0.809***	0.097	0.174	0.120	0.176
IE4	***0.802***	0.088	0.204	0.146	0.162
CK1	−0.033	***0.562***	−0.069	−0.038	−0.017
CK2	0.081	***0.797***	0.092	0.142	0.126
CK3	0.055	***0.765***	0.130	0.075	0.115
CK4	0.059	***0.821***	0.103	0.151	0.145
EK1	0.003	−0.075	***0.489***	−0.119	−0.052
EK2	0.163	0.097	***0.750***	0.105	0.124
EK3	0.166	0.096	***0.747***	0.127	0.032
EK4	0.154	0.096	***0.788***	0.125	0.121
TD1	0.079	0.034	0.024	***0.742***	0.098
TD2	0.135	0.171	0.206	***0.844***	0.235
TD3	0.135	0.153	0.178	***0.821***	0.167
TD4	0.157	0.135	0.131	***0.798***	0.240
ER1	0.015	−0.040	−0.035	0.058	***0.631***
ER2	0.111	0.118	0.112	0.162	***0.775***
ER3	0.175	0.158	0.089	0.207	***0.829***
ER4	0.135	0.111	0.126	0.209	***0.836***

Table 9
Full regression analysis results of the structural model and mediating effects.

Variables	EK			ER			TD (Mediator)
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 3
Control Variables							
Regions	−0.030 (t = 0.568)	−0.062 (t = 1.308)	−0.075 (t = 1.599)	0.064 (t = 1.164)	0.070 (t = 1.439)	0.071 (t = 1.456)	
Independent Variables							
EK				0.128* (t = 2.217)	0.108* (t = 2.056)	0.117* (t = 2.176)	
IE		0.216** (t = 6.296)	0.203** (t = 5.552)				0.151** (t = 3.840)
CK		0.125 (t = 1.581)	0.110* (t = 2.013)				0.164** (t = 3.517)
Mediator							
TD			0.150** (t = 2.953)				
Mediating Effects							
IE → TD → EK	The analysis revealed that the indirect effect of IE on EK through TD was significant (β = 0.023, p < 0.05; 95 % Confidence Intervals [0.007, 0.045]). The direct effect of IE on EK also remained significant (β = 0.203, p < 0.01). This indicates partial mediation, suggesting that IE influences EK both directly and indirectly through TD. In other words, TD enhances but does not fully replace the direct contribution of IE to EK.						
CK → TD → EK	The results show that the indirect effect of CK on EK through TD was significant (β = 0.025, p < 0.05; 95 % Confidence Intervals [0.006, 0.047]). The direct effect of CK on EK was significant (β = 0.110, p < 0.05). This indicates partial mediation, suggesting that CK influences EK both directly and indirectly through TD. In other words, TD enhances but does not fully replace the direct contribution of CK to EK.						

** *p-value* ≦ 0.01, * *p-value* ≦ 0.05.

Table 10
NCA analysis results (τ = 0.95).

Predictor Variable	Effect Size (*β* at 95 %)	Significance	Conclusion
IE - > EK	0.143	p-value <0.05	**Necessary**
CK - > EK	0.000	p-value >0.05	Not necessary
TD - > EK	0.143	p-value <0.01	**Necessary**
IE x TD - > EK	0.028	p-value <0.05	**Necessary**
CK x TD - > EK	0.020	p-value <0.05	**Necessary**

indispensable role is further reinforced in the presence of trust, and CK becomes necessary only under conditions of high trust. In this sense, TD plays a dual role: it mediates the pathways toward EK while simultaneously acting as a contextual enabler that activates or strengthens the necessity of other mechanisms.

Taken together, the findings reveal a layered necessity structure. IE is indispensable on its own, CK requires the enabling presence of TD to attain necessity, and TD itself is both a mediating mechanism and a direct foundational requirement for EK. This demonstrates that shaping EK relies not only on direct engagement but also on trust as a contextual trigger that consolidates and activates the contribution of multiple mechanisms.

6. Discussion

This study examines how a metaverse-constructed educational ecosystem cultivates students' entrepreneurial resilience learning. The empirical results show that the system promotes interactive engagement (IE), supports contextual knowledge integration (CK), and, through ongoing instructional interaction, accumulates immersive trust dynamics (TD). Together these three elements shape an entrepreneurial knowledge field (EK), which in turn advances entrepreneurial resilience learning (ER). They are not independent components; they interact to form a workable instructional mechanism. The following sections address the three research questions in order.

The first research question examines how IE and CK contribute to the formation of EK. The analysis results show a stable positive effect of IE on EK across models. By contrast, CK is not significant when TD is excluded, but becomes significant once TD is included. This shift indicates that whether knowledge can be integrated into the field depends on whether the learning context provides sufficient trust and psychological safety. In line with the knowledge-based view, knowledge becomes a useable learning resource only when it is activated through interaction and required for application in concrete contexts (Feng et al., 2021; Pillay & Barnard, 2019). Our findings are consistent with this view: IE enables students to reference, share, and make decisions in uncertain simulated settings (Rahman et al., 2024), while CK anchors knowledge in specific problem contexts and requires reorganization (Kaigom, 2024). From a resource-based view, IE works as a mechanism that mobilizes and coordinates dispersed resources so that explicit and tacit resources can converge and be transformed into deployable capabilities, and CK completes the combination and configuration of resources by embedding external and internal resources in task contexts, creating persistent utility and hard-to-imitate value (Barney, 1991; Bobe & Kober, 2015). Without trust, these integration attempts tend to remain superficial. When TD is present, students are more willing to reveal cognitive gaps, accept external perspectives, and complete deep integration, which makes the effect of CK on EK visible. This reinforces prior emphases on interaction and contextual design (Lackéus, 2020; Suhail et al., 2024) and further shows that both require trust as a condition to converge into a viable knowledge field.

The second research question addresses whether TD mediates the relationships between IE, CK, and EK. The analysis results show significant indirect effects of TD on both IE → EK and CK → EK, while the two paths retain significant direct effects. These results indicate partial mediation. The NCA results further reveal the structural conditions. IE and TD are both necessary conditions for EK. CK is not necessary by itself, but its interaction with TD becomes necessary. This combination conveys a clear message. First, IE constitutes the basic engine for the formation of the knowledge field; without sufficient interaction it is difficult to reach high levels of EK. Second, TD is both a social mediator in the process and a necessary condition. It reduces perceived participation risk and provides psychological safety, allowing learners to experiment, err, and reconstruct knowledge with an open mindset. Third, the necessity of CK is activated only under high-trust conditions. Contextual integration does not occur automatically; it depends on the enabling context provided by TD. From the perspectives of KBV and RBV, TD can be seen as a social resource and governance mechanism that mobilizes and coordinates explicit and tacit resources distributed across networks and that increases exploration and risk-taking under pressure and ambiguity (Barney, 1991; Gully et al., 2002). As the ecosystem continues to operate, repeated collaboration and shared experience consolidate TD, which stabilizes the emergence and maintenance of EK (Lin, 2024; Sghaier et al., 2022). This result is also consistent with the view of social reconfiguration in dynamic capabilities, where trust and consensus catalyze knowledge restructuring and coordinated action (Teece et al., 1997).

The third research question explores how EK promotes ER. EK has a significant positive effect on ER and maintains a stable direction and significance across models. This indicates that entrepreneurial resilience is not merely a personal trait but a learnable outcome nurtured by structured and demanding knowledge environments. Under the KBV, EK provides a knowledge structure that is validated in context and repeatedly tested, enabling students to apply, adjust, and reinterpret knowledge under uncertainty (Feng et al., 2021). Under the RBV, EK is not only a site of knowledge input but also a platform for developing dynamic capabilities. Within EK, students engage in repeated cycles of decision making, reflection, and adaptation, gradually internalizing interpretive routines and adaptive strategies for addressing complex problems (Barney, 1991). Earlier work often emphasized individual adaptability or long-term coping capacity (Bhoyar et al., 2025; Ediagbonya et al., 2024; Jardas Antonić et al., 2024). This study adds that when interaction, context, and trust are organized as a mechanism, students can construct their own knowledge field and form transferable resilience through failure and iteration.

Taken together, the results explain why a metaverse entrepreneurial ecosystem can effectively cultivate entrepreneurial resilience. The key lies in an internal mechanism that forms and operates over time. Interactive engagement and contextual knowledge integration are triggered and strengthened within the psychological safety and risk-bearing space provided by immersive trust dynamics, and they converge into an entrepreneurial knowledge field with absorptive and applicative capacity. As a carrier of action and reflection, this field enables students to adjust, experiment, and reconstruct cognition under uncertainty, and it culminates in entrepreneurial resilience learning. The analyses trace this path in detail. Interaction and trust are necessary conditions. Contextual integration becomes a critical aid under high trust. The three forces jointly drive the knowledge field, and the knowledge field advances resilience. In this way, the study's questions of why and how receive empirical answers at the level of mechanism.

7. Conclusion

This study concludes that a metaverse-constructed educational ecosystem cultivates entrepreneurial resilience by forming an instructional mechanism. Within this mechanism, interactive engagement and contextual knowledge integration, supported by immersive trust dynamics that provide psychological safety and room for risk-taking, converge into an entrepreneurial knowledge field; this field then enables students to adjust, recover, and persist in entrepreneurial contexts. The analysis results provide clear evidence for this pathway: trust activates and strengthens interaction and contextual integration; together, these forces build the knowledge field, and the knowledge field advances entrepreneurial resilience. This mechanism-focused conclusion aligns with the aims stated in the introduction by explaining both why and how organizing interaction, context, and trust within a metaverse-constructed entrepreneurship education ecosystem develops entrepreneurial resilience.

7.1. Theoretical implications

Although metaverse-constructed entrepreneurial ecosystems have been widely recognized as promising instructional environments in entrepreneurship education, existing research has yet to provide a detailed explanation of how such environments support the development of entrepreneurial resilience as a core learning outcome.

This study addresses that theoretical gap by demonstrating how a metaverse-constructed entrepreneurial ecosystem cultivates entrepreneurial resilience through an interrelated instructional mechanism. By uncovering the structural and interactional conditions that make this possible, the findings offer a mechanism-based explanation that clarifies why these environments are effective. This not only enhances the explanatory power of future claims about the impact of metaverse learning but also provides a testable framework for further theoretical refinement.

More importantly, the mechanism identified in this study yields a dual contribution that is consistent with the evidence reported. For design science, it turns the empirical pattern into testable design conditions: interaction and trust appear as necessary conditions for building the entrepreneurial knowledge field, while contextual integration becomes operative once trust is established. These conditions can be expressed as sequencing and process rules that travel across settings, such as “prioritize trust building and high-quality interaction until basic psychological safety is observed, then embed contextual integration tasks to consolidate the entrepreneurial knowledge field.” For instructional technology theory, the study specifies a process model for immersive environments by tracing a clear pathway from interactive engagement and contextual knowledge integration, under trust, to the entrepreneurial knowledge field and then to resilience. This yields falsifiable propositions, for example that the effect of contextual integration on the entrepreneurial knowledge field will weaken or disappear when trust is suppressed, while the effect of interactive engagement will remain but be amplified as trust increases. A simple illustrative example follows from these propositions: in two otherwise similar cohorts, one configured with early trust-building and structured interaction and the other without that configuration, contextual integration should contribute to the entrepreneurial knowledge field only in the trust-configured cohort, and both cohorts should still show a positive contribution of interactive engagement, stronger in the trust-configured one. By moving from surface features to mechanism-level, testable rules, the study offers a transferable middle-range explanation that both guides design and strengthens theory.

7.2. Practical implications

The findings provide concrete guidance for planning immersive entrepreneurship education and designing metaverse-based instructional environments.

First, entrepreneurial resilience does not arise automatically in virtual settings. It depends on the organic integration of several key conditions: the intensity of interaction, the contextualization of knowledge, and the trust dynamics between instructors and students. Instructional designers should account for these elements from the outset and strategically use platform features to deepen contextual application and sustain stable patterns of social engagement. Trust dynamics require deliberate cultivation. Teachers can create psychologically safe spaces where students feel comfortable sharing unfinished ideas, encourage constructive peer feedback rather than evaluative criticism, and use platform tools such as one-on-one mentoring sessions or small-group discussions to reduce fear of judgment. Alumni mentors who offer supportive yet realistic feedback can further signal that student effort is taken seriously. These practices help transform the virtual environment into a setting where students are willing to take risks, address setbacks openly, and keep improving their projects. Based on the analysis evidence, a practical design sequence is as follows: prioritize establishing and consolidating trust and psychological safety while simultaneously raising the quality of interaction; subsequently embed contextual integration into key tasks so that the three elements converge into a workable entrepreneurial knowledge field.

Second, practitioners should avoid treating the metaverse as a stack of instructional functions or isolated tools. It should be approached as a dynamic and adjustable learning ecosystem that supports pedagogical transformation. Relying only on surface features such as visual immersion, real-time interaction, or simulation capabilities will not meet the deeper cognitive and affective demands of entrepreneurial contexts. Effective use begins with aligning platform characteristics to the instructional mechanism. Through intentional design, students can be guided into sustained engagement and iterative reflection, allowing actions in the virtual environment to gradually become the capacity to navigate uncertainty and manage the pressures of failure.

The instructional mechanism model proposed here serves as a concrete and adaptable reference for practice. It can guide the design of metaverse-based entrepreneurship courses and function as a flexible framework that can be tuned across different educational settings. By adopting a mechanism-oriented approach, practitioners can move beyond technological novelty and use the metaverse as a

pedagogical space for leading students into meaningful challenge, continuous exploration, and the deliberate development of entrepreneurial resilience.

7.3. Research limitations and future directions

This study clarifies a key instructional mechanism that shapes entrepreneurial resilience learning in immersive environments, yet several limitations remain. First, the formation of the entrepreneurial knowledge field was assessed using self-reported data within a cross-sectional design. Although this captures perceptions at a specific point in time, it does not show how the knowledge structure emerges and evolves through repeated interactions and contextual shifts. Future research can adopt longitudinal or process-oriented methods and combine objective records, such as platform interaction logs and versioned artifacts, to map the timing and dynamics of the mechanism.

Second, although the model received empirical support, the sample was drawn from a single national context with relatively homogeneous cultural and institutional conditions. The conditional mechanisms identified here may not generalize directly to other countries or education systems. Future work should employ cross-national or cross-institutional samples to examine whether the model holds in more diverse social and organizational environments, and compare how differences in platform design and course pacing influence the efficiency of the mechanism.

Ethics approval statement

This study does not involve human participants, animal subjects, or sensitive data requiring ethical approval. As such, formal ethics committee approval was not applicable.

Declaration of competing interest

The authors declare no conflict of interest.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Micro-credentials in Malaysian higher education: a comprehensive case study approach

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Abstract

Micro-credentials have become increasingly popular in the modern job market due to the ability to address rapid changes in various industries. These credentials offer flexibility, targeted and tailored learning experiences that fill specific skill gaps while preparing learners for job roles. In the hope of capitalizing on the advantages of this flexible education, higher education institutions in Malaysia are increasingly adopting micro-credentials. Although all micro-credentials offered in Malaysia's higher education institutes must conform to the Malaysian Qualifications Agency's standards and regulations, the set-ups and implementation, however, are flexible depending on the institution's ecosystem. As micro-credentials are relatively new in Malaysia and the references to success stories are usually from overseas universities, which have different settings and environment. Therefore, there is a need for a comprehensive overview of micro-credentials implementation in the context of Malaysian higher education institutions. This study adopted a qualitative case studies approach on three universities in Malaysia, which represent the public and private universities with different micro-credentials implementation competence. Collation of insights, which includes comparisons on the composition of the working committee, sustainability strategies, and collaboration efforts are documented. An elaborate suggestion for micro-credentials newcomers is also included in this study through a proposed core team composition and detailed implementation pathway. Ultimately, this study contributes to providing potential micro-credentials providers in Malaysia with a reference to micro-credentials best practices.

Keywords Micro-credentials · Higher education learning · Lifelong learning · Education innovation · Education leadership

Extended author information available on the last page of the article

1 Introduction

Micro-credentials are gathering greater momentum on a global scale, with a heightened interest in short learning experiences that gained momentum following the onset of the COVID-19 pandemic. The World Economic Forum (2020) forecasts that in the decade following the COVID-19 pandemic, roughly half of all employment positions will undergo significant alterations due to automation (Lee at al., 2023), leaving the current workforce with no other alternative except re-skilling or up-skilling. Micro-credentials provide learners with a quick and flexible way to sharpen competency or develop a new skill set. As the global online degree market with micro-credentials is predicted to grow exponentially (Ahsan et al., 2023), the potential of micro-credentials attracted the attention of a growing array of stakeholders, including global higher education institutions, employers, and government authorities (Varadarajan et al., 2023).

Micro-credentials play a crucial role in shaping the definition and structure of teaching and learning in higher education institutions (HEI). According to Uggeri and Barlassina (2019), micro-credentials is defined as a sub-unit of a credential that could accumulate into a larger credential or degree or to be part of a portfolio, for example digital badges, nano degrees or micromasters. The importance of standardized frameworks is emphasized rather than solely focusing on creating content (Wheelahan & Moodie, 2021). However, this presents a significant challenge because HEIs are often bound by educational accreditation requirements imposed by governing bodies. Globally, issues related to micro-credentials framework validation, quality and accreditation are the concern of universities that intent to implement micro-credentials.

New Zealand, Australia, Europe and Malaysia are countries that already have an established micro-credentials qualification guidelines and framework to ensure the quality of micro-credentials ecosystem (Steel et al., 2022). The micro-credentials developed in New Zealand and Australia are abide to the New Zealand Qualifications Framework and the Australian Qualifications Framework respectively while Europe uses the European Qualifications Framework. These qualification frameworks do not bind all micro-credentials developed in the respective countries with strict compliance but as a driver and guideline for formal academic credit qualifications (McGreal & Olcott, 2022). However, although qualification frameworks are established, the challenges of successfully implementing micro-credentials in HEIs are still not clearly understood (Zhang & West, 2020).

In Malaysia, micro-credentials emerged in 2019 when the Malaysian Qualification Agency (MQA) launched the micro-credentials guidelines for HEI that are interested in developing accredited micro-credentials programs. Micro-credentials is still relatively new in Malaysia and a few HEIs have started offering them in their institution (Che Ahmat et al., 2021), while other HEIs are baffled by the struggle to adopt micro-credentials. The common challenge lies in the HEIs' readiness to implement micro-credentials that are amplified by institutional factors such as lacking of established procedures, low awareness on the value of micro-credentials among HEIs academic staffs and low completion rate among students (Abdul Halim et al., 2024). Inadequate support system and blurred line of responsibility between the faculty and university learning center on who should be in charge of developing and coordinating

the micro-credentials modules (Rami et al., 2023) further exacerbates the struggle of HEIs in their quest to execute micro-credentials.

Despite governed by the guidelines of MQA, each institution has a different approach to micro-credentials set-up and implementation, tailored to the institution's ecosystem. Many success stories of micro-credentials implementation are dominated by HEIs in the west or other foreign countries, that have different contexts. Current studies are focusing on presenting the challenges and providing recommendation to better implement micro-credentials in Malaysia. There is a need for more studies that explore successful micro-credentials implementation cases in Malaysia where comparative analyses can be carried out to provide different perspective (Abdul Halim et al., 2024). These successful case studies can be used as references by other local HEIs that are planning to venture into micro-credentials.

Therefore, the objective of this study is firstly, to garner understanding on the practical implementation of micro-credentials in Malaysia and secondly, to provide recommendations and implementation pathway for nascent micro-credentials developers in Malaysia. Three diverse HEIs are chosen for this study, namely Universiti Sains Malaysia (USM) representing established micro-credentials offering in public HEIs, Multimedia University (MMU), representing established micro-credentials offering in private HEIs and Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA), represents emerging public HEIs offering micro-credentials.

Qualitative approach is used in this study where in-depth interviews were conducted with three respondents, each representing the mentioned three HEIs. Comparative analysis of the three HEIs on the composition of micro-credentials working committee, sustainability strategies as well as progression and collaboration will be presented based on the data and information gathered through the interview session. Based on the comparative analysis, a proposed blueprint for establishing micro-credentials committees and a pathway depicting micro-credentials implementation are presented to serve as a reference to potential micro-credentials providers. This study contributes to a deeper understanding of successful micro-credentials cases in the Malaysian context, providing HEIs that are interested in offering micro-credentials in Malaysia and related stakeholders with insights into micro-credentials formation to meet the evolving needs of learners and industries.

2 Literature review

2.1 Micro-credentials

A micro-credential is a comprehensive term encompassing a variety of certification types, such as nano degrees, micro-masters, badges, credentials etc. which has gained much popularity in recent years (Varadarajan et al., 2023). They provide a flexible, targeted approach to assisting people in developing the information, skills, and competencies required for personal and professional development (Che Ahmat et al., 2021). Sometimes, it is also represented by icons or graphics that serve as digital badges to indicate that a learner has completed a learning experience from an accredited institution.

In fact, nano degrees, micro-masters, and badges are termed interchangeably in Micro-credentials (Brown et al., 2021; Che Ahmat et al., 2021). Pawilen et al. (2024) mentioned the lack of common definition shows plurality of understanding throughout the globe, in which cater specific learning objectives and career aspirations. Nano degrees, showcased by platforms like Udacity and Coursera, deliver concise, online programs focused on imparting sought-after technical skills essential in today's job landscape (Flynn et al., 2023; Lemoine & Richardson, 2015). Meanwhile, the most common elements in digital badges are about certification and mastery of specific competencies. This online learning has emerged as a flexible method for acknowledging new skills and accomplishments across diverse domains (Ponte & Saray, 2019). These badges, issued by organizations, educational institutions, and contributing to a more adaptable and transferable credentialing framework (Milligan & Kennedy, 2017). Collectively, these micro-credential formats offer flexible routes for individuals to acquire and showcase specialized skills aligned with the evolving needs of various industries.

Different from the macro-credentials, micro-credentials are certified documents that offer recognized proofs of the learner's achievement of learning outcomes from shorter, less duration, educational or training activities. These skills-focused courses are cheaper, adaptable, flexible, and easily accessible for individuals to up-skill or re-skill to meet immediate skills gaps and position themselves competitively within challenging labor markets (Aripin et al., 2023; McGreal & Olcott, 2022). According to European Commission (2020), many countries are pitching micro-credentials as a tool to fulfil businesses' shifting needs in the face of quickly shifting skills demands that caused by COVID-19-related unemployment issues, plus the transition to technological advancements.

Moreover, micro-credentials are increasingly seen making the labor market more accessible and equitable, by allowing employers to hire people based on their skills, rather than their educational background. In the United States, micro-credentials programmes are gaining popularity as part of professional development programmes (Kumar et al., 2022). Che Ahmat et al. (2022) added that professional development courses typically rely on short and standardised workshops; with micro-credentials, working adults will have opportunities to engage in self-paced learning that is relevant to their daily jobs and later earn recognition in the form of digital badges for completing the modules.

2.2 Micro-credentials in higher education institutions

HEIs are looking for ways to effectively implement micro-credentials by adopting innovative and flexible methods, as well as updating their policies and taxonomies. A study by MicroHe (2019) found that there is a need for a recognition-framework that defines micro-credentials, set quality standards, and develop a system for assessing learning outcomes. It would also help to coordinate the efforts of different stakeholders involved in micro-credentials, such as students, universities, employers, and regulators. This framework is particularly important for standardization and transparency, ensuring that micro-credentials are designed to provide skills, knowledge, or compe-

tencies that are tailored to a range of needs, including those of society, individuals, culture, and the labor market (Ralston, 2021).

Micro-credentials are subject to quality assurance processes that are in accordance with a quality framework, ensuring their consistency and reliability in the educational landscape (Kumar et al., 2022). For Malaysia, the micro-credentials goal set for HEIs is intended to address the skill gaps among graduates. While Malaysia's keenness to advance onto the micro-credentials bandwagon is encouraging, there is no noticeably sufficient empirical scrutiny that provide understanding on micro-credentials in the specific context of Malaysian HEIs (Che Ahmat et al., 2022; Kumar et al., 2022).

Nevertheless, micro-credentials, provide a straightforward way for HEI students to certify talents that may not be evident from their academic records (Randall & West, 2020). These micro-credentials can be implemented in a variety of ways, including a hybrid approach or by supplementing standard courses (Boud & Jorre de St Jorre, 2021). However, the effectiveness of these initiatives is dependent on ingenuity and perceived worth. In addition to validating students' skills and competencies, micro-credentials can also be stacked together to create a more comprehensive learning journey. This can be done by bundling together related micro-credentials, or by unbundling them and taking them in a different order (Pickard et al., 2018).

2.3 Common challenges faced in implementing micro-credentials

Standardizing micro-credentials frameworks can be challenging when developing and offering them to a diverse range of learners. Different stakeholders, such as learners, educators, universities, micro-credentials providers, and employers, may have different perceptions or strategies of micro-credentials (Rami et al., 2023). Without a clear framework to guide and validate these strategies, unregulated proliferation has made micro-credentials a source of uncertainty for stakeholders, as their complexity and diversity often bewilder stakeholders. Stefaniak & Carey (2019) also pointed out that issues in HEIs often stem from problems related to usability, applicability, and a lack of clarity about goals and value. Therefore, the importance of standardized frameworks should also be emphasized rather than just focusing on creating content (Wheelahan & Moodie, 2021).

Additionally, the online nature of micro-credentials programs may be difficult to monitor and assess learners from all over the world. Quality assurance in the delivery system must be accentuated to implement and scale micro-credentials programs successfully (Che Ahmat et al., 2021). However, this presents a significant challenge because HEIs are often bound by educational accreditation procedures and requirements that imposed by governing bodies. Though these compact requirements provide quality assurance and the sources may become less obscure, they may also potentially limit content development and slow down the implementation of innovative strategies. Similarly, questions also surrounding the long-term value due to rapid technological advancements potentially making skills obsolete (Varadarajan, 2023).

Limited recognition could hinder acceptance by employers or academic institutions, affecting credit transfer and reducing micro-credentials value (Uggeri & Barlassina, 2019; Zhang & West, 2020). It is important to ensure that micro-credentials are recognized and portable internationally (Alias, 2020), thereby learners could transfer

their micro-credentials to other countries and have them recognized by employers in those countries. Practically, Rami et al. (2023) pinpointed lack of coordination of micro-credentials for ensuring coherence among education providers.

In course development stage, insufficient resources in terms of financial supports (Chung et al., 2020), technological literacy (Rami et al., 2023), and commitment of time (Abdul Halim et al., 2024) are the challenges when developing micro-credentials certification programmes. Creating micro-credentials modules requires complete dedication from module producers, involving time-consuming activities such as idea brainstorming, content outline, activity planning, and video creation. Chung et al. (2020) stated that to overcome this issue, institutions and micro-credentials providers should consider financial incentives as well as non-monetary support, such as clear guidelines and credential recognition, to encourage developers to create quality micro-credentials courses. In execution stage, although micro-credentials are more affordable than traditional degrees for learners, technological online platform tools and cost of acquiring multiple micro-credentials can be a barrier to access. This financial barrier may limit opportunities for those who could benefit from upskilling or reskilling (Inside Higher Ed., 2023). Hence, equity issues arise, especially for marginalized learners from disadvantaged or vulnerable backgrounds, such as prisoners, refugees, retired elderly, or rural residents, who have limited access to resources.

2.4 Challenges in global practices of micro-credentials

Comparing global practices with the Malaysian context reveals that there are no one-size-fits-all approach for the implemented micro-credentials and no established standards to guarantee the quality of micro-credentials across different countries, such as Philippines, Malaysia, Japan, United States, Australia, China, and South Africa (Che Ahmat et al., 2021; Lyu, 2023; Mahlasela & Steyn, 2023; Pawilen et al., 2024; Rami et al., 2023; Selvaratnam & Sankey, 2021).

Offering micro-credentialing policy in Australia universities had not been standardized or even established as highlighted in Selvaratnam and Sankey (2021). There is a challenge of low social recognition of non-degree learning outcomes in China (Lyu, 2023). In order to sustain the quality of micro-credentials in Japan and Philippines, Pawilen et al. (2024) proposed a quality assurance framework with four assessment areas, which are standards, design, achievements, and learner's data.

In Malaysia context, initiatives focused on standardization and quality assurance seek to establish clear criteria for assessing the rigor and validity of micro-credentials, thereby enhancing their credibility and recognition (Keoy et al., 2023). Moreover, teaching innovation supports teachers with a competency-based and diversified certification system for learning outcomes. However, Lyu (2023) stated only the theoretical aspects of using micro-credentials for teaching at the Open University of China while the practical implementation strategies on teaching innovation should be explored as teachers' professional development in micro-credentials can move towards a more personalized direction.

Recent advancements in micro-credentialing technologies, such as digital badging and blockchain verification, offer promising solutions to issues related to credential authentication and portability (Chukowry et al., 2021). Digital badges provide

visual representations of skills and achievements, enhancing their recognizability and shareability on online platforms. Moreover, blockchain technology ensures the security and integrity of micro-credentials through tamper-proof verification mechanisms (Poudel & Gajjela, 2019). These innovations have significant implications for Malaysia's micro-credential initiatives. By leveraging digital badges and blockchain, Malaysian institutions can enhance the credibility and portability of micro-credentials, facilitating recognition by employers and academic institutions globally (Rami et al., 2023).

Existing studies on micro-credentials largely focus on global practices and challenges, with limited attention to successful implementation within Malaysian HEIs. The specific institutional and cultural contexts of Malaysia are often overlooked (Che Ahmat et al., 2021; Nguyen et al., 2022). This study addresses this gap by examining detailed case studies of three Malaysian HEIs, offering practical insights to guide local institutions in effectively adopting and implementing micro-credentials.

3 Methodology

3.1 Research design

Qualitative case study was the methodology adopted in this study. A case study was chosen because the current study aimed at getting rich information on the many "how" and "why" (Yin, 2009) of micro-credentials implementation by the sampled Malaysian universities. Further, researchers had identified cases and sought to provide an in-depth understanding of the cases (Creswell, 2007). Using qualitative case studies, researchers explored the issue through detailed, in-depth data collection from multiple sources of information, reports case descriptions, and case-based themes. The current study also opted multiple cases approach to enable different perspectives on an issue understudied be explored to solicit views and input from the selected exemplary cases (Creswell, 2007).

3.2 Population and sampling procedures

The population of interest are Malaysian universities that have implemented micro-credentials. Purposive sampling through criterion sampling strategy was used to select the intended respondents. Purposive sampling identifies and selects information-rich cases relevant to the phenomenon of interest (Patton, 2015), that is, the micro-credentials implementation among Malaysian universities. Using the criterion sampling strategy, the study has identified three universities, namely USM, UMPSA, and MMU. The selection criteria are based the recommendation by Creswell & Plano (2011), that is the selection of individuals knowledgeable about or experienced with the phenomenon of interest. In line with this view, USM, UMPSA, and MMU display comparatively more proactive and comprehensive implementation of micro-credentials that allow them to comment with sufficient rigor on the micro-credentials topics.

Notably, despite being an organizational study, the sample consisted of three individuals, who are the leaders of the micro-credentials working committee at their

respective universities. They are qualified as key informants to comment on the organization-wide phenomena and processes underlying their university's micro-credentials given their prominent role. Table 1 depicts the credential details of the selected informants. However, it is important to mention that their recruitments were also subject to their willingness to participate.

Besides, the selection also catered for the sample representativeness in terms of having both government and private universities samples, with the former two being the government counterparts. This is important as both may differ in different aspects of governance. Another representativeness concern was that the samples comprise different levels of micro-credentials implementation competence, with MMU, USM, and UMPSA respectively serve as distinct reference points on the spectrum between the most developed and developing state of micro-credentials implementation. Further, the sample also comprised universities with research- and non-research-based courses as well as those of sciences- and social-sciences-based courses.

3.3 Data collection

Data was collected using the in-depth individual interview with open-ended questions. In-depth individual interview was employed as it is a powerful tool for gaining understanding and exploring topics in-depth (Fontana & Frey, 2000), and hence enables elicitation of rich information on the perspective understudied in this research (Russell et al., 2005). Open-ended questions were used in this study as such design is able to exhaust the capture of rich inputs from respondents (Yin, 1994).

The interview sessions with the respective case informant spanned across five months between 17 December 2022 and 17 April 2023. These sessions were carried out through an online platform namely Microsoft Teams, each of which took around two hours. To ensure the interview went as planned and the interviewees are appropri-

Table 1 Informants' information table

Traits	USM	UMPSA	MMU
Informants	Professor Dr. Abd Karim Alias	Associate Professor Dr. Awanis Binti Romli	Dr. Tenku Putri Norishah Tenku Shariman
Institutional Position & Professional Experiences	• Director, Centre for Development of Academic Excellence (CDAE), USM • Director of Micro-credentials Committee, directly reporting to Vice Chancellor of USM • Founder of USM's micro-credentials since 2018; pioneers the development of micro-credentials in Malaysia • Renowned guest speaker, trainer, discussants in various micro-credentials -related talks, seminars and forums	• Director, Centre of Instructional Resources and e-Learning (CIReL), UMPSA • Director of Micro-credentials Committee, directly reporting to Deputy Vice Chancellor (Academic) • UMPSA offered 70 new micro-credentials between 2021–2024 under her leadership • Established collaboration with international universities and industry players	• Director, Centre for Lifelong Learning and Education Content Development (LEAD) • Director of Micro-credentials Committee, directly reporting to the President of MMU • Pioneering Master's degree via micro-credentials (the first university in Malaysia to offer a Master degree entirely through micro-credentials) • Guest speaker & discussant at various micro-credentials related forums

ately guided and addressed, the researchers had communicated the intended content to the interviewees beforehand. During the interview, the researchers also facilitated the online interview session with a PowerPoint slide that indicated the main contents. This step was important to assist the interviewees in focusing and navigating through the topical points. The researcher also clearly segregated the contents on topical basis to promote smooth flow of inquiry communication.

As a qualitative study, the essence of reliability lies in the consistency, with a tolerated acceptable margin of variability for the results (Carcary, 2009; Grossoehme, 2014). Validity in qualitative research dictates appropriate use of tools, processes, and data (Leung, 2015). Therefore, the researchers carefully planned out the inquiry framework to ensure that the themes and their respective topical inquiries aligned with the research objective to optimize the probability of attaining consistency. To address validity, researchers followed recommendations of Leung (2015) that is to employ appropriate methodology and research design, which included prudent sampling technique, sample selection, and data analysis. Researcher also made sure that the research outcomes (results and conclusions) were tailored to the specific context of the study and its samples.

For the purpose of interview recording and transcription, researchers employed note-taking and benefited from the video-recording function of Microsoft Teams. However, the latter was done with the consent of the participants because recorded data could be a source of danger given its incontrovertible nature. This data was carefully guarded and destroyed once the analysis was done (DiCicco-Bloom & Crabtree, 2006).

In order to ensure the inputs solicited were able to address the research issue raised aptly, thorough literature review was carried out to identify relevant aspects of focus for the interview. Researchers made sure that these identified aspects aligned with the Research Objectives. Tabulated in Table 2 are the underlying themes for the interview and some examples key questions asked during each the interview session.

3.4 Data analysis

Data analysis-wise, this research was generally inductive and researchers conducted thematic analysis to identify themes and patterns of themes which were later interpreted for their inherent meaning (Braun & Clarke, 2006). Practically, the researchers conducted thematic analysis on the online interview transcripts, reading through them line by line, and noted down the themes as they appeared (Bryman, 2012; Bryman & Bell, 2019). In carrying out thematic analysis, researchers were careful to solicit what was said rather than how it was said (Bryman & Bell, 2019). With the contents being the core, themes were identified based on how frequently certain incidents, phenomena, words, phrases, etc. were repeated (Bryman, 2019; Saldana, 2021; Wicks, 2017).

For a comprehensive step-wise procedure, the current research followed Creswell's (2007) case study procedures and analytic strategy which are tailored to addressing multiple cases. There are four main steps. Guided by Creswell's procedure, firstly, data collection through interviews was carried out. Secondly, within-case analysis was done by providing detailed descriptions of each case, based on which themes were extracted. Thirdly, a thematic analysis across the cases (cross-case analysis) was

Table 2 Research objectives, underlying themes, and examples of key questions

Research Objectives	Underlying Themes	Examples of Key Questions
1. To garner understanding on the practical implementation of micro-credentials in Malaysia	• Motivation of initiating micro-credentials at the selected university • Practical stages of micro-credentials development	• Are micro-credentials in your university a top-down directive? • How do you evaluate your micro-credentials's achievement? • What are the steps practically taken to establish micro-credentials course.
2. To provide recommendations & implementation pathway for nascent micro-credentials developers in Malaysia	• Establishment of micro-credentials committee • Leadership and accountability for micro-credentials • Composition and capacity of micro-credentials committee	• Is there any institution/ responsible centre particularly assigned to oversee/monitor the development of micro-credentials in your university? • What are the significant basic functions & activities one micro-credentials responsible centre/institute should have? • At the initial stage of micro-credentials, what is the size of the working committee/ responsible centre in charge of micro-credentials? • What is the composition, for example the leader and different roles and expertise assigned? Academic & non-academic? • Who heads the responsible centre?
	• Identification of customers, revenue models & marketing strategies • Pricing strategies & affordability	• Who are your target customers? • At the beginning of the micro-credentials implementation, how did your university market its micro-credentials to its customers? • What kinds of platforms used to market & promote its micro-credentials?

carried out by identifying issues within each case and looking for common themes that transcended the cases. This brought to extraction of patterns of themes. Finally, the patterns of themes were interpreted to bring forth the meaning of the cases. This analytic strategy dictated much of the way as to how the discussions of results are organized.

4 Result

4.1 Micro-credentials in USM, MMU and UMPSA

According to USM, currently, micro-credentials implementation among HEIs in Malaysia is in the infancy stage. Nevertheless, micro-credentials are already seen as a potential game changer and the answer to flexible education due to its dynamic nature. Aligned with the potential of micro-credential, MMU shared that although some universities are ready for micro-credentials while some hesitate, the Malaysian Ministry of Higher Education (MOHE) is working to introduce a national framework of micro-credential for Malaysian universities.

All three HEIs examined in this study implemented micro-credentials to comply with a top-down directive from the Malaysian's Ministry of Higher Education. USM, implemented micro-credentials in year 2018 while UMPSA and MMU offer micro-credentials in year 2020. USM's School of Management and School of Pharmacy

are the two earliest schools that implemented micro-credentials. USM classifies its micro-credentials development into six stages which are the conception of ideas, identifying the target program, training course developers, developing the program, deploying quality control, and lastly publishing the material to the public. UMPSA also entails a systematic progression through three main stages before releasing the micro-credentials courses to the university's online platform, ILMU for public access. The stages start with an in-depth study of job market trends, job postings, and consultations with industry professionals. This process is important to develop targeted and up to date offerings that align with employers' demands. Next, content development process starts, follow by internal evaluation by expert panel assessors, and then external assessment by renowned subject matter experts. All these processes are to ensure the content and delivery of the developed micro-credentials are of the finest quality.

MMU executed a micro-credentials module known as the Executive Leadership program to TELEKOM Malaysia, its parent company starting March 2021 and this program is mandatory for TELEKOM Malaysia's executives and employees. This heightened the visibility of micro-credentials in MMU and motivated MMU to extend micro-credentials to other conventional programs such as MBA and Computer Sciences. MMU follows five micro-credentials stages before making the materials available to public. Similar to UMPSA, in the first stage, a survey is conducted to identify suitable courses and to ensure these courses are aligned with market needs. Next, the course content is developed, reviewed by subject matter experts and then suitable storyboard and digital content is created. Lastly, the content developer applies for copyright, and the course is ready to be enrolled by public.

Table 3 Composition of micro-credentials committee of USM, UMPSA and MMU

USM	UMPSA	MMU
1. Vice Chancellor 2. Deputy Vice-Chancellor (academic) 3. University Bursary 4. 3 USM campuses' directors 5. Leader of USM micro-credentials working committee, housed under the Centre for Development of Academic Excellence (CDAE) 6. CDAE staff 7. 26 micro-credentials representatives from faculties **Assisted by additional entities for marketing**: Not mentioned	1. Deputy Vice-Chancellor (academic) 2. Deputy Vice-Chancellor (Strategic Plan Quarterly) 3. Director of UMPSA's micro-credentials working committee housed under the Centre of Instructional Resources and e-Learning (CIReL) 4. CIReL staff 5. Representatives from faculties **Assisted by additional entities for marketing**: 1. UMPSA Advance (subsidiary company)	1. President of MMU (equivalent Vice Chancellor), 2. Director of Finance Deans, 10 faculties 3. Director of Quality Assurance Centre, 4. Director, the Centre for Lifelong Learning and Education Content Development (LEAD) 5. LEAD staff 6. 10 micro-credentials Champions (coordinator at faculty level) **Assisted by additional entities for marketing**: 1. MMU Marketing Department (University level) 2. Cynergy, MMU's subsidiary marketing company

4.2 Composition of micro-credentials working committee

Each of the HEIs examined in this study has set up their micro-credentials committee as summarized in Table 3. Within the micro-credentials committee, each case has also established a specific working committee which is consigned to oversee the planning and development of the HEI's micro-credentials initiative or portfolio. In all cases (USM, UMPSA, and MMU), the micro-credentials working committee is not a standalone centre, but rather under a university-level centre responsible for e-learning and academic development. The centres are USM's Centre for Development of Academic Excellence (CDAE), UMPSA's Centre of Instructional Resources and e-Learning (CIReL), and MMU's Centre for Lifelong Learning and Education Content Development (LEAD). The HEI leaders sit at the top of the micro-credentials committee and there are also micro-credentials representatives from each faculty.

Also noticeable across the cases is that micro-credentials working committees also receive supports from additional entities for the marketing and outreach purposes. For instance, UMPSA's micro-credentials working committee is supported by its own subsidiary company, UMPSA Advance. For MMU, the professional marketing is carried out by MMU's own subsidiary company, MMU Cynergy and MMU's university's marketing department. However, these entities are not comprised within the micro-credentials committee and are standalone external entities. Although the size of the micro-credentials committee is rather small for such an immense duty, USM asserted that:

> *…the continuity and success of USM's micro-credentials heavily depending on the collective commitment shouldered by the whole micro-credentials committee. For example, the first rolled out of USM's micro-credentials program such as the nursing and pharmaceutical attribute their rapid kick-off to the strong commitment of the coordinators at the faculty level and the respective deans who worked very closely with them…*

Likewise, UMPSA reflected that although the size of their micro-credentials working committee is small and challenging at times, but the good collaborative bonding formed within the committee is the key.

> *…all works of recording, running workshops and many others are carried out together. There is also a WhatsApp group set up to facilitate completed and current work progress. There is also a specific rubric given to help verify the progress. The university's top management is supportive in terms of financial support request for a studio, facilities and devices used for hybrid classroom, micro-credentials module development, and live lecture recording…*

MMU heightened that:

> *…every university that are interested to implement micro-credentials should have a working committee established at the university level. MMU's micro-credentials working committee works closely with the faculties and subject mat-*

ter experts to develop the content of the courses. In order to nurture and grow micro-credentials, MMU makes it mandatory that all faculties should offer at least one standalone micro-credentials course…

Further, to coordinate the MMU's micro-credentials initiatives at the faculty level, a coordinator entitled micro-credentials champion is placed at each of its ten faculties. Similarly, USM enlightened that, although the micro-credentials working committee is directly held accountable for the tactical development and implementation of USM's micro-credentials initiatives, the real power runners that mobilize USM's micro-credentials are its 26 micro-credentials representatives at the faculties, one from each of the 26 faculties.

According to USM, specific criteria of micro-credentials representative candidates are carefully outlined and provided to the Heads of Departments or the Deans. Later, the 26 representatives were carefully hand-picked, and official appointments were provided to the micro-credentials working committee. Some of the important recruitment criteria for micro-credentials representatives include the existence of one's experience in conducting online courses, ones who are highly active and passionate, someone who walks the talk, resource person, and someone who has a strong portrayal of a role model at their respective faculty.

After the appointment, micro-credentials representatives were given training, detailed explanation of their role and duties, expectations, exposure, timeline, and deliverables. These 26 representatives become the focal links between the micro-credentials working committee and the faculties as well as customers.

4.3 Continuity and sustainability strategies

As far as micro-credentials continuity is concerned, the revenue or sustainability model is one of the most challenging avenues. This boils down to the practicality of getting the most profitable customer segment through sound strategies. Table 4 summarizes the interview outputs for the target customer segments, marketing strategies, and payment options.

All three HEIs have developed at least one distinct customer segment to focus on. USM's most lucrative customers are the segment of professional practitioner who needs to fulfil their continuing professional development (CPD) requirement. This customer segment includes professionals such as pharmacists, nurses, doctors, and lawyers. USM captures this customer segment through strategic partnerships with the identified industry player. According to USM:

…one successful micro-credentials deal is the partnership established with the Malaysian Pharmacist Society (MPS), which brings about 18000 registered pharmacists. MPS endorses USM's micro-credentials programs and makes them legally eligible to their registered pharmacist members. These pharmacist members are required to accomplish at least 50% of their CPD with USM's micro-credentials modules…

Table 4 Target customer segments, marketing strategies and payment options of cases

	USM	UMPSA	MMU
Target customer segment	1. Professional practitioner in need of CPD (paid by employees or self-financing) E.g.: pharmacists, nurses, doctors, lawyers	1. Local working adults who need to fulfil the requirement of upskilling & reskilling 2. Local workers who wished to enrol into the university through APEL A 3. UMPSA's own students	1. Adult learners 2. Local SPM holders 3. MMU's own students 4. Working adult (sponsored by employee) 5. Working adult (self-financing) 6. International students recruited through paid private recruit agents (E.g.: Indonesia, Middle East)
Marketing Strategies	1. Partnership with local industry players 2. Partnership with international counterparts and industry players 3. Customize micro-credentials courses according to the need of industry players. (Eg: Nursing courses for Middle East segment) **Note**: Marketing through paid recruit agent: No	1. Partnership with local industry players (recurring demand) 2. Marketing and networking through Education University of European Countries (EURIE), an international conference and exhibition platform for alumni universities (alumni network), to attract international learners **Note**: Marketing through paid recruit agent: No	1. Partnership with local industry players 2. Partnership with international counterparts through franchising strategy to capture international learners 3. Customize micro-credentials course to adjust value propositions 4. Marketing through paid recruit agent to attract international learners **Note**: Marketing through paid recruit agent: Yes
Payment options	Offers flexible payment options 1. Upfront payment model 2. Subscription model	Offers flexible payment options 1. Upfront payment model 2. Subscription model	Offers flexible payment options 1. Upfront payment model 2. Subscription model

For the case of UMPSA, its micro-credentials customers' segments are made up of staff or working adults from the industry who undertake micro-credentials to fulfil the requirement of upskilling & reskilling, workers who wish to enrol in the local university through APEL A (accreditation of prior learning experience - admission) and M (micro-credentials) as credited to their industry and work experience, and UMPSA's own students. According to UMPSA:

> *…for working adults with adequate experience that are not eligible to enrol into the university during their younger years due to unfavourable Sijil Pelajaran Malaysia (SPM) results*, *now can do so in UMPSA via APEL A and M…*

Besides adult learners and SPM holders, MMU's own students are also undertaking the micro-credentials courses. According to MMU:

> *…this group does it more for professional growth. For example*, *students from the Faculty of Management take the data science micro-credentials course for curriculum vitae's embellishment*, *aiming at employability enhancement…*

MMU also receives international learners which are recruited through recruitment agents paid by MMU. Among these are students from Indonesia and the Middle East.

Previously during the COVID-19, MMU also received students from China. However, this customer segment has since reduced as the Chinese government ceased to recognize open distance learning (ODL). According to MMU, in order to revive this potential yet idle customer segment:

> *…MMU discusses with the Chinese government on the potential of offering the program via face-to-face course. For this new value proposition offering, the micro-credentials course may be offered in partnership with an institution in China through a franchising strategy…*

All cases adopted innovative marketing strategy, for example USM creatively customizing its micro-credentials courses to capture spin-off opportunities by offering existing micro-credentials program in the language of the prospective learners outside Malaysia.

> *…as USM's nursing micro-credential program slowly gaining popularity, the Middle East industry players express their interest on our nursing program. Therefore, using the same content, subtitles are added and voiceover are customized. Such spin-off is feasible because micro-credentials program is made in the modular format…*

UMPSA acquires its customers through partnerships with the identified industry players, especially focusing on those of recurring demand within Malaysia. However, recently, UMPSA also ventured into the international market.

> *…the Education University of European Countries (EURIE) platform is a great venue for UMPSA to network and promote our micro-credentials programs to international learners as EURIE is a platform that gathers exhibitions and conferences for European alumni universities…*

MMU capitalizes on a good network of alumni and industry partnerships to reach out to international customers. MMU Cnergy plays a critical role in recruiting clients among those who are paid, financed, or sponsored by their employers for the purpose of CPD requirements or other purposes of upskilling or re-skilling. This particular customer segment forms the most profitable customer base for MMU's micro-credentials courses.

All cases take advantage of the flexible payment options to attract customers. The flexibility in payment mode caters to affordability. The two prominent payment options offered are the upfront payment model and the subscription model.

4.4 Progression and collaboration

USM, UMPSA and MMU all agree that the development and implementation of micro-credential among universities in Malaysia are progressing. MMU highlighted that more industries are turning to micro-credentials for the purpose to upskill and reskill their employees. According to MMU:

…micro-credentials are becoming more attractive as compared to MBA due to flexibility, affordability and shorter duration and there is a possibility that micro-credential will replace traditional degrees in the future given the current generation highly favours flexibility…

MMU added that:

…professional bodies can collaborate with universities to develop related micro-credentials courses and these courses can be used for learners that apply for certification from the collaborated professional body…

USM recommends building awareness among the industries on micro-credentials offered in universities. As such, the Malaysian Human Resource Development Corporation (HRD Corp) has launched micro-credentials initiatives through a collaboration between the Ministry of Human Resources and the MOHE which will popularize micro-credential among industries. According to UMPSA:

… UMPSA offers micro-credentials industry where academicians in UMPSA collaborate with companies to develop the course content. The inclusion of industries' input as case studies, further increase the relevancy of the developed micro-credentials…

MMU also highlighted the need for collaboration among universities through micro-credentials credit transfer:

…as a Government-Linked Company university, MMU has actively engaging in collaborative efforts with Universiti Tenaga Nasional, Universiti Teknologi PETRONAS and Universiti Kuala Lumpur to create micro-credentials courses across various programs. These modules will receive recognition from all Government-Linked Company universities…

Furthermore, MMU also collaborates with other international universities to jointly develop micro-credentials content. This creates a strategic move towards collaborative models for future micro-credentials development, where universities cooperate externally instead of working individually.

5 Discussion

5.1 To newcomers: Setting up micro-credentials committee

For nascent micro-credentials start-ups, it is of utmost importance to form and put in place specific micro-credentials working committee to plan, manage, monitor, and scaffold the development process of the university's micro-credentials initiatives from the onset. This is in line with the guidelines underlined by MOHE that, every

university that intend to embark on micro-credentials should have a specific working committee established (Malaysian Qualifications Agency, 2020).

This study found that although USM, UMPSA and MMU have slightly different compositions of micro-credentials committees, all three cases have four similar main parties that transpire across their micro-credentials committees. These parties are namely the university's highest leadership, leaders at the faculty level, the specific working committee or centre managing the university's micro-credentials, and coordinators or representatives from each faculty. This pattern of committee composition resembles the three levels of organizational decision-making model, namely the strategic, tactical and operational planning and management (Yorks et al., 2022).

The theoretical notion underpinning this Strategic-Tactical-Operational (STO) decision making model is that effective planning and implementation requires understanding about the global goal desired by an organization (strategic level) and the specific courses of actions (tactical and operational level) developed to achieve the strategic goal.

Figure 1 depicts a proposed blueprint for establishing micro-credentials committees. At the strategic level, top university leadership ensures alignment with academic objectives and quality standards. Moving to the tactical level, the micro-credentials working committee takes charge, led by a designated leader. The Director of University's Teaching and Learning Centre offer expertise in pedagogy and instructional design. Representatives from the university's marketing departments contribute insights into market trends and promotional strategies. The Centre of Academic Excellence Development ensures adherence to best teaching and learning practices.

On the operational front, representatives ensure coordination across administrative units. Faculty-level representatives of micro credentials serve as liaisons between the working committee and academic departments, facilitating integration. Meanwhile,

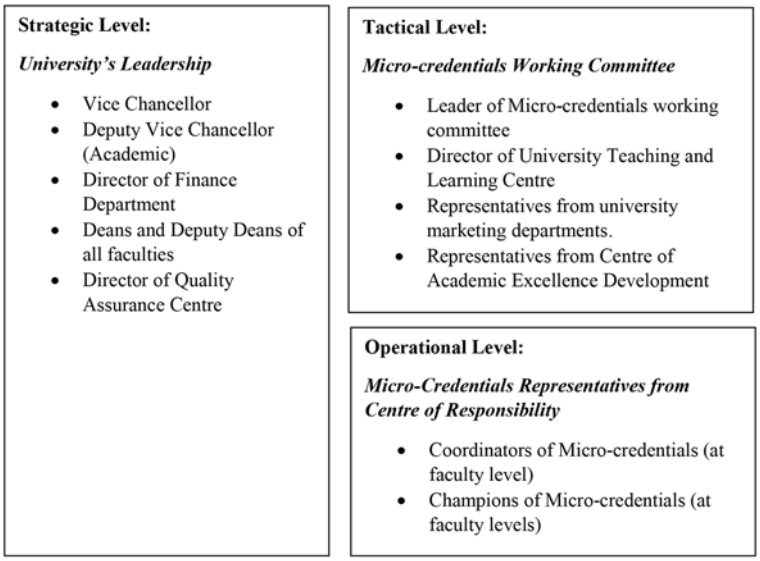

Fig. 1 Proposed blueprint for establishing micro-credentials committees

champions of micro-credentials at faculty or school levels advocate for the program and drive adoption.

This proposed blueprint echoed the effective micro-credentials core team presented by Bigelow et al. (2022) for micro-credentials ecosystem in Ontario where the support of senior executive team such as the vice-president, director and dean who believe and advocate micro-credentials implementation are as important as the involvement of the subject matter experts, specialist pedagogical, learning design and educational technology support. Brown et al. (2023) added that the success of micro-credentials is subject to the involvement of multiple stakeholders and working is silos should be avoided. Key collaborators such as international office, alumni office, graduation office, student union and employers can be included to ensure the success of micro-credentials strategy (Brown et al., 2023). In a survey on the potential of micro-credentials adoption, conducted by Pirkkalainen et al. (2023) among European Commission, quality assurance agencies, the private sectors and HEIs reaffirmed the significance of top-down guidance during the micro-credentials strategy development.

5.2 To newcomers: Identifying customers, revenue model, marketing strategies

The centre of any project or business continuity is a solidly defined revenue or sustainability model. It is likewise for the university's micro-credentials initiatives. First, the universities should identify potential customer segments and the most profitable ones. Secondly, universities are to develop sound marketing strategies to attract each of the targeted customer segments. These two constituents correspond to two of the nine components heightened in Osterwalder & Pigneur's (2010) business model canvas, which are customer and marketing channel segments. The business model by Osterwalder and Pigneur is a strategic management tool particularly useful for developing a new business model or start-ups (Shah & Zainudin, 2022).

The two tasks are illustrated in Fig. 2. At the tactical level,, potential micro-credentials customer segments are identified using market analysis to determine potential demand of the most profitable segments, which in turn decides the micro-credentials courses to be offered. Market needs analysis that based on learners' motivation (Keoy et al., 2024; Lyu, 2023) and Five W's and One H (MQA, 2020), are manifested as institutional context analysis, competitor analysis, demographic analysis, and data analytics. In all, only courses with affirmed demand should be offered. Likewise, the universities should also decide on how many customer segments to take on at a certain planned period based on their capacity. This prudent selective behaviour is important to mitigate risk. Customer segmentation also allows HEIs to allocate limited resources more efficiently during the first few years of the business operation.

It is noteworthy that the most profitable customer segments vary across the studied universities, despite legal resemblance as an institution of higher learning within the Malaysian context. The proposed pathway shows some consistencies with micro-credentials of other international universities. In the international practices, after forming committees in strategic level, a market survey to understand market needs and identify potential learners is essential for micro-credentials' success, as Mahlasela

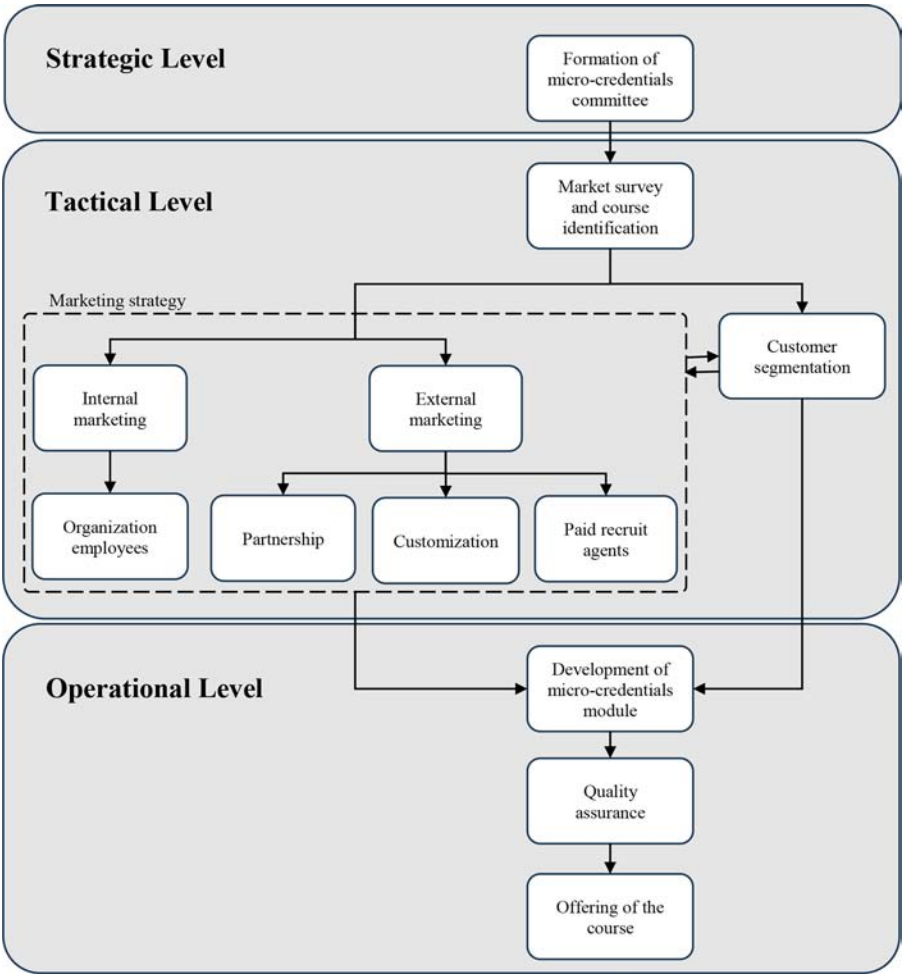

Fig. 2 A pathway of micro-credentials implementation according to STO levels

and Steyn (2023) conducted a study on South Africa, emphasized understanding market requirements to reduce inconsistent values of supply and demand.

With the target customer segments decided, universities progress into developing marketing strategies. The data collected demonstrate such strategies to encapsulate the internal and external marketing efforts. These marketing strategies aim at achieving competitiveness to attract prospective targets (Kamboj & Rahman, 2017). Internal marketing focuses on respectfully treating and valuing employees as internal customers in order to attract, develop, motivate, and positively affect employees' work attitudes and emotional investment toward the organization. The ultimate objective of internal marketing is to promote employees' engagement with the organization's desired objectives and goals (Reed et al., 2016).

Data collected reveals the three main tactical approaches used by USM, UMPSA and MMU for external marketing are partnership, creative value proposition offer-

ing (e.g., through customization), and marketing through paid recruit agents. The former two involve direct dealing between the universities and partners, while the latter is carried out through intermediary parties. Among these tactical approaches, data indicates partnership as the most prominent marketing strategy employed by the cases examined.

In particular, the first tactic, in partnership, the examined cases capitalizing on the network of alumni and industry players. Hence, the partnership variations include collaborations with local industry players to attract customers, local training institutions to capture learners, and international counterparts to reach global students. Internationally, most of the HEIs in South Africa target micro-credential courses for postgraduates within universities, or collaborate with industrial employers (Mahlasela & Steyn, 2023). Similarly, HEIs in New Zealand and Australia implement strong partnership tactic to support portability and validation of credentials (Selvaratnam & Sankey, 2021), while simultaneously enhancing employability (Mahlasela & Steyn, 2023; Reynoldson, 2023). These partnerships are backed by government funding and regional cross-border collaborations among universities, commercial entities such as IBM and Amazon, and digital enterprises like banks (Reynoldson, 2023; Selvaratnam & Sankey, 2021).

The second tactic, creative value proposition offering approach is observed as related to the capturing opportunities in face of unexpected change. Data collected from the three HEIs indicates that, opportunities breed from challenges and problems. Micro-credentials newcomers who identify a problem or challenge would need to creatively turn them into a value proposition. Customization is one of the thinking hats used. One such good example is USM's offering of nursing micro-credentials courses to the Middle East customer segment by customizing it to fit their language. Similarly, MMU tackles China's post-COVID policy change and rejection to ODL by provide face-to-face courses through franchising.

Lastly, the third tactic, marketing is carried out through paid recruit agents for HEIs who intend to recruit international learners. International marketing effort can be better performed by professional recruit agents, and it is also more cost effective. This condition is consistent with the principle of cost-driven strategy which aims at minimizing cost by employing competitive alternative like outsourcing that gain cost privilege (Edvardsson et al., 2020). However, this study reckons that employing service of recruit agent may not be a compulsory immediate marketing strategy for micro-credentials start-ups. Most importantly, micro-credentials newcomers should first establish solid micro-credentials working committee within the university and work closely with the marketing supporting entities of the university.

In operational level, the development of the micro-credentials module and quality assurance are pivotal processes before offering a course to the public. Data collected suggests the importance of teaching innovation can be manifested in the development of micro-credentials modules. HEIs can also opt to integrate micro-credential initiatives with current institutional programs, thus amplifying micro-credentials value added benefits for all stakeholders (McGreal & Olcott, 2022). Pawilen et al. (2024) proposed a quality assessment framework for Japan and Philippines universities to assess the operation of micro-credentials, based on factors such as teaching quality, internationalization, innovation, compliance to government's education standards,

contribution to sustainable development goals, and many more. Another worth-noting competitive feature notable in micro-credentials by other international universities is thorough co-designing and co-development of micro-credentials courses' curriculum with industry players. One such exemplary micro-credentials course's co-designing is the teaching of mathematics for engineering students by Swinburne University of Technology Melbourne, Australia (Cook, 2021).

6 Conclusion

Micro-credentials implementation in Malaysia is in the infancy stage, therefore the references to success stories are usually from overseas universities that have different ecosystem and environment. Despite being a relatively new concept, micro-credentials adoption is gaining momentum due to its dynamic nature and the Ministry of Higher Education Malaysia's call for flexible education.

In all, the findings of this study contribute to micro-credentials policies, practices, and theories. Firstly, it offers MQA insightful guidelines to develop micro-credentials policies, offering a structured approach to start up micro-credentials in Malaysian HEIs. These guidelines can serve as a national benchmark, ensuring consistency and quality across institutions. Secondly, this study provides a practical viewpoint on Malaysian micro-credentials experience and a comparison to other international micro-credentials counterparts. The insights gained from this comparison serve as a valuable resource not only for Malaysian institutions but also for higher education institutions worldwide, offering a framework that others can adapt to their local contexts. Lastly, this study enriches the existing literatures and shed light on micro-credentials implementation within the theoretical framework of STO. The blueprint and pathway diagrams for establishing micro-credentials will be particularly beneficial for newcomers that intend to develop and implement micro-credentials.

This study is limited by its focus on three Malaysian HEIs, including two public and one private university, representing varying stages of micro-credentials adoption. Future work can include a broader range of local and international universities to capture diverse educational contexts. Additionally, there is also potential to explore micro-credentials offered by companies and training providers, comparing their implementation processes with those in HEIs. Longitudinal studies tracking the evolution and impact of micro-credentials over time could provide foresights into long-term impacts and trends.

Finally, there is no one-size-fits-all approach that will guarantee the success of micro-credentials execution. Three HEIs in Malaysia with different background, ecosystem and micro-credentials implementation stages had been presented in this study, along with a detailed blueprint on micro-credentials core team composition and micro-credentials implementation pathway. Ultimately, this study provides potential micro-credentials providers in Malaysia or other international institutions a references of micro-credentials best practices and then tailor-made their own micro-credentials approach suitable within their institution's ecosystem and higher education landscape.

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Predicting Learners' Agility and Readiness for Future Learning Ecosystem

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Abstract: Agility and future readiness are fundamental 21st-century skills that could guide university students globally to thriving and benefiting from a VUCA—volatile, uncertain, complex, and ambiguous—world. The ability to respond flexibly, make informed decisions, and adapt to rapid change reflects future-readiness capabilities. However, little is known about the empirical role of the university curriculum, learning ecosystem, and learning experience as perceived by university students in developing these skills. Therefore, we analysed data collected from 209 Malaysian university students from 16 universities to assess whether these three pertinent factors impact the students' learning agility and determine how well learning agility predicts learners' future readiness. The present study empirically assessed a theoretical model using a partial least squares structural equation modelling (PLS-SEM) approach. The analysis supported all the hypotheses proposed in this study, which implies that the extended model could effectively predict learners' agility and future readiness. The results revealed that the university learning experience, ecosystem, and curriculum positively, directly, and significantly affected learning agility and future readiness. Furthermore, the findings showed that student agility significantly mediated the relationships between the student learning experience, university learning ecosystem, and curriculum and student future readiness. Taken together, these results highlight the importance of a future-ready education nurtured by a vibrant learning ecosystem that delivers lasting values and experiences for students and communities to appreciate the opportunities for a challenging yet exciting future offered by a VUCA environment. The established empirical model describing the empirical interplays between these correlates could, in turn, aid better evidence-based policy making in higher education.

Keywords: learning agility; future-ready; future learning experience; university ecosystem; 21st-century curriculum

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1. Introduction

In 2021, The Malaysian Higher Education Ministry officially launched The Experiential Learning and Competency Based Education Landscape (EXCEL) framework developed by the Ministry together with the Malaysian Qualifications Agency, government agencies, industries, and public universities to support a holistic student learning experience at Malaysian universities (Department of Higher Education, Malaysia, 2021). The framework outlined four experiential learning thrusts, namely Industry-Driven Experiential Learning (IDEAL), Community Resilience Experiential Learning (CARE), Research-Infused Experiential Learning (REAL), and Personalised Experiential Learning (POISE). IDEAL provides an immersive learning experience for learners to work and study within an industrial context, whereas CARE brings students to learn with the community, fundamentally enhancing their roles within a society. REAL nurtures learners to be explorative and research-minded via undertaking research projects with scientists and other stakeholders. POISE will enable learners to personalise their self-designed learning curriculum according to their passions

and interests, nurturing them to become active lifelong learners. As a result, it is necessary to assess students' readiness in terms of agility.

Learning agility research has shed new light on the study of the education of the future and has inspired the development of a new body of research, both of which have contributed to deeper comprehension of learning agility and its key role in the future education ecosystem [1–3]. In today's inter-related and complicated world, having a better understanding of learning agility is critical. The only way for an organization to stay ahead of the curve is to acquire knowledge more quickly and effectively than its rivals do. Educational sectors and individuals must work harder than ever to keep up in today's ever-changing technological landscape. Educational institutions all over the world are incorporating a learning agility culture into their daily operations to deal with the ever-changing dynamics of business, come up with novel solutions to problems, strengthen resilience, and prepare for the future. It is now one of the foundational principles that encourages a more welcoming and creative work environment for everyone. The same holds true for individuals, who must adapt to the new realities of information and communication technologies. As a result, these new technologies have the potential to improve learners' agility. The biggest challenge that higher education leaders, educators, and learners must overcome is the rapid change offered by the VUCA environment. To successfully lead and manage learning in these times of rapid change, leaders, educators, and learners must master agility [4,5]. Agile leaders, educators, and learners are adaptive, flexible, and keenly aware of their surroundings. The significance and relevance of learning agility in Malaysian future citizens cannot be overstated. However, there is still a dearth of understanding regarding learning agility, especially in the Malaysian higher education context. A vast number of educational researchers, policy makers, principals, instructors, and administrators are researching, evaluating, and implementing various solutions and strategies to strengthen higher education, whether on their own campuses or across the industry. However, there is one factor that is essential to adjusting in times of uncertainty, and that factor is learning agility. As a result, new information about the higher education ecosystem, like it is for any other industry, is critical as the area of higher education continues to change dramatically. In today's constantly changing world, learning agility is a vital indicator of higher education success that must be assessed, analysed, and evaluated. The purpose of this study is to look into Malaysian students' behaviours regarding future education, their agility, and how students perceive the future learning experience, curriculum, and the overarching higher education ecosystem. Although there are several research studies on future teaching and learning that explain factors underlying students' experiences in the current educational system in general and higher education in particular, limited research has looked into the relationships between curriculum, experience, and ecosystem of future education using a structural equation model.

2. Literature Review

2.1. Learning Agility

Learning agility is a relatively new term drawn from the field of organisational behaviour that refers to the desire and capacity to enhance experiential learning and later adapt that learning to new settings [6,7]. Learning agility refers to an individual's ability to learn from experience. Lombardo and Eichinger [7] defined learning agility as "willingness and ability to learn new competencies to perform under first time, tough, or difficult conditions" (p. 323). Learning agility has been discovered to be a strong predictor of success and high performance. According to different research findings, learning agility is a powerful predictor of future success since it stresses the capacity to adapt, adjust, and expand individuals' learning styles to deal with new circumstances [6,8]. In a study conducted by Lombardo and Eichinger (2000), learning agility was found to predict the extent to which people performed well in their current job and had the potential to progress to the next one. According to Lombardo and Eichinger [7], learning agility is classified into four categories: people agility, mental agility, change agility, and results agility. Each

one has unique abilities and a distinct description that distinguishes it from the others (see Table 1).

Table 1. Different aspects of learning agility (Adapted from Ref. [7], p. 324).

	Agility Element	Description
1	People	Describes people who know themselves well, learn from experience, treat others constructively, and are cool and resilient under the pressures of change.
2	Results	Describes people who get results under tough conditions, inspire others to perform beyond normal, and exhibit the sort of presence that builds confidence in others.
3	Mental	Describes people who think through problems from a fresh point of view and are comfortable with complexity, ambiguity, and explaining their thinking to others.
4	Change	Describes people who are curious, have a passion for ideas, like to experiment with test cases, and engage in skill-building activities.

According to Lovell et al. [9], considerable attention is paid to the factors that impact students' learning agility and how agility enhances students' future readiness. Some of the factors known to influence learning agility are experience, curriculum, and ecosystem. In addition, previous studies confirm that learning agility might improve future readiness [10,11]. Thus, the current study looks at these factors that impact students' learning agility and determines how well learning agility predicts learners' future readiness in Malaysian tertiary students. Based on these insights, the following hypothesis is proposed:

Hypothesis 1 : *Student learning agility positively affects student future readiness*.

2.2. Learning Experience

Scholars in teaching and learning have indicated that learning occurs via interactions between individuals and/or groups wherein experiences and ideas are exchanged and implemented to develop new knowledge [12,13]. In education theories, individuals are described as active learners who grow via lived experience [14–16]. The capacity of people to learn through experience allows them to succeed at a skill in a world where change is regarded as a need and learning is becoming an increasingly critical aspect of success [17,18]. As mentioned earlier, learning agility focuses on the capacity to learn new activities and the ability to learn from experience to perform well in new settings. Learning agility is a notion that helps us understand how people learn from their experiences in ways that improve their performance. As a result, personal experiences provide valuable learning opportunities.

Furthermore, although learning agility is thought to be predictable by learning from experiences, earlier studies on the relationship between learning experiences and learning agility yielded contradictory results. As a result, the impact of learning experiences on improving students' learning agility is still unclear. Understanding the effects of learning experience on learning agility could have practical and theoretical implications. First, educational sectors and organisations will be able to target development opportunities for individuals who are more likely to use what they have learned in previous experiences in the future. Second, researchers will be able to better understand the relationship between learning experience and learning agility. Therefore, the following hypothesis is posited:

Hypothesis 2 : *Learning experiences positively affect students' learning agility*.

2.3. Future Curriculum

A future-focused curriculum, according to Sinnema and Stoll [19], "presents ambitious goals for reach impacts and the kinds of learning that would indicate success" (p. 12). Ornstein [20] stated that, with regards to a future curriculum, many significant factors

are predicted to influence curriculum development. Lifelong learning, international collaboration, and communication are among them. Research reveals that learning must be collaborative as well as collective, with new paths for knowledge advancement [21–23]. In terms of curriculum, learning must concentrate on curriculum change, recognise what the curriculum changes are and what they signify, understand how to respond to curriculum changes, and finally develop a practice to meet the curriculum objectives [19]. Despite the importance of future curricula in students' learning agility and future readiness, research on the impact on learning agility in higher-education contexts is limited. Furthermore, demonstrating that a person's future readiness results from the relationship between the future curriculum and learning agility would add to the significance of learning agility in higher education. Therefore, the present study will examine the effects of the future curriculum on learning agility and future readiness in Malaysian tertiary education. Based on these insights, the following hypotheses are proposed:

Hypothesis 3 : *Future curriculum positively affects students' learning agility.*

Hypothesis 4 : *Future curriculum positively affects students' future readiness.*

2.4. Future Learning Ecosystem

The learning ecosystem concept helps organisations in understanding how learning occurs as a dynamic process of interaction between a range of components across location and time [24]. A comprehensive learning ecosystem is a collection of all learning solutions and materials that can help educational institutions promote learners' development. Therefore, educational institutions must ensure that all students have access to learning opportunities, which contributes to the institution's learning ecosystem. The influence of the ecosystem on students' learning highlights the need to reconsider the future classroom's structure to make them more flexible and adaptable [25,26]. The readiness of learners to make the transition from the current ecosystem to the future one should be a primary consideration during the design phase of future ecosystems. Future ecosystems will rely heavily on communication and information technology. Intelligent technologies and smart devices can assist students in developing their skills in future learning environments. Future educational ecosystems will benefit greatly from the smart learning environment's potential to facilitate the development of novel pedagogical approaches. As a result, creating learning ecosystems that leverage smart learning to improve students' educational experiences will be a significant challenge. The education industry can determine which models are the most effective by observing students' unique characteristics, academic progress, and personal development, as well as experimenting with new instructional methods. To tackle the challenges of the future ecosystem, educational institutions must reimagine their teaching and learning approaches. With the appropriate adaptations, future classrooms might be effective in meeting ever-increasing student demands and ensuring satisfying learning results. Research suggests that future learning ecosystems will include the most recent stage of development, solutions, equipment, and technology that will prepare students for the future (future readiness). In addition, future learning ecosystems must address both theoretical and methodological perspectives, tackling how future ecosystems expand to new ways of approaching the complicated subject of environmental issues that emerge in dynamic ways through time and space. In order to gain a competitive advantage, future learning ecosystems should embrace the use of technology in teaching and learning. Although the future ecosystem plays a vital role in students' learning, there has been little research into the role of the future ecosystem on learning agility and future readiness in higher education contexts, which is an important feature that requires further investigation. Therefore, the current study proposes that the future ecosystem improves students' learning agility and makes them future-ready. Consequently, the hypotheses regarding the future ecosystem are stated below:

Hypothesis 5 : *The ecosystem positively affects students' learning agility*.

Hypothesis 6 : *The ecosystem positively affects students' future readiness*.

2.5. Future Readiness

It is self-evident that education must prepare individuals for future employment and life. According to recent research, "future-readiness demands cultural sensitivity, adaptability and the ability to think across multiple disciplines to find innovative solutions" [27] (p. 10). The development of a learner's future readiness needs a creative mindset and the agility to evolve and adapt constantly [28]. Tibbetts and Leeper [29] claim that education's future lies outside the traditional classroom, so various and related activities should be considered regarding technology immersion in educational settings. Therefore, it can be stated that in the education sector, the inclusion of the most recent technologies into the learning environment is critical to success. According to Clem and Junco [30], the "classroom of the future will look like an engaging social space, bringing forth vigorous conversation and debate while using technologies to help students collaborate, communicate, and build a sense of classroom community" (p. 526). As a result, future-ready learners should master new skills, develop a body of knowledge, and be eager to learn new skills [27,31]. This study argues that the key to future readiness is strongly reliant on students' learning experiences, future curriculum, future ecosystem, and learning agility. It also proposes that student learning agility mediates the impact of experience, curriculum, and ecosystem on students' future readiness. As a result, the following hypotheses are proposed:

Hypothesis 7 : *Students' learning agility mediates the relationship between the ecosystem and students' future readiness*.

Hypothesis 8 : *Students' learning agility mediates the relationship between the curriculum and students' future readiness*.

Hypothesis 9 : *Students' learning agility mediates the relationship between learning experience and students' future readiness*.

3. Research Methodology

The survey research method was used to collect data in this study. The survey was conducted using the SurveyMonkey questionnaire (https://www.surveymonkey.com/ (accessed on 1 August 2022)). The questionnaire was distributed to university students in Malaysia. All participants were drawn at random and voluntarily from public and private universities in Malaysia. Participants were informed of the purpose of the study as well as the strict confidentiality and anonymity of the survey. Prior to filling out the instrument, all participants were given a consent form.

A total of 209 valid questionnaires were obtained, forming the dataset for data analysis. In terms of educational level, 78.5% (n = 164) of the participants were undergraduates, 12.9% (n = 27) were graduate students, and the remainder were enrolled in diploma programmes. Regarding the participants' academic performance, survey respondents were asked to rank their level of performance in the classroom. The results indicated that only 1.4% of the participants rated their academic performance as "below average," while 74.6% rated it as "average." In contrast, nearly 17.2% of students rated themselves among the "top ten students" in their classroom. However, 6.7% of respondents claimed to be among the "top five students" in their classroom. The data for this study were gathered from students from various fields of study. At the time of the study, the majority of participants 64 (30.6%) were studying in the field of "Business Studies and Management Sciences," while 35 (16.7%) were studying in the field of "Social Sciences," and 28 (13.4%) were studying in the field of "Education and Training." The demographic information of the respondents is shown in Table 2.

Table 2. Demographic information of participants (n = 209).

Profile of respondents		Frequency	Percentage (%)
Education	Undergraduate	164	78.5
	Postgraduate	27	12.9
	Diploma	18	8.6
Academic Performance	Below average	3	1.4
	Average	156	74.6
	Among top ten students	36	17.3
	Among top five students	14	6.7
Field of Study	Business and Management	64	30.6
	Social Sciences	35	16.7
	Education and Training	28	13.4
	Others	82	39.3

4. Data Analysis and Results

The current study used the Partial Least Square-Structural Equation Modelling (PLS-SEM) technique with Smart PLS 3.0. to evaluate the proposed model and corresponding hypotheses. Partial least squares (PLS), a component-based SEM technique, is considered an alternative to covariance-based SEM. The component-based SEM technique addresses some of the constraints of covariance-based SEM, such as sample size requirements, conditional multivariate normality, and model complexity [32]. Furthermore, unlike covariance-based SEM, which is solely concerned with explanatory model testing, PLS-SEM allows for evaluating a model's prediction capabilities [33].

A two-stage procedure was used for data analysis and interpretation, as Hair et al. [33] recommended. First, the measurement model was examined to verify the proposed model's reliability and validity, and then the structural model was analysed to test the research hypotheses empirically.

4.1. Measurement Model Assessment

Reflective measurement models need to be evaluated in terms of their reliability and validity. Following Hair et al. [32] recommendations, four criteria were used to assess the measurement model: indicator reliability, construct reliability, convergent validity, and discriminant validity. First, the indicator reliability was assessed using standardised factor loading of latent variable indicators. When all indicator factor loadings surpass the cut-off value of 0.70, item reliability is regarded as satisfactory. The measurement model assessment results showed that all construct indicator loadings were above the thresholds, suggesting adequate item dependability (see Table 1). Second, the reliability of the latent variables is considered acceptable when Cronbach's alpha, Dijkstra-rho Henseler's (ρA), and composite reliability (CR) exceed 0.70. The measurement model assessment results revealed that all variables had values greater than 0.70, indicating construct reliability (see Table 1). Third, researchers need to examine the average variance extracted (AVE) and indicator loading for convergent validity. Indicators of a latent variable are said to have convergent validity when the AVE value of the latent variable is higher than 0.50 and all indicators load substantially on their respective latent variables with item loading of 0.7 or above (factor loading). The results revealed that all latent variables' AVE values and item loadings exceeded the recommended threshold values, signifying a satisfactory degree of convergent validity (see Table 3).

Table 3. Measurement model results.

Constructs	Loadings	Alpha	ρA	CR	AVE
Future Ecosystem		0.856	0.859	0.893	0.547
Ecosystem1	0.783				
Ecosystem2	0.776				
Ecosystem3	0.761				
Ecosystem4	0.774				
Ecosystem5	0.723				
Ecosystem6	0.756				
Future Curriculum		0.872	0.887	0.914	0.727
Curriculum1	0.903				
Curriculum2	0.910				
Curriculum3	0.862				
Curriculum4	0.721				
Learning Experience		0.876	0.880	0.915	0.730
Experience1	0.883				
Experience2	0.832				
Experience3	0.855				
Experience4	0.846				
Learning Agility		0.861	0.864	0.894	0.547
Agility1	0.707				
Agility2	0.760				
Agility3	0.716				
Agility4	0.799				
Agility5	0.756				
Agility6	0.713				
Agility7	0.719				
Future Ready		0.872	0.873	0.907	0.662
Future1	0.782				
Future2	0.814				
Future3	0.804				
Future4	0.847				
Future5	0.821				

Fourth, the discriminant validity of the study's constructs was tested using the Fornell and Larcker [34] criterion and the heterotrait–monotrait (HTMT) ratio method (Henseler et al., 2015). According to Fornell and Larcker [34], the square root of AVE for each latent variable should be greater than the construct's highest correlation with any other latent construct. Furthermore, HTMT was also employed to examine the discriminant validity since it has been found to be more reliable in uncovering discriminant validity in PLS-SEM [35]. According to Henseler et al. [35], an HTMT value greater than 0.90 indicates a lack of discriminant validity. The findings indicate that the discriminant validity of the latent variables was confirmed because the Fornell–Larcker criterion was satisfied and all HTMT values were less than 0.90 (see Table 4).

Table 4. Discriminant validity.

	Fornell–Larcker Criterion					Heterotrait–Monotrait Ratio (HTMT)				
Constructs	1	2	3	4	5	1	2	3	4	5
1. Agility	**0.739**									
2. Curriculum	0.463	**0.853**				0.527				
3. Ecosystem	0.461	0.678	**0.762**			0.529	0.771			
4. Experience	0.411	0.309	0.358	**0.854**		0.471	0.354	0.408		
5. Future ready	0.476	0.469	0.490	0.782	**0.814**	0.548	0.539	0.564	0.893	

The diagonal (in bold) represents the square root of AVE.

4.2. Structural Model Assessment

Following the assessment of the measurement model, an analysis of the structural model was performed to determine the explanatory power, predictive relevance of this study's proposed model, as well as the size of the path coefficients and the significance of the hypothesised relationships. The structural model was evaluated using the following criteria: coefficient of determination (R^2), predictive relevance (Q^2), and path coefficient.

First, the proposed model's explanatory power was evaluated by R^2. The R^2 value represents the percentage of variation in the endogenous latent constructs explained by the model. R^2 values range from 0 to 1, with higher R^2 values indicating stronger explanatory power. According to Chin [36], R^2 values of 0.67, 0.33, and 0.19 can be considered substantial, moderate, and weak. According to Hair et al. [32], R^2 values are interpreted based on model complexity and research contexts. The study's findings demonstrate that the proposed model could explain up to 33.5% of the total variation in participants' future readiness technology for learning, as shown in Figure 1 and Table 4. Furthermore, the proposed model could explain more than thirty percent of students' learning agility through the influence of the variables ecosystem, curriculum, and experience. Therefore, the proposed model could be assumed to sufficiently reflect learners' future readiness technology for learning. Second, the Stone-Geisser's Q^2 Test [37,38] was used to confirm the predictive relevance of the model through the blindfolding procedure. Values of Q^2 greater than zero for a specific endogenous construct indicate the predictive power of the structural model for that construct under consideration [39]. As shown in Table 5, the Q^2 values were greater than zero, establishing the model's predictive capability.

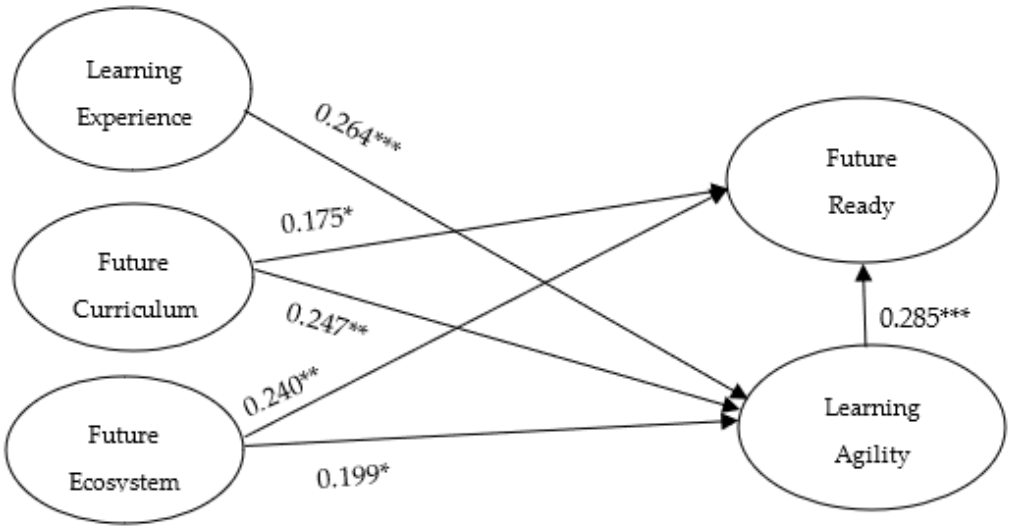

Figure 1. Structural model test results. Note: * significant at $p < 0.05$, ** significant at $p < 0.01$, *** significant at $p < 0.001$.

Table 5. R^2 and Q^2 of endogenous variables.

Endogenous variable	Explained Variance (R^2)	Prediction Relevance (Q^2)
Future Ready	0.335	0.213
Agility	0.314	0.164

Third, to test the hypotheses and investigate the significance of the path coefficients, the structural model was assessed through a bootstrapping procedure that used 5000 subsamples [32]. The findings in Table 6 illustrate that ecosystem had a positive and significant effect on learning agility ($\beta = 0.199$, $t = 2.343$, $p = 0.019$) and a positive and significant effect on

students' future readiness (β = 0.240, t = 3.446, p = 0.001). Moreover, the study also has found a significant relationship between curriculum and agility (β = 0.244, t = 3.058, p = 0.002) and future readiness (β = 0.175, t = 2.137, p = 0.033). In addition, the relationship between experience and agility was positive and significant (β = 0.264, t = 4.320, p = 0.000). Additionally, agility exerted a positive effect on future readiness (β = 0.285, t = 5.369, p = 0.000). Thus, all the direct relationships hypothesised in H1 to H6 were supported. Next, using the approach by Sarstedt et al. [40], the study examined the mediating effect of learning agility on the relationship between the ecosystem, curriculum, experience, and future readiness. A mediation analysis was run using bias-corrected bootstrapping with 5000 iterations and a confidence interval of 95%. Bootstrapping is preferable to the classic Sobel Test of mediation because it works well with small samples, minimises Type I error rates, and does not assume normal distributions (Hayes, 2017). Hypothesis 7 posits that student learning agility mediates the relationship between the ecosystem and student future readiness. The result showed that the indirect effect of the ecosystem on future readiness via student learning agility was significant (β = 0.057, t = 2.242, p = 0.025), supporting Hypothesis 7. Hypothesis 8 assumes that student learning agility mediates the relationship between curriculum and students' future readiness. The results were statistically significant (β = 0.070, t = 2.625, p = 0.009), supporting Hypothesis 8. Hypothesis 9, which assumes that students' learning agility mediates the relationship between experience and students' future readiness, was also tested. The results were statistically significant (β = 0.075, t = 2.588, p = 0.010), supporting Hypothesis 9. Thus, H7, H8, and H9 were also supported. Figure 1 illustrates the path coefficients and R^2 values of the structural model.

Table 6. Results of the structural model.

Relationship	Path Coefficient	*t*-Value	*p*-Value	95% Confidence Interval	Decision
Direct effect					
Ecosystem → Agility	0.199	2.343	0.019	[0.030; 0.369]	Supported
Ecosystem → Future	0.240	3.446	0.001	[0.110; 0.381]	Supported
Curriculum → Agility	0.247	3.058	0.002	[0.087; 0.401]	Supported
Curriculum → Future	0.175	2.137	0.033	[0.006; 0.329]	Supported
Experience → Agility	0.264	4.320	0.000	[0.151; 0.388]	Supported
Agility → Future	0.285	5.369	0.000	[0.185; 0.391]	Supported
Mediating effect					
Ecosystem → Agility → Future	0.057	2.242	0.025	[0.008; 0.110]	Supported
Curriculum → Agility → Future	0.70	2.625	0.009	[0.024; 0.129]	Supported
Experience → Agility → Future	0.075	2.588	0.010	[0.030; 0.141]	Supported

5. Discussion

This study highlights the importance of future-ready education in nurturing a vibrant ecosystem that delivers lasting value for students and communities. With diverse learning experiences and a future-ready curriculum, universities empower their students to thrive and be agile in an environment where creativity and innovation are valued. Universities are required to continue to innovate by rethinking and reshaping students' learning experiences, crafting future curriculum frameworks and ecosystems to produce graduates with the skillsets they need to succeed in their lives and careers. Hence, future-ready education is a system that is agile and relevant to contemporary learners and needs to be founded on the quality and variety of learning opportunities and informed by a partnership with industry, governments, and alumni.

This study also concludes that learning agility is an essential soft skill that enables students to find themselves and succeed in a situation where they have never been before. It helps them have a broader repertoire of things they do in their lives, and this energy of power will allow them to move quickly and flexibly through known and unknown situations. Therefore, universities must start responding to learners' needs by assisting them in discovering and living their purpose for a successful and fulfilling life and career.

The university needs to be a place for students to create more significant impacts by solving the world's problems guided by the learners' purpose and passion in life. To do so, universities must create a future ecosystem that provides a personalised and meaningful learning experience to students, and a future-ready curriculum needs to represent the students' identity and provide a learning experience that is flexible and aligned with their purpose and passion. In addition, future-ready education needs to provide a platform for students to take time to reflect, seeking to understand why things happen, in addition to what happened, as well as developing them to remain present in challenging situations and open to new experiences.

The McKinsey Global Institute (MGI) estimates that globally, about half the work people are paid to do today could be automated by existing technology by 2030. Meanwhile, there will be strong growth in global employment due to new jobs created by worldwide investment in technologies. Tapping into the opportunities brought by technologies, universities must embrace change and have strategic insights to anticipate VUCA conditions and counter them with strategies, processes, and crisis management plans to mitigate difficult times successfully. As change agents, educators must also learn to anticipate and embrace change to facilitate their students to stay relevant in a rapidly changing world. This could be done by creating the flexibility of learning that works best for their students. It creates a comfortable environment for students to choose their own learning pace and lead their learning while changing the routine from "teacher-centred" to "self-centred" learning. All these initiatives will eventually contribute to producing a future generation of learners ready in the face of uncertainty.

6. Implications

This study suggested that a university's curriculum, learning ecosystem, and learning experience would influence learning agility, and that learning agility would predict future readiness. The findings revealed strong positive connections between these three variables and learning agility, as well as a significant positive relationship between learning agility and future readiness. In other words, individuals with higher levels of learning agility displayed higher levels of readiness to evolve and adapt constantly. Thus, the results supported the tested framework, demonstrating significant relationships between a university's curriculum, learning ecosystem, learning experience, learning agility, and future readiness.

This study contributes significantly to the learning agility literature by providing support for the relationship between the university curriculum, learning ecosystem, learning experience, and learning agility, as well as extending previous research connecting learning agility to students' future readiness. In addition to theoretical contributions, this study provides a substantial contribution to the practical application of learning agility. It is essential for policymakers and university principles to be able and willing to adapt to new environments in a highly complex and constantly evolving educational environment. Universities are vital to the establishment of educational ecosystems focused on innovation. Universities can actively encourage innovation ecosystem growth and renewal in ways that support the universities' other main goals of educating students and carrying out research. The university must be a part of an innovation ecosystem, which includes institutions, activities, and culture that encourage technological and pedagogical innovation and are assisted by the resources of the university.

The consequences of decisions made by governments, universities, and policymakers that have an effect on the sustainability of an innovation ecosystem ought to pique the interest of a wide range of individuals. In addition, the learning process is significantly influenced by the learner's prior experiences. One of the pillars of understanding the components of student agility is the significance of the experience. Learning is a lifelong process founded on experience. As a result, institutions can improve students' agility by redesigning the student experience in order to facilitate enhanced learning. To improve learning agility, students must be allowed to experience new innovations so that they can

understand the flexibility of the many different learning techniques. Furthermore, the study reminds policymakers and curriculum designers of the importance of the curriculum in students' agility and, as a result, their future readiness. The curriculum can be viewed as the primary source of students' learning and future readiness. Policymakers must provide students with more up-to-date and relevant content to boost their learning agility and future readiness. As a result, the study's findings have important implications for policymakers, curriculum designers, and higher education institutions, who can use them to foster continuous improvement conditions, thereby promoting future student growth and development. Universities and colleges should strive to provide their students with the most up-to-date and relevant curriculum, a modern learning ecosystem, and an enhanced student experience in order to increase their learning agility and future readiness.

7. Conclusions

As the EXCEL framework in Malaysia is still at its infancy stage and needs further exploration in terms of its effectiveness, this study has proactively approached the research topic of predicting students' agility and future readiness for educational purposes by completing a confirmatory analysis of an established theoretical and empirical model. It predicts the challenges and potentials of the EXCEL framework in Malaysia and proposes a bigger and clearer picture of an alternate exploratory model that better captured the relationship between learning experience, future curriculum and future ecosystem, and their influence on learning agility and future readiness. An important contribution made by this study includes the demonstration that an established empirical model describing the attributes interrelates with attributes of future readiness in terms of agility and views of the future.

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Principles, organisation, and methods of digitally transformed universities

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Abstract

Higher education institutions (HEIs) face challenges in adopting digital practices. Neither newly founded nor existing institutions can yet be considered digitally transformed. One important reason for this is the lack of experts which are capable of driving digital transformation (Dx). This shortage of skilled labour for Dx is not only visible in HEIs but throughout society. The solution to this shortage may lie in providing qualified teaching of Dx at the university level in a highly digitised ecosystem that applies Dx to itself. Experiencing digital transformation in problem-based learning scenarios can facilitate a deeper understanding of the methods involved. Breaking up academic programmes into smaller learning units may facilitate lifelong learning and professional development, particularly for experienced individuals. This paper presents the organisational, educational, and scientific perspective of the Digital University (DU) as a mature digital ecosystem which implements this vision for society. The highly interrelated principles between the core functions of the DU enable optimal growth as well as financial and environmental sustainability. The paper discusses bootstrapping new institutions as well as transforming existing universities into this digital ecosystem. In consequence, this paper envisions the DU as a realistic future scenario, which might develop a disruptive power enabling Dx for all HEIs in the long run.

Keywords: Digital Ecosystem, Higher Education, Digital Transformation, Dx, Digital Platform, Sustainability, Microdegree, Disruption

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1 Introduction

Today universities are primarily dedicated to education, research, and public service. Their organisational principles embrace autonomy, academic freedom, equity and inclusion, accountability and quality assurance, and sustainability, distinguishing them from typical digitally transformed organisations such as entrepreneurial start-ups.

The organisation of universities is designed to support academic freedom, the creation and dissemination of knowledge, and the holistic development of students. Universities often feature shared governance, involving faculty, administrators, and sometimes students in decision-making processes. This model supports academic freedom and collective responsibility but can lead to slow decision-making. Typically, universities do not have a centralised decision-making structure, with executives making strategic decisions quickly to respond to market demands. Universities are generally structured around academic departments, faculties, and research centres, with significant autonomy granted to each unit to pursue academic objectives. Their organisational structures are not built around service or project delivery and business development. They are typically not organised around practice areas, with teams formed dynamically to work on specific projects, with a particular emphasis on flexibility and responsiveness.

Financially, universities rely on a mix of tuition fees, government funding, philanthropy, and research grants. This diversification can influence their governance and strategic priorities, with a need to balance educational goals with financial sustainability. However, universities are typically not funded by venture capital or bootstrapping, and focus on growth and scalability to secure further investment or achieve profitability. As a result, there is rarely a direct link between performance in terms of growth or market share and their decisions. Universities evaluate performance based on teaching quality, research output, and contribution to the academic community. Tenure and promotion processes reflect these priorities. In contrast, universities do not focus on monetary results and scalability based e.g., on growth metrics, market penetration and investor satisfaction.

But why are universities trying to look like they are transforming themselves into digital organisations? Have universities been asking the right questions about this transformation? What might digital disruption look like if the primary goals of universities are maintained? Could a digitally transformed university be built from scratch like a start-up company? Many similar questions have been asked by Ehlers & Eigbrecht (2024) and answered by a large team of authors in their recent book. However, there is no specific approach on how to build the universities of the future with the next skills at their core. The following article outlines a vision based on organisational principles of digitally transformed business models combined with future skills and a problem-based learning approach.

2 Motivation and vision

Our vision is to support society in an age of digital disruption and change. By shaping the future through learning and communication, we can make progress along this path. Today's higher education institutions (HEIs) are facing an accelerated need for digital change (von der Heyde, 2022), but have failed to guide this through appropriate enterprise architecture and other core methodologies (von der Heyde & Hartmann, 2023). To consistently pursue our vision, we believe that teaching digital transformation (Dx) by people who have experienced Dx themselves is a key mission.

The mission is based on the following hypothesis: Applying Dx to teaching, learning, research, and university administration is essential for acquiring, understanding, and improving the relevant future skills and Dx competencies - and thus, evolve into a digitally transformed HEI.

The approach requires a radical shift to digital-readiness, breaking with some university traditions. At the same time, it is important to maintain a focus on humanity e. g. applying the United Nations' sustainability goals from the very beginning. All human activities must be sustainable as early as possible. Therefore, any future university must comply with this and mindsets yet to come.

The envisioned Digital University (DU) is best described as a scaling digital ecosystem for co-created learning and research, following the generic idea of von der Heyde et al. (2019a,b). We propose that all core areas of the university, including research, teaching and learning, as well as any supporting function, are based on participation. Learning is facilitated by matching personal interests with Dx specific extensions of the future skills, as proposed by Ehlers (2020). Selection and sponsorship of research topics follow a similar approach, involving both companies and public interests. They are matched with the time, budget, and corresponding competencies of the researchers. Supporting administrative processes result from similar matching procedures. All activities follow a generic pattern of short units (sprints) of problem based learning (PBL). See Dolmans et al. (2005) or Thomassen & Stentoft (2020) on the application of PBL in HEIs. Elements of building an agile organisation as described by Bondar et al. (2017) and Alghamdi (2021) can be applied. However, our concept is more focused on matching supply and demands corresponding competencies - a key feature of successful digital platforms. Agility is essential though, as markets and customers expect fast lifecycles and response times. Similarly, the hybrid approach to localisation is crucial to the digital nature of the organisation. Although some university facilities require physical space, most teaching, learning, research and administration activities do not. Therefore, all activities at the DU are hybrid by default. See Raes et al. (2020) for a systematic literature review of the gaps identified in hybrid learning environments.

This paper discusses building a (hypothetical) DU from scratch or transforming an existing organisation into a digital transformed DU, considering the financial effort required. An alternative concept of participatory cost sharing and long-term benefits for all members is presented as having high potential for the sustainable and beneficial realisation of the DU's vision. The upcoming sections will introduce the core concept of such a DU.

While this approach is expected to work best for advanced students and professional development in Dx, it is not limited to this area. This concept has the potential to be applied to most academic topics once universities of this organisational type are established.Therefore, it has the capability to transform or disrupt higher education itself.

3 Thinking a university as digital ecosystem

3.1 Build a platform by co-creation and participation

As previously mentioned, DU is best described as a digital ecosystem for education and research. The concept is based on the idea that digitally transformed organisations often replace traditional governance structures with modern digital platforms. Starting from scratch, we introduce a definition, an operating model, and relevant success factors of this new platform.

The role of digital platforms has been widely discussed e.g., by Kenney & Zysman (2016) and de Reuver et al. (2018). Digital platforms match supply and demand in innovative ways - thinking along the value proposition of AirBnB or Uber. In higher education, typical examples include social networks like ResearchGate or MOOC providers such as Coursera, Udacity, and edX. However, these digital platforms do not encompass the complete ecosystem of the symbiosis between teaching, learning, and research.

As proposed by von der Heyde et al. (2019a,b) a digital platform's ability to scale itself is based on seven factors, which can be viewed from business, market, and organisational perspectives. The

platform's growth is driven by these factors, with at least three (connectedness, rating/credibility, and global offer) acting in positive reinforcing feedback. The remaining factors (openness, payment/billing, private resources, and the common legal context) amplify the platform's scale.

Participation is one of the biggest drivers for the success of a platform. Therefore, DU as a platform is built as a product of co-creation. All university stakeholders enter a clear digital path tailored to their needs and demands. Students find content and peers - teachers find learners interested in their content - researchers find funding - enterprises find researchers applying their skills to real-world problems. Everyone participates, contributes, and benefits from the interactions facilitated by the DU; the more people participate, the better the model succeeds.

The following paragraphs present the specific matching problem (and solution) of DU as a platform. The envisioned DU is a scaling digital platform building an digital ecosystem for education and research about and powered by Dx.

3.2 Match learning and teaching

As a platform, DU is designed to match supply and demand for education. In combination with the central hypothesis that "you learn better if you are interested in what you want to achieve", we apply Problem-Based Learning (PBL), which has been extensively researched in recent years as summarised by Raes et al. (2020) in their systematic literature review.

In short, PBL significantly enhances critical thinking and problem solving skills in higher education. It encourages self-directed learning, enabling students to take the initiative in their educational journey. It also develops teamwork and collaboration skills, which are essential in the workplace. The real-world applications of PBL provide contextual relevance to academic studies and link them to future careers. Despite its benefits, PBL in higher education faces significant challenges. It needs a lot of resources, including time, staff training and materials. Assessing student progress in PBL is complex due to its subjective and open-ended nature. The risk of insufficient coverage of essential theoretical knowledge as required on the Bachelor level and unequal participation with potential conflicts can affect learning outcomes. Effective PBL requires teachers with specific training and experience.

Traditional curriculum design and preparing learning materials is time consuming and mainly based on manpower. PBL in the DU, however, needs much more agility and thus much faster response cycles. Similar to the industry, our aim is to decrease time-to-market for teaching topics and learning materials. To keep up with that speed and agility, teachers need automated tools that can be integrated into delivery pipelines. We will describe a possible solution for that specific problem as follows.

Generative AI has become capable of delivering high-quality content to whatever is prompted. Not only students already use GPT[4] to assist in homework and theses. Teachers also use GPT to summarise important passages of text books or create interesting figures and other content. Given a proposed and agreed problem in PBL, teachers can use generative AI to prepare whole classes and material for the aimed timeframe in an instance. What content the AI generates - it is much less time consuming for teachers to perform quality assurance instead of creating everything from scratch. AI generated content comes with more flexibility. Even exam questionnaires and exercises may be supported. Once the generative AI has been integrated in a delivery pipeline (similar to CI/CD), the new content can pass the quality assurance and directly be delivered into a learning platform as part of the DU's ecosystem. More best practices from agile software engineering are just waiting to be applied in this scenario.

[4] E.g., ChatGPT as published by OpenAI

At DU, we propose to co-create digital education programs based on PBL ideas with faculty, students and external partners. As key stakeholders, students or faculty members propose exciting topics and projects. The immediate influence of all participants on the learning content of the units guarantees a high level of relevance as well as a high degree of topicality. In addition, this accelerated influence on the learning content could also have a self-reinforcing effect. A Dx-specific CAtalogue of LEarning GOals and competencies (CaLeGo) has been created based on the known future skills discussed by Ehlers (2020). By expanding the scope of "object and individual related", "individual development related", and "individual and organisation related" with "specific Dx related" items, we add robustness, abstraction, self-similarity, credibility, connectedness and openness to the generic list of learning goals and competencies. Other disciplines would need to extend CaLeGo specifically for their core methodologies, if these are not covered by the generic futures skills defined by Ehlers.

Each project is proposed in relation to some of the elements of CaLeGo. In addition, students can suggest faculty or external experts as additional mentors. After the preparation of suitable content, matching available timeframes is being addressed. Both teachers and students indicate their availability as a preferred timeframe on the platform, as explained in the section on 'time and speed' below. A sufficient number of interested participants trigger the public offering of a topic. If no faculty member is available, external experts are engaged. The selection is based on their skills profile (e.g. from data in the DU's membership database). Faculty, experts and students confirm time and content, and the unit is scheduled within the agreed timeframe. During and after the unit, continuous evaluations are conducted to ensure teaching quality, student engagement, and organisational alignment. These rating systems also play a specific role in the scaling of a digital platform. Upon successful participation, students receive a microdegree that confirms their level of competence in CaLeGo.

The PBL and CaLeGo based approach will replace traditional education programs. Common to both is a catalogue of learning objectives. At DU, the student's goal is to propose a coherent collection of self-directed learning units that cover almost the entire CaLeGo. In this way, the academic committee agrees on the CaLeGo rather than on the individual implementation of a learner's path. As a result, an appropriate collection of microdegrees that match the CaLeGo elements can qualify for a particular degree. In summary, DU supports students with the ambition to complete their individual education program with an appropriate choice of learning units - matching their required demands.

3.3 Match real-world problems and research

In a similar way to matchmaking in teaching and learning, the DU ecosystem enables matchmaking in research. The underlying hypothesis is that applied research and basic research have one thing in common: a passion for solving problems. Here too, faculty, students and external experts work together to generate valuable project proposals. This creates a pool of ideas, research questions and demands. Due to the in-depth, focussed examination of specific questions within the research units described later, more research questions are generated. External partners, which are business members of DU, can suggest research topics that they would like to support with funding or grants.

The research cycles can be linked to the traditional view, often discussed in the context of the DDC Curation Lifecycle Model or Research Data Management (see Figure 1). Here, the proposing community produces a project outline, so that original ideas initiate projects. The first step is to state the fundamental research question and proposed methodology of the project. The projekt is broken down into many three-week chunks to define a series of Minimum Viable Products (MVPs), which are presented in Figure 1 as smaller research units. The main challenge in these research units is used to specify an ideal team based on a selection of CaLeGo items (as a reference to necessary competencies). Students and faculty then commit to the topics of the research units and indicate their available time. As soon as the team positions are assigned for the required timeframe, the research project is ready to start. As each research unit links back to the overarching research question,

personal continuity, a clear MVP focus and knowledge management techniques are crucial in compensating for knowledge drain between the units. The results of, for example, an initial literature review, which in several units focuses on different disciplines or areas, must be compiled in annotated bibliographies that maintain the link to the original research question of the overall project.

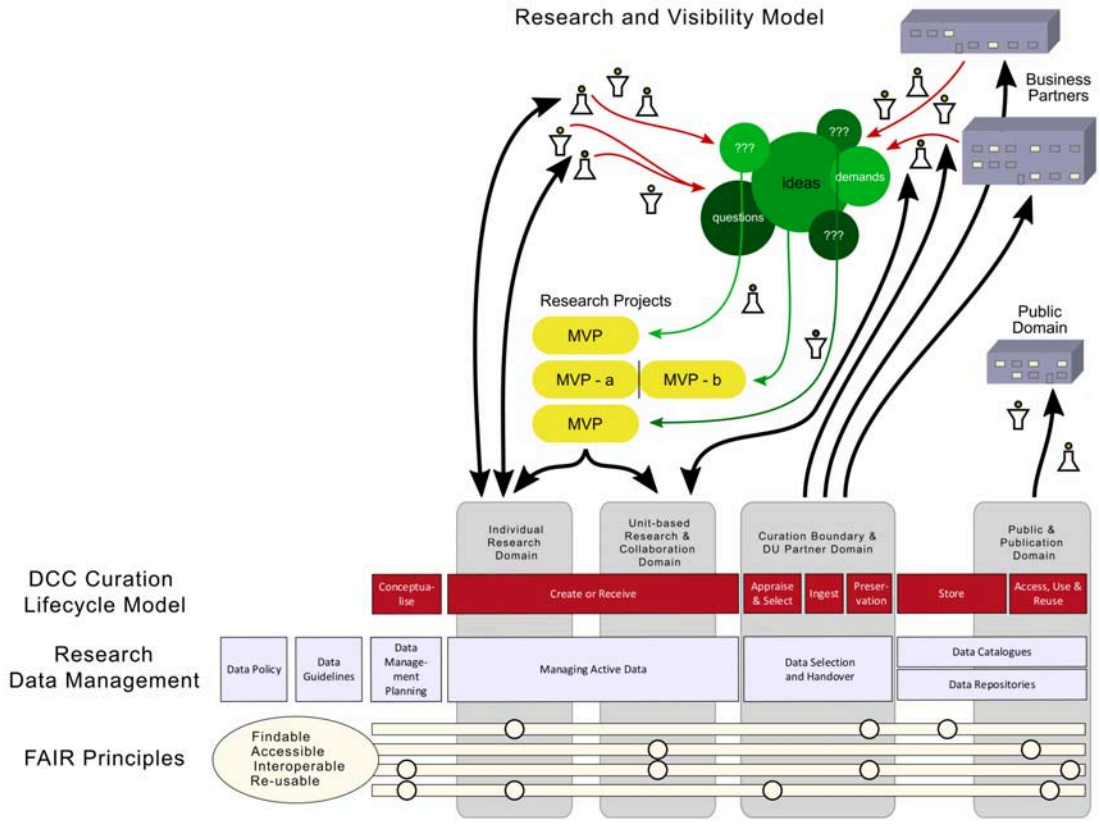

Figure 1: DU's research and visibility model is anchored in traditional research models. It extends the generation of ideas and dissemination of results in line with scaling principles.

As research is funded by business members of the DU, all involved members benefit from the existing resources. Faculty can additionally apply for public funds from the national government, EU and international higher education partners.

After the research has been carried out, all dissemination materials will be published as learning materials and are open to all members of DU. In this way, research has a crucial role in the teaching domain.

3.4 Match graduates to future job profiles based on their microdegrees

At DU, students are evaluated at every stage of their educational journey. By continuous feedback they are empowered to decide when and how to engage in professional job roles. The application of PBL enriches both student and faculty portfolios. This academic portfolio becomes also visible to business members of the DU ecosystem, allowing students to present their competencies when seeking employment opportunities. Business partners can review anonymised skills profiles and propose to potential candidates (see Figure 2). Matching candidates can confirm their interest in being contacted, facilitating a data-driven matching process on the ecosystem. Successful employment

enables students to lower their repayment obligations, as the hiring business partner contributes a fee based on the candidate's skills profile. If the match is not working out, DU professionals assist both parties to find a more appropriate placement. This matching mechanism not only helps students find sustainable and valuable employment, but also promotes long-term satisfaction for members and reliable financial returns for DU.

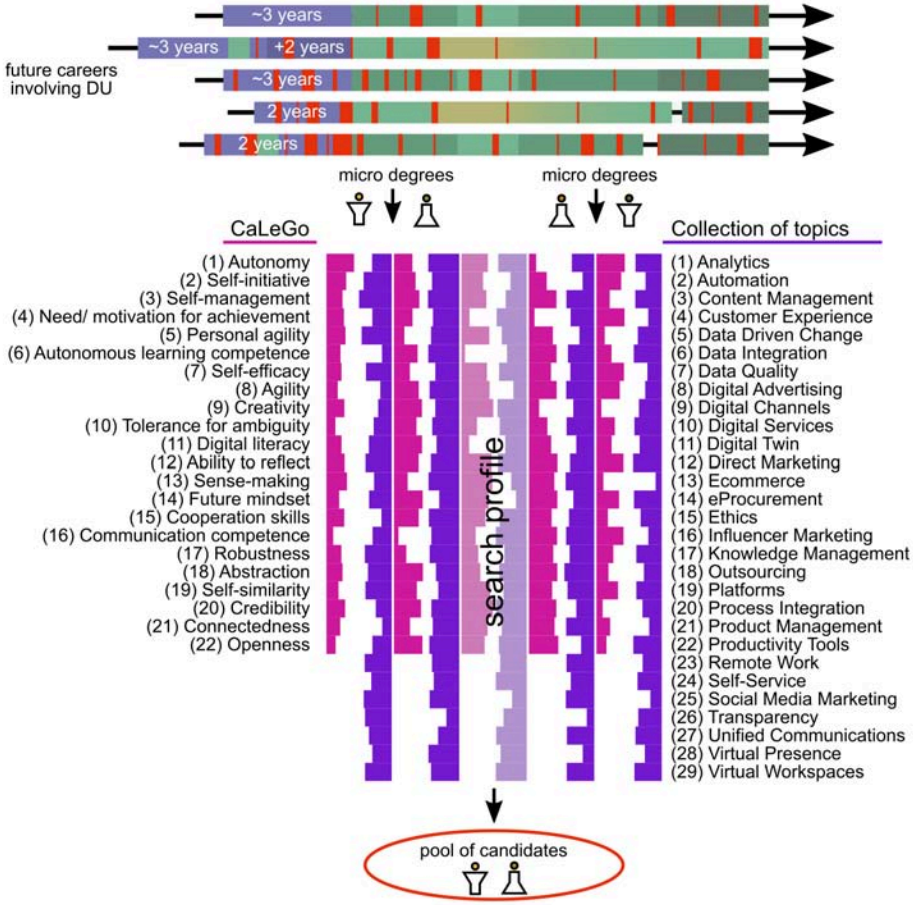

Figure 2: The matching of CaLeGo topics and items enables a selection process based on competences and interests.

In this section we introduced a new design for a digital university (DU), that can best be described as a digital ecosystem. The concept of the DU is based on three essential pillars:

- Match learning demands with teaching offerings
- Match real-world problems with agile research projects
- Match high-value job profiles to graduates based on their individual microdegrees

Being digital by design, all stakeholders are considered members of the DU ecosystem and they co-create from the very beginning.

4 Organising the ecosystem

4.1 Time, speed, and learning dynamics in the TEaching REsearch and LEarning (TeReLe) framework

The TeReLe framework recognises that educational needs are shaped not only by content but also by time and resources. The approach is characterised by an intensive focus on a single topic over a three-week unit, ensuring undivided attention. Each unit, which is equivalent to a project, is worth 4 ECTS and an appropriate microdegree. The units can be linked sequentially to provide a cumulative learning experience.

There are 16 different units scheduled each year, allowing students to fill these units with learning goals of their interest, based on the matching of demand and supply, as shown in the grey columns of Figure 3. The structure allows for three-week timeframes of participation that cater for learners of all ages and backgrounds, regardless of their organisational affiliation. The TeReLe framework emphasises inclusive participation in the review week at the end of each quarter, where all stakeholders are encouraged to provide constructive feedback on methods, content and organisation.

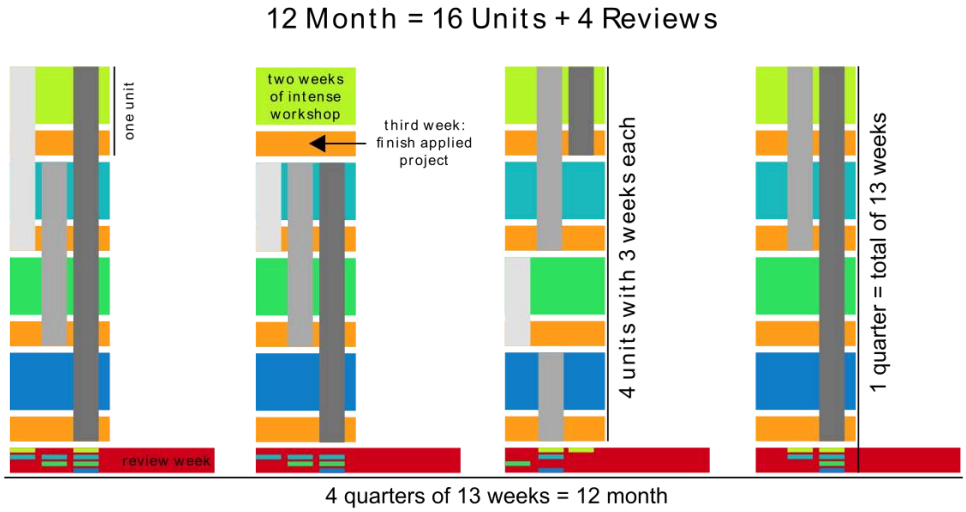

Figure 3: The proposed quarter based academic schedule in the TeReLe framework is based on three week timeframes, respective units. They are flexibly combined to form larger coherent periods if necessary. During a single unit DU members are committed to one type of work only and can therefore give full attention to it.

A typical workload is four days per week, with the fifth day reserved for individual innovation activities. Units are closely linked to either TeReLe activities or academic self-governance. By fostering a highly dynamic environment, TeReLe actively promotes innovation and adapts to the evolving needs. However, because of this volatile environment, knowledge management is a key asset in the DU digital ecosystem. As Dei & van der Walt (2020) point out, current HEIs often fail to establish the required tools and methods.

4.2 Hybrid by default: Balancing digital and on-site spaces

In the TeReLe framework, achieving optimal learning outcomes requires a careful balance between physical presence and digital engagement. Flipped classrooms and other digital teaching

methods have been embraced by those who recognise their benefits. These digital approaches increase flexibility, potentially reduce carbon emissions, and encourage participation from a wide range of audiences.

However, the role of physical laboratories and makerspaces cannot be fully replaced by virtual alternatives. These spaces are crucial in enabling students to fully engage with and understand the practical aspects of their studies. While digital tools can support creativity, for some people they cannot fully replace the tangible experience of interacting with physical objects and people.

To support this blended learning approach, DU is committed to employing educational experts. These experts will assist faculty members in effectively integrating hybrid teaching methods. This hybrid TeReLe model aims to maximise the benefits of both digital and face-to-face modes of education, creating a more robust and versatile learning environment.

4.3 Dynamic (academic) administration

The Digital University (DU) embraces a vision in which organisational learning is an integral part of its core ethos. The aim is to develop an organisational structure that is both highly flexible - in terms of content, space and time - and resilient to external disruption. This structure is inspired by the organisational model of consulting companies, starting with a lean approach without traditional departmental structures.

To maintain this dynamism, DU devotes a week after every four units to an organisational review (red bar in Figure 2). Substantial changes are proposed and form the basis of administrative project units that implement the core functionality of DU's digital ecosystem. Changes within the DU ecosystem and its organisational structure are therefore conceptualised as transformation projects within the TeReLe framework. The operational administrative tasks are performed by an external service unit (e.g., a German Law based gGmbH) we call Administrative Service (AS) GmbH. Collaboration with AS GmbH is based on the principles of involvement, co-creation and active participation.

A distinctive feature of DU's approach is its reluctance to expand its payroll. Instead, the university relies heavily on self-service, automation and partnerships with other educational institutions. Hiring is possible, but used only when collaboration or sourcing is insufficient.

Academic self-governance is reduced to its essentials and is part of the faculty's regular obligations, such as participation in a corresponding unit. In summary, most of DU's innovative organisational approaches are being applied to support services to create a dynamic self-governance.

4.4 Financial and funding strategies at DU

In conceptualising DU as a start-up, it is imperative to adopt a business-like approach to its operations. The institution identifies four interrelated value streams: learning, research, career and intellectual property:

- Learning: Students receive default support during their learning phases through a scholarship (e.g., of 1000 € per unit). In return, they provide a small proportion of their future income (e.g. 0.3% over ten years) to the DU. Teaching faculty and external experts receive an immediate income and a fraction of the students' down payment over the same period, thus benefiting from higher teaching success.
- Research: As external sources are the primary source of funding, all participating research faculty and students are paid according to their workload. However, if students register for the project as a learning unit, similar mechanisms as in the regular teaching and learning scenario will apply. Experts would also benefit if their share is reduced initially and extended based on the long-term revenue generated by advanced academic students.

- Career: Due to the CaLeGo topics and items, the DU can search for detailed matches between job postings and the students' capabilities. Each match benefits the student, the external company, and the DU itself through proportional payments based on the candidate's gross income.
- Intellectual Property: Specialised professionals facilitate the commercialization of patents, licences, and other valuable assets created through research. All members involved benefit from the long-term revenue, thus maintaining a positive attribution to the original source of additional income.

Each of these streams not only supports but also enhances the others, creating a symbiotic relationship.This can for example be seen by the overarching principles between career revenue of the students and DU for standard teaching units or even research units. Each of these streams also support the DU core platform including the AS. As far as possible positive self reinforcing factors are carefully selected to support growth and sustainability at the same time.

DU's overarching goal is to become a financially self-sustaining organisation. To achieve this, revenue generation is strategically planned across all value streams, with continuous reinvestment to fuel growth and development. The potential for successful scaling of all streams lies in the use of self-perpetuating mechanisms. A detailed business plan underpins this strategy, providing a structured framework to guide DU towards its financial goals and ensure the realisation of its visionary model in the long term.

5 To build or transform?

DU's proposition is that healthy ecosystems have beneficial spillover effects on their immediate surroundings and on the international level. At the heart of this is openness, which in turn links back to the scaling platform factors. DU aims to lower barriers to entry by offering simple, concise and short agreements for cooperation and membership. This approach accommodates common criteria while recognising the unique needs of different entities such as individuals, NGOs, start-ups and established industries. This also creates a common legal framework that is typical for scaling platforms. Membership begins simply by creating an account, as with other social networks. Interaction begins immediately by browsing other people's learning suggestions or creating your own.

The ethos of DU is to co-create while remaining open to change. The value of providing knowledge through openness and transdisciplinary collaboration does not only enhance DU’s own ecosystem, but also contributes positively to the broader community.

However, this article would not be complete without describing how to reach this state of a functioning digital ecosystem. The bootstrapping or transformation of existing institutions is described in the following sections.

5.1 Constructing DU as a transformative university model

The rationale for DU's new organisational structure is based on assembling a small team of highly competent and committed individuals united by a shared vision. This team includes faculty, students and external experts, all of whom are integral members of the DU community. The strategy is to create minimum viable products for all essential components of the DU platform, ensuring basic functionality and effectiveness.

Modifications and enhancements to the platform will be based on critical business requirements and ensure a sustainable return on investment. There is a strong focus on prioritising automation and self-service to streamline processes. DU applies agile principles to address regulatory, technological and societal challenges, emphasising flexibility and responsiveness.

Central to DU's ethos is the creation of a culture that emphasises problem solving while keeping risks within acceptable limits. This approach ensures that DU remains innovative and adaptive, yet firmly grounded in practical and risk-aware strategies.

5.2 Student attraction and selection at DU

DU believes that learning should fit seamlessly into any schedule, recognising that education is a continuous journey. The University caters primarily for part-time students, with the expectation that most students will be employed during their breaks from DU units. The target demographic includes students of all ages with a sound general background who resonate with DU's vision. This approach allows students with varying levels of experience to collaborate in the units, facilitating a two-way exchange of knowledge rather than a one-way transfer. The teacher's role shifts to that of a knowledge coach.

The selection process at DU is highly competitive and primarily AI-driven, leaning towards self-service mechanisms. Recognising that each student brings unique knowledge to the table, the learning model actively involves students in pedagogical roles, encouraging them to teach, advise and provide feedback to their peers and teachers.

Initially, DU is focusing on enrolling advanced students at the Master's and PhD levels, and will later open enrolment to undergraduates. Students will be provided with comprehensive support, including scholarships, to foster an environment of continuous engagement and minimise dropout rates. This approach underlines DU's commitment to creating an inclusive and supportive learning environment in line with its innovative education model.

5.3 Strategies for attracting staff, mentors, and experts

At DU, attracting highly qualified individuals is a significant challenge, especially when considering long-term commitments. The standard form of engagement for teaching, mentoring and professional staff is flexible and often part-time. This approach recognises that many professionals have commitments elsewhere.

The primary motivation for involvement at DU is not financial reward, but a genuine interest and concern for the educational mission. The goal is to attract the best talent, even for a short period of time, and allow them to experience DU's unique environment.

DU focuses on individual benefits and ease of engagement, striving to minimise any potential barriers, whether legal or financial. Long-term contracts are only considered after a thorough matching and evaluation process. Emphasis is placed on the prestige and status associated with being part of DU, highlighting the institution's distinguished image as a key attraction for potential staff, mentors and experts.

5.4 Transform existing universities into the DU model

Alternatively, DU can emerge through the gradual transformation of an existing organisation, with multiple shifts aligned to the principles envisaged. A first step could be the adoption of the new timeframe concept, gradually filling traditional lecture-free periods with three-week unit schemes. As project-based methods increasingly replace conventional teaching, traditional semesters could be systematically reduced until all teaching shifts to the unit-based approach.

Research planning and execution would adapt alongside teaching, and be integrated into teaching-free periods. At the same time, traditional funding models could evolve towards an income credit system to ensure stable and sustainable funding. Contract transformations would take a long-term view, respecting current commitments while offering attractive rewards to encourage staff to move to the new model.

These examples demonstrate the feasibility of a phased approach to introducing the DU model within existing universities. Overcoming the operational challenges requires a clear strategy and unifying vision to anchor the transformation and ensure a smooth transition to this innovative educational framework.

6 Core concepts overview

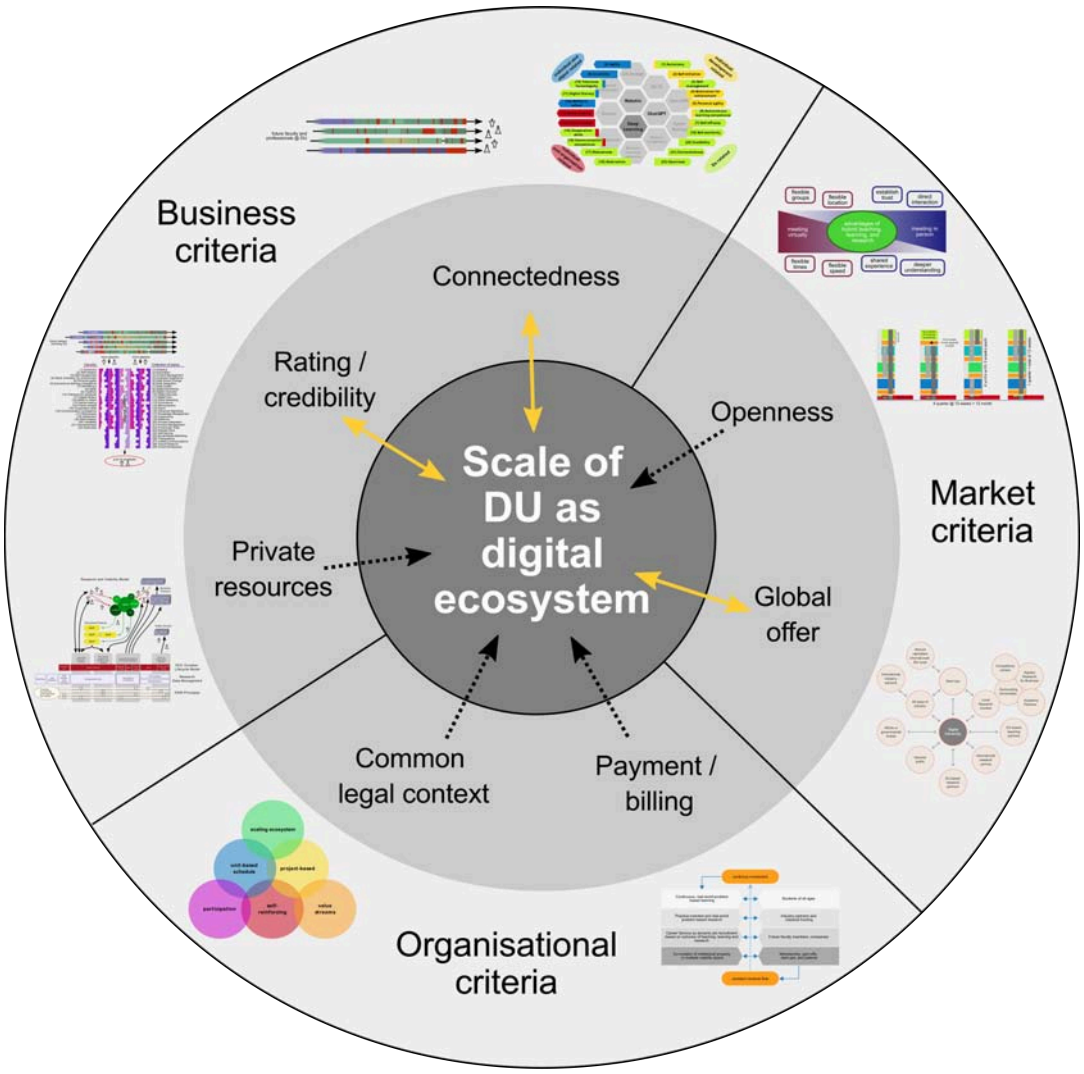

Figure 4: Overview of core concept of the Digital University (DU) in relation to the scaling factors of a transformational digital ecosystem in adoption to von der Heyde et al. (2019b).

6.1 Vision

The Digital University's vision focuses on organisational learning in all areas of the scaling digital ecosystem as shown in Figure 4. It emphasises co-creation and active participation within the academic community. A project-based approach structures the curriculum into distinct units, promoting openness and integration with industry and wider society.

6.2 Credibility

The Digital University is committed to using digital transformation (Dx) to innovate education and research. It aims to establish itself as a data and demand-driven digital platform, ensuring a deep understanding of subjects while discouraging multi-tasking. The curriculum design allows for individual learning pathways, with microdegrees assembled into coherent degree programmes.

6.3 Sustainability

Sustainability guides the Digital University's ambition to become financially self-sufficient, reducing its financial impact on the public. Initial government funding is seen as an investment in creating a start-up and Dx-based ecosystem. Decisions about physical locations are informed by sustainability, favouring digital or hybrid formats. Content generation follows a tiered visibility strategy, involving units, the university, partners and open access resources, ensuring broad and strategic dissemination of knowledge.

7 Acknowledgements and resources

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Road works ahead: the journey of an innovative cross-campus hybrid learning space navigating higher education institutions' organizational setbacks

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The most recent UN publication on Sustainable Development Goals (SDGs), which covers issues related to socioeconomic, environmental, and technological development on a global scale towards 2030, has expanded its focus to include tertiary education and the role of Universities in contributing to societal development. SDG 4, particularly, calls for equal access to tertiary education from a lifelong perspective, and consequentially an increasing need for flexible education. It has therefore become pivotal for Higher Education Institutions to promote the implementation of both flexible study programs and related innovative learning environments to sustain learners' lifelong education and the development of critical skills in an increasingly digitalized world. Innovation, however, has a cost. In Higher Education, innovation must necessarily reconcile academic advantages with economic conveniences. In this paper, we look in retrospect and share our experiences from a major research project linked to creating and implementing an innovative hybrid learning space within the frame of a cross-campus and cross-institution master's degree based at two Norwegian universities. In the evaluation phase of the project, tension became apparent between the underlying pedagogical visions that sparked the enthusiasm for the project and the challenging reality of having to create, organize, and manage a complex cross-campus and cross-institution study program and build the learning space related to it. It seems that traditional university structures as a closed ecosystem made it difficult to anchor the development of the program in/within/between the organizations. The administration did not seem equipped to manage the uncertainty such an innovative project presented in the form of many new unforeseen, challenging, and unpredictable variables. In two related publications we have specifically discussed the results from the project by focusing on the experiences educators and students collectively reported about working and studying in the *ad hoc* learning environment developed for the master's program. We wish now to look back and explore the topic from an organizational perspective where the administration of the cross-campus and cross-institution project acts as a filter between the educators' pedagogical vision and the students' experiences. In this **exploratory case study,** we have opted for a phenomenological investigation and a qualitative approach to research design that is informed by constructivist grounded theory methods. We went back to the educators' and students' feedback and tried to understand not just what worked and what did not, but why. What contributed the most to the increasing tension between the initial pedagogical vision of the educators and the practical development of the project in reality? We believe that sharing the experiences harvested from our project along the road can be of help to other researchers and

stakeholders in confronting and finding solutions to the challenges that complex innovative projects might constitute for higher education institutions.

KEYWORDS

cross-campus learning environments, cross-institution collaboration, higher education, cross-campus teaching and learning, future higher education

1 Introduction

The most recent United Nations (UN) publication on Sustainable Development Goals (Global Sustainable Development Report, 2023; United Nations' Sustainable Development Goals, 2023), which covers issues related to socioeconomic, environmental, and technological development on a global scale towards 2030, has expanded its focus to include tertiary education and the role of Universities in contributing to societal development. SDG 4, particularly, calls for equal access to tertiary education from a lifelong perspective, and consequentially an increasing need for flexible education. In the past couple of years, a new awareness also has risen about the need to provide flexible study programs to guarantee continuity of education in times of crisis. Students' expectations of higher education are evolving with a direct focus on flexibility, inclusion, and personalization, the opportunities to acquire knowledge and skills transferable to their work life, and equality of access. For many students, particularly adult and vocational students, equality of access has become synonymous with flexible education and fully digitally-based education to overcome potential socio-economic barriers to participation (Pelletier et al., 2022; Penrod, 2023, p. 27). The European University Association (EUA) therefore has emphasized the necessity for Higher Education Institutions (HEIs) to adapt and expand traditional university teaching on campus to include hybrid and fully online study programs to realize the UN's SDGs by 2030. The policy document "Universities without walls" is a EUA manifesto envisioning the future of European universities as "innovation ecosystems" (EUA, 2021, p.9) and active contributors to environmental, technological, and social innovation processes to support Europe's open, pluralistic and democratic societies (EUA, 2021, p. 7). This ambitious vision is endorsed by the EU and implemented through international research and educational programs like Horizon Europe, 2021–2027 and Erasmus Plus 2021–2027.

Considering these international trends, and the acknowledgment of the limitations of human, financial, ecological, and socio-cultural resources, it has become apparent that the traditional university campus is a finite ecosystem that cannot be subjected to endless expansion (Ninnemann et al., 2020, pp.25–26). The traditional idea of the university campus as a conglomerate of buildings and spaces each with a specific function belongs to the way past generations intended teaching and learning and working academically. Even with the introduction of ICT in education, e-learning, and the promotion of virtual learning environments, university campuses are still claiming more space and more funding to build new and bigger, while physical, hybrid, and virtual spaces are still constructed separately from one another (p. 25): "Lecture halls and cellular offices still exist, although learning and working can take place independently of space and time through the integration of ICT. Lecture halls are not dedicated to new usage possibilities, although lectures can be recorded […]" (Ninnemann et al., 2020, 25). As Ninnemann acknowledges, building more physical infrastructures on campus without integrating them with virtual infrastructures and the reality of a campus in the cloud stretches financial and human resources to the limit and poses a serious environmental hindrance to achieving the UN's SDGs (p.25). Even if physical presence on campus will probably remain a default feature for most HEIs, the successful implementation of innovative hybrid (physical and virtual) or fully digital learning environments that can sustain learners' education and promote the development of critical skills to meet future work-life challenges and possible new crises has now become pivotal to ensure the survival of HEIs in an increasingly digitalized world (Bozkurt et al., 2020; Hodges et al., 2020; Shearer et al., 2020; Williamson et al., 2020b). At the EUA annual conference in April 2021, President Michael Murphy summarized his vision: "The key word is 'open'. No more ivory towers: blended campuses are here to stay, tradition combined with online" (Mitchell, 2021). The concept of openness also includes building and crossing cultural, transnational, and trans-sectorial bridges (Murphy and Crowfoot, 2021, p.5). In this envisioned open academic landscape, cross-campus, and cross-institution cooperations are considered pivotal in the development of future universities. Virtual campuses, which are holistically developed along the already existing physical ones, will guarantee an innovative, ubiquitous university that can accommodate the different needs of a diverse student body and allow for flexible and equitable education (Murphy and Crowfoot, 2021, p.6-7).

Innovation, however, has a cost. In Higher Education, innovation must necessarily reconcile academic advantages with economic conveniences. Considerable economic and political pressures in the aftermath of the pandemic and the following economic crisis and cuts in funding are forcing HEIs to rethink how to meet the academic and social needs of future students (Leadership and Organisation for Teaching and Learning at European Universities, 2022; Coburn and Derby-Talbot, 2023). This new generation of students is more diverse. Students are now older and often must balance education with work and family and have vastly different needs from first-time traditional students in terms of cost for the institution, access possibilities, and workforce readiness (Alexander et al., 2019). As HEIs continue to be a primus motor for socio-economic mobility toward 2030, as envisioned by the UN, equal access to lifelong learning for all types of students becomes imperative (Castro, 2019; European Commission, 2021). To deliver and sustain quality hybrid and online higher education into the future, new investments in infrastructure, technology, and competent staff are then required

(Castro, 2019; European Commission, 2021). Organizational practices related to "mainstreaming" hybrid/remote learning modes is arguably one of the most complex and challenging predicaments for institutions to undertake at this moment (Pelletier et al., 2022, pp.26–28), while universities are struggling against a backdrop of increasing economic, environmental, social, and political changes (Coburn and Derby-Talbot, 2023). A considerable amount of organizational effort and administrative support is necessary when considering the implementation of innovative projects from a cross-campus and cross-institutional perspective. The "openness" of the future academic landscape is not yet secured.

In this paper, we look in retrospect and share our experiences from a major research project linked to creating and implementing an innovative hybrid learning space within the frame of a cross-campus and cross-institution master's degree. This is the third of a series of articles from the project. The scope of our research is to harness experiences and new knowledge that can both inform and inspire similar projects and offer useful information for the development and implementation of cross-campus and cross-institution study programs.

In this particular case, the master's program in Music, Communication and Technology (MCT) started as a collaboration between the Norwegian University of Science and Technology (NTNU) and the University of Oslo (UiO). The program was co-located at both campuses and entailed the management and refinement of *one shared hybrid*, physical and virtual, learning space for physical-virtual interaction across the web called the Portal. In the Portal students and teachers from both universities were meant to share physical and digital resources to collaborate and explore educational, methodological, and technological solutions together (Støckert et al., 2019, 2020).

In our previous articles (Nykvist et al., 2021, De Caro-Barek et al., 2023), these authors have discussed the results from the project in depth by focusing on the experiences educators and students collectively reported on working and studying in the peculiar learning environment of the Portal. We wish now to look back and explore the topic from an organizational perspective where the administration of the cross-campus and cross-institution project acts as a filter between the initial pedagogical vision and the educators' and students' experiences. We want to go back to the educators' and students' feedback and try to understand not just what worked and what did not, but *why*. What contributed the most to the increasing tension between the initial pedagogical vision and the practical development of the project in reality? From a vision of creating a sustainable and innovative cross-campus and cross-institution master's program, sharing human and technical resources, to NTNU's withdrawal from the program in 2021, resulting in a revised master's program managed and run alone by the University of Oslo.

In this paper, we want to explore whether and how organizational and administrative aspects affected students' and staff's working situations.

What organizational elements seemed to promote and/or hinder teaching and learning for students and educators in a cross-campus and cross-institution situation?

After an initial review of the literature and some terminology clarifications, we will present a brief section illustrating the background for the project and the methodology employed. Results will then be set forth followed by a discussion and a conclusion section where we offer some suggestions for a possible way forward.

2 Literature review and terminology clarifications

The evolution of the university as an institution has been a journey where form and function have adapted to the changing times. From its origins as secluded castles, often described as 'Ivory Towers' (Behrent and Steven, 2022), to its transformation into more accessible brick-and-mortar institutions, the university has continually evolved. Today, we are witnessing a shift towards a vision of a university without walls (Murphy and Crowfoot, 2021). This transformation is not without its challenges. The European university's history dates back to the Middle Ages when the first universities started developing many features that are still prevalent today - a name with a motto and a poignant moral and educational message, a central location, autonomous masters, students, a system of lectures, examinations, and degrees, and even an administrative structure with its faculties. As Kerr (2001) remarks in his classic *The Usage of the University*, universities were often detached from contemporary events, standing like castles without windows. This introverted nature is still prevalent in many institutions today. Despite external pressures and reforms, many universities have managed to maintain their functions throughout history by maintaining internal continuity. They have managed to shield themselves from external public, social, political, and economic pressures while interacting with those factors at a distance (Clark, 2003). However, this persistence of Higher Education Institutions (HEIs) in desiring to exist as they always have done, clinging on to the vestiges of the past, has by many been addressed as *organizational inertia* (Clark, 2003), and it has been thoroughly criticized. The Organization for Economic Co-operation and Development (OECD, 2020) and the Council of Europe (COE, 2022a) claim that European universities are not responding quickly enough to strategies and reforms needed to handle a complex and fast-changing world. Reformers argue for a vision where the university is dynamic and adaptive toward its customers and prioritizes innovation, entrepreneurship, and market orientation (Olsen and Maassen, 2007). This vision is partly supported by governmental approaches allowing universities a more autonomous role and being more exposed to market mechanisms. This has led to the transformation of universities from social institutions into industries (Maassen and Stensaker, 2011; Huisman and Lyby, 2020). However, there are also external factors slowing down higher education's ability to cope with fast changes and market dynamics as well. Particularly, higher costs (tuition) and building/maintenance costs, power issues, and lower enrolments are some other challenges faced by universities today. At the same time, in recent years traumatized by pandemic health threats, the use of digital technologies in Higher Education to guarantee continuity of education has escalated. Consequently, new professional roles have made entrance into traditional university organizational structures. New competitors are offering just-in-time education, so-called micro-credits, and more flexible and tailored educational solutions. As Santos et al. (2023) have written in a compelling piece on the

new hybridity of universities, third-space professionals such as educational developers and Information and Communications Technology (ICT) staff have become more visible and salient within universities. Given their role as 'digital experts', these professionals are increasingly significant for academics who require support to design and deliver teaching in digital environments, as was the case during the COVID-19 pandemic. Pinheiro et al. (2023), for instance, have newly investigated the impact of digital transformations on both established and emerging professional roles in the aftermath of the dynamics initiated by the pandemic, asking to what extent the digital transformation of higher education is affecting traditional academic roles and authority relations within public universities. The authors hypothesize that these developments can lead to power shifts where technically skilled staff have a significant say in defining and assessing student learning, to the detriment of educational experts and digital pedagogical approaches (Pinheiro et al., 2023).

Innovation within Higher Education (HE), as a key driver of economic growth and societal progress (Bleiklie and Michelsen, 2013; Williamson et al., 2020a), can encounter significant obstacles, particularly in the New Management era that has affected university governance in Europe since the last turn of the century. Among these impediments are an excessive emphasis HEIs might develop on prestige, an over-reliance on specialization, and a lack of exposure to transnational collaborative methods beyond conventional committee work and meetings. The undue focus on prestige can stifle innovation by prioritizing reputation over novel ideas and risk-taking. This can lead to a conservative approach to research and development, hindering the exploration of groundbreaking concepts. Similarly, an over-fixation on specialization can limit the scope of innovation. While expertise in a specific field is crucial, excessive specialization can restrict interdisciplinary collaboration and holistic problem-solving. This siloed approach may prevent the cross-pollination of ideas necessary for breakthrough innovations. Lastly, traditional methods of collective work, such as committee meetings and hierarchical organizational structures, may not be conducive to fostering innovation. These structures often promote conformity and discourage dissenting opinions. Addressing these headwinds to innovation requires a shift in organizational culture and practices. Emphasizing the value of novel ideas over prestige, promoting interdisciplinary collaboration over excessive specialization, and exploring alternative methods of collective work can help foster an environment conducive to innovation (García-Morales et al., 2021).

While there undoubtedly are considerable differences in university governance in Europe and around the world, in Scandinavia, the landscape of HEIs is quite homogenous. Universities present similar governance systems being almost entirely public and supported by governmental financial investments (Bleiklie and Michelsen, 2019). In this respect, Scandinavian HEIs mirror the Nordic model of social democratic welfare orientation that the Nordic countries are well-known for (p. 198) and can fall "under the common label of a Scandinavian Model of HE" (p. 205). Also, even if Norway is not a member of the European Union, all universities in Scandinavia have implemented policy resolutions resulting from the Bologna process (Zahavi and Friedman, 2019). The Council of Europe policy document «Council Recommendation of 5th April 2022 on building bridges for effective European higher education cooperation» (Council Recommendation (COE, 2022a,b) represents a call for action for European and Scandinavian universities alike to achieve the goals of seamless and ambitious transnational cooperation expressed by the European Education Area by 2025. It highlights the necessity for HEIs to develop and deliver solutions to enable the sharing of «human, digital and physical resources, and services, to operate virtual inter-university campuses and interoperable platforms for joint digital or blended activities» (C160, 2022, p 4). These ambitious formulations picture a visionary future of flexible and inclusive mobility for learners, academics, researchers, and staff where joint degrees and interdisciplinary modules are the norm, and the Bologna Process instruments are actively implemented at national, regional, and institutional levels in all universities in Europe (Council Recommendation (2018/C 444/01); Council of the European Union, 2019). International research programs such as Horizon, student exchange programs such as Erasmus+, the European student card initiative, the promotion of mutual automatic recognition of credits to facilitate student mobility, and the implementation and recognition of micro-credentials across institutions, businesses, sectors, and borders for lifelong learning and employability are examples of named instruments COE (2022b, pp. 18–20). As clearly expressed in this recommendation, it is not possible to concretize the CoE's goals of transnational and inter-university cooperation without actively implementing digital hybrid and blended teaching and learning activities.

In the international relevant literature, both in Europe and trans-continentally, the terms *hybrid learning*, and *blended learning* are often used interchangeably to describe both synchronous and asynchronous learning modes and learning spaces with students and/or educators located in different places, *in situ* and/or online (Goodyear, 2020; Raes et al., 2020; Saichaie, 2020; Bülow, 2022; Eyal and Gil, 2022). Terminology in this research field is yet not settled as novel publications, often from the field of computer science in education, often put forth new ways of employing already-known terms. To complicate the matter, the internationalization of faculty cooperation and study programs across national borders has put the terms *cross-campus and cross-institution teaching and learning* in the spotlight. In a recent review, Mavroudi and Gynnild (2021) for example refer to cross-campus teaching or multi-campus teaching as a form of hybrid education where onsite and remote students attend the same classes either from campus or their homes. In this paper, to avoid any confusion and to strengthen a common understanding of the concept at a European level, we will refer to the definition of blended learning given by the Council of Europe: «Blended learning is the term used in formal education and training to describe when a school, educator or student takes more than one approach to the learning process. It may combine learning at school and in other environments, as well as using different digital and non-digital learning tools» (COE, 2022b). We will then employ the term "hybrid" to refer more specifically to complex, multifunctional learning spaces and arenas of "merging interactions" (Eyal and Gil, 2022) where students and educators have access to both digital and material artifacts (Goodyear, 2020), digital and non-digital learning tools and can engage in both synchronous and asynchronous learning activities. We will finally refer to either cross-campus or cross-institution teaching and learning to describe the organizational model within which the study program and learning activities are framed. In this paper, cross-campus describes study programs and learning activities where students and educators belong to the same

university but are located at different campuses and can attend both *in situ* and/or remotely. Cross-institution describes joint study programs where different universities collaborate and organize teaching and learning activities where students and educators belong to different universities, are located at different campuses, and can attend both *in situ* and/or remotely[1].

Irrespective of the choice of terms employed, the need for designing and implementing hybrid learning spaces for blended learning activities to reach the European Educational Area's lofty goals of flexible and equitable education for all by 2030 puts a stressful economic strain on higher education institutions. Universities in Europe struggle against a backdrop of increasing economic, environmental, and social changes. The progressive depletion of financial support for universities due to the post-pandemic economic crisis and the ongoing war situation in Ukraine, make national and international inter-cooperation, thus cross-institution and cross-campus initiatives, a difficult and costly affair nowadays (Chankseliani and McCowan, 2021). Universities regardless of the location and the governance model followed, can be described as "complex adaptive systems" (Bryant et al., 2020; Renfrew, 2020). While having established hierarchies, universities also are characterized by self-sufficient ecosystems where decentralized units, as well as individuals "operate in a federated manner with a high degree of autonomy" (Bryant et al., 2020, pp. 5–6). Cross-institution and cross-campus collaborations can then pose pedagogical, technical, support, and administrative challenges to university organizations because of the institutional "diffusion of authority and decision-making responsibility" in those ecosystems (pp. 1–6).

2.1 Cross-campus and cross-institution practices

Higher education institutions (HEIs) are increasingly operating in multiple locations or campuses, often across different regions or countries, to expand their reach, diversify their offerings, and enhance their impact. However, this cross-campus/institution (or multicampus) perspective poses significant challenges for the governance models of HEIs, which are the ways in which they structure their decision-making processes, roles, responsibilities, and relationships among different actors and stakeholders (Burns and Köster, 2016). Cross-campus/institution teaching and learning involves the delivery of educational programs across multiple locations by employing digital technologies and online tools to support communication and collaboration. This phenomenon poses various challenges and opportunities for higher education institutions, especially in the Nordic European context, where there is a strong tradition of social equity, education democratization, and public funding. One of the challenges is how to balance centralization and decentralization in the governance and management of cross-campus/institution programs. This involves finding an optimal level of coordination and autonomy for each campus, as well as defining frameworks and clear roles and responsibilities for the different actors involved, such as the board, the rector, the management team, the faculties, and the departments (Bahmani and Hjelsvold, 2020). Another challenge is how to design and implement pedagogical approaches that are suitable for multicampus teaching and learning. This involves selecting appropriate methods, tools, and resources that can enhance the quality and innovation of teaching and learning across different locations, as well as fostering a culture of sharing and learning from each other. In a previous parallel publication (Nykvist et al., 2021), these authors showed that this challenge requires creating flexible learning spaces that can be used with different teaching methods, such as student-active learning and session-based teaching in both synchronous and asynchronous teaching modes. A third challenge is how to cope with cultural diversity and relations dynamics in cross-campus/institution teaching and learning environments. This involves addressing the different needs and contexts of the students and staff across the campuses, as well as dealing with the potential issues or conflicts that may arise from cultural, linguistic, or disciplinary differences (Christensen and Nilsen, 2021). On top of these above-mentioned challenges, there are also strong cultural barriers to the innovation of governance models within HEIs.

Traditionally, centralized coordination and integration are important for ensuring coherence, alignment, and efficiency in the HEIs' strategy, policies, and operations. However, too much centralization can stifle innovation, creativity, and responsiveness to local needs and opportunities. Autonomy and diversity are for instance paramount to fostering a sense of ownership, identity, and empowerment among the different campuses (Bahmani and Hjelsvold, 2020). Too much decentralization, on the other hand, can also lead to fragmentation, duplication, and inconsistency in the HEIs' performance and quality. These internal tensions are amplified by external factors as well, and the challenge lies in how to manage the complex dynamics of the external environment. The external environment refers to the factors that affect the HEIs' activities and outcomes, such as political, economic, social, cultural, legal, and technological changes. The external environment can vary significantly across different locations or campuses, requiring different responses and adaptations from the HEIs. Moreover, the external environment can change rapidly and unpredictably, posing new opportunities or threats. Therefore, HEIs need to develop governance models that are flexible and adaptive enough to cope with the diversity and uncertainty of the external environment (Renfrew, 2020). Another important external factor entails the engagement and involvement of various stakeholders in the governance process. Stakeholders are the individuals or groups that have an interest or influence on the HEIs' activities and outcomes, such as students, staff, faculty, alumni, partners, funders, regulators, and society at large. Stakeholders can have different expectations, preferences, and perspectives on the HEIs' goals, strategies, and performance. In a newly published study series on the Nordic Educational Model (NEM), Tröhler et al. (2022) puts these internal tensions and external factors that contribute to shaping the reality of local universities in a historical

1 To clarify, it must be said that the terms cross-campus and multicampus teaching and learning are often used interchangeably. However, it seems that cross-campus teaching and learning is more commonly used, particularly in Norway, to describe a form of hybrid education where the on-site students are distributed on different campuses, often within the same country or region (Mavroudi and Gynnild, 2021). Multicampus teaching and learning, on the other hand, is more often used in international literature to describe a situation where an organization operates on multiple locations or campuses, often across different countries or regions (Lourenço, 2018; Leask, 2020). Therefore, the choice of term may depend on the scope and scale of the teaching and learning activities involved.

perspective and ponders the ability of NEM to cope with these modern challenges posed by globalization. The question asked is whether the Nordic educational systems and educational research can deal with the current challenges. In order to survive, HEIs need to develop governance models that are inclusive and participatory enough to ensure stakeholder representation, consultation, and feedback (Geschwind et al., 2019).

2.2 NTNU organization

In Norway, most universities are public with the Norwegian University of Science and Technology (NTNU) being the largest public university in the country. On 19 June 2015, the Government in the Council of State decided to merge the University of Science and Technology in Trondheim, Sør-Trøndelag University College, Ålesund University College, and Gjøvik University College into *one* university named The Norwegian University of Science and Technology. This gave the final go-ahead for the NTNU merger in 2016 (NTNU, 2015). After the merging process, NTNU has now three campuses in Trondheim, Gjøvik, and Ålesund, and a satellite "campus office" in Oslo; it employs about 8,000 staff and educates about 43,000 students.

Besides its strong focus on science and technology, NTNU also offers programs in other research fields such as humanities, social sciences, arts, and medicine. The university is governed by a board consisting of 11 members, of which five are externally elected by the Ministry of Education and Research, and six are internally elected by the staff and students. The board is chaired by an external member and appoints the rector as the chief executive officer of the university. The rector is responsible for the academic and administrative activities of NTNU and reports to the board. The rector leads a management team composed of three pro-rectors, one university director, and two vice-rectors representing the campuses in Gjøvik and Ålesund. The management team is responsible for developing and implementing the strategies, objectives, and expected results of NTNU, as well as overseeing the quality assurance and performance evaluation processes. The university is organized into eight faculties, each headed by a dean appointed by the rector. The faculties are further divided into departments, each headed by a head of department elected by the faculty board. The departments are responsible for conducting teaching and research activities within their disciplines, as well as managing their human and financial resources. NTNU has a collegial governance model that emphasizes academic freedom, autonomy, and participation. However, it also faces challenges such as increasing competition, complexity, and accountability in the higher education sector. Therefore, it has adopted various governance mechanisms to enhance its performance, efficiency, and transparency, such as professional management, leadership structures, performance indicators, and external stakeholder involvement (NTNU, 2021). These mechanisms are influenced by both global trends and national contexts but also reflect the values and identities of NTNU as a higher education institution.

NTNU's management of its three campuses has been posing a challenge in adapting teaching and learning to the different needs and contexts of the students and staff across the campuses. NTNU has adopted various strategies and measures to cope with this challenge, however with various degrees of success, such as (NTNU, 2018a):

Developing a common vision and identity for NTNU as a whole, while respecting the diversity and autonomy of each campus.

Establishing a governance model that balances centralization and decentralization, with clear roles and responsibilities for the board, the rector, the management team, the faculties, and the departments.

Creating learning spaces that are designed to be used flexibly with different teaching methods, such as student-active learning, multi-campus teaching, and session-based teaching. These learning spaces are equipped with digital infrastructure, such as Zoom Rooms, that enable synchronous and asynchronous communication and collaboration across the campuses.

Providing teaching and learning support for teachers and students through various channels, such as online resources, courses, events, forums, and help desks. These support services aim to enhance the quality and innovation of teaching and learning at NTNU, as well as to foster a culture of sharing and learning from each other.

Implementing holistic teaching and learning support in alignment with NTNU's goals, strategies, and guidelines, and that delivers services that are experienced as integrated by the target groups.

However, recent years' increasing cuts in governmental funding and subsequent re-organization and effectivization measures within the university's governance model have given rise to critical voices that question the rigid structures NTNU seems to be trapped in. In a series of statements, professor and safety representative Brandtsegg (2023) has written about the individual employee's relationship with the university. Here the expression "The black box" is borrowed from the field of artificial intelligence to describe decision-making processes that preclude insights into how decisions actually are made at the university. NTNU formulates collective business strategies that inform all employees about the general goals and help them move in the same direction. It creates expectations. The institution's expectations of the employees, but also the employees' expectations of the institution. Expectations that the institution will facilitate the achievement of the strategic objectives it has posed for itself. The reality, however, presents a different outlook where a rigid level structure *"i linje," down the line*, from the Rectorate at level 1 to the Departments at level 3 and, in some cases, Sections and Units at level 4 cuts out direct contact between the innovative ideas educators and researchers might have and their realization. Innovative projects in research, teaching, and learning meet a long way ahead from the first developmental stages to possible implementation, filtered by the different administration layers. Administrative employees at each level in the organization seem more often to express loyalty upward the system instead of listening to the needs of the level below. This rigidity perpetuates and fossilizes organizational practices instead of promoting innovation. As Brandtsegg claims, it is essential that the administration at the faculty and rector level uses its energy to get the academic body the resources it needs, rather than starve academic environments that try to meet NTNU's strategic goals with closed walls (Amble et al., 2020). Without transparency, cooperation, and decision flexibility across the administration levels, conflicts emerge that put the employees' loyalty and trust in the organization they work for at risk (Amble et al., 2020). Amundsen and Kongsvik (2016) name these conflict dynamics as "change and innovation cynicism," the development of a state of apathy or demotivation - which occurs when employees' voices seem not to be heard and structures at work are perceived as meaningless or deterrent to the academic work performance. Conversely, when organizational structures encourage employees'

participation in changing processes and their autonomy, employees' trust manifests itself in higher creativity and work performance (Bozkurt et al., 2020; Amundsen, 2021).

In the following, we outline the organizational synergies that when channelized in the right direction from different levels in the organization, can spark creative professional innovative cross-campus and cross-institution collaborations.

3 Context: the master's program in music, communication and technology (MCT) and the SALTO project

The master's program in Music, Communication, and Technology (MCT) started as a collaboration between the Norwegian University of Science and Technology (NTNU) and the University of Oslo (UiO). The program was a development project within the University's Teaching Excellence initiative and got public funding for the period 2017–2021 (NTNU, 2018b). NTNU Teaching Excellence is an integrated and wide-ranging initiative aimed at helping NTNU achieve its strategic goals of providing education characterized by quality at a high international level. The initiative consists of a portfolio of development measures, which together are intended to strengthen teaching skills by developing innovative teaching, learning, and assessment practices. The measures aim to improve students' learning outcomes.

The MCT master's program was co-located at both campuses in Trondheim and Oslo but in addition, it entailed the management and refinement of one *hybrid* (physical and virtual) learning space for physical-virtual interaction across the web called the Portal to share resources in terms of staff, rooms (labs), recording studios, and software. In the Portal students and teachers were meant to collaborate and explore educational, methodological, and technological solutions together (Støckert et al., 2019, 2020). The master's program was also "the living lab and testbed" for the related research program SALTO (2017–2021). SALTO has represented the successful concretization of a pedagogical vision that values collaboration and knowledge-sharing among students and educators and goes beyond educational institutions' classical physical barriers. The scope of the research in SALTO entailed the development, investigation, and evaluation of cross-campus/institution hybrid learning spaces and innovative teaching and learning solutions.

Cross-campus and cross-institution collaborations have become a highly relevant issue in Norway given a structural reform in 2016 where different HEIs in the country were merged into larger entities. SALTO aimed to develop through the MCT master's program effective pedagogy with synchronous student-centered learning activities at both campuses, with particular emphasis on interaction, resource sharing, and communication. Established strategies for student-active learning were adapted in a cross-campus context while being anchored within Radcliffe's Pedagogy-Space-Technology (PST) framework (Radcliffe et al., 2008) for the sustainable design of physical and virtual learning spaces. Key pedagogical approaches and relevant activities at the base of the SALTO project and MCT master's program have been:

Collaborative learning: Project work, problem-based learning, and development projects in groups across campus.

Flipped classroom: Development of digital learning materials and common methods for in-depth study, discussion, and application of subject matter across campus.

MCT was designed as a different master's program. Music technology was at its core, but the scope was larger. Students were educated as *technological humanists*, with technical, reflective, and aesthetic skills. The core is the belief that the solutions to tomorrow's societal challenges need to be based on the intimate link between technological competence (musical) aesthetical sensibility, humanistic reflection, and creative adjustment and adaptive skills. The choice of a master's program in Music, Communication, and Technology lies in the assumption that if pedagogical and technological innovation can overcome spatial challenges and facilitate communication and collaboration through flexible solutions, resulting in productive crossings between musical performance and technological innovation, then the same innovative approaches can successfully be employed in other subject areas (De Caro-Barek et al., 2023).

4 Theoretical perspective and methodology

In two previous related publications (Nykvist et al., 2021; De Caro-Barek et al., 2023), these authors have offered a comprehensive account of the epistemology, methodology, and methods employed in the research project. In this paper, we will briefly summarize our research position and rather refer to our previous articles and the extra material section accompanying this paper for further information. Being our focus on the description of phenomena from the perspective of the participants, that is students and educators from the master's program in Music, Communication, and Technology, in this **exploratory case study** we have opted for **a phenomenological investigation** (Creswell and Poth, 2018) and a qualitative approach to research design that is informed by **constructivist grounded theory methods** (Charmaz and Thornberg, 2020). By including the **constant comparative method** (CCMA) to structure and guide data analysis (Postholm, 2019), the research group managed to gather richer data and achieve a deeper analysis of the phenomena investigated than by a pure phenomenological or a pure grounded theory research approach (De Caro-Barek et al., 2023).

4.1 Our participants

4.1.1 The educators

Six educators ($N = 6$) were involved in the design of the learning experiences during the first 2 years of the program. All educators were males and, except for one educator at the university of Oslo, Norwegian. However, the teaching language of the study program was English. Interviews with the educators took place in two stages. In the first stage, a focus group semi-structured interview was conducted with three educators ($n = 3$), two of them being the founding members of the study program. The third educator in this group was chosen based on their role in providing practical, pedagogical, and technical expertise to the teaching team. This first interview resulted in the identification of recurrent ***themes*** that were then used as a starting

point for the second round of interviews. Drawing on the analysis of the case study data, the following seven themes emerged during the first interview with the educators in MCT: *Trust, the human factor, sharing resources, building ownership, leadership support, flexibility and equality,* and *focus on pedagogy first*.

In the second stage of interviews, an additional three educators ($n=3$) participated in individual semi-structured interviews. These educators were new to the MCT program in its second year and were consequently asked questions relating to the themes that had emerged from the initial data collection in the first stage.

4.1.2 The students

Students enrolled in the MCT-program came from all over the world, so our project participants presented good variation in language and cultural backgrounds with a larger number of international students. The participants we have chosen to interview for this study were those ($N=9$) who had been students at MCT for more than 1 year and had experienced the program from its very beginning, and both before and during the pandemic. We identified these students as the ones more apt to offer us a greater amplitude of reflections on their experiences. Our nine informants consisted of both Norwegian and international students, two females ($n=2$) and seven males ($n=7$)[2].

4.2 Methods

Data was gathered via semi-structured interviews. An interview guide was used where questions were designed to make the informants talk freely about their experiences. The interviews were conducted in both Norwegian and English, according to the participants' preferences. Questions were adapted to either focus on the student role or the educator's responsibilities but in both cases, **participants were asked about which organizational elements or factors they believed contributed the most to the success of the program, and conversely, what elements had been a hinder and created difficulties or tensions.** *They were asked about how the organization and administrative support worked in a cross-campus, cross-institutional perspective. What did students and teachers had to say about the organization and the institutional process? How did this affect the students and staff's working situation? What promoted their teaching and learning work, and what hindered it? How did this affect their learning environment?*

The interview guide is included in the extra materials section.

Due to the pandemic, the interviews were conducted online via Zoom, audio recorded through a Dictaphone app called *Nettskjema*[3] developed at the university of Oslo, and then manually transcribed. Thereafter a phenomenological analysis (Moustakas, 1994) was conducted to identify blocks of information relevant to answering our research questions. The blocks of information were then structured and organized through a process of **open coding** (Corbin and Strauss, 2015) with reference to the **constant comparative method** (Corbin and Strauss, 2015). This process led to the definition of **categories** named on the basis of the type of information within each category. Each transcribed interview was categorized, and each category was then condensed and refined. The condensed texts for each category were subsequently assembled across all interviews and condensed once again. The result of this condensation process in stages was a final text that comprehensively described the informants' experiences and beliefs across interviews for each of the identified categories. Validity in the process was secured by triangulation between all five researchers in the research group and by the constant comparison of data throughout the analysis phases. In the two parallel articles the research group published about the educators' and students' experiences, it was also clarified that internal validity occurred between each of the researchers and was confirmed by an observer (Nykvist et al., 2021; De Caro-Barek et al., 2023). The role of the observer was to conduct a confirmability audit to assess how well the findings were supported by the data collected and then resolve any differences with the researchers (Nykvist et al., 2021).

5 Results

The results presented in this paper look back at what educators and students reported on their experiences with the MCT master's program and reflect the three stages of the program's organization from the planning phase, through the implementation phase, and finally, to the current evaluation phase. The educators' experiences are obviously at the core of the planning phase, while both educators' and students' comments define the results for the implementation and evaluation phases. For each phase, a comprehensive text based on the final condensation from data analysis for both educators and students is presented. Each phase covers and explains relevant aspects brought upon by the participants and illustrates the organizational journey of the study program, from the educators' pedagogical vision to the concretization and evaluation of the program by educators, students, and local leadership.

Table 1 below summarizes the results by highlighting which supporting and hindering factors, at both the organizational and pedagogical levels, affected the development of the study program in each organizational phase. In addition, a keyword for each phase is chosen based on data categorization to express the most prominent aspect discussed by the study participants.

The paragraphs in the running text under Table 1 offer an extended explanation of the results presented.

5.1 The planning phase—trust

One of the founding members of the program explained the initial vision for the cooperation model that underpinned the pedagogical approach of the study program:

"There has been an academic group with representatives from each university. In addition, we have held workshops with both professional, technical, and administrative staff. The content of the program is largely based on the research carried out at the two universities. Here in Oslo, we work a lot with movement, sound and machine learning, while NTNU does a lot of sound processing and

2 For a clarification of the methodology, methods and on the gender gap of the study participants, please refer to De Caro-Barek et al., 2023.

3 https://www.uio.no/english/services/it/adm-services/nettskjema/help/nettskjema-dictaphone.html

TABLE 1 Results summary.

	Supporting factors	Hindering factors
Planning	**Keyword: trust**	
Organizational level	Both bottom-up and top-down process Hands-on, Cooperation model	Project acceptance at the Rector staff level (the head of academic and administrative activities at NTNU) but not anchored downwards to the faculty and department levels Different LMS patforms Different Administrations Different economic and personal resources and space availability Communication issues
Pedagogical level	Shared pedagogical vision *Experts in Team* pedagogy Radcliff's PST framework as a shared inspiration for the creation of cross-campus symmetrical hybrid learning arenas	Communication issues
Implementing	**Keyword: leadership support**	
Organizational level	Cross-campus cooperation at all levels of the two organizations: between students and educators, program leaders, faculty administrations, IT departments, and organization leaderships	Top-down decisions > Lack of leadership commitment downwards the organization > Friction Difficulty in freeing economical resources and supporting staff
Pedagogical level	Sharing resources and technical solutions to guarantee flexibility and equality in teaching and learning. Students' involvement throughout the process	Students' diverse subject and academic backgrounds. Cross-campus educators' struggling with more and unrecognized workload
Evaluating	**Keyword: flexibility and equality**	
Organizational level	*Ad hoc*, flexible, hybrid (physical and digital) learning spaces and arenas adapted to students' needs Symmetry of learning spaces	Poor management and underestimated costs. Leadership concerns for involved costs.
Pedagogical level	Shared learning materials Educators present *in loco* at each physical location. Transparent assessment criteria shared with the students	Leadership unwilling to pay for extra workload or extra staff > Discontinuity of teaching staff > extra workload on remaining educators

practice. We have put together the expertise, and so communication is the supporting element."

"Experts in teams" pedagogy[4] (EiT) was the starting point for the development of teaching and learning activities at MCT. The core of EiT pedagogy is to make people collaborate across professions and professional backgrounds, so MCT students came from different educational, professional, and cultural background. Students were put together in cross-campus groups to collaborate with each other in solving theoretical and practical tasks. Supported by immersive activities, discussions and short, intensive sessions, teachers had an ambition to move away from the traditional "lecture" teaching paradigm focused on transferring knowledge to involve and engage the students in the teaching and learning process, developing skills through authentic problem solving.

To create such an innovative learning environment, practical organizational aspects, technical issues and bureaucratic hiccups needed to be discussed and solved.

On the pedagogical level, educators carefully tried to safeguard Symmetry in teaching and learning and develop their spatial, social, and didactic competence to teach in an innovative hybrid learning space. They created a mirrored physical learning environment in the Portal that could be very similar at each campus and had local teachers on both campuses facilitating students' work. Educators also have to delegate tasks and decide who among them would be responsible for each course topic, who would create and publish resources cross-campus, and who would teach locally. A challenge was the hourly weighting of educators' work being different at each university thus creating an unfair distribution of resources.

On the organizational level, a great deal of preliminary administration issues needed to be sorted out. First of all, communication issues and cultural differences between the two university partners. Both administrations had to cooperate, so student advisors and the center for international students at both universities were consulted about the available possibilities for taking joint subjects

4 Experts in Teamwork (EiT) is a master's degree course in which students develop their interdisciplinary teamwork skills. The course is compulsory for all students in master's programmes and programmes of professional study at NTNU.

at both universities. Then more practical aspects and challenges were dealt with specifically concerning the set-up of the physical and digital learning environment at each campus, such as different IT-administration rules at each university, different levels of economic resources available, different space availability, and adequate rooms equipment, and different learning management systems. Each physical campus also had specific spatial characteristics, so much time was spent trying to identify the best "*ad hoc*" solutions to connect the physical and digital learning environments, optimizing sound and image solutions, and overcoming technical challenges.

Educators and students alike underlined the importance of **Trust** as a key element in promoting fruitful collaborations and to establish a common pedagogical working platform.

To support and develop Trust, three initiatives were highlighted:

- Creating an informal arena for social contact or informal social activities.
- Laying the foundation for a learning culture based on collaboration among and between educators and students, student initiative (student as an independent learner), and teacher facilitation.
- Sharing a common understanding of how to work together and interact. The importance of informal interaction with the students was highlighted to create a social–emotional learning environment based on trust.

5.2 The implementation phase—leadership support

As introduced in the previous section, there were different challenges related to the cross-campus cross-institution setup for the study program: Different administration systems, different learning management systems, and information and communication channels.

On the pedagogical level, the students' diverse subject and academic backgrounds led to challenges concerning the need for *ad hoc* curriculum development. Teachers needed to adapt and revise both the content of the curriculum and the teaching methods. In addition, the hybrid learning spaces had to be built with the help of the students. After the first half year into the program, it became clear that to guarantee equality in the teaching and learning experience, at least an educator had to be present physically at each location to facilitate students' learning activities. Extra resources were then hired at the start-up. Unfortunately, the progressive lack of leader commitment in the organizations led to a lack of follow-up and support that caused troubles for the further development of the program. Resources were cut back and with diminishing IT and technical support, teachers had to do all the work themselves. They did not have the time to collaborate, plan, and discuss pedagogical issues with colleagues. Organizing teaching cross-campus was demanding, it required extra working hours to create digital pedagogical resources that could be shared. However, educators' extra workload was neither recognized financially nor symbolically (f.ex. in the form of merit points). The situation was worsened by the fact that several teachers left and new came into the program without having the originally shared understanding of pedagogical practices (challenging the traditional teacher role) and the same spatial, social, and didactic competence. Continuity in the teaching staff is paramount to further development and the change of personnel required even more extra work from the existing staff. Understandably, this affected the learning experience of the students. Even if it was made clear from the beginning that student-centered learning forms and active student cooperation were at the core of the curriculum, many students struggled initially with the extra work demands required to build the actual learning space of the Portal. Many reported that even if rewarding in terms of acquired new skills, this phase was stressful.

On the organizational level, much of the developmental and implementation work was spent on finding sustainable solutions to safeguarding pedagogical symmetry on the local campuses and appropriate hybrid ad fully digital technology solutions for online interaction. Educators, technical and administrative staff, and leaders at all levels of the organization had to cooperate in new ways to secure the concretization of the project. Economic resources needed to be released and redistributed to guarantee the implementation of a balanced learning environment at each campus, and flexibility and equality of study offered for both students in Oslo and Trondheim. Much time was spent on discussing roles differentiation and delegation of tasks. Who were the real decision-makers? A lot of emphasis was put on the economic aspects and the actual costs involved in the program. In the beginning, the faculty supported the academic innovative value of the project and seemed to understand the uncertainty accompanying the development of a novel cross-campus study program. However, after a while, administrative-related economic concerns took over and negatively impacted the academic development of the program. Resources were drastically cut back, leading to increased responsibility pressure on the educators, who now had to solve administrative problems and hiccups by themselves.

Cross-campus is a novel model in Norway; development is time-consuming, and it challenges the number of available resources. According to the study participants, the key aspect throughout the process must be **leadership support**.

When leadership is committed and appropriate administrative and economic support is guaranteed, the academic staff can better exert their role and concentrate on developing high-quality learning materials and equitable learning experiences for all students in a cross-campus situation.

5.3 The evaluation phase—flexibility and equality

To ensure flexibility and equality in teaching and learning experiences in a cross-campus situation, it is paramount to anchor the development of an innovative study program at all levels of the organization (s). It seems that a proactive and problem-solving-oriented leadership involvement in coordinating administration issues and economic aspects might have more positive outcomes for the teaching and learning experience of both staff and students. Conversely, a lack of leadership commitment and a focus more on cost awareness than academic value is detrimental to innovation in Higher Education.

On the pedagogical level. To focus on student active learning, teachers needed to be more observers and supervisors, to mediate and motivate students' interaction, discussion, and collaboration by

including a flipped classroom approach and cross-campus group activities. This required a practical organization of courses that entailed a direct collaboration with students and teachers at both campuses. Because of the students' different academic backgrounds, teachers needed to actively provide a variety of opportunities for learning and to develop projects with a breadth of activities to create relevance for all. Students on their turn were required to be active in choosing and developing their learning path and to learn how to best collaborate cross-campus. Since students were involved in the program from the beginning and had to work alongside their teachers, they were encouraged to take responsibility for their own learning and for how to support cross-campus collaborations. Students needed to become aware of how to contribute to an equal experience for remote students, so they had to find out how to navigate and sustain "netiquette" or their social and technological awareness. Students realized that the biggest challenges were rarely caused by cultural differences and that good communication and coordination skills, and English proficiency were the most important factors in intercultural teamwork. To organize and support their work cross-campus, most teams used multiple tools, preferring video and text-based communication channels over voice-based tools. The cross-campus digital setting did not really seem to be an issue for the group dynamics, but the groups still needed facilitation and help "on demand" from their teachers. Transparency throughout the process was also an important factor contributing to flexibility and equality. Transparent and clear assessment criteria, known in advance, and transparent and appropriate forms for project management, contributed to developing students' responsibility for their own learning and deliverables.

On the organizational level. After the initial enthusiasm for the academic novelty of the study program, friction developed between the administration and the academic staff, particularly at NTNU which traditionally receives less government financial support. The administration staff demanded clearer leadership intervention and guidelines regarding the increasing costs of the program The academic staff wanted and needed a swifter administrative process to free important financial and staff resources to guarantee quality in teaching and learning. Poor administrative management and underestimated costs drew a challenging picture for the Institute leadership level. Support was revoked or reversed, and the hiring of extra staff was declined. Consequently, existing educators had to work extra with noneconomic returns, and several educators decided to leave the program. New educators came in, but the discontinuity of teaching staff implied an extra workload on the remaining teachers who now had to train colleagues in the pedagogical innovation of the program. Teaching cross-campus in a hybrid learning environment proved to be cognitively challenging. Maintaining equality when teaching students present both physically and digitally demands a complex set of skills that involved both pedagogy and spatial and technological competence. New educators had to get acquainted with the pedagogical vision for the program and the physical and technological aspects of the teaching. More experienced educators had then less time to dedicate to the development of the program because they had to follow up with the new staff. Because innovation in pedagogy takes time, cross-campus cooperation between teachers is paramount to sustain the continuity of responsibility in the teaching staff. To support the academic development of cross-campus collegial cooperation, measures must be in place in the form of freeing an adequate number of personal resources.

6 Discussion

Projects exploring new technologies and innovative pedagogical practices are necessarily characterized by a certain degree of uncertainty and are most likely to be costly. Results from our study confirm that universities should take these aspects well into account. Even with external funding present, university administrations would have to chip in with extra resources. Cross-campus and cross-institution innovative projects, therefore, constitute in many respects a double threat, because organizational and administrative challenges can most certainly be expected to come on top of extra costs.

This is perhaps the reason why, despite the international and governmental reforms that have been challenging the foundation, sustainability, legacy, and legitimacy of European and Norwegian Universities for the past two decades, HEIs still strive to adapt and fully embrace the concept of an open university. The current form of Norwegian governance and associated policy models within Higher Education are also undeniably influenced by these international and European concerns about reforms and changes (Maassen and Stensaker, 2011; Bozkurt et al., 2020; Huisman and Lyby, 2020). Strategies and policy ambitions work splendidly on paper but are rather more difficult to implement in reality. The goal of the SALTO project and the joint MCT master was in many respects to challenge the organizational inertia typical of academia and create a shared vision built on a common platform by combining two strong and complementing academic groups in both music and technology from two different universities. This platform was meant to provide grounds for new ways of student/teacher collaboration and cross-campus/institution cooperation by paving the way for the design of future hybrid learning spaces. The vision entailed a shared pool of available physical/virtual resources in terms of staff, rooms (labs), recording studios, and software. The project was aligned both with governmental reform policies on the digitalization of Higher Education in Norway and the two universities' strategic policies. However, as this study uncovered, important aspects to consider in this context is how the demands for reforms and actions are interpreted and implemented within university governance and leadership. In relation to the MCT/SALTO project, it is intriguing to notice that the project ticked many boxes on the leadership agenda and was considered a prestige project. It fitted into the government digitalization and effectivization strategy that had been concretized in the Strukturmelding (Re-Structure Document) from 2015, which reduced the number of state universities and university colleges from 33 to 21 (Ministry of Education and Research, 2015; Wiborg et al., 2022) and paved the way for merger consolidation of geographically distributed units with larger distances between campuses and institutions. Furthermore, the project was meant to become a concretization of the European trends and strategies on digitalization used as a process to enhance the quality of higher education in general, but also to facilitate better collaboration, communication, and resource sharing among the emerging cross-campus/institutions constellations (Ministry of Education and Research, 2017; Kunnskapsdepartementet, 2021). The way from strategic and pedagogical visions to actual implementation was however more

complex than expected. This is not groundbreaking news, Maassen (2017) for instance writes about the University's Governance Paradox, when the more university leaders take on and operate in line with the reform agenda's ideologies, the less effective they appear to be in realizing the reform intentions. Bryman's (2007) literature review on academic leaders also points out that there is no clear evidence that digital technology usage is a priority on most academic leaders' agendas. Their responsibilities are broad and contextually bound, with a tendency to display a range of competing competencies and priorities that sometimes clash. Tømte et al. (2023) and Fossland and Tømte (2020) also reveal that about half the deans at all public Norwegian HEIs reported having no or limited knowledge about how their own faculty addressed issues related to digital technology usage for teaching and learning purposes. A key consideration then emerges of a *dual structure*, which implies a separation between the actors and bodies responsible for administrative matters and those for academic matters. This structure is often characterized by two parallel but loosely coupled hierarchies: one academic and one administrative, each with its own decision-making structures (Larsen et al., 2009). In the case of the cross-campus and cross-institution collaboration between NTNU and UiO, this dual structure resulted in a *double dual structure* operating across distance, with various systems creating barriers for seamless, synchronized collaboration. This includes issues related to Learning Management Systems (LMS), administrative IT-support, purchase agreements for equipment and software, grading systems, teaching hours, ownership of students, and teaching topics. The complexity of the challenges involved reveals the inadequacy of normative models for cross-campus and cross-institution collaboration and learning design. In other words, those creating new spaces for hybrid learning often do so in ways that exceed the capacities of existing design models and university affordances (Goodyear, 2020). In cases of disagreement or conflict, either the administrative or the academic leadership has the final responsibility. Conflicts and tensions may arise both within as well as between different decision-making bodies. Maassen (2003, p.32) discusses for instance four basic dilemmas in university governance reforms. Of particular interest to the MCT/SALTO situation is the dilemma between integrated management structures and dual management structures. This was evident in the establishment of MCT in Trondheim, where the academic line of command from the Ministry-rectors-faculty-institute pushed a decision without consulting the administration with respect to financial and organizational issues. If the heart of any radical change in higher education is not followed by the willingness of the administration and faculty to also embrace change, then there will be no change.

Bahmani and Hjelsvold (2023) refer to Porras and Robertson (1992) and their theoretical framework for organizational development and posit quite clearly that changes in the behaviors of individual members of organizations form the crux of organizational change. Measuring educators' readiness for change in teaching mode is fundamental to cross-campus collaboration and, by extension, cross-campus learning environments and course development (Bahmani and Hjelsvold, 2023, p.2). Consequently, measuring the administration's attitudes to and readiness for change in tackling the uncertainty and complexity posed by the double threat of cross-campus and cross-institution innovative projects is a pivotal contributing factor in the success of said projects. In addition, Abualrub and Stensaker (2018) point to a potential decoupling between 'administrative' and 'academic' responsibilities. Universities are not only places for teaching students and conducting research but are also workplaces. The hybrid campus, which might be in a cross-campus or cross-institution governance model, will require leaders to identify functions that are critically important to the institution's mission and then focus their resources on those functions. How can they facilitate cross-campus/institution collaborations and the management of related hybrid learning spaces?

These authors suggest that colleges and universities seeking to innovate on an institutional level should understand the importance of the *culture* that is needed at its base. **The experiences gathered through the MCT/SALTO project show that innovation is not effective as a top-down initiative; rather, it is most effective when it is developed as the result of allowing faculty, staff, and students to experiment in service to improve the learning that takes place at their institution**.

In a study by Hannon et al. (2018), engagement with interdisciplinary knowledge was shown to have profound effects on academic culture and identities among participating students and teaching staff; however, significant challenges arose in the coordination and administration of interdisciplinary education, with institutional structures highlighted as a contributing factor. In the context of developing cross-campus/institution settings, community building has been identified as a key to successful teaching innovations (Wenger, 1998, pp. 72–73). This approach emphasizes the importance of establishing a Community of Practice (CoP) (1998), a supportive and collaborative environment that fosters learning and engagement among students and teachers alike. According to Wenger (1998, pp.72–73), the concept of a CoP is integral to illustrating how students and educators work across universities. This concept, primarily academic in nature, should also be extended to those educators who undertake administrative tasks as middle managers with primarily administrative tasks.

According to Wenger (1998, pp.72–73), a CoP is characterized by three interrelated elements:

1 An identity defined by a shared domain of interest.
2 Members engaging in joint activities or discussions.
3 Members developing a shared repertoire of practice and artifacts to address recurring problems.

Given the hierarchical nature of academic administration, those at the mid-level are often constrained in reaching beyond their units because they report and respond "up" through linear reporting structures. One advantage of this is that mid-level leaders in a CoP which *crosses organizational boundaries* (university borders), act as direct individual contacts and nodes for connecting unrelated units across or between universities (Akkerman and Bakker, 2011). However, one side effect might be that they only report upwards and may not be concerned about the activities or challenges at the level below. This concept of boundary crossing was introduced to denote how professionals at work may need to "enter onto territory in which we are unfamiliar and, to some significant extent therefore unqualified" (Suchman, 1993, p. 25) and "face the challenge of negotiating and combining ingredients from different contexts to

achieve hybrid situations" (Engeström et al., 1995, p. 319). Therefore, we suggest that such a CoP should include administrators as well as educators and students so that the academic perspective does not pulverize away in front of administrative barriers. To succeed in establishing good management practices for cross-campus and cross-institution projects, universities should primarily invest in activities related to strengthening CoP work. These authors share the suggestion by Bahmani and Hjelsvold (2023) that leaders should therefore initiate measures to prepare the academic and administrative body for the transition to the cross-campus/institution mode in different stages [freely adapted from Bahmani and Hjelsvold (2020)

- Pre-contemplation stage: Seminars/workshops on cross-campus/institution education for educators and other teaching staff.
- Contemplation stage: The creation of a central hub for educators from all campuses to provide networking opportunities, cross-campus/institution coordinators, and the facilitation of a sharing culture to get to know teachers at other campuses and hear about their experiences with cross-campus/institution collaboration.
- Preparation stage: Additional time for research and team development, and the ability to share responsibilities.
- Action stage: Administrative support, better collaborative tools, and communities of practice including the administrative body.
- Maintenance stage: Supervision and support for those engaged in cross-campus/institution collaboration by providing a strong motivational factor to individual educators, and arrangement of a cross-campus/institution day.

These measures might then counteract some of the identified disadvantages of cross-campus/institution collaboration we discussed earlier in this section: Time and cost issues related to planning and coordinating additional work and extra infrastructure, increased administrative overhead, and challenges in maintaining control over the process.

A study by Christensen and Nilsen (2021) aimed at identifying key moderators of staff and student satisfaction at multi-campus universities shows four key moderators, all surrounding dissatisfaction within the different stages of a cross-campus/institution project: Inconsistent technology, hesitation to innovate, geographical separation of staff, and geographical separation of students. **The principles guiding the MCT/SALTO project** had indeed the intention of minimizing these potential dissatisfaction elements. They **were meant to solve the distance boundary between UiO and NTNU by creating a common learning space, thus breaking down the physical/technical boundaries**. Educators on both sides agreed and made a concerted effort to prepare and initiate action. Fortunately, they also were technologically adept educators who put in an extraordinary number of working hours to get the specific learning environment up and running and to facilitate contact and collaboration with the administration. Parallelly, by embracing the concept of "technical humanist" proposed by the MCT program, students also became designers and developers of their own learning space, actively participating in the digital transformation with a pedagogical pathway to motivate them. However, the need for more resources in terms of time, money, several teachers, and administrative support became more evident in the later stages of project implementation. It became clearer that so-called *symmetry issues* were more complex than expected.

6.1 Symmetry

Symmetry is a principal concept in the development and utilization of university learning spaces for student active learning, communication, and collaboration across campuses (Bülow, 2022; Eyal and Gil, 2022; Penrod, 2023). This concept encompasses essential elements such as time, money, infrastructure, and ideally shared strategies at the political level (in this case, the Ministry of Education and the Nordic NREN – National Research and Education Network) that are transformed into the university leadership/administrative level (Lillejord et al., 2018; Støckert. et al., 2020). However, the top-down transition and anchoring of strategies and symmetrical attempts in cross-campus and cross-institution innovative projects often do not deliver as expected by the leadership. This is due to these strategies being filtered through the organization. Furthermore, initiatives that originate from the bottom-up and are locally anchored often face difficulties in being transferred across locations and departments due to issues of ownership (Pinheiro et al., 2023, pp.175–188).

The anchoring within the organization requires a comprehensive set of parameters describing *symmetry* on multiple levels when providing the same learning and teaching experience to all participants, regardless of their physical location. This involves developing a transparent fabric that covers and binds all parameters together. Institutions should seek to optimize students' successful access to cross-campus/institution education by looking for impediments to a seamless student learning experience and taking necessary actions to revise or remove those obstructions. Sometimes the change needed is structural, sometimes it's procedural, and sometimes the problem lies in the approach to service delivery. In many cases, it's a combination of all these factors (Marthers and Rosowsky, 2021).

Unfortunately, most traditional HEIs' management systems seem to be insufficient to successfully lead a geographically distributed university and workforce (Groenwald, 2018). To harness the benefits, central leaders must create a culture that supports communication, collaboration, and inclusion; build an infrastructure to ensure consistent quality academic outcomes; and devise system-wide processes and technology to enhance communication and collaboration as well as efficiency (2018).

To develop the MCT master and the related research project SALTO, numerous resources were mobilized. Although the project had undoubtedly leadership support from the rectors, it appears it was not likewise well-anchored in the rest of the organization. Consequently, many of the planned measures like technical framework design, student support systems, topic selection, ownership of courses, weight of courses, grading, hours of teaching, and activities to take place synchronously across campuses did encounter several hinders along the way and sometimes could not run as smoothly as desired.

For example, while UiO had facilities available, NTNU had to design and build the Portal environment from scratch. In the lack of local support resources from the university's property division, educators at NTNU had to work as project leaders with architectural drawings, as well as installation professionals for HVAC, electricity/technical infrastructure, and IT/AV infrastructure. This led to an uneven start, with the necessity of using temporary spaces/studios at the Department of Music Technology in Trondheim compared to a

complete "portal" room already available at UiO. The NTNU Portal environment, however, even if delayed, had the time to be designed and built as a small ecosystem with one major portal room but with adjacent group rooms and a social zone. This solution seemed to provide much greater flexibility and offered students a better learning environment they felt complete ownership of. This uneven development of cross-campus learning spaces resulted in an unbalanced approach toward delivering a shared and equal experience to participants on both ends of the Portal. The students at UiO did not have a social zone or *local* group room in the beginning. Conversely, the students at NTNU had to wait 1.5 semesters to get their hands on the new Portal. Meanwhile, the educators needed to adjust both shared and local activities according to the development and access to the Portal environment (Støckert et al., 2019).

Costs piled up in the attempt to guarantee symmetry of the learning experience across the Portal. Educators' pedagogical vision wanted to include innovative space and technology solutions in a more holistic framework for the development of student-centered learning environments and teaching practices. The pedagogical focus on cross-campus interaction, collaboration, and resource sharing demanded the presence of educators and/or teacher assistants at both locations to facilitate equal access to learning resources and technical infrastructure (Xambó et al., 2020). This was especially important due to the shift in staff that happened during the first years of running the MCT program. New educators not familiar with the initial pedagogical vision for the project needed to be trained and taught. Also, from a spatial-technological perspective, symmetry had to be delivered in the basic functionality of room layout, acoustic properties, lights, AV equipment, and *ad hoc* infrastructure with related costs addition. The Portal was designed as a hub connecting people and resources across distance, and this demanded the deployment of a range of technologies from high-end, low-latency AV systems to, at that time, still under-used communication platforms like Zoom and Slack, which were not yet licensed and integrated within NTNU and UiO software portfolio.

The complexity of managing the related costs to maintain such a learning environment proved to be too much for the university in Trondheim. Organizational structures collapsed at level three when the Department of Musicology at NTNU decided to withdraw from the joint master's program in Autumn (Looney and Briga, 2021). The new Department leadership meant the project had been pushed through the organization by the academic body not taking into consideration the expenses it constituted for the Department already facing economic struggles. The administrative side had notified the academic leaders, from the rector to the previous head of the department, that the project would have been too expensive to be able to start. However, NTNU is a company where academic management is the one with the decision-making power, and they chose not to listen to their advisers. The administration, with the new head of the department in front, felt overruled, and the only way to re-establish a reasonable economic balance was to shut down the master's program and reallocate resources. This was first and foremost decided by the Department alone, and then the second level, the Faculty of Humanities, had to capitulate because there was no other extraordinary funding to free.

MCT/SALTO in many ways exemplifies paradigmatically the double structure conundrum discussed earlier in this paragraph.

7 Conclusion and the way forward

Academic organizations are complex systems that require anchoring at several levels - department, faculty, and technical-administrative. This requires a willingness to be humble, to have mutual respect, and an understanding of complex processes. It is important to have an open attitude and accept trial and error, even if it involves the risk of error. A solution-oriented attitude is essential to overcome obstacles in an organization that may seem too large, without a clear path through the system. Navigating a university organization can be compared to entering a maze with several possible exits, detours, and wrong exits: It takes time and energy to move around. Unclear structures and pathways can make it difficult to find the right persons to talk to or turn to - until you find an exit. Roadworks certainly lie ahead. There follows a danger of pulverizing responsibility and innovation initiatives when there are too many layers within the organization. This can lead to measures not being clearly or firmly enough anchored.

This study aimed to shed some light on these challenges and envision possible solutions for more effective organizational anchoring. Presenting the experiences of educators and students may offer new insights into how organizational constraints can negatively affect the work performance of the academic staff and the learning experiences of students.

Much of the work involved in the MCT/SALTO project was based on personal contacts and not via organizational structures, as the tasks to be solved did not quite fit into the usual booths of the units that were supposed to help. This emphasizes the need for flexibility in the organizational structure. There is also a contrast between zealots who are eager to help and work for free and the need for routines defining areas of expertise and responsibility, associated costs, and responsibility flow throughout the organization. The time factor also comes into play - sometimes it takes so long "to get the work done" that educators rather do it themselves.

The experiences gathered during the development, implementation, and ending of the MCT/SALTO project are by no means unusual in academia. There is always a risk that innovation in education, as we discussed, might be most often intended as a way to cut costs by automating processes rather than actually innovating teaching and learning practices. Particularly in times of recession like the present, universities are forced to reconsider their finances and prioritize. In Norway, where most universities depend on public funding, administration bodies within academia need sometimes to make tough unpopular decisions to keep the boat afloat. However, economic resources, though an important part of the equation, are not necessarily the direct cause of organizational inertia that slows down or even puts a stop to educational development projects. We also must start questioning whether it is not becoming counterproductive to let economic concerns trump the social mandate that HEIs have pledged to uphold. As former vice president and vice principal at King's College London, Jonathan

Grant argues universities are living in an "in-between time" of growing uncertainty. The sociopolitical landscape of variable economic growth and inequity further threatened by the current climate crisis, pandemics, and the rise of populism in several countries seems to urge for a change and a re-consideration of the new public management that has characterized university governance in the past decades. A new body of students has also been emerging. Younger students are digital natives bringing with them a set of new values with a clearer focus on globalization, climate issues, and the decolonization of culture and the university curriculum inherited from previous generations. Older students, in turn, need constant skills and knowledge updates to navigate an increasingly unpredictable work life where traditional academic degrees alone are no longer sufficient. At the same time, the current surge in advanced technological breakthroughs in artificial intelligence will forever change the way we approach academic studies. Universities must change the way they govern themselves if they want to survive. We are now witnessing the emergence of a *new power university* (Grant, 2021) that breaks free from obsolete governance models. Some of the *new power* trends are already beginning to be visible. New power learning is more representative and relevant, it delivers knowledge and skills on demand on digital platforms in a life-long perspective and will lead to more participation in higher education globally. Universities must cope with these emerging changes. The instrumentalized managerialism of today's universities will end as universities will need to introduce and include new staff roles where the boundaries between the bureaucratic staff and the academic body are blurred out to ease organizational-level transitions and support genuine innovation in teaching and learning from a pedagogical standpoint. New power universities will need to be transnational in nature and share resources, staff, and degrees. New power research will underpin this development by focusing on multidisciplinary research and using crowdsourcing, citizen science, and open innovation platforms to disseminate knowledge and freely and openly publish research data and results. It is our duty as educators and researchers to demand a more transparent university administration so that we can carry on our work in preparing students for life beyond their degrees. Let us hope roads work ahead.

8 Limitations

The present qualitative study, like many others, draws on a limited sample size from a single Master's program, thus its findings are specifically applicable to this context and may not be generalizable. However, knowledge derived from single case studies, while not formally generalizable, can be valuable and often paves the way for scientific innovation (Lysne et al., 2023). With its focus on the educators' and students' experiences, this study tried to uncover fundamental organizational challenges to the development and implementation of innovative cross-campus and cross-institution projects at higher education institutions. Despite the limited and specific context of the study, results seem to echo and confirm international issues related to the topic and therefore can positively contribute to the wider academic discussion with suggestions and further research.

Data availability statement

The datasets presented in this article are not readily available because they are subject to GDPR regulations in Norway. Requests to access the datasets should be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by the NSD - Norwegian Centre for Research Data. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

VC-B: Conceptualization, Writing – original draft, Writing – review & editing. RS: Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The Future of Higher Education: A Call for Radical Pedagogical Innovation in Post-Pandemic Times

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Abstract

The COVID-19 pandemic disrupted higher education globally, revealing both traditional pedagogies' strengths and weaknesses. As institutions turned to online learning, significant gaps in accessibility, digital literacy, and adaptability became apparent. This paper argues for a radical transformation of pedagogical innovation in post-pandemic higher education, advocating for a shift towards more flexible, inclusive, and student-centred learning models to bring the sustainable change we all want. It highlights key strategies, such as hybrid models, personalized learning, active and experiential learning, and rethinking assessment methods. These innovations, supported by digital tools, can better address diverse student needs and prepare learners for a rapidly evolving workforce. Nevertheless, institutional resistance to change, addressing the digital divide, and ensuring scalability remain potential barriers and challenges that must be overcome to achieve it. This paper, therefore, calls for collective and coordinated efforts by higher education institutions, stakeholders and policymakers to drive the required systemic change in higher education. By embracing these innovations, universities can build a more flexible, resilient, equitable, and future-ready education system that moves beyond the limitations of traditional pedagogies. The pandemic offers a unique opportunity to rethink the foundations of higher education and prioritize pedagogical practices that promote critical thinking, adaptability, and lifelong learning in an uncertain world.

Introduction

Many scholars agree that the COVID-19 pandemic didn't just disrupt higher education worldwide, it changed it forever (Barrett-Fox et al., 2020; de Wit & Altbach, 2022; García-Morales et al., 2021; Lemoine & Richardson, 2020; Ling Koh et al., 2023; Naibaho, 2022; Purcell & Lumbreras, 2021; Roesel & Dobrijević, 2024; Tilak & Kumar, 2022; Wang & Sun, 2022). It fundamentally transformed higher education, forcing institutions to quickly rethink and adapt to online teaching and learning, which was unfamiliar to many educators and students. It exposed some overlooked and critical issues deeply rooted in traditional teaching methods and approaches. The rapid shift to digital platforms has exposed weaknesses and vulnerabilities in our education systems. It highlighted the need for greater flexibility and inclusivity in education, revealing long-standing challenges such as accessibility and equity. What was initially a temporary response to a crisis sparked a much-needed conversation about the future of education. As we move into a post-pandemic era, it is clear that returning to pre-pandemic models is neither sustainable nor desirable (García-Morales et al., 2021). This paper argues that universities must embrace radical pedagogical innovation, shifting towards more flexible, student-centred learning models that can better meet the diverse needs of today's learners. The rigidity of traditional methods, centred on lectures and standardized testing, must give way to approaches that promote engagement, critical thinking, and adaptability, better preparing students for a rapidly evolving world. Higher education must evolve to stay relevant in an increasingly diverse and dynamic global landscape (Huang & Yanan, 2024; Judijanto et al., 2024).

The Pandemic as a Catalyst for Change (a Wake-Up Call)

Before diving into what needs to change in higher education, it is important to reflect on how the COVID-19 pandemic served as a wake-up call for change. When higher education institutions worldwide were forced to transition to online teaching and learning, it became evident that there was a big gap in digital preparedness for students and teachers (Adamson & Sloan, 2021). Not all students had reliable internet or access to essential technology, and many faculty who lacked experience with digital tools struggled to adapt to online teaching tools, revealing a gap in digital literacy across higher education, which put them at a distinct disadvantage (Ling Koh et al., 2023). We can only imagine the gravity of such an impact on the less-resourced institutions, especially those in third-world countries. These challenges indicated a larger issue: the traditional, one-size-fits-all approach to higher education was not treating or serving everyone equally.

The pandemic also accelerated the use of online tools and learning management systems (LMS), previously underutilized, becoming central to the learning experience. While some faculty adapted quickly, others found it challenging to engage students as they would in a physical classroom. Many universities adopted blended learning models, integrating synchronous and asynchronous instruction (Adamson & Sloan, 2021). The use of digital tools such as Zoom, LMS, and other virtual collaboration tools, and asynchronous learning methods demonstrated both the strengths and weaknesses of the digital learning environment. On the positive side, online education opened opportunities for flexibility, enabling students to learn on their own time. However, it also revealed how crucial in-person interactions can be for meaningful learning experiences. We now stand at a critical crossroads. Do we revert to outdated models, or do we take this moment to imagine the future of higher education?

The Need for Radical Pedagogical Innovation

Higher education has been slow to change, clinging to traditional methods like lecture-based teaching and instructor-focused methodologies, emphasizing the unidirectional knowledge transfer from a seasoned expert to the learner and standardized assessments. Although this system has endured through generations, its relevance in today's fast-paced environment is increasingly questioned following its significant limitations in today's context. However, the pandemic showed us that these methods aren't equipped or sufficient to handle the complexities of modern education. The swift evolution of the labour market makes the workforce to be changing, paired with the varied learning preferences, the evolving needs of students, diverse learning styles, and growing expectations of modern students, and the way we deliver education must adapt accordingly (García-Morales et al., 2021), hence calls for an educational renovation; one that is dynamic, embraces flexibility, and centers on the learner's experience (student-centred). Below are four key areas where radical pedagogical innovation is needed to ensure higher education remains relevant and effective.

1) Personalized and Student-Centred Learning

One of the most significant limitations of traditional education models is their inflexibility. With their rigid, lecture-based formats, traditional education models assume all students learn at the same pace and in the same way, which is far from true. In the post-pandemic era, universities must shift toward personalized learning, tailoring education to individual students' needs, strengths, and learning styles. Leveraging technology, such as adaptive learning platforms, allows for customized lessons that adjust based on students' progress. This approach enables learners to take ownership of their education, transitioning from passive recipients to active participants. Personalized learning fosters critical thinking and problem-solving, essential skills in the modern workforce (García-Morales et al., 2021). It also promotes deeper understanding and engagement by accommodating diverse learning preferences. The flexibility of personalized learning not only enhances student outcomes but also makes education more inclusive as it accommodates students with different learning styles. Ultimately, embracing this student-centred model empowers learners and transforms educational experiences, preparing them for lifelong success in an ever-evolving world.

2) Active and Experiential Learning

Another area of significance for innovation is the shift from passive to active learning. Traditionally, students have been expected to absorb information during lectures and then regurgitate it during exams. However, research consistently shows that students learn more effectively when actively engaged. Active learning techniques, such as group discussions, problem-solving exercises, and collaborative projects, encourage students to apply their knowledge in real-world contexts. Experiential learning goes further, offering students hands-on experiences that prepare them for the workforce (García-Morales et al., 2021). Internships, project-based learning, and service-learning opportunities enable students to apply their knowledge in practical settings. Not only do these experiences deepen learning, but they also develop critical skills such as teamwork, problem-solving, and adaptability skills that employers increasingly value.

3) Hybrid and Flexible Learning Models

Hybrid learning, which combines in-person and online instruction, proved its worth during the pandemic (Clifft & Assiouras, 2022). This model offers the best of both worlds: online education's flexibility and face-to-face learning's interpersonal connections. Hybrid models allow students to attend in-person classes while participating in asynchronous online activities, such as discussion boards or digital group projects. Post-pandemic, hybrid learning should become the new normal (Liu et al., 2022), offering greater flexibility to students, particularly those who may be balancing work, family, or health concerns. It also allows universities to expand their reach, catering to students who are geographically remote or who prefer a blended learning environment. Ultimately, hybrid learning provides a more inclusive and adaptable framework for education, ensuring that more students can access higher education on their terms (Clifft & Assiouras, 2022).

4) Rethinking Assessment and Evaluation of Students in Higher Education

Assessment has long been a sticking point in higher education. Traditional methods, such as standardized tests and essays, fail to capture the full range of a student's abilities and knowledge. These assessments often prioritize memorization over critical thinking, creativity, and real-world problem-solving. In the future, universities need to rethink how they evaluate student performance. Alternative assessments, such as portfolios, peer evaluations, and project-based assessments, provide a more holistic view of student learning. These methods encourage students to demonstrate their understanding more meaningfully, showcasing what they know and how they can apply that knowledge in various contexts. Additionally, formative assessment, where students receive ongoing feedback throughout a course, should replace summative assessment, which focuses on high-stakes exams at the end of a term. Formative assessments help students identify areas for improvement and encourage continuous growth, rather than one-time performance.

Overcoming Barriers or Resistance to Change in Higher Education

While the need for radical pedagogical innovation is clear (Adamson & Sloan, 2021), significant challenges must be addressed because change will not come easily. Resistance to change is perhaps the most significant barrier, particularly in institutions with deeply entrenched traditions and hierarchies (Roesel & Dobrijević, 2024). Faculty who have built their careers around traditional teaching methods may be hesitant to adopt new pedagogical models, particularly those that require unfamiliar technology or significant changes to their teaching styles. To overcome this resistance, universities must provide support and training. This includes professional development in areas like digital literacy, instructional design, innovative teaching practices, and active learning strategies. Universities must also foster a culture of experimentation and collaboration, encouraging faculty to innovate without fear of failure. Leadership plays a crucial role here. Institutions that prioritize and invest in pedagogical innovation will see more success in implementing these changes.

Another significant barrier is the digital divide. The shift to online learning during the pandemic highlighted stark inequalities in access to technology. Not all students have reliable internet, or the devices needed for digital learning (Liu et al., 2022). If higher education is to embrace technology-driven models, it must also address these disparities. To ensure pedagogical innovation benefits all students, institutions must prioritize equity in their technological investments and support students who may face barriers to digital learning. Universities and policymakers must work together to ensure that all students, regardless of their socio-economic background, have access to the tools they need to succeed.

Finally, scalability remains a challenge. While innovative pedagogical models have been successfully implemented in small pilot programs, scaling these initiatives across entire institutions or national higher education systems can be difficult. Universities will need to invest in infrastructure technology, training, and resources to support large-scale innovation, and policymakers must provide the necessary funding to ensure these initiatives are sustainable. Additionally, institutions must be willing to re-imagine their organizational structures and decision-making processes to support large-scale change. This will enable and ensure that all students can benefit from these innovations.

The Role of Policy-Makers and Institutions in Driving Change

The future of higher education is not just in the hands of faculty and students. Radical pedagogical innovation in higher education requires more than individual faculty members adopting new teaching methods. It necessitates coordinating efforts from institutions, policymakers, and stakeholders across the education sector. Policymakers, university leaders, and other stakeholders must play a role in driving change. Governments must provide funding and create policies that encourage innovation, rather than stifle it. This could include funding for research into new pedagogical models, grants for technology infrastructure, and support for professional development programs that equip faculty with the skills needed for modern teaching. University leaders, too, must take a proactive approach. This means prioritizing pedagogical innovation in strategic plans, investing necessary resources, and fostering a culture that embraces change. Collaboration with industry leaders and employers will also be crucial, ensuring that educational innovations are aligned with the needs of the modern workforce (García-Morales et al., 2021). Finally, stakeholders from across the education ecosystem, including employers, industry leaders, and community organizations, must be involved in shaping the future of higher education. By collaborating with these stakeholders, institutions can ensure that their pedagogical innovations aligned with the needs of the workforce and society at large.

Conclusion

The COVID-19 pandemic has forced higher education to confront its limitations and opened the door to unprecedented opportunities for radical innovation. The future of higher education must be flexible, inclusive, and student-centred, embracing personalized learning, active engagement, hybrid models, and new forms of assessment. However, this transformation will not be easy. It will require a concerted effort from faculty, institutions, policymakers, and stakeholders to overcome resistance to change, address the digital divide, and scale innovative practices. The time for radical pedagogical innovation is now. If higher education is to remain relevant in a rapidly changing world, it must adapt, evolve, and rethink its core principles. The pandemic has given us the push we need. It is now up to us to take the leap, a wake-up call for higher education. The future of higher education depends on our willingness to think boldly and act decisively in reimagining pedagogy for the post-pandemic world. Institutions that seize this opportunity to innovate will better serve their students and play a pivotal role in shaping the future of education and society. The time for radical pedagogical innovation is now.

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Transforming Teaching Practices: The Critical Role of Teaching-Learning Centers in Academic Institutions

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***Abstract*— Teaching-Learning Centers (TLCs) play a crucial role in transforming teaching practices within academic institutions, driving innovation and enhancing educational quality. This paper explores how TLCs serve as catalysts for change by equipping educators with the tools, resources, and support needed to adopt and implement innovative pedagogical strategies. Through professional development programs, collaborative learning opportunities, and the integration of technology, TLCs empower faculty to create more engaging, inclusive, and effective learning environments. The study also examines the positive impact of TLCs on student learning outcomes, highlighting their role in fostering critical thinking, problem-solving which are the key skills necessary for lifelong learning and navigating an increasingly complex world. The findings emphasize that TLCs are vital to the success of academic institutions, helping to cultivate a culture of continuous improvement and excellence in teaching.**

***Keywords*— critical thinking; lifelong learning; problem solving; Teaching-Learning Centers (TLCs); Effective teaching**

ICTIEE* Track*: Entrepreneurship, collaboration and administration

ICTIEE Sub-Track: Role of Teaching and Learning Centres in Transforming Engineering Education

I. INTRODUCTION

Higher education in India is undergoing significant changes driven by a combination of policy reforms, technological advancements, and shifts in societal needs. The NEP 2020 emphasizes a more holistic and multidisciplinary approach to education, with flexible curricula that encourage critical thinking and creativity.

To make sure that graduates possess the skills required for today's workforce, educational institutions are increasingly collaborating with industry partners. Accreditation processes are expected to become more stringent and outcome-based, ensuring that institutions meet high standards of education.

Faculty being the backbone of the education system, their training is crucial to implement policies effectively, deliver high-quality education, and contribute to the overall development of students and institutions. Therefore, enhancing the quality of teachers is essential for achieving long-term and sustainable nation-building (Kim et al., 2019).

By prioritizing faculty development, the NEP aims to empower educators to deliver high-quality education that meets the needs of a rapidly changing world.

In the rapidly evolving landscape of education, the need for continuous innovation and improvement in teaching practices has never been more critical. Teaching-Learning Centers (TLCs) have emerged as pivotal institutions within academic environments, dedicated to fostering excellence in pedagogy and enhancing the overall educational experience. These centers serve as hubs for professional development, offering faculty members the resources, training, and support necessary to refine their teaching methodologies and stay abreast of the latest educational trends.

The role of TLCs extends beyond mere instructional support; they are instrumental in cultivating a culture of continuous learning and improvement among educators. By promoting evidence-based teaching practices, facilitating interdisciplinary collaboration, and encouraging the integration of technology into the classroom, TLCs play a crucial role in transforming traditional educational paradigms. They empower educators to adapt to the diverse needs of students, thereby enhancing student engagement and success.

II. METHODOLOGY

The perception among some faculty has to change that the "chalk and talk" method is sufficient for teaching, particularly in fields like engineering. The repetitive nature of "chalk and

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talk" can stifle both student and faculty creativity. It often fails to inspire innovation or encourage students to think outside the box.

Continuous professional development for faculty is often neglected, leading to stagnation in teaching practices and knowledge. Without regular upskilling, faculty may struggle to keep pace with the rapidly evolving field of engineering.

According to Kautilya, education should aim to cultivate three key outcomes as defining traits in graduates.

□□□□□□ - the idea of education as a means of generating new knowledge

□□ve□ - The wisdom to apply the right knowledge at the right time, in the right place, and for the right purpose, and

□□□□□□□□□□ – The ability to effectively apply knowledge in real-life situations to achieve desired results.

These outcomes are possible only when the Education System is properly balanced with the integration of knowledge and skills in an appropriate manner. In today's education, organization of knowledge content "what to know" has taken over the best of knowledge seeking 'inquiry', i.e., "how to know". The entire Indian Knowledge Tradition has always focused on 'how' rather than 'what'.

While many workshops and conferences emphasize the desired learning outcomes and the types of learning expected from students, there is often less focus on the essential requirements for effective teaching. According to Radhika (2016) many a time the teachers are just ignoring some of the very important qualities, which one should have to effectively transfer the knowledge (subject) to the students. According to Skinner et al (2021), teachers who haven't been trained in diverse teaching strategies might inadvertently create disparities in educational outcomes.

Competency Based Learning (CBL) goes beyond acquiring knowledge; it focuses on cultivating skills that hold enduring value. Critical thinking, problem-solving, and adaptability are essential elements within CBL. Teachers must possess higher order teaching skills to implement the competency-based education.

Teaching and Learning Centre was established in the year 2015. From 2018, a course EECP – Engineering Educators Certificate Program was designed in tune with the IIEECP course that is offered by IUCEE. The EECP course was mandated for all the newly recruited faculty of the institute. Six modules covered various aspects on managing the course content, techniques of effective course delivery, incorporating technology in teaching, designing higher level questions. The faculty were given one semester time to implement the strategies learnt during the course and a capstone presentation was mandated after completion of the semester to reflect on the practices.

III. RESULTS & DISCUSSION

The current paper is on the training program that is conducted by TLC in six modules and its impact in improving the teaching skills of the faculty. There were 130 faculty members participating. They were from different departments and are all newly recruited. A survey was taken for all the faculty who have taken the EECP course to identify the impact of the course in enhancing their skills. A total of 130 faculty responded. The experience of the faculty members ranged between 0 to 21 years.

Below graph gives an idea of the impact and is discussed below.

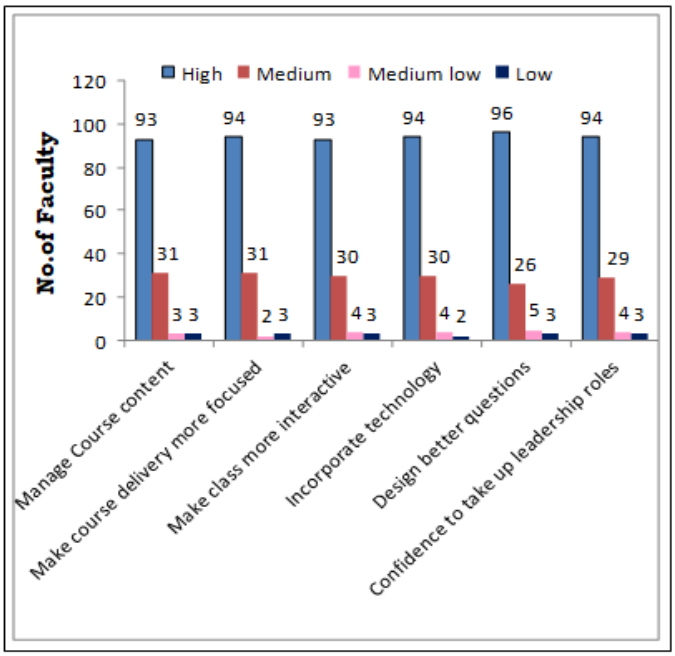

Fig. 1. Impact of EECP course

On a scale of 1-4 (1 being lowest, 4 being highest) six parameters were surveyed. 71.5% of the total respondents have indicated that they are able to manage the course content effectively and 23.8% indicated that they need more improvement. 72.3% have responded that they are able to make more interested and focused delivery of the content. The usage of different teaching techniques was evident from 71.5% of them opting to the highest level and 23% indicated further improvement. In order to enhance the learning experience, usage of technology was focused. 72.3% have responded that they are able to incorporate technology in their teaching. Designing higher level questions being very crucial the survey identified that 75.3% are able to design higher level questions and 20% need improvement. 72.3% responded that there is an overall impact and improvement of the EECP course on the confidence to take up leadership role.

In order to understand the real impact of EECP course the IQAC wing audits the course files for each unit of the course of all the faculty and specific attention is given on

i. CO-PO Mapping with justification
ii. Designing of session planner: the sub sections include
    a. COTs-Concept Oriented Tutorials
    b. Two micro-projects
    c. Video resources for a topic
iii. Designing of questions as per Bloom's Taxonomy

iv. Planning and Implementation of different learning strategies
v. RTA- Real Time Applications

Faculty have to prepare all the above for the course that they are handling in the particular semester. Without concrete evidence of how lessons are enacted in the classroom, it can be difficult to assess the effectiveness of teaching strategies (Diem &Thathong, 2019; Jacobs et al., 2008). Therefore, an audit of the activities carried out in the classroom is performed. Marks were allotted to each of the criteria based on the rubrics designed. Following is the marks distribution for different parameters.

TABLE I
MARKS DISTRIBUTION FOR DIFFERENT PARAMETERS.

Parameter	Marks allotted
CO-PO Mapping with justification	5
Designing of session planner	5
Bloom's Taxonomy level questions	10
Planning & implementation of ALS	10
RTA-Real Time applications	5

A cutoff of 75% and above is considered to understand the impact. The graph gives the statistics.

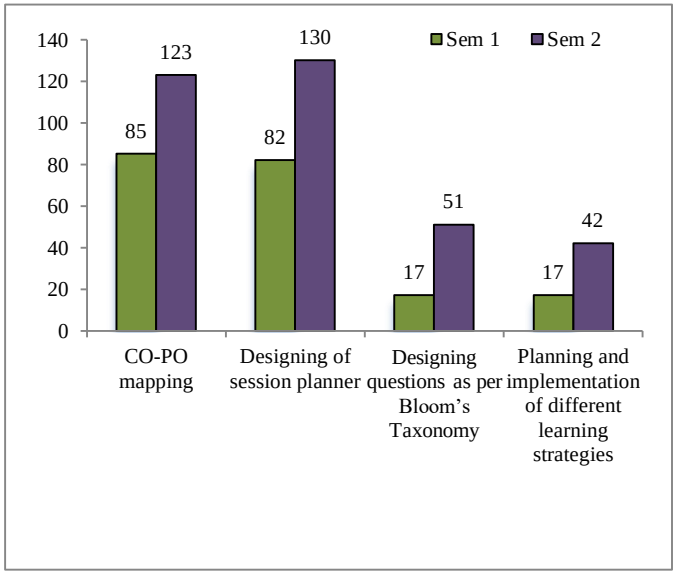

Fig. 2. Audit scores of the four criteria during semester 1 & 2

1) CO-PO mapping

As the CO-PO mapping provides a basis for evaluating the effectiveness of a program, it is important that faculty can clearly define course outcomes and map to program outcomes. Since the mapping process holds educators accountable for delivering a curriculum that meets predefined educational goals, thereby ensuring the quality and integrity of the academic program, the audit is carried out for the CO-PO mapping. It is clear from the graph that in the first semester of their implementation 85 faculty could score more than 75% of marks and the number increased to 123 in the next semester

2) Designing of session planner

Planning is essential for every teacher's professional development (Ruys, van Keer & Aelterman, 2012).A session planner helps educators allocate appropriate time to different activities, ensuring that each segment of the lesson receives the attention it deserves. It was mandated that faculty prepare the session planner including the use of diverse teaching methods (e.g., lectures, discussions, group work, hands-on activities) within a single session, catering to different learning styles and keeping students actively engaged. The audit of the session planner revealed that 82 faculty were able to design effective session planner and in the next semester the count increased to 130 members.

3) Designing questions as per Bloom's Taxonomy

Marlina et al., (2023), pointed out that the integration of high-order thinking skills from pedagogical perspective with full mastery of the subject matter is pivotal in the curriculum. It is noted that when teachers ask higher-order questions and provide students opportunities to analyze, learning is enhanced across content areas. These higher-order questions often start with question stems such as "Why," "What caused," "How did it occur," "What if," "How does it compare," or "What is the evidence". Critical thinking skills which are very important for a 21st century learner can be developed by encouraging students to engage with these types of questions. Teachers need to understand students' higher-order thinking skills (HOTS) to deliver quality instruction in science (Anderson &Krathwohl, 2015). Therefore criteria –iii that focuses on designing questions as per bloom's level is much stressed and more weightage is given in the audit. During the first semester only 17 faculty could design questions at different levels of Bloom's taxonomy. With the intervention of TLC the number increased to 51.

4) Planning and implementation of different learning strategies

To foster positive classroom interactions and achieve high learning standards that support lifelong learning, teachers should provide activities that are logically challenging and intellectually stimulating. (Daflizar, 2023). Traditional teaching methods that are based on a one-size-fits-all approach are not suitable for education today (Bondie et al., 2019). Implementing varied learning strategies, such as group work, discussions, hands-on activities, and multimedia presentations, increases student engagement. Active learning strategies help maintain student interest and motivation by making learning more interactive and enjoyable. The activities that are thoughtfully integrated and reflected in session planner are audited. It is clear from the graph that only 17 faculty members could plan and implement and the number increased to 42 with the intervention of TLC by next semester.

5) Impact on the course outcomes attained

The impact of the implementing different strategies in the classroom by the faculty on course outcomes is studied. For the courses Applied Physics, Linear algebra, English, Engineering Drawing dealt in the first year for two academic years is compared. It is noted that the course attainment values improved in the subjects. The below graph reflects the same.

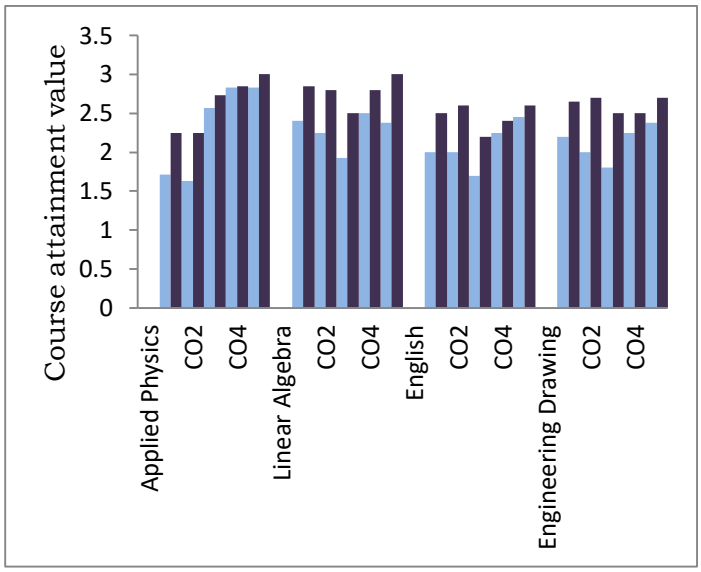

Fig. 3. Improvement in the course attainment

CONCLUSIONS

The impact of the EECP course offered by TLC is evident from the marks scored by the faculty and improvement during the next semester audit.

The findings presented herein underscore the significance of investing in and supporting Teaching-Learning Centers as vital components of any educational institution's mission to deliver high-quality education.

This study explored by examining the strategies employed by TLC and their effects on educational practices. It is evident that the TLC at the institute has empowered educators to refine their teaching methods, adopt innovative strategies, and remain responsive to the evolving needs of their students.

It is also clear that TLC has fostered a culture of continuous improvement in teaching practices through the EECP course and thus encouraging faculty to experiment with and integrate diverse instructional approaches.

It can be concluded that through enhancing teaching strategies, improving learning outcomes, and fostering essential learning skills, these centers contribute significantly to the overall quality and effectiveness of academic programs,

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Workforce upskilling: can universities meet the challenges of lifelong learning?

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Abstract

Purpose – Since new digital micro-credential technologies emerged a decade ago, there has been a rapid rise in micro-credentials in the education landscape. Much has been promised about these educational technologies, yet there is much confusion by key stakeholders in the digital micro-credential ecosystem. This confusion has led to significant efforts globally to define micro-credentials to ensure quality learning and generate beneficial impacts to learners, employers, education providers and edtech organisations.

Design/methodology/approach – This commentary reviews relevant literature on digital micro-credentials and other alternative credentials to determine how these educational technologies can meet the demands of the Fourth Industrial Revolution to nurture lifelong learning for working learners.

Findings – Universities are being challenged to address the changing needs and uncertainty being introduced by the Fourth and Fifth Industrial Revolutions, particularly with implications for workforce upskilling and lifelong learning. To adapt, universities will need to rethink their roles and shift their institutional mindsets in how they may approach the challenges through mechanisms such as digital micro-credntials.

Research limitations/implications – This paper focuses on the analysis of five policy statements about micro-credentials. While these policy statements represent a sample, there is a representation of Western education-related systems. Thus, they skew the findings towards Western education systems thinking.

Practical implications – Understanding how micro-credentials are being positioned within education-related systems is useful for applying the educational technologies by, for example, universities, learners and employers.

Social implications – Provides an overview of how these educational technologies may provide beneficial impacts for society as it plans to adapt to economic uncertainty and change.

Originality/value – The commentary provides a policy context for the emerging use of micro-credential technologies to examine demands for workforce upskilling.

Keywords Lifelong learning, Micro-credentials, Higher education, Workforce upskilling

Paper type Research paper

Introduction

The concept of the university as an institution is at a crossroad. The current blueprint for the university has its foundations built on the contexts of the First and Second Industrial Revolutions (Levine and Van Pelt, 2021). It is no wonder, then, that while we are in the Fourth and on the cusp of the Fifth Industrial Revolutions that the load-bearing structures of the contemporary university are creaking under the weight of change. The Fourth Industrial Revolution is manifested by the Internet and digitalisation, while the Fifth Industrial Revolution is personalising and focusing on human-machine interactions (Regenesys Business School, 2020; Sarfraz *et al.*, 2021). In their review of the literature to unpack the impacts of the Fourth Industrial Revolution on organisational learning and the workplace, Silvia Ivaldi and her colleagues (2022) identified three "significant leading topics" (p. 4) emerging from their analysis of research papers (refer to Table 1 for a summary of these topics and impacts). These impacts correlate with Klaus Schwab's (2016) earlier identified impacts associated with the Fourth Industrial Revolution. Schwab (2016) identified five significant categories of impact: economy; business; national and global; society; and the individual. While Ivaldi and her colleagues focused on impacts related to society

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Significant leading topic	Themes within the topic
Impact on society	• digital transformation is significantly affecting our social and economic ways of working and living • positive potential for new waves of technologies to increase levels of productivity and growth due to increased automation and robots working/living alongside us and respond to major issues of environmental sustainability • with risks of greater social inequalities • greater connectivity through the Internet and a focus on living in a "knowledge-intensive society which requires relevant learning processes at both individual and collective levels"
Labour market and technological unemployment	• widespread implementation of new technologies in the labour market will disrupt and (re)shape the labour supply and demand as well as its composition – with positive (e.g. human skills are valued) and negative (e.g. automation and AI replacing human workers) effects • the line between work and "free" time is blurring – and often only highly skilled workers enjoy greater creativity and autonomy in the workplace • critically, a focus on transversal competencies and human-machine interaction will be imperative to improve the sustainable dimensions of a production system to avoid negative labour impacts; therefore "linking new technologies and sustainability entails a relevant investment in organisational learning, seeking to shape the socio-material conditions"
New competencies to dwell within the digital revolution	• responses to five macro challenges (economic, social, technological, environmental and political and legal) are shaping the trends of the necessary professional competencies and skills within the workplace: technical, methodological, social and personal • new approaches to learning within organisations are emerging to meet the "changes that digitalisation, automation and artificial intelligence . . . Are bringing to the world of work"

Table 1. Significant leading topics of the Fourth Industrial Revolution the workplace identified by Ivaldi *et al.* (2022, adapted from pp 5–8)

and economy, both Schwab and Ivaldi's team arrive at a similar conclusion: that the Fourth Industrial Revolution is a human construction and thus its disruption and impacts have human decision making at its core. Dependent on our decisions, the policy and actions we take to change and adapt to the Fourth Industrial Revolution will lead to either positive or negative impacts. The investigation by Ivaldi's team (2022) of introducing technology and digitalisation within the workplace reveals that learning is at the core of positive adaption and minimising negative impacts for the workforce. Their research found that organisational learning and a process of expansive learning (e.g. Engeström, 2001) offers workplace sustainability where a "learning process in which the experience and practical knowledge of people represent important resources for the introduction, the development and the integration of innovative technologies, matching both knowledge exploration and exploitation" (Ivaldi *et al.*, 2022, p. 21). Arguing for organisational learning approaches for workplace resiliency in times of uncertainty, Ivaldi's team (2022) identified the need for new competencies to adapt to Fourth Industrial Revolution workplace environments as illustrated in Table 1. Schwab (2016) goes deeper and identifies that the Fourth Industrial Revolution is an opportunity for us to create human systems (e.g. policies) and enact changes that lead to adaptation and resilience to these new challenges and environments that are driven by the Fourth Industrial Revolution. While he does not use the term "learning" as a means of

arriving at how to address these Fourth Industrial Revolution challenges, Schwab asserts the need for "nurturing and applying four different types of intelligences", which implies a process of lifelong learning:

(1) contextual (the mind) – how we understand and apply our knowledge

(2) emotional (the heart) – how we process and integrate our thoughts and feelings and relate to ourselves and to one another

(3) inspired (the soul) – how we use a sense of individual and shared purpose, trust and other virtues to effect change and act towards the common good

(4) physical (the body) – how we cultivate and maintain our personal health and well-being and that of those around us to be in a position to apply the energy required for both individual and systems transformation (Schwab, 2016, p. 106).

The work of Gratton and Scott (2016) discussed the issue of human longevity and how it is influencing changes in life and work patterns across the lifespan, as the concept of a 100-year life becomes normalised, rather than a rarity as a human milestone. The elongated lifespan is yet another factor contributing to the advancing disruption to universities and whether they will have a role to support the increasing demand for lifelong learning – both within and beyond the workplace. Other inescapable swirling winds of macro-trends affecting universities encompass globalisation, and the broad sustainability issues such as climate emergency (e.g. Intergovernmental Panel on Climate Change (IPCC) reports [1]) and loss of biodiversity (Attenborough, 2022); the social sustainability pillars that bring social equity, harmony and political integrity within nation states and globally, such as the UN Sustainable Development Goals [2], and particularly SDG 4 Quality Education: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all [3]. Add to this milieu, the Fourth and Fifth Industrial Revolutions and you have the perfect storm for disruption – and universities can no longer sit outside looking in, they are being dragged into the storm's eye – willingly or not.

Within this context of change, uncertainty and disruption, what is the role of the university? If it continues to dislodge itself from these winds of change, the university will likely return to its earlier roots of providing an education for an elite at best, or at worst, become irrelevant to meeting society's needs (Levine and Van Pelt, 2021). Christopher Dede (Dede and Richards, 2020) brings an interesting perspective to the discussion – he argues that universities need to think about their responsibility to growing the learned society, where universities need to (re)think about delivering programs of learning across the lifespan, not only focusing on conventional undergraduate education. He poses that universities need to create and engage with the 60-year curriculum, which supports society's needs for lifelong learning. For universities to take up this challenge, there will need to be a shift in institutional mindsets.

Shifting institutional mindsets

Sean Gallagher (2016) interviews diverse industry and academic leaders to gain insights into the intersection of university education and talent hiring across diverse industry sectors. He provides a compelling argument for the need for innovative change in university credentials to meet the complex needs of workforce development in the 21st century. In his conversation with New York's University's School of Professional Studies Dean Dennis Di Lorenzo, Gallagher unpacked the School's strategy for change in their offering of industry-focused non-credit professional development programmes once Di Lorenzo noticed their "appeal and resonance" had waned from the perspectives of employees and employers (Gallagher, 2016, p. 155).

In response, they designed diplomas to replace certificates that were created with, or informed by, industry partners as well as government agencies to meet the needs of employers and professionals. As Di Lorenzo reflected, this change to competency and career development was the outcome of a deliberate mindset shift in conceptualising their Continuing Professional Education programmes not as a "market construct' but rather "start thinking about credentialing in the noncredit space as a true educational construct. We needed more transparency" (Gallagher, 2016, p. 156).

The call for new credentials is also supported by Dede, who sets the challenge for the higher education sector to play a significant role in upskilling adults across their lifespan "creating this transformational evolution of higher education [that] requires developing novel services for adults learning while working" in formal, informal and non-formal learning contexts (Dede and Richards, 2020, p. 16). Michelle Weise (2021) links the demand for lifelong learning along with Gratton and Scott's (2016) notion of human longevity with the "future of work [which] becomes inextricably tied to the future of learning. In a 100 -year life, we may find ourselves in a state of continuous pivots – 20 to 30 job transitions might become the new normal. Ongoing skill development will become a way of life . . . we will all become *working learners*" (Weise, 2021, p. 5, my emphasis). Weise argues there will be a plethora of organisations that will provide this workforce upskilling because the "current system of higher education is not forgiving" and results in significant attrition citing some "36 million people in the United States made it into college; they just didn't make it through or out of college" (Weise, 2021, p. 6). Dede agrees but offers hope to universities. He argues that to support adult learning across the lifespan, universities will need to achieve institutional transformation; the academy will need *un*learning to develop an aspirational vision of the 60-year curriculum. Drawing on the 60-year curriculum (60 YC) term phrased by the Dean of University Extension at University of California, Irvine campus (Dr Gary Maitlin), Dede describes the concept as "[the 60 YC] focuses on the transformational evolution of higher education toward novel strategies to enable adults to add skills – via formal instruction, employment and daily life – as their occupational and personal context evolves and shifts" (Dede and Richards, 2020, p. 1).

Ann Brewer (2020) illustrates how the 60-year curriculum approach might be strategically applied within the university sector. She discusses the need to apply a human design thinking process to deliver the 60 YC that incorporates a student-centric approach to curriculum design and institutional systems that build strong and positive relationships with students through its student support services and marketing, which will require "integration between learning and digital strategies" (Brewer, 2020, p. 67). Brewer concludes that applying such a 60 YC framework will foster a "student-centric co-design" approach that offers learners diversity of learning experiences and environments that nurtures 'democratic, practical and empowering process in action-learning through interactive inquiry and focused on how to learn within perpetual, co-creative learning processes of learning partnerships at both the institution and local levels" (Brewer, 2020, p. 69).

The theme of designing learning that engages its key stakeholders, the learners, and, I argue, if learner motivations for learning are upskilling as working learners, then engaging employers in curriculum design is also imperative. These principles of engagement and human-centred design to curriculum and student support shift higher education towards constructing personalised learning (Ward, 2020) and "wraparound supports" (Weise, 2021, see Chapter 6) that include ongoing career navigation services and systems for working learners to make sense of the workplace complexity and need for upskilling and reskilling. Opening up to new ways of thinking about designing and delivering programmes for working learners is essential for universities to rethink their roles in education for the Fourth and Fifth Industrial Revolutions. Alternative credentials, and particularly micro-credentials, offer new opportunities for meeting the demand for upskilling and lifelong learning.

Emerging education policies to define micro-credentials

Across the globe, nation states and collaborative networks are attempting to define micro-credentials to make meaning of the rapid rise of alternative credentials, such as micro-credentials, entering the marketplace in response to skills shortages and skills shifts in the economy that require workforce upskilling and reskilling and demand for lifelong learning (e.g. European Commission *et al.*, 2020; Goger *et al.*, 2022; Kato *et al.*, 2020; Selvaratnam and Sankey, 2021; Sigelman *et al.*, 2022). Without common policy and practices, there is confusion about the value and role of micro-credentials in learning and employment by key stakeholders within the ecosystem, e.g. learners, employers and providers such as higher education institutions. With a multitude of variations in what constitutes micro-credentials, there is increasing policy urgency to define micro-credentials and align them with, for example, regulatory frameworks or quality assurance systems. Table 2 captures a sample of recent global activity to qualify and define the concept of micro-credentials to facilitate shared understanding by key stakeholders within the micro-credential ecosystem.

As Table 2 illustrates, emerging definitions for micro-credentials in policy constructs attempt to generate shared understanding of its conceptualisation while retaining flexibility to use the affordances of the educational technology and mechanism across multiple learning contexts while ensuring explicated shared purposes. The key documents in Table 2 were selected as samples of evidence of policy statements that are influencing practices of micro-credentials, particularly within university contexts.

In determining its policy guidance, UNESCO (Oliver, 2022) used an adapted Delphi methodology to come to a consensus of a micro-credential definition amongst experts that would not replace localised definitions but provide an overarching statement and an international reference point to bring clarity to the micro-credential discourse and practice. Thus, UNESCO's definition may be used as a policy lever at local, regional, or global levels, with hopes to influence localised policy and practice. It outlines key indicators of quality such as assessment, stacking and pathway options and quality assurance standards. Since the UNESCO and Australian policy framework documents were both chaired by Emeritus Professor Beverley Oliver, it is perhaps not surprising that there is an overlap of themes. However, as a local policy document, the Australian micro-credential framework is cognizant of the Australian policy context. Defining a micro-credential as a period of study anywhere "from one hour and less than AQF [4] award qualification" (DESE, 2022, p. 3) acknowledges the Australian Qualifications Framework as a key policy document used by education providers to create curriculum programmes – yet it is also limited by its current framing of specifying volume of learning as a currency of learning. The tension of using volume of learning (e.g. hours) is evident and reflects current understandings rather than heeding the call to shift towards a recognition of acquiring a competence or skills based recognition – which is, for example, embedded within the micro-credential definition in the recent report by American Association of Collegiate Registrars and Admissions Officers (ACCRAO). Yet the rest of the ACCRAO definition is broad – and it is only when you look at their guiding advice on good and best practices within the university sector that you delve deeper into possible opportunities to use the technological affordances of micro-credentials to develop innovative practices to extend to new types of learning programmes offered by the sector.

Both Australia and the United States of America reflect a political system of federalism, where education responsibilities are often state-based policy domains and limited at the federal level. For this reason, it is interesting to observe that Australia has managed to create a federal policy framework for micro-credentials – tied to the nation's Australian Qualifications Framework (and its policy review cycle). The ACCRAO approach that has compiled good practices across the higher education sector seems to be an attempt to drive shared understandings through evidence of lived experience and institutional practice rather than rely on a national micro-credential policy.

Table 2. Emerging policy definitions for digital micro-credentials to create shared understandings

	Definition of micro-credential	Document
UNESCO	A micro-credential: • Is a record of focused learning achievement verifying what the learner knows, understands or can do • Includes assessment based on clearly defined standards and is awarded by a trusted provider • Has standalone value and may also contribute to or complement other micro-credentials or macro-credentials, including through recognition of prior learning • Meets the standards required by relevant quality assurance	Oliver, (2022). *Towards a common definition of micro-credentials*. Paris: UNESCO
Australia	The framework defines micro-credentials as a certification of assessed learning or competency, with a minimum volume of learning of one hour and less than an AQF award qualification, that is additional, alternate, complementary to or a component part of an AQF award qualification This definition is supported by a number of unifying principles; that micro-credentials should be: • Outcome-based • Responsive to industry-need • Tailored to support lifelong learning • Transparent and accessible *The policy document then further outlines eight minimum standards to be associated with micro-credentials within the Australian context*	Department of Education Skills and Employment. (2022). *National Micro-credentials Framework*. Canberra, Australia: Department of Education, Skills and Employment, Australian Government
New Zealand	A micro-credential is an award that is not a qualification NZQA quality assured micro-credentials: • are listed on the Qualifications and Credentials Framework • are delivered by registered tertiary education providers • can be up to 40 credits in size and at any level of the framework • have learning outcomes • have evidence of need from employers, industry, workforce development councils, iwi and/or communities, as appropriate Micro-credentials are part of New Zealand's regulated education and training system	*Micro-credentials* in the New Zealand Qualification Authority (NZQA), n.d – policy statement

(*continued*)

Table 2.

	Definition of micro-credential	Document
Europe	A micro-credential is a proof of the learning outcomes that a learner has acquired following a short learning experience. These learning outcomes have been assessed against transparent standards The proof is contained in a certified document that lists the name of the holder, the achieved learning outcomes, the assessment method, the awarding body and, where applicable, the qualifications framework level and the credits gained. Micro-credentials are owned by the learner, can be shared, are portable and may be combined into larger credentials or qualifications. They are underpinned by quality assurance following agreed standards	European Commission *et al.* (2020). *A European approach to micro-credentials: Output of the micro-credentials higher education consultation group: final report*. Luxembourg: Publications Office of the European Union
American association of collegiate registrars and admissions officers (AACRAOS)	*Micro-credential is defined as:* A competency or skills based recognition that allows a learner to demonstrate mastery and learning in a particular area. A micro-credential is generally a subset of learning achievements or outcomes that is less than a full degree or certificate. A micro-credential offered by an institution of higher learning should be asserted by a recognised campus authority	ACCRAO (2022). *Alternative Credentials: Considerations, Guidance and Best Practices*. Washington, DC: American Association of Collegiate Registrars and Admissions Officers

To some degree, Europe also works like a "federation" of nation states and does have a history of attempting to collaborate to establish broad policies to influence governance within localised contexts of Europe's nation states. The European approach to micro-credentials (European Commission *et al.*, 2020) is based on access to quality education and is in response to the European Skills Agenda as well as a strong connection to the United Nation's Sustainable Development Goal 4 related to education and lifelong learning. The European approach overtly advocates for micro-credentials to enact personalised learning to meet the rapid changes in the workplace and that both higher education and the vocational education and training sectors to actively participate in "promoting lifelong learning by providing more flexible and modular learning opportunities" through the innovation of micro-credentials (European Commission *et al.*, 2020, p. 6). The approach by the European Commission to align and connect multiple significant education policy agendas, seems to inspire the depth of purpose for micro-credentials, which may strengthen policy implementation and practice across Europe. The Australian micro-credential framework also acknowledges that micro-credentials are a significant shift in the education system to meet the "growing demand for shorter-form courses that enable workers to rapidly upskill and encourage lifelong learning" (DESE, 2022, p. 2), illustrating attempts for alignment across policy agendas. Furthermore, in place since 2018, New Zealand's micro-credential policy provides empirical evidence that micro-credentials have been meeting the need to upskill the workforce as well as provide "fast market responses to new or emerging skill needs" (NZQA, 2022, p. 3). As is demonstrated by these policy documents, the theme of upskilling the workforce is deeply connected to micro-credentials and offers opportunities for universities to play a significant role in contributing to the 60-year curriculum and go beyond their remit of providing undergraduate and conventional postgraduate programmes.

Policy insights into determining quality micro-credential design

As the brief policy analysis of micro-credential definitions has illustrated in Table 2, digital micro-credentials are verifiable awards that have been assessed by rigorous processes and assure quality academic standards. Micro-credentials are underpinned by digital badging platforms (e.g. Credly, Canvas Credentials, Accredible) and other educational technologies that support surfacing skills in the metadata represented when using the badging platforms (e.g. edtech company Edalex and their platforms: openRSD and Credentialate). Since the emergence of these educational technologies to generate digital micro-credentials in 2012, there has been, amongst other hopes, a promise that it will afford the opportunity to provide fine granularity of what was assessed and to better represent the learner's assessment performance of the knowledge learned and demonstrate the skills developed (Finkelstein *et al.*, 2013). Connected learning, (which incorporates learner participation with agency, peer learning, learner centredness and inclusive curricula and pedagogies), was a key underpinning design principle that informed the founding edtech organisations, such as Mozilla, as they conceptualised and designed the initial digital badging platforms (Knight and Casilli, 2012). This early vision has led to interoperability, which also allows learners to own and share their micro-credentials on their terms and is a fundamental operational feature of the Open Badges standards [5] that continues to be reflected as a critical aspect within the micro-credential ecosystem today.

Learning outcomes, assessment and metadata

The universality of learning outcomes to drive the micro-credential design and that they are assessed are common to all the emerging definitions presented in Table 2. Transparency of the assessed standards is either explicitly stated (e.g. Australia) or implied (e.g. AACRAO) as are the calls for quality assurance by all policy examples in Table 2. Transparency of the standards

associated with the evidence of learning improves shared understanding of the achieved learning for a micro-credential, which is critical to establish trust amongst the key stakeholders within the micro-credential ecosystem, particularly in a complex environment "without common definitions, standards or utility" (AACRAO, 2022, p. 8). In addition, I argue that in a market that has so much variation in the micro-credential product, this transparency is key to reveal what learning was achieved and at what proficiency, which is particularly important if (l)earners want to use their verifiable award to, for example, gain recognition of prior learning for further studies, promotion, or recruitment. This is when the affordances of the digital badging platform that generates the data fields for the micro-credential's metadata becomes essential in telling the learner's narrative of their achieved learning and output, which can provide finer data granularity than conventional university degree transcripts and testamurs.

The European Commission's micro-credential definition (see Table 2) clearly articulates the criticality of assessment standards to drive quality and trust in micro-credentials. Their definition identifies several qualities that will indicate the micro-credential's value that include: evidence assessed learning; align assessment to learning outcomes; provide transparency of assessment standards; and, where possible, provide stacking and pathway options to further studies. This European approach has numerous connections with the vision to have transparency of standards within the Australian micro-credential policy framework. The Australian national framework's (DESE, 2022) standards aim to facilitate key stakeholders in the micro-credential ecosystem to better understand the value of learning achievements and how they can apply within the skills ecosystem and employment.

New Zealand embeds micro-credential definition into its existing qualification system

New Zealand provides an interesting policy perspective in the mix of micro-credential definitions because it was one of the first nations to formally introduce micro-credentials into its national qualifications regulatory framework in 2018. It is intriguing to observe that New Zealand's micro-credential definition (see Table 2) appears to take on the discourse of its regulatory framework. For example, it specifies that the micro-credentials can only be delivered by registered tertiary education providers and size is determined via the localised credit-bearing point system and must be on their qualification registry. Such an approach firmly embeds micro-credentials within the existing New Zealand's accreditation ecosystem – and thus there is familiarity for key stakeholders using existing systems. Yet it does beg the question whether this approach allows for experimentation with new design and delivery modes. An opportunity to experiment might arise with another stipulation in the policy definition that there is a need for the education provider to "have evidence of need from employers, industry, workforce development councils, iwi, and/or communities, as appropriate" (NZQA, see Table 2). This micro-credential standard signals the need for collaboration with industry or relevant groups beyond the education provider and may provide the opportunity to innovate and integrate a user-design approach in the creation of micro-credentials. The initial focus for micro-credentials was on vocational education and training and centrally approved by the New Zealand Qualifications Authority (NZQA), n.d that is responsible for quality assurance of the non-university tertiary sector [6]. Universities are also now able to develop micro-credentials and as self-accrediting organisations, can approve micro-credentials through their own institutional quality assurance processes. However, there has been a low uptake of micro-credential development by New Zealand's university sector with Victoria University of Wellington dominating the micro-credential market offering nine of the 17 micro-credentials (NZQA, 2022, p. 3). In part, this may be the effect of the government's initial policy focus (including funding for development) on vocational education and training system. The impact of funding to socially engineer the response to policy changes with the introduction of micro-credentials as a qualification has also been argued by others (Fisher and Leder, 2022).

Industry collaboration and stackability

There is unambiguous reference to industry collaboration in the micro-credential definitions of the Australian and New Zealand policy statements (refer to Table 2). This signals the importance of using micro-credentials to upskill the workforce – and that universities should recognise the contribution of industry as a key stakeholder and engage them in micro-credential design and delivery. Such shifts in approaches have been identified by other researchers as well and can be achieved through, for example, government levers to encourage the university sector to shift their practices to "emphasise business renewal by allowing universities to explore new ways of co-creating or co-delivering short learning opportunities [such as micro-credentials], together with other stakeholders [eg business, industry, professional associations] . . . [and] the growing importance of connection [with] commercial employment platforms" (Pirkkalainen *et al.*, 2022, p. 12). Another example to illustrate the growing call for cross-sector collaboration for alternative credentials including micro-credentials were articulated in a recent report that identified "seven short-term actions which government, higher education providers and industry can take to promote greater collaboration. . . .[to] help Australia move rapidly towards a system which invests more effectively in building capabilities and skilling the wider workforce through lifelong learning" (Bean and Dawkins, 2021, p. 9). One of the seven actions was to enhance cross-sectorial partnerships through building stronger partnerships supported by the establishment of a fit-for-purpose cross-sectorial teaching and learning innovation fund.

A closer look at the policy definitions of micro-credentials in Table 2 also raises the importance of stackability to allow learners to create their lifelong learning pathways that can incorporate a mix of conventional qualifications with alternative credentials such as micro-credentials. Each policy statement in Table 2 either explicitly states or implies generation of stacking. With their assessment standards, micro-credentials can offer higher education institutions to credit learners for study into accredited programmes – if the micro-credentials are designed carefully to provide such stacking mechanisms. UNESCO, New Zealand and Europe's policy statements add the dimension of identifying that micro-credentials need to be credit-bearing, while the Australian and United States' policy statements allude to such possibilities (refer to Table 2). This is a significant affordance of micro-credentials as it indicates the opportunity for designing on and off ramps to learning while working and disrupts the conventional thinking of learning as a linear activity across the lifespan (Fain, 2018; Weise, 2021). It creates opportunities to be more inclusive of alternative pathways to recruit and admit students into conventional and alternative credential learning programmes, particularly for learners from disadvantaged backgrounds or those discouraged to enter the education system (ACCRAO, 2022; European Commission *et al.*, 2020). These opportunities will enable working learners to manage their lifelong learning and make their own decisions how they want to use, store and share their credentials through technology solutions such as digital wallets and lifelong learning accounts (e.g. European Commission *et al.*, 2020; Goger *et al.*, 2022; Oliver, 2019) i.e. they have the principle of having sovereignty of their own data – but such issues of sovereignty and portability need to be built into the micro-credential and skills ecosystems by education providers, badging platforms and edtech organisations (ACCRAO, 2022; European Commission *et al.*, 2020; Goger *et al.*, 2022).

Conclusion

Digital micro-credentials offer the opportunity to engage with the agenda of lifelong learning and create a new landscape for higher education institutions to play, for example, in workforce upskilling and reskilling. As micro-credential technologies enter their second decade of existence, there is still much work to be done. Although it appears that micro-credential policy statements across the globe are steering towards commonality of definitional principles to ensure quality

learning, the diversity of micro-credential offerings are likely to remain. And this expectation may be a good thing as it will continue to allow experimentation with alternative models to meet the needs of diverse stakeholders. As an emerging area of educational technologies there is limited research and evidence-informed solutions in implementation of micro-credentials for lifelong learning and the role that universities may play. This scholarship will be key to sustaining the micro-credential for positive impacts if, as Klaus Schwab (2016) encouraged, we are to adapt and thrive in the Fourth (and Fifth) Industrial Revolution. Think about how we as educators could contribute Schwab's (2016) four intelligences within micro-credential design to counter negative impacts of the Fourth Industrial Revolution. Already there are models and practices surfacing based on lived experiences and experimentation with these educational technologies. For example, the conceptual framework for guiding implementation of digital credentials is based on four pillars of equity, sovereignty, mobility and trust – and provides suggestions derived from case studies about the roles of stakeholders and strategies for beneficial impacts within the micro-credential ecosystems (Goger *et al.*, 2022). Other examples of universities engaging with implementing micro-credentials in continuing professional education are being detailed in the literature with ideas for future research (e.g. Dede and Richards, 2020; Hickey and Chartrand, 2020; Lang *et al.*, 2022; Lang and Giglietta, 2022; Pirkkalainen *et al.*, 2022). While research and scholarship will be an essential contributor to micro-credential innovation to inform beneficial impacts, there is also a need to respond to critiques of the role micro-credentials may play in higher education. For example, Wheelahan and Moodie (2022) argue that micro-credentials blur the boundaries between higher education and the workplace with meaningless short learning that focus on skills without context and loss of transferability of learning. Boud and Jorre De St Jorrie (2021) postulate that in the rapid uptake of micro-credentials, attention to purposeful learning and assessment hasn't been well-researched or claims of efficacy in upskilling tested. Such analyses are important to acknowledge and provide opportunities to investigate, for example, whether micro-credentials offer opportunities for discovering new ways of (re)thinking learning, teaching, assessment that can live up to the promise of lifelong learning for working learners that meets the demands of complexity and uncertainty of the 21st century.

Notes

1. IPCC, refer to https://www.ipcc.ch/
2. United Nations Sustainable Development Goals (SDGs), refer to: https://sdgs.un.org/goals
3. SDG4, refer to https://sdgs.un.org/goals/goal4
4. AQF – Australian Qualifications Framework, refer to https://www.aqf.edu.au/
5. Open Badges, refer to https://openbadges.org/
6. NZQA > Micro-credentials, refer to https://www.nzqa.govt.nz/providers-partners/approval-accreditation-and-registration/micro-credentials

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Preparing the future workforce for 2030: the role of higher education institutions

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The invasion of futuristic technologies has made it inevitable for the future workforce to confront this reality and be ready to work in the new world of work in 2030. Higher education institutions (HEIs) are obligated to assume a pivotal role in equipping students with the requisite competencies. COVID-19 has expedited the development process compelling HEIs to make a mega shift to prepare the future workforce. Primary data was collected from HEI students across 11 countries to analyse their confidence to work in the new world of work in 2030 and to understand the role of HEIs in influencing students' confidence. Exploratory Factor Analysis (EFA) and Partial Least squares (PLS) based structural equation modeling (SEM) procedures were employed to estimate a structural model of awareness and readiness (cognitive) and confidence (affective) factors, and the combined effect of HEI, awareness, and readiness on overall student confidence in their knowledge, skills and abilities. The statistical results indicate that there are strong significant relations between the HEI-Awareness; HEI-Awareness-Confidence; HEI-Readiness; and HEI-Readiness-Confidence and these dependencies are not just by chance. The results of this research are significant for higher education policy developers and curriculum developers to incorporate future competencies in the program. Further, educators and researchers will benefit from the results to develop teaching strategies and content to equip the future workforce for 2030.et.

KEYWORDS

future workforce, higher education, future work, self-efficacy, work readiness, confidence, awareness, students' perception

1 Introduction

The invasion of virtual reality, augmented reality, mixed reality, artificial intelligence, and machine learning in the faculty lounge took over the scholarly discussions. It is inevitable for the future workforce to confront this reality and be ready to work in the new world of work in 2030. It has become imperative for higher education institutions (hereafter, HEIs) to play a significant role in enabling the students with the required knowledge, skills, abilities, and other characteristics (KSAO) to become a successful workforce of the future. McKenzie reported the anticipated displacement of over 375 million jobs with new jobs by 2030 (Manyika et al., 2017), a prediction supported by PwC (2018), raising questions about the intervention of human capital in future jobs. This paradigm shift in the world of work is not confined to specific regions, as reports suggest its implications will span across all nations. For instance, Western countries are projected to witness a 50% job displacement, while in the Middle East, the impact may reach up to 40%. The advent of COVID-19 has accelerated this transformative process, compelling HEIs

to undergo a significant shift in preparing the future workforce (Abbas Zaher et al., 2021; Godber and Atkins, 2021; Verde and Valero, 2021; Saleem et al., 2022). Camp et al. (2020) reported the need for readjusting employee roles and competencies to align with the post-pandemic 'new normal', emphasizing its enduring nature.

The future workforce will predominately consist of Millennials and Generation Z, the current student body pursuing their senior high school and post-secondary education. Their readiness, awareness, and confidence to work in the new world of work in 2030 are pivotal for their success, and HEIs must guide them through influence (Azhenov et al., 2023). Pandya et al. (2020) established the critical role of HEIs in developing knowledge, skills, abilities, and other characteristics required to perform well in the new world of work. The researchers also suggested that HEIs should influence the students to become more confident in performing future work. This research paper extends the work conducted by Pandya et al. (2020), aiming to investigate the role of HEIs in building students' confidence for future work.

While a wealth of literature exists on students' confidence, the importance of work-readiness, and the role played by HEIs in enhancing competencies is available, there remains a dearth of research gap concerning the influence of HEIs on student awareness, readiness and confidence to work in the new world of 2030. HEIS must comprehend the intricate relationship between these variables and reassess their educational policies, programs, systems and capabilities to adequately prepare students for the new world of work. This study aims to elucidate the role of HEI in preparing students for the new world of work by elevating awareness, readiness and confidence to work in future. It also presents the interrelationship between these competencies and contributing new knowledge to this field.

2 Theoretical background

This new world of work in 2030 will rely heavily on partnerships between humans and technology (Manyika et al., 2017; Schwab, 2018) leading to the displacement of existing jobs by artificial intelligence (CBRE, 2014; PwC, 2018). The physical, technological, purposeful, and emotional reforms of the workplace in past decade have already reared a significant challenge for the workforce in adapting to this new dynamic (Jones and Punshi, 2013). A new set of competencies among students will be imperative to navigate in the new world of work in 2030 (Pandya et al., 2020). Future job performance will necessitate certain competencies (Goffin and Woycheshin, 2006) aligned with measurable skill sets against performance expectations (Fawcett, 2017). Mahmud and Wong (2022a,b), have identified and emphasized the development of 21st-century skills, categorizing them into four groups: Data literacy skill, Problem-Solving skill, Programming skill and Creative thinking skills. Another study by Mahmud and Wong (2022b) underscores the importance of HEIs in equipping undergraduate students with these 21st-century skills for employability.

The regional meeting of Ministers of Education of Latin America and the Caribbean has accentuated the role of HEIs in fostering 21st-century skills through improvements in education quality, curriculum revisions, program development, and policy design (UNESCO Office Santiago and Regional Bureau for Education in Latin America and the Caribbean, 2017). The Dubai Initiative (2016) posits that the ongoing advancement of digitalization and automation will continually redefine competency requirements for employees in the coming years. Consequently, it becomes important to assess if HEIs are adequately preparing students for the future workplace. It becomes imperative to dissect the existing literature to find if HEIs influence readiness, confidence, and awareness amongst the students for future work.

While readiness, confidence, and awareness have been explored in earlier scholarly works, the precise definitions remained unexplored. To address this, we turn to the Merriam-Webster dictionary, defining all three aspects as "the quality or state of being." In this study, awareness refers to the state of being aware (knowledge and understanding), readiness refers to the state of being prepared and at ease, and confidence is a state of being certain. Here, for this study awareness will be the state of knowing the future world of work and the competencies required to be successful in that world of 2030. Readiness means preparing oneself for the new world by seeking associated competencies delivered by HEIs. Confidence implies being certain of implementing these competencies upon entering the new workforce of 2030.

Several studies have delved into the pivotal role that HEIs play in raising readiness, awareness and confidence among students (Payne et al., 2008; Casey et al., 2011; Lozano et al., 2012; Martin et al., 2020). Casey et al. (2011) investigated students' beliefs regarding their readiness to enter the workforce, discovering that students exhibited high confidence in their job competencies. While this quantitative study assessed students' comfort with competencies applicable to their practice and gathered recommendations for HEIs to enhance job preparation, the focus remained predominantly on readiness, providing only a superficial understanding of the association between readiness and students' confidence in their future practice.

An earlier study by Payne et al. (2008) systematically explored students' concerns about their competencies for success (readiness) and their confidence in implementing these competencies in practice (confidence). Findings revealed that despite being ready, students lacked confidence and motivation to apply such competencies, highlighting a gap in self-confidence and self-efficacy. Hoover et al. (2018) tapped into the relationship between the students' confidence and readiness to perform their tasks but did not explicitly address the influence of HEIs in shaping these dimensions.

In the realm of building confidence among students, Pollock et al. (2004) posited that HEIs should organize awareness events and campaigns on their campuses. These initiatives may include sessions with role models, speakers raising career awareness, and educational sessions on careers and requisite competencies. However, Maxwell et al. (2016) cautioned that while students' confidence and awareness are interconnected, evaluating and assessing these aspects remain challenging. Drawing from student perceptions and recommendations, HEIs can enhance their curriculum and facilitate students' transition into their practice (Casey et al., 2011). Additionally, establishing a feedback system within HEIs is crucial (Payne et al., 2008), allowing students to express their concerns about entering the new workforce.

The above studies have highlighted the relevance of awareness, confidence, and readiness required to be successful in future. However, the role of HEI in influencing these remains understudied. Therefore, this study will add to the current knowledge on the role of HEIs in raising awareness, confidence, and readiness of students to become a successful

workforce in the future. The future workforce by 2030 will be represented by automated workplaces, netizens as the workforce, and the world as a whole as a job market (Frey and Osborne, 2017). Artificial intelligence, robotics, virtual reality, machine learning, augmented reality, and further development in the fourth industrial revolution have already initiated the transformation in the workplace (Mathijssen et al., 2015; Bhattacharyya, 2017; Bhatia, 2018; Anderson, 2019; Pandya and Janahi, 2021). As the world thrives in the Fourth Industrial Revolution age marked by the adoption of more complex automation technologies and accelerating innovation, the fundamental question that has re-emerged among workers, business leaders, policy-makers and the broader public around the globe is the future of the workplace (Annunziata and Rostom, 2016). The pandemic of COVID-19 has accelerated the pace of this transformation manifold compared to what was anticipated in earlier studies (Camp et al., 2020). The question then arises from this narrative is that - Are the current students, who will be in the workforce of 2030, actually confident to work in this rapidly transforming workplace and ever-evolving technologies? Furthermore, does HEIs have any role in building confidence amongst students? This section provides a narrative review of literature sourcedfrom the institutional library and prominent education research databases, including Ebsco, ProQuest, ERIC, Web of Science, Scopus, and Google Scholar. Scholarly articles, books, reports and content from official websites were systematically reviewed to establish the theoretical foundation for this study. The focused review aimed to explore concepts and theories pertaining to students' confidence in working in the future and the role of HEIs in influencing this confidence.

2.1 Concepts, models, and theories addressing confidence to work in the future

García-Aracil et al. (2021) and Mahmud and Wong (2022b) study show that HEI graduates perceive under-preparation for future work, as the competencies required for future work are not completely integrated into the curriculum. Caballero and Walker (2010) posited that employers emphasize on work readiness of a graduate in the selection criterion and authors advised HEIs to prepare students with competencies demanded by the job market. This entails HEIs to stay abreast with the job market requirements in future and build the confidence of students to work in the future. Pandya et al. (2020) postulated the necessity for HEIs to develop knowledge competencies, skill competencies, ability competencies and competencies to perform in the era of Artificial Intelligence. These competencies are crucial for students to become successful workforce of the future. The authors discussed the vision of the workplace and workforce in light of the displacement of current jobs with new jobs by 2030. The study found that nearly 40% of students in HEIs are not confident about possessing the required competencies for future work. Their confidence is low concerning the future world of work due to uncertainty as to their HEI preparing them for this new dynamic. The authors set the direction for studying the interrelationships between the following three dimensions, in context of the future world of work, – awareness about future work; readiness for future work; and confidence to work in the future work and if HEI plays any role in influencing these dimensions. Our study undertook this direction to determine if HEIs impact the awareness, readiness and confidence of students.

Tanius and Susah (2015) suggest that HEIs should develop curricula matching the supply and demand of talent in the industry. Mashigo (2014) posited that graduates are less confident as they are incompetent to face challenges in the new work environment. Makki et al. (2015) study found a positive significant relationship between work readiness skills, career self-efficacy and career exploration among graduate students. Tentama et al. (2019) found that the higher the student's confidence and hardiness, the better the work readiness.

Schembari (2018) found that there was little or no relationship between anticipated person-job fit and the role of HEI in raising confidence. Prikshat et al. (2019) argue that even though work readiness is an important factor in understanding the transition of graduates from education to work, confidence must be shaped by HEI to orient the graduates according to their needs. Fenech et al. (2019), posited that the perceived work readiness of female Emirati graduating students is a positive perception; however, graduating students perceive that they are the least work-ready concerning skills related to their personal development, confidence and stress management (personal work characteristics).

2.2 Social cognitive career theory

Social cognitive career theory (SCCT) developed by Lent et al. (1994) delineates three interrelated facets of career development: (1) how basic academic and career interests develop, (2) how educational and career choices are made, and (3) how academic and career success is obtained. This theory affirms that an individual's internal cognitive and affective states, coupled with external environmental factors and overt behaviors, mutually influence one another (Kelly, 2009; Doe, 2015). SCCT incorporates diverse concepts such as interests, abilities, values, and environmental factors derived from earlier career theories, thus influencing overall career development. Rooted in Bandura's general social cognitive theory (1986), which explores cognitive and motivational processes across various psychosocial domains, SCCT has found widespread application in research. Scholars have employed SCCT to investigate aspects of career development, career choices, academic success, the prediction of self-goals, and future aspirations (Segal et al., 2002; Ali and Saunders, 2006; Lent et al., 2010). Doe (2015) embraced Social Cognitive Career Theory (SCCT) from Bandura (1986) to elucidate the connection between work readiness and success in the workplace.

2.3 Self-efficacy theory

Bandura (1977) introduced the concept of self-efficacy, defining it as an "individual's belief in his capacity to execute behaviors necessary to produce specific performance attainments" (p. 3). Lent et al. (2010) discussed that self-efficacy beliefs stem from four primary sources of information: personal performance accomplishments, vicarious experiences (e.g., observing similar others), social persuasion and physiological and emotional states. They further identified self-efficacy beliefs, outcome expectations and personal goals as three building blocks that regulate an individual's career behavior. In terms of future career-related behaviors, a person's self-efficacy beliefs will enable the future workforce to judge his capacity

to not only organize but to implement various actions to arrive at a goal.

Van Dinther et al. (2011) postulated that HEIs can influence students' self-efficacy, stating that "80% of the intervention studies across several types of study and across several domains demonstrated a significant relation between an intervention programme and students' self-efficacy" (p. 104). Further, Arico (2014) presented that academic self-efficacy has a direct impact on the student's confidence level. Academic self-efficacy is defined as a motivational variable whereby a student's performance can be predicted (Kim et al., 2018).

According to SCCT and the social cognitive theory, persons' engagement in activities, the effort and persistence they invent, and their ultimate success are partly determined by both their self-efficacy beliefs and outcome expectations. Bandura (1977, 1986) explains that outcome expectations refer to beliefs about the consequences or outcomes of performing particular behaviors. Though SCCT focuses on career development, it assumes that people are likely to become interested in, choose to pursue and perform better at academic activities at which they have strong self-efficacy beliefs as long as they also have the necessary skills and environmental support to pursue these activities. These skills and competencies are developed at their respective higher education institutions. Moreover, students' outcome expectations are key to their success in the future world of work.

2.4 Role of higher education institutions in developing confidence to work in the future

AACU (2015) and Manyika et al. (2017) advocate for HEIs to cultivate skills not only for current job roles but also for the evolving demands of future work. This encompasses future skills such as virtual competencies (Pandya, 2019), awareness of the trending realities in the relevant field, building technical and innovative capabilities, understanding of various disciplines, and building the right attitude toward work. For the development of the future workforce, the neoliberal higher education systems are transforming into a blend of a business school and a start-up incubator (Gannaway et al., 2013; Hameed et al., 2016).

Lozano et al. (2012) and Salas Velasco (2014) propose a capabilities approach for HEIS to design curricula, aiming to equip students with competencies for the future. However, the capability is just one facet of the KSAO, which may not comprehensively address the holistic development of students. They also understudied the future context, which this study focuses on. Boyer and Bucklew (2019) emphasized competency-based education and proposed HEIs to focus on "course/program catalogues, class/schedule building, and term/sub-term timeframes" to develop future generations by utilizing an interplay between future technologies and education systems while retaining the focus on individual students (p. 1, p. 18). However, these studies highlight the role of HEIs in developing competencies for the present but understudy the evolving technologies that will evolve in future.

3 Research model and methods

Our conceptual framework is structured upon the Social Cognitive Career Theory (SSCT) and Self-efficacy Theory (Bandura, 1977) as HEIs must prepare their students for the future world of work. However, at the same time, students themselves must be cognitive and confident of the competencies required to be ready for this very challenging future workplace and develop their careers based upon these constructs.

3.1 Objectives and hypotheses

Based on the results and findings of the previous research study (Pandya et al., 2020), it was found that students perceived that they lacked confidence in the future of work. From this finding and grounded upon the themes and concepts discussed in the literature review specifically the SSCC theory and the Self-efficacy Theory above, this research was based on five hypotheses specifically HEI students' awareness, readiness and confidence for the new world of work in 2030.

> *H1*: Higher levels of preparation at HEI has a positive effect on a student's awareness of the new world of work in 2030.
>
> *H2*: Higher levels of preparation at HEI has a positive effect on a student's perceived readiness to work in the new world of work in 2030.
>
> *H3*: Higher levels of preparation at HEI has a positive effect on a student's confidence to work in the new world of work in 2030.
>
> *H4*: Greater awareness of future work has a positive effect on a student's confidence to work in the new world of work in 2030.
>
> *H5*: Higher levels of perceived readiness for future work has a positive effect on a student's confidence to work in the new world of work in 2030.

3.2 Research design and context

A research model was formulated and validated to analyse the role of HEIs in fostering student awareness, readiness, and confidence for the workforce of 2030 (Figure 1). The dataset comprised perceptions collected from 190 students across the world using an online survey.

3.3 Instrumentation

The research model was validated through a quantitative investigation using an online survey instrument. The survey questionnaire comprised questions on demographics including age, gender, and country of residence, and psychographic questions related to different constructs in the research model. For each competency domain (Knowledge, Skills, Abilities and Other Characteristics), four items (on a 5-point Likert scale) were used to measure perceptions of students on their awareness

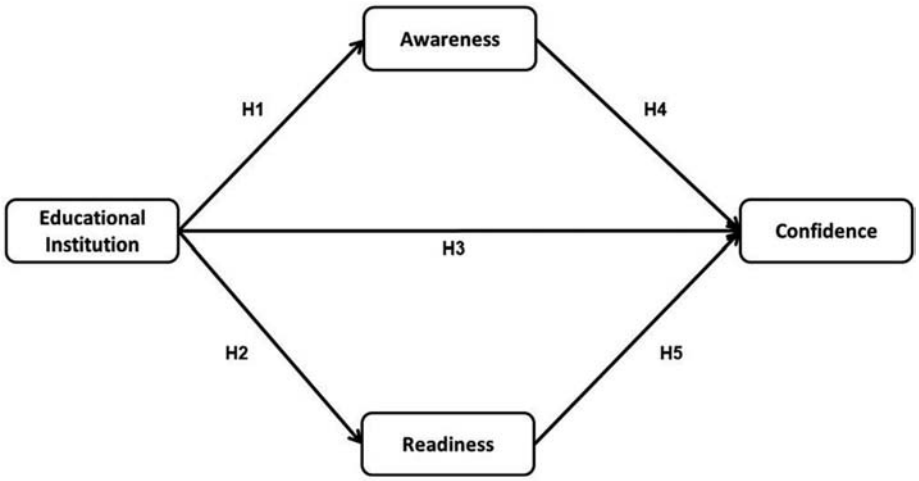

FIGURE 1
Research model determining HEIs role in influencing confidence to work in future.

of work in 2030, readiness to work in 2030, confidence to work in 2030, and also enquired if they perceive that their HEI has been preparing them to be professionally successful in 2030.

The questionnaire items were assessed for face validity through consultations with other research experts at the authors' institutions, and construct validity for each theoretical construct was assessed through exploratory factor analysis (EFA) of the pilot survey responses (n = 22).

Responses to demographic questions were analyzed using descriptive statistics, and testing of research model constructs and hypotheses was conducted through EFA and partial least squares (PLS) path modeling techniques. Descriptive statistics assist in classifying the data, describing the findings, determining relationships, and indicating relations among different aspects (Mertens, 2010). The PLS approach was selected for this study due to its suitability for small-sample exploratory research (Gefen et al., 2000), and its flexibility with multivariate normality assumptions (Thomas et al., 2005).

The sampling techniques used were primarily convenience and self-selection-based. As this study was exploratory, the researchers adopted convenience, snowball sampling methods, and distributed the survey through their professional networks. This network included faculty members from the authors' current and past HEIs and LinkedIn connections. Furthermore, a call of request was made to the network to extend the survey further to their respective peers to disseminate the survey link to their students. The research purpose, data collection procedures, privacy and confidentiality, conservation of data, secondary use of data, potential harms or risks, potential benefits and consent for voluntary participation were undertaken at the beginning of the survey. Research Ethical and Integrity guidelines were administered throughout the project. The data was collected during the Spring semester of 2020. To ensure a diverse selection of respondents, our sampling frame included respondents from all types of fields such as engineering, sciences, technologies, arts, commercial work, trading, and the like. The minimum sample size heuristic for PLS studies (Chin, 1998; Chin and Newsted, 1999) was utilized for *a-priori* calculation of the required sample size. Using this heuristic, the minimum target sample size for this study was determined to be 40 valid responses.

4 Results

A total of 260 responses were collected from across the various sources contacted for potential participation in our study. After discarding partial responses, 190 responses were retained for further analysis. This exceeded our minimum sample size target as specified above. Our analysis results are outlined in the next subsections.

4.1 Participants profile

Table 1 provides a summary of basic demographic information from the survey responses that were analyzed. A significant proportion of respondents were single (72%), males (70%), between the age group of 18–24 years (66%), enrolled in undergraduate programs (63%), studying in the UAE (80%). The majority of the participants were from the Business management program (56%).

4.2 Measurement model assessment

Following the two-step approach for Structural equation modeling analysis (SEM) suggested by Anderson and Gerbing (1988) an examination of the measurement model was conducted before testing the structural model. The measurement model was assessed through a combination of EFA procedures and various tests for discriminant and convergent validities for the constructs in the research model.

We inspected the loadings and cross-loadings of indicators as presented in Table 2. The highest loading for each measurement item (shown in bold) corresponds with its respective latent variable. As

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TABLE 1 Demographic profile of participants.

Demographic factors		Frequency	Percentage	Demographic factors		Frequency	Percentage
Gender	Male	133	70%	Highest level of education	Higher diploma	18	10%
	Female	57	30%		Bachelor's degree	120	63%
Age (yrs.)	16–18	2	1%		Master's degree	31	16%
	18–24	126	66%		Doctorate degree	17	9%
	25–34	34	18%		Professional degree	4	2%
	35–44	15	8%	Program of study	Architecture	1	1%
	45–54	10	5%		Arts	3	2%
	55–64	1	1%		Business	107	56%
	65–74	2	1%		Computer sciences	9	5%
Marital Status	Single	137	72%		Data analytics	2	1%
	Married	37	19%		Education	6	3%
	Others	16	9%		Engineering	3	2%
Country of residence	Argentina	1	1%		Information Technology	19	10%
	Canada	1	1%		Language/ Literature	3	2%
	China	1	1%		Nursing	1	1%
	India	8	4%		Psychology	1	1%
	Indonesia	2	1%		Social Sciences	3	2%
	Malaysia	2	1%		Sociology	3	2%
	Nigeria	2	1%		Others	15	8%
	Singapore	1	1%		Not mentioned	14	7%
	S. Korea	19	10%				
	UAE	152	80%				
	USA	1	1%				

shown in the table, the loading values of a measurement item on its associated target construct were higher in comparison to the item's cross-loadings on other model constructs, and the substantive loading of each item on its construct exceeds the recommended threshold of 0.70, hence indicating item reliability and discriminant validity (Chin, 1998).

Various tests of convergent validity were performed through an assessment of quality indices as shown in Table 3. The average variance extracted (AVE) or the communality index represents the proportion of variance captured by a construct from its indicators. This value for each construct is higher than 0.5 indicating adequate convergent validity. The values of Cronbach's alpha are in the range of 0.60 or higher, further demonstrating the internal reliability consistency of each construct (Gefen et al., 2000). Lastly, the composite reliability values for each construct indicates the internal consistency reliability of a construct in comparison with other constructs. As shown in Table 3, these values are higher than 0.70, satisfying the suggested cut-off for internal reliability consistency of each construct relative to all other constructs in the model (Fornell and Larcker, 1981).

4.3 Structural model assessment

The psychographic model posited student awareness and readiness as cognitive factors comprising the predictor variables, and student confidence as the affective construct representing the endogenous dependent variable. Exploratory Factor Analysis (EFA) and Partial Least squares (PLS) based structural equation modeling (SEM) procedures were used to estimate a structural model of these cognitive and affective factors, and the combined effect of educational institution, awareness, and readiness on overall student confidence in their knowledge, skills and abilities.

EFA and PLS based SEM procedures were used to estimate a structural model of the cognitive and affective factors in the research model, and the combined effect of educational institution, awareness, and readiness on overall student confidence in their knowledge, skills and abilities.

To estimate the structural model, the PLS procedure with bootstrapping using 1,000 re-samples was used. The structural model and the *p*-values are presented in Figure 2 with path beta coefficients depicted along each path. Four of the five hypotheses were supported

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TABLE 2 Matrix of loadings & cross-loadings for discriminant validity assessment.

Measurement items	Model constructs			
	Awareness	Confidence	Educational institution	Readiness
A1	**0.796**	0.711	0.516	0.668
A2	**0.776**	0.513	0.625	0.639
A3	**0.854**	0.67	0.529	0.718
A4	**0.834**	0.605	0.72	0.732
C1	0.721	**0.883**	0.639	0.656
C2	0.73	**0.877**	0.689	0.681
C3	0.681	**0.885**	0.666	0.675
C4	0.719	**0.861**	0.649	0.686
E1	0.674	0.678	**0.896**	0.724
E2	0.635	0.648	**0.872**	0.696
E3	0.663	0.682	**0.915**	0.721
E4	0.664	0.664	**0.858**	0.703
R1	0.653	0.633	0.585	**0.842**
R2	0.712	0.601	0.642	**0.785**
R3	0.667	0.61	0.703	**0.844**
R4	0.724	0.663	0.73	**0.84**

TABLE 3 Validity and reliability assessment of the measurement model.

Model constructs	Validity and reliability indicators		
	Average variance extracted (AVE)	Composite reliability	Cronbach's alpha
HEI	0.785	0.936	0.908
Awareness	0.643	0.878	0.813
Readiness	0.686	0.897	0.847
Confidence	0.786	0.930	0.899

with high degrees of confidence, and the model demonstrated to be a good predictor of student confidence to work in the new world of 2030 (R^2 value of 0.79 for this construct). These results are summarized below.

A significant relationship was validated between HEI preparation and students' awareness of the new world of work (H1 supported). HEI preparation also had a significant positive effect on students' perceived readiness to work in the new world (H2 supported). However, no direct significant association was found between HEI preparation and student confidence to work in the new world (H3 not supported). This direct relationship may be fully mediated through awareness and readiness which both have a significant direct positive relationship with student confidence to work in the new world of 2030 (H4 and H5 supported).

The R^2 values suggest that the model performed well for the dependent variables pertaining to awareness, readiness, and confidence. All dependents in the model compellingly exceed the minimum threshold of 0.10 indicating the usefulness of that variable in the model (Falk and Miller, 1992). In terms of the principal downstream variable in the model, i.e., student confidence to work in the new world in 2030, a significant portion of its variance (around 79%) can be explained by the posited research model.

5 Discussion and recommendations

The findings of this study suggest that the HEIs play a significant role in influencing the awareness, readiness, and confidence of their students to work in the new world of work in 2030. Statistical results indicate that HEIs indirectly impact students' confidence levels by influencing their awareness and readiness for future world of work. The model presented demonstrated strong predictive capabilities in determining the constructs that affect students' confidence to work in the new world of 2030. The observed strong and significant relations between HEI-Awareness; HEI-Awareness-Confidence; HEI-Readiness; and HEI-Readiness-Confidence and these dependencies are not just by chance.

The findings align with the findings from the research project carried out by Pandya et al. (2020) wherein more than 40% of students believed that their HEI had made them aware of the competencies required for the new world of work. Further, around 45% of students believed that their HEI has prepared them by developing their knowledge, skills, abilities, and other characteristics. Moreover, 67% of students expressed confidence in building their competencies for the future, with 35% acknowledging no role played by their HEI in fostering such confidence. This study statistically establishes that HEI influences students' confidence in future work through their impact on awareness and readiness to work in future.

Drawing on the Social Cognitive Career Theory (SCCT) and three aspects of career development proposed by Lent et al. (1994), our

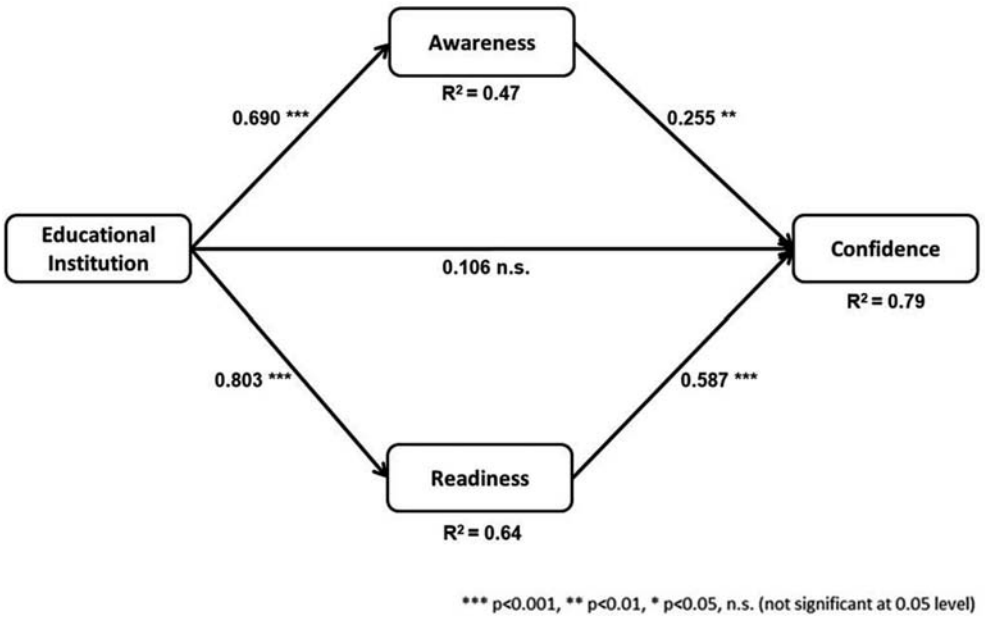

FIGURE 2
Results depicting HEIs role in influencing confidence to work in future.

findings support previous research by Bandura (1977, 1986) whereby outcome expectations (self-confidence) can refer to students' beliefs about the consequences or outcomes of them performing particular behaviors. SCCT is based on career development where students are more likely to become interested in, choose to pursue and perform better at academic activities if they have strong self-efficacy beliefs. Our findings have shown this link to the Self-Efficacy Theory (Bandura, 1977) with the caveat they must possess the required skills and environmental support for these academic activities, developed at their HEIs (Van Dinther et al., 2011; Arico, 2014). We can interpret that HEIs can groom students for the future. This can be done by offering them programs compatible with the requirements of the new world of work; accordingly developing their competencies; and raising awareness and creating interest in new careers (Payne et al., 2008; Casey et al., 2011; Maxwell et al., 2016; Hoover et al., 2018). Further, HEIs can provide an engaging learning environment to influence the students' cognitive, affective, and behavioral states (Doe, 2015). As suggested in Self-efficacy Theory, such influences by HEIs will alter students' beliefs in their academic capacity (Bandura, 1977), build their motivational levels (Kim et al., 2018) to attain their career objectives, and in turn, build their confidence to work in the new world of 2030.

6 Conclusion, limitations, and future research

In investigating the influence of HEIs on the competencies required, we have ascertained that educational institutions play a crucial role in fostering students' confidence by cultivating awareness of future competencies and facilitating their development. The primary limitation of this study lies in its sample size, predominantly comprising participants from Business programs at HEIs in the UAE. Our future research endeavors will aim for larger and more diverse datasets, encompassing participants from various countries and academic programs to enhance the generalizability of findings. Despite this limitation, the results of our research hold significant implications for higher education policy developers and curriculum designers, urging the incorporation of future competencies into educational programs. Additionally, educators and researchers can leverage these findings to formulate effective teaching strategies and content, thus equipping the future workforce for 2030. In the next phase of this project, we plan to expand our scope to include perceptives of educators and industry experts worldwide. This extension aims to provide insights into the role of educators and HEIs in shaping awareness, readiness, and confidence among students, thereby contributing to the development of a successful future workforce.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval was not required for the study involving human participants in accordance with the local legislation and institutional

requirements. Written informed consent to participate in this study was not required from the participants in accordance with the national legislation and the institutional requirements.

Author contributions

BP: Conceptualization, Data curation, Project administration, Writing – original draft. UR: Formal analysis, Methodology, Writing – original draft. LP: Funding acquisition, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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