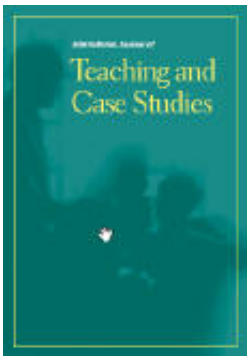

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The future is now: a comparative case study of three innovative adult education approaches in Singapore

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Abstract: Digital technologies and worldwide connectivity are rapidly transforming education and employment sectors globally, generating innovative approaches to skills and knowledge development that serve as the backbone of such transformations. Driven by public-private partnerships between industry, educators, and policymakers, Singapore's adult education sector offers insights into how the future of education could look like. In this paper, we present three pioneering training and adult education providers – Tech Tree, ROHEI, and NTUC LHUB – to illustrate how they embrace in different ways a future-oriented learning ecosystem. To examine their innovative approaches, we assess them in relation to seven education shifts associated with the Fourth Industrial Revolution as outlined by Peter Fisk (2017a). We furthermore identify ecosystem characteristics that facilitate their success. We conclude by tracing potential pathways for innovation and adaptation in response to a changing education and employment environment.

Keywords: adult education; adult learning; Singapore; qualitative comparative case study.

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1 Introduction

Proponents of the Fourth Industrial Revolution predict that the integration of digital technologies and ubiquitous connectivity will bring about a multi-layered disruptive system change. This revolution, according to the World Economic Forum (WEF) in 2019 and the OECD in the same year, will not only transform our way of life and work but our very identities and societies (WEF, 2019; OECD, 2019). In the words of Klaus Schwab (2017, p.1), these technologies will fuse "the physical, digital and biological worlds, impacting all disciplines, economies and industries, and even challenging ideas about what it means to be human".

Education, a cornerstone of societies and their development, stands at an intersection. It is at the forefront of innovation and it is perennially lagging behind the needs of rapidly evolving technologies and societies. On the one hand, this duality makes education an enabler, driver, disruptor, mediator, and anchor of systemic change, inviting individuals, social groups, institutions, and societies to participate in the disruptions wrought by the consequences of the Fourth Industrial Revolution (WEF, 2019; OECD, 2019). On the other hand, many educational programs struggle to adapt to economic, social, political, and technological shifts that occur in a societal ecosystem. But what if the future of education, amid disruptions and losses, holds more ambitious promises? What if, despite its task to adapt to externalities, it is marked by innovation, creativity, and a focus on people? What if lifelong learning is seamlessly integrated into the social fabric, with adult education providers playing a far greater and positive role in this transformation? And what if this future is not just a distant prospect but already here?

This paper explores three innovative and successful training and adult education (TAE) providers in Singapore. These providers, Tech Tree, ROHEI, and NTUC LHUB, have uniquely adapted to shifting educational needs and opportunities in a rapidly evolving society and, more recently, in the face of a highly disruptive pandemic. By examining their unique contributions to TAE and situating them within the framework of Education 4.0, derived from Fourth Industrial Revolution concepts (Fisk, 2017a, 2017b; WEF, 2019; OECD, 2019), we illustrate how TAE providers leverage technology, global connectivity, and societal shifts to reshape the TAE sector and redefine adult learning and training. Our case comparison, identifies four key drivers of their success, offering valuable insights for a possible TAE future.

2 Innovations from three TAE providers in Singapore

2.1 Tech Tree and the tree of knowledge

Established in 2019, Tech Tree is the youngest among the successful TAE providers under consideration here. Tech Tree's adult education portfolio includes online courses, learning chatbots, and virtual workspaces serving local, regional, and international clients. As a start-up specialising in the convergence of technology and impactful learning, Tech Tree found itself well-positioned during the COVID-19 pandemic and has since expanded its operations to Cambodia, Vietnam, and Indonesia. To highlight innovation in Singapore's adult education landscape, we will focus here on one of their distinctive approaches: Tech Tree's chatbots for learning.

Chatbots are software programs designed to simulate human-like conversations with users. Tech Tree employs chatbots for learning, a platform that delivers educational content in an engaging, learner-centric manner. Tech Tree identifies clients' learning objectives, crafts tailored content, and implements customised modules for pre-developed chatbots, which are then deployed accordingly. This adaptability allows Tech Tree to respond effectively to evolving needs across diverse industries, learner groups, and scales. Although still in its early stages, Tech Tree has deployed platforms catering to the educational requirements of various national and international institutions, including banks, NGOs, and sections of the United Nations. Their portfolio extends to English and digital literacy chatbots developed in collaboration with UNESCO for informal school

systems in Myanmar and Thailand, health and hygiene training in the service industry, and enhancing management skills for senior finance executives.

Three noteworthy characteristics sets Tech Tree's chatbots apart in the adult education landscape: First, their platform mirrors the style and functionality of popular social media applications such as WhatsApp and X. This familiar and user-friendly interface facilitates access to learning content via basic smartphone technology, aligning learning with daily on-screen interactions, making education a seamless part of daily life instead of something one must 'go and do'.

Second, Tech Tree's chatbot-based learning embraces a modular and self-guided approach. Learning content is organised into 'nano learning loops' that are compact, interconnected, and relatively independent learning experiences. These loops revolve around specific topics, allowing learners to explore content based on individual interests, pace of learning, existing knowledge, and training needs. By clustering these nano learning loops around client-defined learning goals, Tech Tree creates a knowledge tree for specific training needs while empowering autonomous learning encounters. The compact nature of nano learning loops accommodates learners' time constraints and busy lifestyles, enabling them to dip in and out of the platform at their convenience.

Third, the content of Tech Tree's nano learning loops is designed in collaboration with artists and humanities graduates, incorporating elaborate storyboards, characters, plotlines, and chatbot simulations to mimic culture-sensitive social interactions and peer-to-peer co-learning experiences. This innovative component emphasises performance and skill mastery over traditional rote learning and grading. Chatbots also initiate follow-up conversations with learners days or weeks after completing a module, reinforcing acquisition and retention, and engaging learners with newly acquired skills and knowledge.

Overall, Tech Tree's adult learning approach holds significant promise for integration into diverse educational settings, preparing lifelong learners for the changing demands of the 21st century. Their innovative features include adaptable chatbot technology, capable of customisation for various learning content, environments, and audiences. The platform's modular, self-guided design empowers learners to explore content independently, aligning with their unique preferences and constraints. Furthermore, by seamlessly integrating into everyday smartphone technology and adopting the format of popular social media applications, Tech Tree creates an accessible, familiar, and engaging learning experience. This approach leverages storyboarding and conversational simulations, fostering skills and knowledge acquisition through simulated peer-to-peer co-learning experiences, all supported by follow-ups and feedback loops.

2.2 ROHEI and edutainment

ROHEI, recipient of many awards, including the 'Influential Brands Top Employer Award', the 'Tripartite Alliance Award in Work-Life Excellence', and the Great Place to Work Institute's 'Best Workplaces Award', exemplifies their success in Singapore's TAE sector. Established in 2007, ROHEI has served over 400 clients and trained more than 90,000 learners. The core of ROHEI's expertise lies in assisting companies in leadership development, capacity building, and navigating intricate change management journeys.

In this text, we will focus on one of ROHEI's most successful learning methodologies: learning carnivals. Learning carnivals are based on the understanding that learning is most effective when it transforms into an exciting, emotive, and immersive

experience that stimulates multiple senses. The primary aim of learning carnivals is to create engaging, interactive, and multisensory learning environments. They are co-developed in two distinct phases: In the first, ROHEI collaborates closely with its clients to co-design learning content, aligning it with what clients wish their staff to learn. During this phase, ROHEI often refines the initial learning goals based on long-term industry experience and its success models. This creates learning content that is adapted to specific industries and staff needs, sometimes even transcending the limitations of scope envisioned initially. Alignment of learning goals with learning objectives takes place through design principles, a process aptly described by a senior executive:

> "You start from the need, and then you work from the need towards being able to achieve the outcome. But you have to start from the need [and ask] 'What are learners feeling right now?', 'What do we want them to feel?', 'What are they learning right now?', 'What do we want them to learn?', and 'How do we bring these things together?'"

The process of reverse engineering learning content ensures alignment with industry requirements and learners' preferences, enabling the development of knowledge and skills that are contextually relevant and culturally sensitive.

The second phase involves the transformation of learning content into an interactive and multisensory learning carnival. These carnivals, adaptable to serve small group interactions and settings with over 600 adult learners, incorporate various edutainment and gamification approaches such as stages, installations, role-playing, structured games, and simulations. Learning carnivals encompass music, visuals, materials, stagecraft, dramaturgy, and diverse mental and physical activities, all crafted to create a multisensory learning journey. To foster camaraderie and collaboration among learners, drinks, snacks, and engaging small group encounters are provided. All learners receive an individualised guide, directing them through different learning stations based on their unique contexts and needs. This ensures that specific learning encounters are tailored to individual requirements while everyone collectively enjoys a carnival-like learning experience.

The COVID-19 pandemic compelled ROHEI to evolve its teaching and learning model. Adapting their face-to-face learning experiences into the digital realm was particularly challenging due to the high-energy 'wow' factor integral to the success of learning carnivals. ROHEI identified three key areas for adaptation: fostering meaningful interactions between facilitators and learners, as well as between learners themselves, and maintaining learner engagement and immersion in a positive learning experience.

To encourage meaningful interactions, ROHEI experimented with various backgrounds, props, and digital adaptations of successful games, creating opportunities for discussion and genuine encounters. To enhance the virtual carnival experience, ROHEI developed elaborate learning parcels, which were delivered to learners ahead of the carnival. These parcels not only helped learners prepare but also facilitated hands-on, tactile activities including snacks, learning materials, props, and hybrid games that became integrated into virtual group encounters during the carnival. Expanding the boundaries of edutainment, ROHEI also explored new forms of learning, including digital escape rooms and the integration of AI into online learning carnival experiences.

ROHEI's learning carnivals stand out as highly innovative teaching and learning environments. Whether physical or hybrid encounters, their multisensory learning carnivals aim to make learning engaging, immersive, and enjoyable. ROHEI continues to

lead the way by experimenting with AI, hybrid models, and augmented reality formats. Their learning carnivals can adapt to different group sizes and industry needs, fostering individualised learning journeys within collective settings. Lastly, ROHEI's two-phase co-design of learning content, in close collaboration with industry partners, and the process of reverse engineering to align industry needs with learners' contexts and preferences represent an innovative approach to developing and delivering context-relevant and culture-sensitive content.

2.3 NTUC LearningHub and educational liaison

NTUC LearningHub (NTUC LHUB), established in 2004, is another prominent TAE provider in Singapore. Their mission revolves around enhancing lifelong employability in diverse sectors, including healthcare, security, human resources, workplace health and safety, literacy, cybersecurity, and cloud services. Over the years, NTUC LHUB has offered nearly 3,000 courses, benefiting more than 2.5 million learners. Their contributions to the TAE sector have earned them numerous awards, including the 'Influential Brands Award', 'Top Brand for Continuing Education and Training Institute Award', Microsoft's 'Partner of the Year Award', and HRM Asia's 'Best Training Provider Award', and 'Best Corporate - Learning and Development Provider Award'.

NTUC LHUB is affiliation with, and the official training arm of, Singapore's National Trades Union Congress (NTUC). As a 'social enterprise', NTUC LHUB is dedicated to upskilling, upgrading, and uplifting the workforce in Singapore, guided by its motto: "better worker, better job, better company". Given its pivotal role in the union ecosystem, NTUC LHUB emphasises connecting, collaborating, and liaising with diverse stakeholder groups.

To showcase one of NTUC LHUB's innovative contributions to the TAE landscape, we will focus here on their support for companies that try to navigate rapidly evolving industries. NTUC LHUB often partners with employees operating in dynamic business and production environments that require adaptable, industry-relevant knowledge and skills. In this context, NTUC LHUB follows a two-part approach: First, they collaborate with strategically positioned industry partners and funding bodies to develop customised in-house training programs, thus incorporating occupational placement opportunities. These programs immerse learners in job-specific experiences, enabling them to apply learning materials to new or rapidly changing sectors, often with the aim of transforming temporary training arrangements into permanent employment.

Concurrently, NTUC LHUB develops on-the-job solutions to assist workers facing rapid sociotechnical changes. These solutions manifest as practical 'best of' implementation guides known as 'playbooks.' Collaborating with educational partners, NTUC LHUB identifies effective tools and approaches, aligning expert learning content with cutting-edge technologies, software licenses, and implementation-based training workshops coordinated with industry partners, funders, and unions. A senior executive explains this approach:

> "For example, workflow automation: You could do it in a hundred different areas. Then we say: What are the 10 most common areas where people will implement this technology? And then we come up with a step-by-step guide on how to implement the technology based on these 10 use-cases. We call that a playbook."

The playbook approach illustrates NTUC LHUB's unique position as the central hub connecting three stakeholder groups: industry, learners, and the TAE sector. They leverage this position to design playbooks tailored to specific industry needs while adapting them to various knowledge levels, departments, sectors, industries, organisation sizes, and available funding.

NTUC LHUB's liaison approach to adult learning offers several advantages. By sourcing learning content through collaborations with experts and industry leaders rather than developing it in-house, NTUC LHUB remains agile in adapting to emerging knowledge and technological shifts. This approach eliminates the need to invest in potentially obsolete infrastructure, programs, or skillsets. NTUC LHUB curates expert learning content on a global scale, aligning strategically with employee, client, industry, and worker needs. This ability to contextualise learning while tapping into global expertise provides NTUC LHUB with a competitive edge over traditional adult learning programs. Moreover, NTUC LHUB can count on strong support and goodwill from industry partners, workers, unions, and the Singaporean government because of its deep ties to Singapore's unions and established role as a social enterprise.

3 Education 4.0 and Singapore Today

In line with the Fourth Industrial Revolution, advanced technology and global connectivity are rapidly transforming industries worldwide (Fisk, 2017a; WEF, 2019; OECD, 2019). While a detailed review of these changes is beyond the scope of this paper, such changes significantly influence not only the future of work but also how we think of education, training, and the labour market (Brown, 2020). Changes also involve the obsolescence of outdated knowledge and skill sets, dilution of conventional work arrangements and labour contracts, weakening of commitments between employers and employees, and increasing job and employment instability (Fisk, 2017a; Ioannidou and Parma, 2022; Loo, 2018; Doherty and Stephens, 2023).

The concept of Education 4.0, aligned with the themes of Industrial Revolution 4.0, addresses how education can adapt to this evolving landscape (WEF, 2019; Fisk, 2017a). Fisk (2017a) suggests leveraging digital technologies, personalised data, open-sourced content, and global connectivity to reinvent when, where, and what we learn. Education 4.0 envisions learning ecosystems where resources are abundant and accessible, and learners can autonomously engage in continuous learning flows [Fisk, (2017b), p.1].

Fisk proposes seven shifts for adult education to transition successfully to future learning ecosystems:

1 shifting from episodic to continuous learning formats
2 transitioning from assigning to enticing with content
3 moving from content conveyors to content curators
4 adapting from working at one scale to working across scales
5 shifting focus from degrees to reputation metrics
6 replacing grades with continuous, differentiated feedback
7 moving from traditional lecture halls to collaborative spaces [Fisk, (2017a), p.2].

We will outline each of these shifts and provide examples from our three cases to illustrate their practical implications in Singapore. Our intention is not to suggest that these shifts are inevitable or beneficial, nor that they are fully operational in our three TAE providers. Instead, we aim to demonstrate how elements we identified in the three providers align with Fisk's seven shifts, and how the TAE providers thus explore innovations that offers a context- and culture-specific vision for the future of education and work in Singapore.

3.1 Shifting from episodic to continuous learning formats

Fisk (2017a, p.3) envisions a shift from traditional learning formats, where learning is confined to specific settings (like classrooms), rigid timeframes (during school hours), and delivered by a limited number of specialised teachers. In this new world, new technologies, such as globally interconnected smartphone apps and platforms, enable continuous learning flows where learning content is personalised to learners' interests, contexts, and needs, easily shared and accessible, and flexibly integrated into daily life (Fisk 2017a; Rowe et al., 2023).

While our focus here is on lifelong learning, Tech Tree's innovations exemplify how this shift is realised. They leverage readily available smartphone technology and a global interconnectedness, replicating everyday social media formats through chatbots and storyboards. This transforms learning from a scheduled task to a seamless, daily habit akin to social interactions, enhancing engagement and reducing effort. Tech Tree's chatbots facilitate extended learning conversations in ways that transcend conventional knowledge acquisition by promoting dynamic, generative skills and knowledge development. Their 'tree of knowledge' compartmentalises content into thematic modules, enabling self-guided explorations driven by individual preferences, existing skills and knowledge, and needs and interests. Nano learning loops allow learners to dip into content at their convenience, whether in the morning, during commutes, between shifts, or in spare moments. This flexibility makes continuous learning possible anytime and anywhere, catering to diverse lifestyles and preferences.

3.2 Transitioning from assigning to enticing with content

Education 4.0 must adapt to a world where continuous skills development is essential and career movements are normalised. This will require ubiquitous skills and knowledge acquisition opportunities that transcend set requirements associated with conventional job descriptions and disciplinary boundaries. As learners become more accustomed to a shifting landscape of learning and job opportunities, they will need to be motivated to engage actively in the learning process (Fisk, 2017a). In a sense, learning will be part of work, as part of work will include opportunity provisions for learning. Departing from a traditional stage model that dictates specific learning content for tasks, learning becomes indispensable and inseparable from task performance, and thus appealing in its own right. ROHEI's multisensorial learning carnivals exemplify this approach. These carnivals incorporate elements like music, lights, stages, actors, installations, role-playing, structured games, and simulations to create captivating learning interactions. The diverse mix of participants fosters a friendly learning environment. Furthermore, ROHEI is at the forefront of exploring innovative learning formats, including escape rooms, AI environments, hybrid learning spaces, and augmented reality experiences.

They push the boundaries of how learning can be made enticing but, concurrently, how the skills and knowledge acquired in carnivals are highly industry- and sector-relevant.

3.3 Moving from content conveyors to content curators

This shift builds on the previous ones as it underscores the importance of carefully and strategically curating learning content to make skills and knowledge ubiquitous. As Fisk (2017a, p.3) suggests, this entails "the ability to find, consolidate, and deliver needed information and learning resources at the right time and in the right context". To achieve this, certain conditions must be met: First, curators must navigate vast catalogues of resources, continuously identifying high-quality and cutting-edge content relevant to specific learning and application contexts. This task occurs within a dynamic landscape of competing demands, resource constraints, and rapid ecosystem changes. Second, curators must develop tools for identifying field or industry-specific, culture-sensitive, and context-relevant learning and training content. This involves curators not only as experts, selecting and editing content, but also as learners, allowing themselves to be influenced and guided by their respective fields and developments. Finally, curators must select and provide a platform that seamlessly and appropriately delivers content to their audience, including learners, teachers, clients, industries, governments, and other stakeholders.

All three cases discussed excel in curating learning content tailored to specific industry needs and learner interests. With a focus on practicality and relevance, NTUC LHUB's liaison approach stands out. NTUC LHUB collaborates closely with industry clients and unions to identify learning and training objectives, ensuring that content selection is relevant from the outset. NTUC LHUB employs various strategies to identify top-notch learning and training content sourced from educational experts, organising it into user-friendly playbooks. These playbooks are then enriched with cutting-edge technologies and training courses. Coupled with occupational placements and a strong emphasis on its role as a social enterprise, NTUC LHUB exemplifies the role of a content curator in the field of adult education.

3.4 Adapting from working at one scale to working across scales

Traditional learning institutions operate on specific scales. For instance, universities typically feature large-scale lecture halls or smaller seminar rooms, while TAE institutes specialise in reskilling and training smaller groups within organisations or specific industries. As outlined by Fisk (2017b), global connectivity, content proliferation and new knowledge flows renders stepwise educational models linked to specific knowledge silos obsolete. Education providers must now offer personalised learning content capable of reaching "hundreds of thousands and more when needed" [Fisk, (2017a), p.3]. All three of our cases demonstrate this adaptability:

Tech Tree has effectively tailored its digital platform to deliver learning and training content to various settings, from small management units to national and international businesses and organisations with diverse departments and locations. Even within this scalable environment, the tree of knowledge approach remains highly personalised and self-guided. ROHEI's learning carnivals are adaptable to small, medium, or larger groups, each strategically designed to suit specific learning and training contexts as individuals are guided through activities based on their unique backgrounds and learning

needs. Finally, NTUC LHUB's playbooks are tailored to meet the needs of specific industries or organisations, which are scaled and adapted to diverse stakeholder needs. All these cases illustrate the capacity to personalise, as well as up or downscale learning content.

3.5 Shifting focus from degrees to reputation metrics

Fisk (2017a) notes that contemporary engagement on platforms designed for expressing opinions, sharing views, and reviewing products and services foreshadows a shift in education. Future educational ecosystems are likely to provide ecosystem-specific feedback and assessment. This shift may lead to a fundamental change in educational assessment, as recognition systems move away from traditional measures like college degrees and attendance at Ivy League schools and, instead, embrace a knowledge- and sector-specific performance assessment (Fisk, 2017a). In this context, future approaches to adult learning will incorporate a broader range of skills and knowledge assessments. It is worth noting that none of our cases emphasise traditional grading or credential acquisition. Instead, these learning experiences provide training tailored to specific contexts and associated stakeholders. NTUC LHUB's in-house training approach is an interesting example of this shift. Placement opportunities not only serve as an entry point into new career paths but also offer valuable hands-on experience, coaching opportunities, and access to peer-to-peer feedback (Diaz, 2022; Runcieman, 2021; Keller and Barabasch, 2022). This creates the potential for industry partners to make hiring decisions based on in-house performance or recommendations, rather than relying on traditional credentials.

3.6 Replacing grades with continuous, differentiated feedback

Integrating continuous feedback mechanisms into learning flows complements the shift away from traditional grading or degree acquisition. The convergence of technology, connectivity, and content proliferation offers opportunities to harness big data and advanced analytics for assessment and reputation metrics, thereby creating continuous and differentiated feedback systems (Fisk, 2017a). This approach aims to replace single scalar judgments with assessments that adapt to the multifaceted nature of learning ecosystems, involving multidimensional outcomes and varying levels of mastery.

As previously mentioned, none of the cases examined here rely on traditional grading or performance assessment. Instead, they adopt differentiated process and outcome feedback approaches. Tech Tree's utilisation of peer-to-peer co-learning encounters, positive reinforcement, and continuous feedback serves as an illustration of how feedback on skills and knowledge acquisition, coupled with periodic refreshers through chatbots, can replace conventional grading and certificates.

3.7 Moving from traditional lecture halls to collaborative spaces

The final shift outlined by Fisk concerns changes in the learning environment, particularly the traditional lecture hall, seminar room, and library. Alternative modes of delivery, such as self-learning and assessment, project-specific engagement, and collaborative peer-to-peer learning necessitate new settings that encompass elements like project work, one-on-one mentoring and coaching, and flipped classrooms. These settings

include alternative learning spaces like hacker and maker spaces (Fisk, 2017a), as well as proliferation of employment of hybrid and virtual learning and collaboration applications. This transformation explicitly centres learning encounters and spaces on principles of co-creation, where knowledge and skill formation, acquisition, transformation, and transfer are collaboratively designed by learners. While all three cases depart from traditional learning spaces, ROHEI and Tech Tree stand out for their innovative collaboration approaches. ROHEI, for instance, consciously incorporates design principles into effective learning by co-designing learning modules based on triangulating the client, learner, and cultural contexts in which learners must apply new skills. This co-creation forms the foundation upon which ROHEI constructs its multisensory learning carnivals, which essentially amalgamate social and collaborative learning experiences. In this context, space extends from the intra-individual to the actual sensorial experiences shared with others. In contrast, Tech Tree employs chatbot technology to simulate group learning environments that facilitate collaborative learning spaces. Although learners may technically be alone or only virtually connected to others while using this learning platform, these simulations are thoughtfully designed to encourage peer-to-peer knowledge transfer and reinforce learning through social and collaborative encounters. These interactions can occur with distant co-learners or within a scripted environment guided by carefully designed chatbots.

Fisk (2017a) outlined the seven shifts towards Education 4.0, offering a blueprint for designing, curating, implementing, and accessing adult education in a permanently evolving educational landscape. In this envisioned future, the potential for global connectivity, content proliferation, universal access, and new forms of creation and co-creation could revolutionise adult education. New skills and knowledge should be readily attainable and widely accessible, and opportunities for learning should be abundant. Our case-specific examples of innovations in Singapore's adult education sector provide a glimpse into a potential future for education. They reflect learning in innovative, culturally sensitive, cost-effective, and people-centric ways.

The final part of this paper delves into the underlying factors that facilitate innovation in Singapore's TAE sector.

4 What facilitates education transitions?

We identified four key facilitators that enabled the successful application of TAE innovations, aligning with Fisk's seven shifts (2017a) and our three cases: Singapore's policy environment, strategic partnerships, technological innovation, and learner-centric approaches.

4.1 The policy landscape as a catalyst for innovation

The Singaporean government has a consistent track record of proactive, pragmatic, and science-informed policy development, including in the adult education sector. Bound and Chen (2022) explain how the initial policies and funding mechanisms supporting adult education were established 14 years after Singapore's independence in 1965. These policies were crafted around two core principles: People as Singapore's greatest asset and the imperative of lifelong learning for global competitiveness (ibid). This dual commitment was formalised in 2003 when the government established the Workforce

Development Agency with the mission to "promote lifelong learning [to] make the workforce resilient and competitive" (MOM, 2016). In 2005, the Workforce Skills Qualifications system was introduced, serving as the national accreditation framework that aligned skills and competency training with industry demands. These pivotal developments laid the groundwork for fusing the realms of work and learning, and they facilitated the emergence of "an inclusive, equitable society within a robust, advanced economy" [Bound and Chen, (2022), p.133].

The SkillsFuture Movement, initiated by the government in 2014, marked the most recent policy shift to sustain this momentum. By emphasising the mastery of practical skills and knowledge over formal degree-based education, this initiative sought to empower individuals to reach their "fullest potential throughout life, irrespective of their starting points" (SkillsFuture Singapore, undated; see also James, 2020; Gao et al., 2022). To realise these objectives, the Ministry of Education established SkillsFuture Singapore, a statutory board under its purview, tasked with closely collaborating with industry partners "to foster a culture of lifelong learning and partnering with educational institutions and training providers to deliver high-quality, industry-relevant training" [Bound and Chen, (2022), p.134]. The TAE sector is benefiting from generous funding and support within this policy framework, maintaining alignment with industry requirements, and responding effectively to global sociotechnical and economic shifts. Unsurprisingly, successful TAE providers have a stable and diverse customer base, comprising industry, government, unions, and employees.

4.2 Strategic partnerships for contextualised learning

Our three cases share a considerable success in that the impact they have on adult education outstrips relatively modest budgets and company size, which, interestingly, contributes to their success in that small budgets and company sizes encourage mobility, adaptability, and innovation. Their success is also due to strategic partnerships that contextualises learning within larger national and global trends with the support of government and industry. Our TAE providers are not only education providers but service providers in the form of knowledge and skills brokers. Tech Tree adapts its learning platform and content to fit the needs of clients and learners by adapting existing chatbot technology and carefully scripting storyboards, ROHEI engages in design principles to partner with clients and learners to co-create context-specific and culture-sensitive learning carnivals, and NTUC LHUB's business model thrives on the mediation and partnership between learning providers, technology services, industry sectors, and unions. Strategic partnerships create an interdependent ecosystem that is highly attuned to learning and training outcomes and adept at creating contextualised learning content that responds dynamically to industry needs, market changes, learners' interests and capacities, as well as cultural and national contexts. Interestingly, these business dynamics imprint on the TAE providers themselves. The three TAE providers are exceptional not only at using strategic partnerships to create innovative contextualised learning content that is up to date but, they too, in this particular educational model, are obliged to be continuously innovative and be up to date.

4.3 Innovative use of technology

Pedagogic innovation, especially in the area of digital technology, is a key criterion for adult education organisations to build strategic value (Clifft et al., 2022), and it is unsurprising that the adult education providers we studied leverage technology in innovative ways. Particularly noteworthy is that these providers do not rely on the latest high-tech educational software. Instead, they employ relatively simple, accessible, reliable, and cost-effective technology in original and inventive ways.

Tech Tree's digital platform, for instance, utilises low-tech chatbots integrated into social media-style learning platforms. These are supported by storyboards and interactions crafted in collaboration with artists and humanities graduates. This low-tech, social media-inspired design ensures that the learning technology can be easily accessed on most smartphones and by a wide range of users (Watermeyer et al., 2023). NTUC LHUB's playbook incorporates user-friendly technologies bundled with expert learning content, aiding learners in digitising operations, workflows, and collaboration. NTUC LHUB prefers well-established and easily customisable technologies. To ensure accessibility across income brackets, they offer affordable or sponsored software licenses for their technological learning content. While COVID-19 presented many challenges for adult education (Shostya, 2022; Boeren et al., 2020; Lauder, 2020), ROHEI seized the opportunity to experiment with transitioning their learning carnivals into online formats. This involved the development of digital edutainment and gamification strategies, including digital board games, online escape rooms, and the integration of AI into their learning content. To overcome the challenge of creating and maintaining an active online learning encounter (Smith and Anderson, 2022), they incorporated physical items like drinks, snacks, and props.

In essence, the three TAE providers presented here excel in harnessing accessible and adaptable tech tools and services. Their innovation does not hinge on sophisticated hardware or software development. Instead, their pedagogy-led use of technology is based on an imaginative application of resources in designing, curating, delivering, monitoring, evaluating, and adjusting educational experiences.

4.4 Learner-centric products and services

None of the TAE providers presented here engages in traditional, episodic, off-the-shelf, synchronised, lecture-like learning. NTUC LHUB's playbooks, regularly updated, serve as a repository of 'best-case' illustrations, showcasing approaches and technologies with a proven track record. Instead of a stepwise, cumulative approach along a predefined curriculum, they synthesise learning, ensuring that individuals focus only on what's relevant within their specific context. What sets them apart is their adaptability not just to changing contexts but also to learners' evolving interests, expertise, and employment context. ROHEI's edutainment approach is rooted in the belief that people learn most effectively when multiple senses are engaged, and when learning is embedded within an enjoyable, social experience. Far from traditional learning formats, the carnival approach, while designed to meet clients' needs, is informal, entertaining, and communal. Tech Tree's tree of knowledge is structured around nano learning loops, segmenting learning content into small modules that interconnect thematically within a learning content taxonomy. This approach enables self-guided, flexible learning that can be tailored to the needs, interests, or daily lives of individual learners. These personal learning

environments are not just about independent learning but also about embedding learning within a social media context that is compatible with daily routines, family, friends, information seeking, leisure activities, and enjoyment (Chiang and Greene, 2021).

5 Discussion and conclusions

Driven by global connectivity and disruptive technologies, education, work, and their interdependences are rapidly evolving, thus necessitating innovative approaches to adult education and skills development. The collaboration between key stakeholders, specifically industry, educators, and policymakers, is essential in shaping ecosystems that support innovative education solutions. Singapore has undergone a profound transformation in its adult education landscape, providing valuable insights into the future of education. In this context, we have explored the success of three innovative TAE providers – Tech Tree, ROHEI, and NTUC LHUB – as they depart from traditional paradigms to meet the evolving needs of learners, industries, and society. These providers serve as case studies to map the seven shifts in Education 4.0 as identified by Fisk (2017a) and to examine their practical implication.

These innovative TAE providers reject traditional grading systems in favour of industry-specific recognition and continuous feedback mechanisms, and they foster a skills-driven workforce, thus paving the way for a transition from traditional delivery and assessment to reputation-based metrics. Their utilisation of continuous feedback mechanisms, adaptable technologies, and segmentation of learning content into small thematic modules offers learners a personalised educational journey based on specific needs, contexts, and interests. Additionally, these providers emphasise collaborative learning spaces, highlighting co- creation and real-world application of knowledge, effectively transitioning from traditional lecture halls to hybrid and virtual learning environments.

While not all seven shifts are present in every case, they serve as an illustration of strategic adaptation that may make learning more dynamic, inclusive, equitable, relevant, collaborative, engaging, and enjoyable. We do not advocate that all educational innovation should encompass all of these shifts. But institutions seeking to innovate can learn from how these TAE providers have strategically implemented some of them to ensure their relevance in a rapidly changing education-work-education ecosystem.

While most countries and their educational institutions are preoccupied with identifying knowledge, skills, markets, and value that will shape the world of tomorrow and how their educational system needs to adapt (OECD, 2019), Singapore has developed a well-regarded and well-funded education sector that is co-evolving with national and economic priorities. It is supported by a strong, forward-facing, and science-informed policy platform that is closely aligned with industry and business needs. In this context, TAE providers co-design learning content in an ecosystem that leverages strategic partnerships, including the unique and personalised contexts of learners. While their unique contribution to innovation originates from different sources, their success emanates from the same trend: embracing cultural and national uniqueness while concurrently capitalising on socio-technological developments associated with Industry 4.0.

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