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INTERNATIONALISING VOCATIONAL EXCELLENCE

Building evidence to support vocational excellence for the digital and green transitions

The Role of Centres of Vocational Excellence in the Digital Transition

Funded by the European Union

PREFACE

The study "The role of Centres of Vocational Excellence in the Digital Transition" has been funded by the European Union and produced by the European Training Foundation (ETF).

This report presents four case studies of Centres of Vocational Excellence and their approaches to digital transition. The case studies were carried out in China, Finland, France and Singapore.

The study project was coordinated by Stefan Thomas (ETF). The research design was led by Andreas Bjerre Lunkeit (DTI), Martin Eggert Hansen (DTI) and Stefan Thomas (ETF). The research was undertaken in the period from October 2022 to August 2023 by a team of researchers working at the Danish Technological Institute (DTI) with support from Dana Redford (PEEP). The report was written by Andreas Bjerre Lunkeit, Martin Eggert Hansen, Nikolaj Birkkjær Andersen (all DTI) and Dana Redford (PEEP). Technical input and ongoing support were provided by Julian Stanley, Fabio Nascimbeni and Stefan Thomas (all ETF).

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INTRODUCTION

The digital transition pervades all areas of the economy and society. For decades, Europe's societies and economies have been experiencing a radical digital transformation, fostered by 'digitalisation' and the acceleration of many types of interactions through an increasing number of connected devices and data flows.

What does the digital transition mean for vocational education and training (VET)? How can the journey be managed with excellence? This report presents examples from the United States, Europe and Asia of how Centres of Vocational Excellence (CoVEs) manage the digital transition and of the lessons they have learned to date. Each case study shows that the digital transition requires a 'whole-institution' approach, including the development of an implementation strategy, digitalisation of curriculum content and the learning environment, the development of teacher skills, and collaboration with industry, research institutions and many external stakeholders.

The report focuses on the following four CoVEs, which have been shown to be leading examples of handling the digital transition:

The Shenzhen Polytechnic in China — a public higher technical vocational education (TVET) institution that offers higher vocational education diplomas equivalent to EQF levels 4 and 5. The Shenzhen Polytechnic has been a pioneer among Chinese TVET institutions in formulating action plans for both digital transformation and artificial intelligence and has developed numerous digital learning resources.

The Campus d'excellence Industrie du Futur-Sud (**CEIFS**) in France — an association consisting of a network of general secondary, technological, vocational, and higher education institutions, as well as training organisations, research laboratories and public authorities. The CEIFS prepares young people for jobs at the forefront of industries that are part of the digital transition, such as operating automated equipment, industrial maintenance and robotics.

The Helsinki Business College (**HBC**) in Finland — a private training organisation owned by the Helsinki Chamber of Commerce and the Finnish Business College Foundation. The HBC is a leading school when it comes to digital learning in VET and may be a source of inspiration for other VET providers.

The Temasek Polytechnic (**TP**), Singapore — an educational institution that offers diploma courses equivalent to EQF level 5 across six schools. TP's School of Engineering and its two Centres were selected for this case study because they are significant examples of the use of digital tools to support learning in an integrated way.

Seen as a whole, the cases present very different VET systems and show that VET institutions can adopt a great diversity of approaches to the digital transition. The report sets out examples that may inspire VET institutions and policymakers worldwide.

This report is part of the project 'Building Evidence to Support Vocational Excellence for the Digital and Green Transitions', implemented by the European Training Foundation (ETF). The study was conducted between May 2022 and December 2022/January 2023 by the Danish Technological Institute (DTI).

In terms of structure, the report contains the following main sections:

'Conceptual clarification' introduces key concepts and themes to the reader, e.g. 'What do we understand by Centres of Vocational Excellence?' 'What is the 'twin transition' – the green and digital transition?' 'How do we understand the digital transition of society and the economy?' 'How do we define digital skills?' 'How do we understand the whole-institutional approach?'

- 'Methodology' describes how the cases were selected and how data collection and site visits were planned and conducted in collaboration with each institution.
- 'Key Findings' presents transversal conclusions based on the four cases.
- 'Cases I-IV' presents each of the individual cases.
- 'Appendix' contains a glossary of the abbreviations and terms used in the report.

CONCEPTUAL CLARIFICATIONS

The Centres of Vocational Excellence (CoVEs) are VET Providers, groups of VET Providers or organisations that coordinate VET Providers, which collaborate with economic, educational, social, and political partners and help create local 'skills ecosystems' aiming to provide high quality VET skills, contributing to regional development planning and growth. Their excellence can be described in terms of the extended scope of their activities, the high quality of their performance, and their capacity to respond and develop to meet the needs of their stakeholders. Usually, they play a leadership role in the VET system, acting as a model,

coordinator or pathfinder for other VET Providers. The above definition of CoVEs is based on the EU Commission's description of *Centres of Vocational Excellence'. [1]

- The mapping study 'Mapping Centres of Vocational Excellence' [2] has identified the following key factors in the success of CoVEs:Learner-centred approach: The concept of vocational excellence involves a holistic learner-centred approach. CoVEs encourage experiential, inquiry-based, experimental, and playful learning in the classroom by allowing students to bring their own knowledge, experiences, and ideas into the process of acquiring new information and developing new insights.
- Strong and collaborative relationships with stakeholders: CoVEs have developed networks and collaborative relationships with industry associations, higher education and research institutions, employers, development agencies, and other public authorities that share a common interest in specific sectors or industrial ecosystems.
- Close link to regional development, innovation, and smart specialisation strategies: CoVEs systematically anticipate regional priorities and sectoral skills needs, in addition to national priorities. By working closely with companies on applied research projects, creating knowledge and innovation hubs, and supporting entrepreneurial initiatives of their learners, CoVEs stimulate local business development.
- Responsive to technological development and skills demand: CoVEs have developed agile and flexible organisations that are responsive to evolving technological developments and new skills demands. Curriculum development and skills provision continuously involve industry associations, research institutions, and other external stakeholders. CoVEs enable their learners to acquire both vocational and key competences through education that builds innovative partnerships with the world of work.
- International collaborative networks: CoVEs have developed international collaborative networks with other CoVEs in different countries. The European Training Foundation (ETF) has established the ETF Network for Excellence (ENE) to develop an International Network of CoVEs. The ENE brings together hundreds of organisations and CoVEs from the regions neighbouring the EU, Central Asia, Africa, and the EU.

Becoming a CoVE is essentially a maturing process. Therefore, based on the mapping study, a three-stage maturity model has been developed. In the first stage, the CoVE starts to improve what VET normally does, with close links to the labour market. For example, curricula and programmes are closely aligned with the needs of the labour market. At the second stage, the CoVE improves strategic development by playing a more active role in skills anticipation mechanisms to ensure a close match between VET and labour market needs. At the third, mature stage, the CoVE achieves excellence by co-creating local skills ecosystems, local innovation, and fostering regional development.

What does 'twin transition', a concept that bundles the green transition and the digital transition, mean? Society and the economy are undergoing two simultaneous transitions – the green transition and the digital transition. These refer to the coinciding development of a shift in production and consumption patterns that use natural resources more sustainably, while also adopting digital technologies to enhance energy and production efficiency and reduce waste. This transition reflects both the increasing awareness of the impact of human activities on the environment and the enhancement of renewable energy sources and digital technologies. The twin transition may enable a more sustainable and efficient future, where economic growth goes hand in hand with environmental protection.

The cases presented in this report focus on the digital transition.

What do we mean by digital transition? The digital transition (or transformation) refers to the overall development of society and the economy as they become increasingly digitalised.[1] [2] The EU's digital strategy, 'Europe fit for the Digital Age, aims to make this transformation work for people and businesses, while helping to achieve its target of a climate-neutral Europe by 2050. Digital transformation covers both the integration of digital technologies by enterprises and other organisations and the impact of new technologies on society, such as the Internet of Things (IoT), cloud computing, innovative digital platforms, and blockchain technologies. Digitalisation is becoming an increasingly important condition for modern economies to thrive and has the potential to affect many sectors of the economy (including transport, energy, agri-food, telecommunications, financial services, factory production, and health care) and to transform people's lives. Successful digital technologies are also critical in meeting the sustainable development goals (SDGs) and the climate agenda of reducing CO_2 emissions. Teaching and learning need to address the changes and challenges by introducing digital tools in the provision of education.

According to the Organisation for Economic Co-operation and Development (OECD), this transformation is accelerated by the greater computing power of consumer devices, which are available at ever more affordable prices. Artificial intelligence (AI) and advanced robotics are also viewed as an important manifestation of the digital transformation, with a profound society-wide impact, including on productivity, employment, business models, and public services – a development that requires coherent public policies.

The impact of the digital transition on job content and skills needs. An estimated 90% of all jobs require at least a minimum level of digital skills, and the demand for digital specialists is growing. However, there is a lack of a digitally literate workers. However, 42% of European citizens do not have basic digital skills. 37% of people in the labour force also lack sufficient digital skills, despite the increasing need for such skills in all jobs[3] In addition,

1 'Digital transformation', European Parliament, 2019. https://www.europarl.europa.eu/RegData/etudes/BRIE/2019/633171/EPRS_BRI(2019)633171_EN.pdf

2 'Europe fit for the Digital Age': https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age_en

3 European Commission: Digital skills and job coalition. https://digital-strategy.ec.europa.eu/en/policies/digital-skills-coalition

almost half of EU companies are not yet implementing strategies to re-skill their workforce. However, if managed coherently, the digital transition has great potential to boost productivity and create new jobs. In addition, new markets, such as the apps economy, artificial intelligence, and data analytics create new work opportunities. Many more jobs could be created if the workforce had more digital skills. It is estimated that there are more than 350 000 vacancies in Europe for highly skilled technical experts in areas such as artificial intelligence, data analytics and cybersecurity.

How to define digital skills? Digital skills are broadly defined by UNESCO as the ability to use digital devices, communication applications, and networks to access and manage information. Digital skills are used to create and share content, communicate, and collaborate globally and instantaneously. However, in the workplace, the level of digital skills ranges from entry-level user tasks to advanced and highly specialised abilities. For example, basic digital skills are emailing, word processing, and data entry, while advanced digital skills are coding, programming, and web and app development.

The EU has developed the DigComp Framework[4], which defines five areas of digital competences, including 1) information and data literacy, 2) communication and collaboration, 3) digital content creation, 4) safety, and 5) problem-solving. In the DigComp Framework, digital skills are not only technical competences but also personal abilities and attitudes. For example, communication and collaboration (2) involve the following: '[to] interact, communicate and collaborate through digital technologies while being aware of cultural and generational diversity'. Similarly, safety (4) requires 'being aware of digital technologies for social well-being and social inclusion.' Based on the five competence areas, the DigComp Conceptual reference model includes 21 competences. It is a generic framework, with a focus on the typology of digital skills but not the skill level. For example, problem solving may range from 'troubleshooting to solving more complex problems.'

What do we understand of the whole-institution approach to the digital transition? As mentioned above, the digital transition is a challenge for VET, which requires a whole-institution approach. An institution-wide approach to the digital transition is organised in a process involving all stakeholders – management of the institution, teachers, learners, and the administration – jointly developing a vision and plan for the implementation of the digital transition in the whole institution. The key elements in this process are as follows:

Digitalisation of learning environment and curricula. The digital transition requires a reorientation and digitalisation of the learning environment and learning content. A key element is the implementation of digital tools and platforms that support learner-centred learning and enable teachers as well as learners to collaborate in groups online. Another key element is the digitalisation of learning content in subjects (software applications), where this is relevant to the work world. If software applications are widely used in the industry, then they will be integrated into the learning content. This is key to the learner's development of digital skills that are updated and relevant to the industry.

Digitalisation of management of the institution. The whole-institution approach suggests that the incorporation of digitalisation into educational provision does not only relate to the curriculum, but also takes place through integrated management and governance of the institution, engagement of community and stakeholders, long-term planning, monitoring, and evaluation.

Teacher training. Teachers play a critical role as they are responsible for delivering education to students. The whole-institution approach emphasizes the importance of the professional development and training of teachers to ensure they have the necessary digital skills and knowledge to develop the students' digital skills. Cases in this report show that CoVEs organise the systematic update of teachers' skills and that internships in the industry are important for teachers' understanding of how digital content and technologies are related to their specifc subject area.

Involving external stakeholders in the update of digital content in curricula. The whole-institution approach emphasises the importance of partnerships between VET providers and a wide range of stakeholders to support the digital transition, including government institutions, research institutions, and, not least, the industry sector. The cases show the CoVEs involve industry partners deeply in curricula development where they influence syllabus lists and identification of skill needs and formulation of learning outcomes. Industry partners provide company placements for teachers and work-based learning, in the form of apprenticeships, for students. The involvement in learning content and curricula is regular, formalised, and detailed, which is beneficial to both the CoVE and the industry partners.

The whole-institution approach instructs education institutions on how to organise the digital transition. In the cases presented in this study, we have used the whole-institution approach as a framework to analyse how the digital transition involves the whole institution and its external stakeholders.

This will be explained in the next section, which deals with methodology.

METHODOLOGY

The cases presented in this report are built on a qualitative research design, where most of the data has been gathered through group interviews conducted during visits to the respective organisation.

The study of the Centres of Vocational Excellence (CoVEs) and the digital transition has been conducted in the following main steps:

1. Identifying and selecting CoVEs
2. Preparing and implementing three-day visits and conducting interviews at each institution
3. Developing the case studies (about 30 pages each)
4. Conducting a transversal analysis and reporting on the case studies.

4 EU Science Hub: DigComp Framework: https://joint-research-centre.ec.europa.eu/digcomp/digcomp-framework_en

Identifying and selecting CoVEs

- The CoVEs were selected for the study based on multiple sources such as mapping studies/platforms, ongoing projects, and contact networks of the Danish Technological Institute (DTI) and the European Training Foundation (ETF). Some of the web sites used were: 'Mapping of Centres of Vocational Excellence (CoVEs)', ET 2020 Working Group on VET. (2019). Link
- 'Community of Practice Centres of Vocational Excellence', CopCoves 2021. In this community project leaders of Erasmus Centres share experiences implementing the Centres of Vocational Excellence. Link
- The CVETNET. A European project co-funded by the Erasmus+ Programme, which aims at building the capacity of CVET provider's networks and its members to support SME's adaption to digital transformation. Link

Based on the initial mapping, a varied sample of CoVEs was selected that best represented different continents and countries.

Preparing and implementing three-day visits and conducting interviews at each institution

To ensure informed missions and interviews, the DTI collected as much case documentation as possible from each CoVE before the three-day visit mission, namely website information on the content of learning programmes, statistics, and financial information. Each CoVE appointed a 'liaison officer' to handle correspondence with the DTI. The interviews during the visit were arranged in advance by letting the CoVE plan the time and location of the interviews and fill in a timetable for the DTI.

All CoVEs, except the one in China, which was interviewed online, were visited by one DTI consultant. Each mission had a duration of three days. During the mission, interviews and focus groups were conducted with the management of the CoVE, teachers and trainers, students, external partners, and other relevant stakeholders.

The digital transition is a comprehensive process involving the whole institution and its external partners. The purpose of the case studies is to analyse how the VET institution manages the digital transition, what strategies are used, how the process is organised, and how the management, teachers, learners are involved, as well as collaboration with external stakeholders. The four groups interviewed were representatives from management, teaching staff, students, and external stakeholders. All interviews were semi-structured, meaning they followed a loose interview guide with room for digressions. These are some of the main research questions:

Management

- How does the management 'translate' the digital transition of the economy and society into new skills and programmes?
- Are national strategies/policy initiatives used by the CoVE as a guiding reference for their own digital transition?
- What is the CoVE's understanding of the digital transition?
- Which resources (financial, staff, competences/know how, equipment, etc.) are allocated to the digital transition?

Digital learning content and programmes for digital professions

- How is the digital transition of the economy and society reflected in digital learning content and programmes for digital professions?
- How does the management 'translate' the digital transition of the economy and society into new skills and programmes?

External stakeholders and partnerships

- How does collaboration with external partners contribute to the digital transition of the CoVE?
- Which external partners are involved in the digital transition of the CoVE?
- What are the strategies for cooperation and collaboration with external partners?

Pedagogical approach

- What pedagogical approach is used to support the development of learners' digital knowledge and skills?
- How are learners involved in the digital transition of the CoVE and other stakeholders?
- Which tools are used to create a digital learning environment?
- How are teachers and trainers involved in the digital transition of the CoVE and other stakeholders, and what is their role in relation to learners?
- How are teachers' skills and competences updated to support the digital transition of the CoVE?

DEVELOPING CASE STUDIES

Based on interview data, the case studies were drafted by the DTI. Interview data was supplemented by data from the consultants' desk research and data provided by the case organisation, such as strategic documents. Case reports also drew from other relevant reports on the subjects, such as government papers and Cedefop reports on VET.

CONDUCTING A TRANSVERSAL ANALYSIS AND REPORTING ON THE CASE STUDIES

Based on the case studies, a transversal analysis was conducted identifying common patterns and differences across the cases. The following summary presents the main results of the transversal analysis.

KEY FINDINGS

The four CoVEs represent different countries, VET systems, and fields of educational. Each CoVE has its own contextual background and has chosen its own path of digital transition corresponding to the skills demand of the economy and industry. However, four cases are not sufficient to infer general conclusions. Instead, the four cases should be regarded as inspiring examples on how CoVEs have managed the digital transition and what experiences they have drawn from this experience.

The four case studies represent a very rich pool of practices, tools, and strategies from which we could draw an infinite number of findings and examples across the cases. Therefore, the main results are summarised below, grouped under the main themes of the study. The results are presented in italic, followed by case examples that substantiate the results.

MANAGEMENT

The four cases represent very diverse political systems. However, looking across the cases we can discern that the way CoVEs manage digital transition at institutional level depends on the way the government manages the VET system, the financial resources allocated to it, and engagement of the private sector and other external stakeholders. A persistent national political focus on digitalisation of the economy and the education system is an important precondition for the digital transition, and national strategies for digitalisation of society and the economy help shape the digital skills needs to be addressed by VET institutions. The digital transition requires that the VET system has a responsive organisation involving the private sector in curricula development to keep up with rapidly evolving digital technologies. Flexibility of the provision of education is also enhanced by the modular design of programmes.

In some countries, reforms have been launched to make the VET system more responsive and adaptive to the skills needs of the labour market and ensure that it reflects regional priorities. A VET institution can develop collaboration with the industry so that it becomes an active part of an eco-skills system, including educational institutions, industry partners, trade associations, public authorities, and other stakeholders.

In China, the Shenzhen Polytechnic considers political support to be of great importance for the successful digital development of the school. The focus on digitalisation from the national and provincial governments and the allocation of resources from governmental actors has been important in the process of ensuring a successful digital transition. For instance, Shenzhen Polytechnic has received substantial financial support from the Shenzhen municipal government to support the digitalisation of the school. The Municipal government has supported the implementation of the 5G smart campus infrastructure and, furthermore, they provide a stable subsidy to Shenzhen Polytechnic.

In recent reforms, the Chinese government has increased the involvement of private enterprises in the VET system in order to provide students with more practical experience (UNESCO-UNEVOC, 2018). This means that different stakeholders, including private enterprises, are encouraged to share the costs and benefits of VET programmes. Furthermore, the national government has recently strengthened its focus on the adaption of VET to the demands of the fourth industrial revolution to keep track of the widespread impacts of digitalisation.

The engagement of the private sector is a key aspect of the Chinese political strategy to enhance and develop the vocational education system.

In France, the governance of VET is a tripartite system, in which government, employers, and employees are represented, while responsibility is split between the national government and the regions. The national government sets the overall framework for VET through laws and regulations, while the regions are primarily responsible for implementing and managing VET programmes. An important characteristic is that the VET system and the provision of education programmes is modular so as to be flexible and capable of adapting to the changing needs of the labour market. The modular design of VET courses allows students to progress at their own pace and build their skills over time. There is also a wide range of options for students, including both traditional apprenticeship programmes and classroom-based training on the type of machines that large industry and small entrepreneurs use every day in traditional and advanced manufacturing and technical fields.

In Singapore, the digitalisation of Temasek Polytechnic and its programmes comprises a combination of governmental strategies and the training provider's collaboration with industry partners. The main national political initiative related to digitalisation of Singapore is 'Smart Nation', a strategy launched by the government in 2014. Smart Nation is a comprehensive strategy with the overall aim of transforming Singaporean society to the next phase of nation building. The overall goal is to embrace digitalisation and the benefits it brings. This transformation

relates to several key domains – health, transport, urban solutions, finance, and education. The management of TP describes that the Smart Nation Strategy is used by TP to decide on digital technology content in education programmes, across various fields:

- Smart Mobility: This subject focuses on creating a more seamless transport experience through new travel options and greater access to real-time transport information.
- Smart Living: Improving daily living in our homes through smart devices.
- Smart Health and Wellness: Delivering better healthcare services and wellness applications for seniors and citizens through effective use of information technology.
- Digital Services: Improved government operations and service delivery through technology.

Similarly, the pedagogical approach and the use of digital tools in the learning environment comprises a combination of the governmental EdTech Plan and the Learning Academy at institutional level. The Ministry of Education mainly influences the 'Pedagogical approach and the use of digital tools in learning' while the Skills Future Agency and Industry Transformation Maps (ITM) mainly influence the 'Digitalisation of digital content'.

In Finland, at **Helsinki Business College** (**HBC**)**,** the development of digital skills is guided by national guidelines on the learning outcomes of courses and training programmes. These guidelines still leave HBC with room for manoeuvre to do things their own way. As such, HBC management consider themselves autonomous regarding the learning management systems used by the school, the digital learning content of courses and training programmes, the digital tools used and taught, and digital pedagogy in general. 'Wilma' is a nationally mandatory online program, which handles formal aspects of student information. Besides this, VET providers are free to use the software they prefer. Because of HBC's positive experience with the digital transition — and because HBC is the largest VET provider of ICT qualifications in Finland — the school is currently the coordinator for national requirements in VET ICT programmes. This means HBC staff help formulate the national guidelines for IT VET in Finland. In this way, the HBC can test new digital tools and approaches to digital pedagogy, which may subsequently be implemented nationally.

The CoVEs have established demand-oriented funding systems and allocation of resources that allow for flexibility and private financing. The systems also allow for project-based funding, where collaboration and projects/programmes developed jointly with the private sector are financed depending on need. Such flexible funding systems are beneficial to the digital transition because they mobilise digital know-how in collaborative projects involving educational institutions, training organisations, regional authorities and industry partners. In other words, they create a 'skills-eco system'.

In France, the CEIFS has a project-based allocation of resources. This means that the CEIFS does not have permanent staff. Human resources come directly through project budgets and through the secondment of an Executive Director from the Ministry of Education. At the end of 2022 there were 3.5 full-time equivalents (FTEs) which also include resources from participating companies. This light structure makes the CEIFS better able to react and adapt to the changing needs of its stakeholders and ensures there is no duplication of resources that might be available from the partner organisations with which they work.

The CEIFS identifies potential industrial partners to cooperate with and brings together its members to run projects that generate skilled graduates who can meet their current skills needs. Employers and skills providers collaborate closely to meet the needs created by technological and economic change. Companies are not formally required to pay for their involvement although often they contribute with resources to projects. The companies that work with the CoVE are eligible for a tax refund related to their spending and contribution to workforce training, and member companies such as Thales, Airbus, EDF, Dassault System, and ST Microelectronics have made use of these benefits. To receive the donation tax benefits, a company must apply to the regional government and define the actions that are going to be worked on with the project-based initiatives. Another benefit for participating in the CoVE is the visibility that the initiatives give, demonstrating how multinationals integrate into the regional education system, which can be viewed as a socially responsible corporate practice.

In **Singapore**, VET funding comes from three main sources: government financing, student fees, and the private sector. The Ministry of Education (MOE) provides development and recurrent funds to all educational institutions including TVET institutions like the Institute of Technical Education and the five Polytechnics. The total amount of development funds fluctuates according to the yearly needs of the respective institutions.

In addition to government funding, contributions are also made by the private sector. To this end, the Temasek Polytechnic General Education Fund[5] was established in 2003, to provide scholarships, bursaries and other assistance to students. The Fund supports students' education-related projects/activities and student and staff exchanges with industry and other institutions. In addition, the fund provides seed funding to set up centres of excellence in strategic areas of teaching and research, and to bring renowned experts, lecturers, and speakers to TP.

In **China**, the recent reforms have made the financing of the VET system more flexible and demand-driven. New regulations have been introduced that encourage the sharing of financial costs (and benefits) with the private sector. The Chinese government has implemented various policy initiatives to incentivise the financial involvement of private actors in VET. These initiatives include tax incentives for enterprises that invest in vocational training. In addition, the national government has recently increased its focus on adapting VET to the demands of the Fourth Industrial Revolution in order to keep pace with the far-reaching impacts of digitalisation.

In **Finland,** VET is mainly publicly funded. Private funding only accounts

5 For more information, see TP's 2018/2019 report on the fund.

for 2.6% of all education expenditure. Public funding is mainly provided by the central government (30%) and local authorities (municipalities) (70%). Recent reforms are now introducing a more performance-based funding system, where the funding depends on the VET institution's results, effectiveness, and strategy.

At institutional level, the CoVEs have established strategies for the digital transition. The strategies set objectives for the integration of digital content into programmes in collaboration with external stakeholders and research to ensure industry relevance. These objectives 'translate' the digitalisation of the economy into educational programmes that address the digital skills needs. In addition, the strategies set out plans for aligning faculty, students, and administrative staff with the digital transition of the institution. Among the CoVEs it is emphasised that the digital strategy needs to be holistic, e.g. in that it involves the whole institution and requires continuous focus and an open mindset of teachers, leaders, and students.

In **China**, the **Shenzhen Polytechnic** has formulated two action plans, elaborated into regional and national strategies for digitalisation that specify the goals of the institution and how they are meant to be achieved: the 'Artificial Intelligence Action Plan' and 'Digital Transformation Action Plan'.

The Artificial Intelligence Action Plan describes how the institution will strategically develop programmes related to artificial intelligence (AI) and facilitate intelligent institutional governance and decision-making. The Digital Transformation Action Plan describes plans to promote the quality of talent and deepen the integration of industry and education. These action plans set out specific goals for the institution as a whole and blueprints for their achievement. The strategy recognises that the factors that drive the digital transition are solid and deep collaboration with leading information and communication technology (ICT) companies which, among other things, support the school in identifying relevant and current skills needs, but also provide cases and assignments based on challenges from the real world of work. The strategy and digital transition are influenced and supported by both national and local governments.

Similarly, in **Singapore**, the **Temasek Polytechnic** (**TP**) has developed a strategy with two main components:

The TP addresses the digital transformation of the economy/society in partnership with the industry to develop industry-relevant digital skills. The digitalisation of programme content and the integration of digital technologies in the curriculum is a continuous process carried out by the institutional management in close collaboration with the industry.

TP's pedagogical approach focuses on applying digital tools that support practice-based skills acquired in self-directed, collaborative learning. This approach emphasises a digital learning environment applying pedagogy, tools and structures which help students develop intrinsic motivation and take ownership of their learning. A key digital tool in this regard is the learning management system (LMS), which is used as a platform for collaborative learning and the sharing of learning materials between lecturers and students.

Therefore, the strategy deals with how to translate the digital transition of the economy into programmes that address the digital skills needs and the digitalisation of the learning environment in order to support self-directed learning. Management describes the Temasek Polytechnic as addressing the digital transformation of the economy and society through a combination of curriculum development, industry partnerships and research initiatives.

In **Finland**, the **Helsinki Business College** (**HBC**) has established 'an onion model', visualising the digital software programs grouped into types and purpose. The IT department has designed the model and presented it before the managing board.

The innermost circle of the onion model contains the 'common programmes', which are used by everyone, both students and staff at HBC. These are the basic working tools (e.g., from Microsoft Office) as well as HBC's learning management systems, and national systems. Everyone must have basic skills in using these programs, and the HR department organises training in their use.

The middle circle contains 'programs used for particular tasks,'. Staff can be trained to use these programmes. For some of the programmes technical support is provided by the school's IT department and user support is provided by the school's designated main user — a staff member who is given special responsibility and allocated time for a specific digital tool. For other programmes, technical support is the responsibility of the user him/herself, and there is no main user support on campus.

The outermost circle contains the 'followed programmes and phenomena'. These are interesting software and trends, which can move closer to the core of the onion in the future. Everyone follows the new software, trends, and phenomena to the extent required by their work tasks and needs. Testing of software is agreed on with the school's IT department, but there is no technical main user support. Training in a specific program is agreed on with the supervisor of a given staff member.

HBC's main strategy, including the strategies for digitalisation processes, is updated annually. Looking towards the next 5 years of digitalisation, the HBC expects hybrid and online teaching to gain greater significance. Further, demand for other services related to VET providers, such as employment services, are growing and require cloud-based solutions. On this background, the HBC expects smart AI characteristics to increasingly become part of the digital processes.

A robust digital infrastructure with high-capacity data communication is important to keep enabling advanced digital learning spaces. The case of China, which is advanced as regards the 5G network, may provide inspiration.

The **Shenzhen Polytechnic** has developed a 5G smart campus infrastructure, which enables students' use of digital and online learning. 5G networks have lower latency, higher capacity, and increased bandwidth compared to 4G. The digital focus of the school stands on the shoulders

of the national political focus on digitalisation of the Chinese society. The 5G infrastructure is also seen as an important part of being a digital institution and supporting the use of digital tools and digital learning, and it ensures that online learning can be applied all over the institution.

At CoVEs teacher upskilling is an important part of the digital transition. It must be systematic and involve all teachers on a continuous basis. CoVEs emphasise that it is important to change the mindset of teachers in order to convince them to change and adapt their teaching methods. Furthermore, the private sector must be involved in the training of teachers, by providing industry placements. Furthermore, teachers are encouraged to embrace peer learning and sharing their digital knowledge from company placements with other teachers and students.

In China, the **Shenzhen Polytechnic** has set up a framework to ensure the coordination of the professional development of teachers. Each school/faculty has a pedagogical coordinator who is responsible for arranging weekly workshops and regular training of teachers. It may be necessary to change the mindsets of teachers who are used to teaching in a certain way. The same holds true for students who come from high schools without digital tools and online learning. On this basis, teachers from the school develop teaching materials that are suited to address existing digital skills needs. And the teacher's digital competencies are constantly evaluated and improved. Central for the effort to increase the digital skills of teachers are also the industry partners of the institution. Often, teacher training takes place at the enterprises. The teachers at the Shenzhen Polytechnic frequently visit the industry partners to receive lessons on the latest software etc., as it is decisive for the quality of the education that teachers are up to date on the latest developments in the sector. For instance, every year the teachers from the AI school and the ICT school of the Shenzhen Polytechnic visit Huawei to get acquainted with the certificate courses of the enterprise, so the school can provide the students with certifications.

Similarly in **Singapore**, the **Temasek Polytechnic** finds that the digitalisation of programme content and the learning environment makes it very important that teachers are equipped with up-to-date digital skills and knowledge about their subject. Teachers are entitled to 100 hours of professional development per year and their continuing professional development is funded by the educational institution (Temasek Polytechnic – at school level) based on its governmental funding and grants which are allocated on a yearly basis. Furthermore, the teachers at Temasek Polytechnic who want to have an internship at a company outside the school, can, with the school principal's endorsement, apply for funding from the Teacher Work Attachment Programme. In addition, the school management encourages lecturers' participation in local/international competition as competency benchmarking against other institutions of higher learning.

In **Finland**, the **Helsinki Business College** (**HBC**) believes that the key to the institution's continued digital transformation is to keep teachers interested in new digital solutions and eager to develop their own skills. Due to the high demand for ICT experts in Finland, it is not easy to hire skilled teachers in ICT subjects, as the school cannot match the higher salaries offered by private businesses. Instead of hiring new digital skills, it is thus important to continuously develop the digital skills of existing staff. Knowledge-sharing in teams is encouraged. Teachers are organised into six teacher teams, and within these, teachers help each other develop pedagogical solutions, including digital solutions. Because teachers face similar challenges, peer learning is an important part of strengthening the digital pedagogy.

EXTERNAL STAKEHOLDERS

The case studies show that CoVEs consider it important to involve the private sector in the digital transition, which is done in multiple ways: Industry partners can contribute with expertise and digital technical equipment to be used in education. The CoVEs involve industry partners deeply into curricula development where they influence syllabus lists and the identification of skills needs and formulation of learning outcomes. Industry partners provide company placements for teachers and work-based learning for students, in the form of apprenticeships. The involvement in learning content and curricula is regular, formalised, and detailed, which is beneficial to both the CoVE and industry partners.

In **China**, the **Shenzhen Polytechnic** and its industry partners believe that their collaboration is fostered by advantageous political conditions. The collaboration between providers of vocational education and the industry is a priority for the Chinese government, which by offering tax reductions to private actors encourages both sides to pursue partnerships. This has prompted the Shenzhen Polytechnic to establish collaborations with industry-leading enterprises from the ICT sector. Amongst others, the school has close relations with Huawei and Tencent.

The Shenzhen Polytechnic holds frequent meetings with its industry partners. For instance, meetings between the Shenzhen Polytechnic and Tencent take place on a weekly basis (either online or face-to-face). This happens at both management and teacher level. The weekly meetings involve responsible personnel from the enterprises to discuss the implementation of different initiatives as well as the development of curricula.

In **France**, the **CEIFS** works closely with multinationals and SMEs and delivers programmes through its educational partners. The CoVE aims to support the diffusion of innovative teaching methods and educational content and promotes operational efficiency by using modern digital tools, equipment and infrastructure and integrating the various educational and training offerings in the Sud region. This is achieved through collaborative projects build within a network of regional entities such as educational institutions, training organisations, regional authorities, and industry partners.

In **Singapore**, at the **Temasek Polytechnic**, the formulation of skills/competences for a programme, takes place in close collaboration with industry partners in a technical committee specifically set up for a given subject field. For example, the development of relevant skills for the programme, integrated facility management, takes place in a technical committee with

representatives of the external industry partner Singapore International Facility Management Association (SIFMA). As an industry partner, SIFMA has contact with a broad variety of certified companies which ensures that the programme can be based on deep and updated insights into these companies' use of technologies and their needs. During the meetings the syllabus becomes gradually more detailed and is circulated for comments by trade associations and certified companies.

DIGITAL CONTENT IN CURRICULA AND PROGRAMMES

The four case studies represent a wide range of CoVEs that deliver genuine digital programmes, where digital skills are the key learning outcomes, as well as CoVEs that deliver non-digital programmes.

A key principle in the integration of digital content into programmes is the industry relevance of the digital tools and skills. The identification of digital programme content and curricula changes is done in partnership with industry partners and government authorities at national or regional/local level. In some cases, it may be government authorities that go forward analysing the skills needs across a set of sectors.

In **Singapore**, at the **Temasek Polytechnic** for example, the digital transformation of the economy and society is translated into digital content integrated into education programmes of innovative digital professions at the TP. The Singapore government's Smart Nation Plan, Singapore Green Plan 2030, and Industry Transformation Maps inform the key focus, priorities, strategies, and outcomes of TVET in Singapore. The process of developing new digital programmes at the TP uses an Industry Transformation Map (ITM) for each industry sector as an overall 'vision' or 'roadmap' which is used to elaborate relevant programmes. Hence, the interpretation of the digitalisation of the economy and society is based on governmental analyses, strategies and roadmaps which have been developed for 23 industries in partnerships between government, enterprises, industries, trade associations and chambers. For example, the ITM for Construction unfolds this strategic vision:

'An advanced and integrated sector with widespread adoption of leading technologies, led by progressive and collaborative firms well-poised to capture business opportunities, and supported by a skilled and competent workforce offering good jobs for Singaporeans. The ITM identifies Integrated Digital Delivery (IDD), Design for Manufacturing and Assembly (DfMA), as well as green building as key transformation areas to address the challenges faced by the sector.'

At the TP, this vision has been translated into the 3-year diploma course entitled 'Architectural Technology and Building Services Diploma Programme'. This course equips students with the necessary multi-disciplinary skill sets to design and manage smart and sustainable buildings for tomorrow's cityscape. Students will also get to experience how technology is used in sustainable architecture and systems design within today's digital economy. As mentioned above, the digitalisation of programme content and the integration of digital technologies in the curriculum is a continuous process conducted by the institutional management in close collaboration with the relevant industry. For example, subjects related to security and surveillance are developed in collaboration with the Singaporean security industry.

In **China**, the **Shenzhen Polytechnic** finds that a cornerstone in the preparation and development of the digital content at the Polytechnic is the collaboration with, and input from, industry partners (such as Huawei and Tencent). This ensures that the digital skills taught at the school are relevant and up-to-date in terms of skills demands within the ICT industry. Additionally, curricula are continually developing and are being constantly updated to capture and embrace emerging trends and developments within the ICT sector.

An example of the importance of digital content and educational programmes is the School of Artificial Intelligence at Shenzhen Polytechnic. The School of Artificial Intelligence was established in 2019 as a transformation of the former School of Computer Engineering. This school offers seven different programmes[6], namely: 1) Virtual Reality Application Technology 2) Cloud Computing Technology Application 3) Software Technology 4) Computer Application Technology 5) Big Data Technology 6) Artificial Intelligence Technology Application and 7) Blockchain Technology Application.

In the context of the digital transition, the labour market demands multidisciplinary skills sets that combine digital technical skills with transversal and behavioural skills. Some of the CoVEs are large enterprises that can accommodate such skills needs because they include partner educational institutions in different fields and disciplines that can be combined in multidisciplinary programmes. It takes a concerted effort to organise such multidisciplinary skills packages. A coordinated effort between educational institutions and industry partners is also required to organise company placements/apprenticeships that guarantee practical training for specific digital skills.

In **France**, the **CEIFS** offers multidisciplinary skills programmes by collaborating with its two educational partner organisations: *Arts et Métiers* (Aix-en-Provence campus) and the *UIMM Sud Training Centre*.

The combination of these two organisations enables the CEIFS to offer a wide range of training programmes with a wide range of qualification levels. These include the Btn (Technology baccalaureate), Bac Pro (Vocational baccalaureate), BTS (Higher technician certificate with a baccalaureate), and Professional Master programmes providing students with technical and industrial skills. For example, The Aix-en-Provence campus of Arts et Métiers has innovated with the creation of full programmes such as the Specialised Masters in Nuclear Engineering and Renewable Engineering as well as in courses on Frugal Innovation that emphasise social and environmental issues for Arts et Métiers engineering students, which

6 Shenzhen Polytechnic, School of Artificial Intelligence.

incorporate working with two local high schools.

Hence, the organisational structure enables flexibility and allows the institution to build connections between complementary partners. Furthermore, it is project-driven which means that it can be resilient in the face of changing workforce needs. This is of particular relevance to the digital transition due to the rapid pace of technology changes.

Similarly, in **Singapore**, the **Temasek Polytechnic**, as a large corporation with six schools, can offer multidisciplinary programmes which integrate digital technology and combine courses across several schools. The TP emphasises that it places increasing focus on multidisciplinary or interdisciplinary learning, which typically means that students develop projects in collaboration with students across different subjects, courses, centres or schools. The multidisciplinary projects can take place between students at any of the schools at the TP. It all depends on how the subject of a given project relates to different fields. Contacts and interrelations between different schools may be initiated by students or teachers, in some cases on social media, where students present updates on project activities. In some cases, teachers can enhance multidisciplinary projects by giving the students assignments that require that they collaborate with other schools. The management's approach is that interdisciplinary learning should be rooted in industry-based projects, where external industry-partners have a development project or problem to be solved. For example, Project 3R was an industry collaboration project with LDR Pte Ltd, which involved designing and developing a mobile learning application that allows students to learn mathematics through outdoor activities and quizzes.

Some of the cases show that the CoVEs emphasise flexibility and industry relevance in the educational provision. One approach to doing this is the use of project-based programmes, meaning that the CoVE can use projects to align different educational and industry stakeholders, bringing them together to work in various thematic areas and identify skills needs related to new digital technology trends.

Flexible project-based programme development means that the student can choose his or her own individual path of progression and combine different programmes and projects that address specific sectors and industries. This flexibility benefits the students, improving their ability to keep up with the rapidly evolving sectors/industries.

For example, the **CEIFS** in **France** applies a project based and modular approach, which provides flexibility of educational provision to the student as well as the industry.

The project-based programme approach means that the CoVE align different educational and industry stakeholders to come together in various thematic areas (e.g. aerospace, micro-electronics and nuclear energy). The project-based approach also means that human resources needed can adapt relatively quickly, for instance to changes in specific sectors with regard to emerging technologies and skills needs, making it an agile approach to learning and development.

For example, the RotorSkills 4.0 programme aims to support the transformation of the aeronautics industry, and more specifically the helicopter industry, through the creation of 'agile' training courses. It is a programme that leans heavily on apprentice and hands-on experimentation with professional training equipment. RotorSkills 4.0 is anchored at Airbus Helicopters, one of the largest companies in the Région Sud. Beyond Airbus, there are more than 190 companies in the aeronautics industry that are also in need of skilled professionals for production and development. In total, there are over ten thousand jobs in the region in the helicopter industry. The RotorSkills 4.0 project includes 9 partners from education and industry and has a budget allocation of 3.2 million Euros for this 3-year project which builds on previous editions.

In **Singapore**, the **Temasek Polytechnic** also applies project-based programme development. For example, the Temasek Polytechnic has launched course on 'chiller refrigerant handling'. The idea for a new course focusing on the reprocessing and re-using of chiller gas, a highly potent greenhouse gas emission, came from the National Environment Agency, when a new regulation was introduced which obliges companies to re-process and re-use chiller gas. A company with technical expertise in reusing chiller gas was advised to contact TP with a request to develop a course in the reuse of chiller gas for training companies. Many companies did not know how to implement the new regulation.

PEDAGOGICAL APPROACHES

Taking a horizontal view across the four cases, CoVEs emphasise that digital skills are developed through practice-based and self-directed learning, where the learners develop competences by doing their own practical work and experiments in realistic settings that prepare them for the world of work. One of the ways to achieve this is through solving problems/assignments for real clients.

In **China**, the **Shenzhen Polytechnic** is a key word for the application of a practice-oriented pedagogical approach. The school goes to great lengths to organise curricula, lessons, and assignments around cases from the real world. Therefore, students solve real tasks and assignments for private companies.

Similarly, in **Singapore**, the **Temasek Polytechnic's** pedagogical approach emphasises a Practice-based and Skills Education approach (PSE) which focuses on providing authentic learning to prepare learners for the working world while working in it. The curriculum is developed in collaboration with industry partners, and the TPs technical equipment simulates real work environments, allowing students to develop practice-based skills and experiences. The TP does this by offering authentic 'live' experience with energy equipment and digital data extraction. The TP's use of the institution's own buildings and equipment for energy supply and energy management allows the student to experience a 'live' and realistic world of work. For example, the solar panels on the roof of the building

are connected to a classroom filled with sensors, monitoring equipment, oscilloscopes, inverters, and software, which allow the students to analyse and optimise solar energy supply. Data from the solar panels are used as part of a diploma in Clean Energy and in courses for adult learners (Continuing TVET).

In **Finland**, the **Helsinki Business College** (**HBC**) collaborates with companies that provide assignments for students based on their actual needs, e.g., in order to market a product. Students here use digital tools — either free software programs (such as the social media application Instagram) or programs for which the school owns an educational license (e.g., design software InDesign) — to develop solutions, which they then get to present to the companies. This kind of practical exercise has several benefits. For students, it provides a fun and relevant way to learn and market themselves to companies. For teachers, it provides new inspiration in the classroom. And for companies, the students may come up with feasible solutions. Moreover, companies use these projects to identify possible future hires among talented students.

The CoVEs have all established digital tools and platforms that facilitate collaborate and self-directed learning.

In **Singapore**, the **Temasek Polytechnic**, together with the other four polytechnics, has developed the Learning Management System (LMS), a digital platform to which all students and teachers have access, and which contains a variety of functions. Via personalised access, the students use the platform for accessing learning content and tasks to be prepared before the lesson. All materials handed out by the lecturer will typically be placed on the LMS. After the lesson, the student will be able to access and review the recorded lesson again, if needed. Similarly, the lecturer can upload tasks and assignments for the students to work on after the lesson. The LMS also enables collaborative work between the students of a given class or programme/course. The students may be paired or grouped by the lecturer beforehand, or the students may set up the groups themselves.

When the students work collaboratively via the LMS, they do so via a channel which is only accessible for students belonging to the group. The channel enables the students to exchange messages and files with each other in the group. The real-time collaboration can also apply interactive whiteboard and file sharing capabilities, including 'breakout rooms' to be used for more intense collaborative work in sub-groups.

Similarly in **Finland**, the **Helsinki Business College** (**HBC**) uses digital learning management systems to organise teaching and interaction with students. 'Itslearning' is the primary tool for interaction between teacher and students, and the learning management system used by teachers to organise their classes. Students can log on to Itslearning with their personal Business College credentials, which are the same credentials that they use to log on to Wilma. On Itslearning students are added to the courses marked in their timetables. The teachers add all the assignments and materials to their courses, letting students access all materials in one location. Students can return assignments on Itslearning and the teachers grade them online. The teachers provide students with

instructions for Itslearning as students commence their studies at the HBC. Students can also download an Itslearning app on their smartphones, which enables them to log on to their own courses, study, and do assignments. The app lets students know if their teacher has made an update to the contents of the course or has sent message. As an 'e-campus', Itslearning also allows teachers to counsel students online and allows students easy access to remote student administration services. The HBC has used learning management systems for more than 10 years, and these have continuously been developed with new and improved features.

Digitally enabled gamification of learning can enhance student motivation and excitement. Skills competitions can also motivate learning and performance – and strengthen the identity and prestige of vocations. Winners of skills competitions create role models for other students and enhance the adoption of new technologies. Digital tools are highly compatible with the concept of gamification as, for instance, smart assessment tools allow for instant scoring and ranking of both objective and subjective assignments.

In **China**, at the **Shenzhen Polytechnic** gamification of the learning experience is an important tool to foster intrinsic motivation, make learning more engaging, and increase students' knowledge retention as compared to traditional schooling methods (Putz, et al., 2020). This pedagogical grasp has been made more accessible by digital learning tools. An example of how the Shenzhen Polytechnic uses gamification within training programmes comes from the blockchain programme at the School of Artificial Intelligence. On the faculty's blockchain platform, students can be assigned to write a piece of code, and the platform instantly provides a score and ranks the work provided by the student. With a scoreboard, the students can see their rank and relative success with the task. This competitive indicator of the student's progress is supposed to motivate the students and deepen their engagement. In this way, the assignment also becomes a small internal competition, which several students have described as motivational for their learning.

Skills competitions also play an important role at the Shenzhen Polytechnic. Skills competitions can be organised by the institution itself but can also be international ones arranged by other VET providers or industry partners.

In Singapore, the Temasek Polytechnic applies digital quizzes at the end of e-learning lessons to test the learning effects. The quiz is an element in the learning management system (LMS). When students take the quiz online, the integrated use of a custom browser

locks down the virtual 'test environment', meaning that students are unable to cheat, e.g., by finding answers to test questions on the internet. The duration of each quiz is about 10 minutes. All the scores of the assessments/quizzes are stored in the LMS, with the LMS tracking the progress of each student. In addition, the inventory of all test results enables assessments that make improvements of teaching practices and pedagogical approaches possible.

The CoVEs have established digital learning spaces, that enable collaborative learning, simulation, and experimental learning. The learning spaces are inclusive and open to remote participation, and are accessible to all.

In **Finland**, the **Helsinki Business College** (**HBC**) has various digital learning environments, including smart classrooms equipped with cameras that can record the classes for students who are unable to attend and three virtual reality (VR) simulation training facilities. The VR simulation centres include both VR glasses and VR software tools, which provide the students with the opportunity to enter a relevant virtual setting and to experience professional practices and their outcomes in a virtual environment.

In **Singapore**, at the **Temasek Polytechnic, the Advanced Manufacturing Centre** (**AMC**) is an applied and skills-based training facility in the field of advanced manufacturing, which involves the use of innovative and advanced technology to improve products and processes through enhancing the cyber-physical integration of manufacturing. With financial support from the government and industry partners, the AMC has established the 'proof-of-concept space', which provides advanced facilities for proof-of-concept projects to industry partners who want to test and develop new ideas and products. Proof-of-concept projects are provided in the following areas: smart automation and manufacturing control, connectivity and industrial IoT, robotic system integration. Students will also be involved in proof-of-concept projects, as part of their final-year 'Major Project' and internship programme.

The 'proof-of-concept' space can be used by pre-employment learners and continuing education & training learners, staff, and industry partners. Private companies can benefit from the space in research and development: schools can offer companies access to cutting-edge research and development facilities, as well as collaboration opportunities with faculty and students. This can help companies stay ahead of the competition and improve their products and services.

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CASE I

CAMPUS D'EXCELLENCE INDUSTRIE DU FUTURE – SUD

1. INTRODUCTION

This introductory chapter sets out relevant background information. Initially, it presents the French Center of Vocational Excellence (CoVE) at the heart of the case study at hand. Furthermore, it offers a brief description of the national VET system in France.

1.1 CAMPUS D'EXCELLENCE INDUSTRIE DU FUTURE – SUD

The *Campus d'Excellence Industrie du futur – Sud* (Campus of Excellence Industry of the future – South)[7] consists of a network of general secondary, technological, vocational, and higher education institutions as well as training organisations, research laboratories and public authorities involved in educational and economic development. The Campus – hereafter referred to as a Centre of Vocational Excellence (CoVE) or in short CEIFS – is a member of the French network *Campus des Métiers et des Qualifications* (Campuses of Trades and Qualifications – see section 1.2.2). The VET providers as well as other partners making up the CoVE are geographically dispersed in Provence-Alpes-Côte d'Azur, a region in the south-east of France also known as Région Sud.

The CEIFS prepares young people for jobs such as operating automated equipment, industrial maintenance and robotics at the forefront of the industries that are part of the digital transition. The CoVE develops competences with a focus on supporting industrial production by teaching basic knowledge and providing such as those related to semiconductor manufacturing or specific maintenance procedures for the avionics industry. CEIFS works mainly on a project basis and aims to develop and implement programmes ranging from specialised technical secondary education to master's degrees (EQF 3-7). The CoVE both responds to the needs of students as well as to the needs of regional development and employers.

The CEIFS works closely with multinationals and SMEs, delivers programmes through its education partners. The development of these programmes is managed through an agile training development methodology. Agile means being both reactive to current workforce needs and proactive in equipping students with the skills needed for the 'industries of the future'. In practice, this means that the CoVE enhances existing courses by implementing a modular training approach with many 'on-ramps' and 'off-ramps' for students (see section 4.2). An example of the aim of these pathways is to ensure that if a student fails in one programme, they will have access to other programmes where they can continue their studies and gain further qualifications.

The CoVE aims to support the dissemination of innovative teaching methods and educational content, promoting operational efficiency through the use of modern digital tools, equipment and infrastructure intended to avoid the duplication of costly resources and equipment, and integrating the various educational and training offers in the Sud region. This is achieved

7 This video contains an introduction to CEIFS.

FIGURE 1. CAMPUS D'EXCELLENCE INDUSTRIE DU FUTURE – SUD

Image: TEAM Henri-Fabre Technocentre

through collaborative projects built within the network of regional entities, such as educational institutions, training organisations, regional authorities and industry partners that have come together in the form a regional skills ecosystem under the name Campus d'Excellence Industrie du futur – Sud.

1.2 VET IN FRANCE – A BRIEF OVERVIEW

VET training in France operates within the context of the national system of lifelong learning, which incorporates initial and continuing education for upskilling and reskilling. Approximately one third of students in upper secondary schools follow the vocational path focused on providing tailored support, career guidance and more than 400 VET diploma specialisations in different sectors of the economy. The French VET system is flexible, and is constantly adapting to the changing needs of the labour market. Strengths include the modular design of VET courses which enables students to progress at their own pace and build their skills over time. There is also a wide range of options for students, including both traditional apprenticeship programmes and modern, classroom-based training on the type of machines that large industry and small entrepreneurs use every day in traditional and advanced manufacturing and technical fields. There are also many offerings in the services field.

Educational attainment in France has been consistently increasing, with 80% baccalaureate attainment in 2019 compared to only 29% in 1985 (CEDEFOP, 2022, p. 16). The number of vocational graduates has also been increasing. In 2020, vocational baccalaureates accounted for 22.8% with 18% completing technological baccalaureates and 46.3% graduating with general baccalaureates. In addition, more young people are continuing on to the tertiary level than ever before. In 2020, tertiary education achievement in France was almost 40% of people aged 25–64 (DEPP, 2021).

In France, the governance of VET involves a tripartite system, in which the government, employers, and employees are represented, while responsibility is split between the national government and the regions. The national government sets the overall framework for VET through laws and regulations, while the regions are primarily responsible for implementing and managing VET programmes.

The public institution *France Compétences* is the sole national governance body responsible for implementing VET and apprenticeship policies. The institution ensures that competences are being taught effectively with a high level of quality, and also helps to distribute funding to VET providers as well as apprenticeship funds to the sector-specific skills operators (OPCO) (opérateur de compétences) and the regions (Cedefop, 2022, p. 51).

Also at the national level, the *Campus des Métiers et des Qualifications* (Campuses of Trades and Qualifications) is a government scheme setting the framework for the funding of 95 certified campuses throughout France, as described in greater detail in section 1.2.2.

The training centres and educational entities involved in running these campuses are tasked with supporting regional economic and social development policies by integrating young people into employment and collaborating with regional economic competitiveness clusters. Most importantly, this central government funding scheme requires that regional authorities are also involved in campus design and development around relevant economic sectors in their region. In summary, the Campus des Métiers label and funding scheme is intended to ensure that the development and implementation of the VET system is responsive to the needs of employers and employees, and is in line with regional needs and with the goals of the national government.

1.2.1 FLEXIBILITY FOR STUDENTS IN VET IN FRANCE

VET in France is characterised by its flexibility, which allows students to tailor their training to their specific needs and career aspirations. It is also defined as having multiple 'on-ramps' and 'off-ramps' for students, which contributes to the success of VET across the country. Specifically, the system helps students who may have had difficulties with traditional educational tracks or find that they are interested in a different sector or area.

The French VET system offers a wide range of options and many VET programmes in France are designed to be modular, allowing students to progress at their own pace and build their skills over time with a focus on individual study and career pathways. This flexible approach is designed to help students acquire the skills and knowledge they need to succeed in their chosen field, while also providing them with the opportunity to explore different career paths and adapt to changing labour market demands. Between the different programmes there are ways in which horizontal (across areas) and vertical (between EQF levels) progression can be achieved between the various programmes described below.

The VET system in France is divided into two main pathways: initial VET (*formation initiale*) – for young people wanting to attain qualifications to enter the labour market – and continuing vocational training (*formation professionelle continue*) – for those already engaged in working life.

Within initial VET, vocational and vocationally-oriented programmes are typically offered in upper secondary schools and tertiary education institutions with students required to complete compulsory training periods in companies. For students aged 16–29 years, apprenticeship training centres offer an alternative route to school-based education. Programmes at these centres consist of alternating periods at an apprenticeship training centre and a participating company. The apprenticeship training programmes thus focus to a greater degree on work-based learning with practical training in companies usually covering two-thirds of a programme's overall duration (CEDEFOP, 2022, p. 32–38).

VET qualifications corresponding to EQF levels 3 to 7 – typically delivered in initial VET – can also be attained as part of the continuing vocational training pathway, for instance, by completing apprenticeships and upskilling programmes as well as through the validation of non-formal and informal learning (CEDEFOP, 2022, p. 32).

1.2.2 TRADE AND QUALIFICATION CAMPUSES

The Trade and Qualification Campuses (*Campus des métiers et des qualifications*) programme is a French central government scheme aiming to promote the development and modernisation of VET in France. The programme is implemented through a network of VET providers and the majority of the 'Campuses' are not one physical campus/entity but rather a partnership of various entities that offer a wide range of programmes in several different locations. The scheme was launched in 2013 by the French government and was overhauled in December 2018 with a new set of legislative and regulatory frameworks, including the 'Law on the freedom to choose one's professional future' (*Loi pour la liberté de choisir son avenir professionnel*) and the Investment Plan for Skills (*Plan d'investissement dans les compétences*). These frameworks aim to promote the development of VET, better connect the French system to the rest of Europe and support the day-to-day implementation of the programme.

VET providers in the Trade and Qualification Campuses network are certified for a period of 1 to a maximum of 5 years, and the certifications are renewable. Typically, a certified Campus does not have any employees on long-term contracts. Rather, staff is 'donated' from the ranks of the Ministry of Education or regional authorities or on short-term contracts directly related to the funded projects they are tasked with implementing. The label of *Campus des métiers et des qualifications* is awarded by a commission made up of representatives from regional authorities, university deans, the Association of French Regions (ARF), and the general inspectorates of national education. It is also a combined initiative that works together with departments from the national Ministry of Education, Youth and Sport; Higher Education, Research and Innovation; and the Ministry of the Economy and Finance.

The campuses contribute to supporting regional economic and social development policies through training. They are grouped and classified as follows:

- Mobility, aeronautics, land and maritime transport
- Tourism, gastronomy
- Creation, design, audio-visual
- Chemistry and biotechnologies
- Materials, innovative materials
- Infrastructure, building, eco-construction
- Energy transition, eco-industry
- Innovative systems, mechatronics
- Personal services, well-being
- Business services, logistics
- Food, agri-food
- Digital, telecommunications

Furthermore, the Campuses seek to leverage synergies between vocational and comprehensive high schools, apprentice training centres, training organisations, higher education establishments, research laboratories, and businesses. Against this background, the Campuses represent regional skills ecosystems that comprise a variety of different organisations and stakeholders, including:

- Vocational training centres, such as vocational high schools and colleges that are responsible for delivering the training courses and programmes.
- Employers and industry associations, which provide input on the skills and qualifications needed in the labour market as well as help with apprenticeships and on-the-job learning.
- Regional and local authorities, which provide support for the programme and promote its activities in the community.
- Higher education institutions as well as research centres which provide support for research and development in VET as well as some of the upper-level VET courses.
- Other public and private partners, such as social partners and non-governmental organisations with an interest in VET and the employability of young people.

Funding for the Campuses comes from a multitude of sources which are specific to each of the 95 campuses. The number of Campuses in France is approximate as some are dormant while others have reduced operations. Most funding is provided by the French central government. In this respect, the Campuses are a centralised top-up to an education system which delegates responsibility to the regions. It also ensures a degree of coordination at national level in the choice of this type of specialised mechanism. To manage the Campuses, different parts of the Ministry of Education are used in specific areas such as the agency responsible for course certification (*France Compétences*) or the publishing arm of the National Education service (*Réseau Canapé*).

Regional governments also play a key role in the development and strategies of the *Campus des métiers et des qualifications*. Each of the Campuses needs to reflect the territorial priorities in their local context. The regional authorities help cover the costs of running the programme, including the costs related to the facilities, equipment, and staff. They may also provide funding for specific aspects of the programme, such as training or equipment needed to work in certain industries or in targeted programmes for specific groups of students. In addition, the regional authorities may also offer incentives for companies to participate in the programme, such as tax breaks or grants.

Employers and other private sector partners also contribute to the programme as do funds from the European Union through the European Social Fund (ESF). Regions are responsible for the planning and coherence of vocational training in their territory, except for the provision of work placements. They define the strategies in line with regional economic and social priorities and in consultation with the central government and social partners. The ETF has previously highlighted the *Campus des métiers et des qualifications* as a good practice for how VET centres can improve through networks (ETF, 2020).

Some of the specific good practices highlighted in the scheme include its focus on providing flexible and adaptable training options to meet the changing needs of the labour market, its emphasis on providing opportunities for lifelong learning, and its emphasis on providing opportunities for social and professional integration. The programme also receives recognition for its strong partnership approach between the government, employers and other private partners. Furthermore, the programme's focus on providing training in various fields such as construction, manufacturing, health care and information technology is also considered a good practice as it allows for programme adaptation to local needs and the regional labour market.

2. MANAGEMENT AND ORGANISATION AT CAMPUS D'EXCELLENCE INDUSTRIE DU FUTUR – SUD

The Campus d'Excellence Industrie du futur – Sud (CEIFS) focuses on providing regional-based solutions for vocational needs and competence development. It operates on the basis of a common strategy developed jointly with all its partners and focuses on central government objectives and Région Sud priorities, the labour force needs of local SMEs and large multinationals operating in the region that support the next generation of specialised workers and entrepreneurs through a network of education and training providers.

This chapter examines the management and organisation of CEIFS and describes the human and financial resources that it can rely on in terms of promoting the digital transition of VET.

2.1 ORGANISATIONAL STRUCTURE AND GOVERNANCE

The CEIFS is a public interest association founded as a tripartite partnership between the Provence-Alpes-Côte d'Azur (PACA) region, the PACA Academic association, and the 'Mediterranean Industries' association, which comprises the Région Sud government, its education authority and the regional industry representation body, respectively.

As a legal entity, the CEIFS comprises a formal, not-for-profit association consisting of eight autonomous training centres and educational institutions as well as three multinational enterprises and one shared innovation centre 'dedicated to the Industry of the Future' as full partners. The association has the powers and resources to run projects, develop and fund training programmes, and provide resources which are shared between all or some of its academic members.

The full partners making up CEIFS are:

INDUSTRY PARTNERS	TRAINING CENTRES AND EDUCATIONAL INSTITUTIONS
Airbus Dassault Systèmes EDF	Aix-Marseille Université Arts et Métiers d'Aix-en-Provence École des Mines de Saint-Étienne Les Greta-CFA (l'académie d'Aix-Marseille) Lycée Jean-Perrin - Marseille Lycée polyvalent Pierre Mendès-France Lycée polyvalent Rouvière Pôle formation UIMM Sud
Shared innovation centre	
TEAM Henri-Fabre	

Source: CEIFS

Against this background, the CoVE is a federated network of multiple actors that shares resources, responsibilities, and decision-making power among its partners. In this decentralised system of organisation, the partners retain their autonomy and operate independently, while working together toward common goals in the area of vocational excellence.

This organisational structure principally allows for flexibility and the ability to build connections between complementary partners. Furthermore, it is project-driven which means that it can be resilient in the face of changing workforce needs. Because of its organisational structure, the CEIFS can be described as an additional layer or amalgamation of different offerings which provide additional opportunities and facilitation of relationships between its members. But it would be misleading to imply that these offers are fully integrated and coordinated. In reality, most of the activities and even the strategies within the different institutions and their educational offerings fall outside of the CoVE. The main benefit is that its activities and contributions can be 'added' on to the historically complex French educational system and can generate some opportunities for shared activities and resources.

In line with the above, the CoVE is mainly decentralised in its management with a small team of representatives travelling throughout the region visiting with partner organisations and signing up new entities to join initiatives.

The main governance body of the CEIFS is a Strategic Orientation Committee. The Committee is composed of the Rector of the academy (*Recteur d'académie*), the President of the region, a representative of the economic sectors concerned, the Head of the supporting institution and the Operational Director of each campus. This group meets once a year and determines the overall priorities of the CEIFS. The President of the Campus Strategic Orientation Committee is currently also the head of the Mediterranean Industries Association. She signs agreements for

the administrative and financial structure that will be used in each CoVE project implemented with associated schools, training centres and universities. For the educational partners, agreements must be signed by the Rector of the academy or leader of the VET provider.

As previously mentioned, the provisions, operation, organisation and administration of the Association are in line with the framework of the *Campus des Métiers et des Qualifications* – as described in section 1.2.2 – and the CEIFS has been certified with the 'Excellence' label, which it must re-apply for at regular intervals.

2.2 SOURCING RESOURCES

The integration of its educational partner programmes is just one of the benefits that CEIFS offers its students. Another innovation is how the resources needed to support students in the digital transition are sourced. The CoVE is able to leverage, circulate and disperse additional funding above and beyond what its individual members might be able to raise on their own. It is connected with the university deans' association, the directors of the training institutions, the regional governments, the central government as well as local innovation centres, SMEs and multinationals. These connections have placed the CEIFS in a position where it is able to source funding from different organisations for the specific needs of the member institutions. This has included receiving support from the regional government for metal 3D printers or in the case of one of the programmes, part of the student fees from the central government. A sizable financial contribution comes from regional authorities. The educational resources the CEIFS receives from the Région Sud can then be dispersed to its partners.

The CoVE develops specific projects and initiatives and does not have permanent staff. Human resources come directly through project budgets and the secondment of an Executive Director from the Ministry of Education. At the end of 2022, there were 3.5 full time equivalents (FTEs) which also include resources from participating companies. This light structure makes the CEIFS better able to react and adapt to the changing needs of its stakeholders and ensures there is no duplication of resources that might be available from the partner organisations with which they work. On the other hand, at times those running the CoVE are overextended and unable to do everything that they wish to support member organisations because of limited human resource capacity. They are seeking to remedy this through creating new projects so that more people can be allocated to CEIFS management.

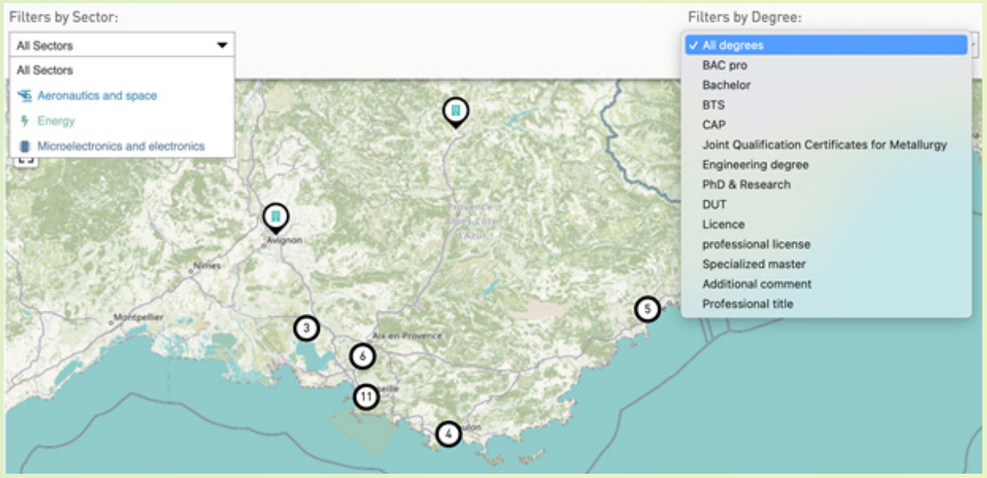
The CEIFS activities and budget are overseen by a treasurer and an auditing process has been put in place. In France, for more than EUR 152 000 an association is required to have this type of process. The CoVE provides added value by writing grant proposals, managing large projects and controlling the financial mechanisms through which partner institutions gain additional funding. Through a series of agreements, the CEIFS monitors the project both in terms of investment and operational aspects. The CoVE is also responsible for ensuring that equipment is shared, investments are not duplicated, and synergies are established between organisations within close geographic proximity to leverage the value of the network.

2.3 COOPERATION WITH PRIVATE AND PUBLIC PARTNERS

The CEIFS identifies potential industrial partners to cooperate with and add value through providing the type of skilled human resources that they require. Companies are not formally required to pay for their involvement, although they often contribute resources to projects. The companies that work with the CoVE are eligible for tax refunds related to their spending and contribution on workforce training, and member companies such as Thales, Airbus, EDF, Dassault System, and ST Microelectronics have made use of these benefits. To receive the donation tax benefits, a company must apply to the regional government and define the actions that are going to be worked on with the project-based initiatives. Another benefit for participating in the CoVE is the visibility that the initiatives provide, demonstrating how multinationals integrate into the regional education system, which can be considered a socially responsible corporate practice.

One of the most important drivers for the success of the CEIFS is having the right human resources to coordinate organisation and a dynamic leadership that is highly involved with partners. These leaders are able to establish connections with the right people and engage in dialogue with them. While partnerships can be difficult to establish

FIGURE 2. SCREENSHOT FROM AN INTERACTIVE 'TRAINING MAP' ON THE CEIFS WEBSITE



Source: CEIFS, n.d.

and maintain, this issue is addressed by organising and participating in events, such as conferences, webinars and skills weeks with a specific sectoral focus, that provide many opportunities for networking and input by bringing together professionals from government and industry, entrepreneurs and students. The CoVE has been successful in establishing a network of partners beyond the public and private members that are full partners within the CEIFS. These include industry partners, such as SNEF Group and ERM Automatismes, as well as other educational institutions and training centres offering VET (e.g., UIMM Alpes Méditerranée, GIP-FCIP Aix-Marseille, Lycée Régional Professionnel Montesquieu).

The map below illustrates the geographical spread of the training providers that are part of or collaborate with the CEISF and shows in which sectors and at what qualification level training is offered.

Another important aspect helping the CEIFS to succeed is having a collective, as opposed to an individual, business model. In this regard the balance is achieved through the light government structure of the CEIFS and the fact that the individual mission of each partner organisations are incorporated while the general mission of the CEIFS is not perceived as a threat by them.

2.4 ORGANISATIONAL STRATEGY

The strategic objectives of the CEIFS can be grouped into five areas that include: 1) Strategic partnerships with an emphasis on several major regional employers; 2) Key investments in specific technologies with a vision as to the added value these investments can bring to key sectors in Région Sud; 3) Enhancing the engagement of educational organisations and their leadership; 4) Spreading pedagogical innovations through sector-specific projects, and 5) Strengthening the CEIFS capacity to interface with government authorities – for instance, with regard to regional funding and planning, the national qualification board, etc.

These objectives are also reflected in the 2019 updated bylaws of the association Campus d'Excellence Industri du futur – Sud. According to it, members aim to:

- '…affirm through the Association their desire to work together to develop support and training in the Provence-Alpes-Côte d'Azur region on the issue of the industry of the future;
- undertake to draw up and lead a roadmap for the development of information and guidance for the public, as well as training courses on occupations and their impact on future transformations, but also on the impact of the industries of the future on occupations;
- propose to develop joint projects with local actors by pooling investment and by promoting the teaching and industrial expertise of local actors;
- support the development and promotion of these actions at local, national and international level and showcase the way in which the Campus of Excellence Industry of the Future – South label embodies these.

(Source: Internal documents)

Through its partners, the CEIFS offers a wide range of training programmes and qualifications providing students with technical and digital skills required in the sectors that contribute to and/or are driven by the digital transition, namely aeronautics and space, (micro) electronics, as well as energy. In line with its strategic objectives, the CoVE seeks to implement and further develop these programmes for the 'Industries of the future' through strong cooperation among the private and public partners. The next two chapters of this case study offer examples of relevant digital training programmes (chapter 3) and describe the pedagogical approaches applied in this context (chapter 4).

3. DIGITAL EDUCATION PROGRAMMES AT THE DIFFERENT PARTNER ORGANISATIONS

The CEIFS encompasses many different aspects of digital educational content and programmes, and it would not be possible to describe all in detail. This chapter discusses the overall approach by the CoVE and then goes into more detail about two educational partner organisations: *Arts et Métiers* (Aix-en-Provence campus) and the *UIMM Sud Training Centre*.

The identification of regional technical and digital skills needs through the tripartite relationship between the regional government, the industry and academia plays a critical role in curriculum and programme development. The regional government often takes the lead in initiating this collaboration by identifying priority sectors for economic development and growth. Working with the industry and academia, the government then conducts a comprehensive analysis of the labour market to identify the skills that are in high demand and the gaps that need to be filled. Industry, in turn, plays a crucial role in providing insight into the latest trends and emerging technologies that are shaping their sectors. Through collaboration with academia and the regional government, industry experts can contribute to the development of sector-specific training programmes that are relevant to the current and future needs of their sectors. VET providers bring the necessary expertise to develop and deliver training programmes and the CEIFS assists in working with the central government's certification body and in drafting new curricula and programmes to promote digital skills for a specific sector. The regional government can then provide funding or incentives for students to enrol in these programmes.

By working together in this way, the regional government, industry, and academia can ensure that the VET students receive training that meets the needs of the labour market, and that the region has a workforce that is equipped with the necessary skills to drive economic growth and development in the sectors that CEIFS focuses on.

3.1 IMPLEMENTING THE DIGITAL TRANSITION AT THE DIFFERENT EDUCATIONAL LEVELS AND ORGANISATIONS

The CEIFS supports the different needs of its educational and industrial partners, and its initiatives span many organisations. To illustrate how the digital transition is promoted at different levels of education and how the CoVE's organisations relate to each other, the cases of *Arts et Métiers* (Aix-en-Provence campus) and the *UIMM Sud Training Centre* are highlighted and explained in more detail.

PARTNER: ARTS ET MÉTIERS

One of the full partners in CEIFS is the Aix-en-Provence campus of Arts et Métiers, a leading science and technology university that is part of the Grande École in France and operates at EFQ levels 6, 7 and 8. With an international reputation for teaching and research, Arts et Métiers is one of the oldest and best engineering schools in France, specialising in mechanical, industrial and energy engineering. Arts et Métiers has more than 250 years of tradition in technical innovation and industrial engagement.

The Aix-en-Provence campus of Arts et Métiers has innovated with the creation of full programmes such as the Specialised Masters in Nuclear Engineering and in Renewable Engineering as well as in courses on Frugal Innovation, which emphasise social and environmental issues for Arts et Métiers engineering students, but also include work with two local high schools.

At EFQ level 6, they have the Technician Bachelor degree programme in the field of digital engineering, which is designed to train technicians capable of interacting in project management and collaborative engineering.
The course is designed as a post-BTS professionalisation year and is structured around the project management skills block. The training includes five specialised blocks in different technology areas related to digital design. They provide the digital engineering technician with knowledge of the methods and tools used, as well as the know-how to carry out basic tasks. For more in-depth tasks, the Project Technician Bachelor's degree enables technicians to dialogue, exchange and share information, and direct the work of experts.

The first pilot group of 11 students from 3 BTS courses participated in the programme in the areas of 1) Design of Industrial Products – CPI; 2) Design of Product Production Processes; and 3) Design and Industrialisation in Microtechnology – CIM. The industrial

innovation dimension of the programme aims to prepare students for future careers within the 'industry of the future' in Région Sud.

The Technician Bachelor's Degree programme is the result of a collaboration between Arts et Métiers, eight partner companies, and the regional government. The companies involved in the initiative include Airbus Helicopters, Croust'wich, EDF-DIPDE, Inovsys, Ipenergy, the AMU-CNRS Mechanics and Acoustics Laboratory, Temisth, and Virbac. These companies provide the students with the necessary resources, including equipment, facilities, and expertise. The CEIFS provides partial financial support and ensures that priority is given to the use of existing solutions or resources whenever relevant. According to Xavier Dufresne, Director of Initial Training at Arts et Métiers, 'businesses appreciate the multidisciplinary vision, pragmatic approach, technical and behavioural skills and the human values. And we tailor the course to territorial issues'.

FIGURE 3. A DIGITAL WHITEBOARD AS AN EXAMPLE OF EQUIPMENT FUNDED THROUGH CEIFS

Image: DTI

As part of its involvement in CEIFS, Arts et Métiers has hired two Learning Designers to specifically support the university's digital transition. Over a period of 1.5 years the Learning Designers have been able to meet individually with academic staff members and discuss aspects of digital literacy and digital methodologies involved in teaching programmes related to CEIFS initiatives.

Another example of a digital programme at Arts et Métiers is the Apprenticeship Engineering Programme. It consists of an 18-month period of work experience that supports the development of specialised engineers with a profile sought by recruiters, with a programme that guarantees placement in a job after graduation. Arts et Métiers, Aix-en-Provence has three specialisations: Mechanical, Public Works and Electrical Engineering. In these programmes five factors are key to attracting students, including: 1) paid apprenticeship training; 2) dynamic community life; 3) dual school/company mentoring; 4) the teaching excellence and expertise of Arts et Métiers, and 5) guaranteed professional integration. All of these programmes support specific aspects of the digital transition through this strategy.

Arts et Métiers staff members explain how difficult it can be to work outside of the educational level that their organisation serves and to communicate with the other parts of their education value chain. This means that, under normal circumstances, a Grande École would probably not be in dialogue with VET centres or involved in a larger project, if it were not for the CEIFS. The Arts et Métiers has been linked to the UIMM Sud Training Centre through projects sponsored by the regional government under two specific programmes that are currently being implemented. These collaborations concern both initial and continuing VET and the promotion of engineering and digital skills. It is also through these links that the UIMM Sud Training Centre can connect to the higher VET levels, such as EQF level 7 in Masters programmes in a clear pathway for VET students. This allows each educational organisation that is a partner in the network to have its own business model, but the CoVE is able to adapt to the overall business model throughout focusing on projects, and the value chain that CEIFS can offer to its members.

PARTNER: UIMM SUD TRAINING CENTRE

The UIMM Sud Training Centre has its own employment training network in the Région Sud, providing training to nearly 130 000 employees and 43 000 people on work-study programmes each year. The UIMM Sud comprises the following four entities:

- *AFPI Provence*: the Associations for Professional Training in Industry of Provence, which provide continuing VET;
- *CFAI Provence*: the Training Centres for Industry Apprentices of Provence, which provide diploma or professional training in industrial and tertiary trades.
- *L'école de production – Je fabrique mon avenir*: The I Make My Future Production School is a technical and general education school for students aged 15 to 17 years that focuses on entrepreneurial skills.
- *L'ITII PACA*: The Institute of Industrial Engineering, Provence-Alpes-

Côte d'Azur, which is based on a partnership between regional engineering schools and offers accredited industrial engineering degrees.

(Source: UIMM Sud, n.d.)

UIMM Sud's main campus is in Istres, but it has 20 smaller regional campuses. The UIMM Sud also implements regional engineering and consultancy projects for manufacturers, using human, technical and educational resources to support industrial partners. Its training offer ranges from EQF level 3 (CAP) to level 7 (engineer) and includes preparatory training, CQPM (Certificate of Joint Qualification in Metallurgy), Bac Pro, BTS, professional certifications and Bachelor's degrees.

The UIMM Sud Training Centre offers innovative programmes, such as those focusing on advanced manufacturing techniques, optimisation of production flows and maintenance of industrial equipment and technologies. They help to provide the skills needed by people working as operators of automated equipment, industrial maintenance, and robotics. Other programmes focus on integrated circuits and circuit boards, or equipment and components related to AI, computer security and connectivity.

In addition, UIMM Sud students in the field of energy can be trained in a mini-laboratory that simulates urban management systems (e.g., street lighting, water and electricity systems, etc.) where they can use digital management systems that correspond to equipment just outside the training centre's building (see Figure 3 below). This type of hands-on equipment that is connected to digital systems is a powerful learning tool that provides students with the relevant practical experience that they can take back to more than 600 partner companies

FIGURE 4. CITY MANAGEMENT DIGITAL SIMULATORS AND COMPONENTS AT UIMM SUD TRAINING CENTRE

Images: DTI

that are a part of UIMM's regional network.

At UIMM Sud, there are a number of key factors that promote the digital transition at UIMM Sud. One of them is the wide range of qualification levels offered by the training institution. These include the Btn (Technology Baccalaureate), Bac Pro (Vocational Baccalaureate), BTS (Higher Technician Certificate with a Baccalaureate), and Professional Master programmes, which provide students with technical and industrial skills.[8]

In addition, teachers and trainers at UIMM Sud tend to have industrial experience, which students say is important for their mastery of digital skills. At the same time, teachers are aware that technologies and their application in a sector can change relatively quickly. For example, one of the teachers interviewed described how keeping up to date with the latest technologies being used in industry was essential for his ability to pass on relevant knowledge with his students. He explained:

'Beyond what I can read, I am constantly working to update my own skills so that I can share the latest technology with my students. For me, after having left industry 5 years ago, this is the biggest challenge as technology is always changing.'

(Source: Interview)

It is the ongoing commitment to lifelong learning by the teaching staff at UIMM Sud that enables them able to excel in aspects such as advanced manufacturing and prepare their students for the world of work. The necessary teacher training to support this is partly done through CEIFS-funded projects.

8 Annex A sets out a more detailed descriptions of these certificates and degrees.

4. PEDAGOGICAL APPROACH

As CEIFS is an association of different educational institutions that offer programmes at different EQF levels, there is no single pedagogical approach that encapsulates the CoVE. However, what is a pedagogical constant across CEIFS is the integration of regional priorities and the alignment of educational institutions with regional industrial leaders. This integration has been most evident in the development and implementation of a number of collaborative skills development projects within the CoVE. These are described in more detail in the following section.

4.1 THE PROJECT-BASED AND AGILE APPROACH ON CAMPUS

CEIFS uses a project-based approach, which is an important key to its success. It is through projects that the CoVE is able to bring together different educational and industry stakeholders around thematic areas (e.g. aerospace, microelectronics and nuclear energy). The project-based approach also means that the human resources required can adapt relatively quickly, for example to changes in specific sectors in terms of emerging technologies and skills needs, making it an agile approach to learning and development. In addition, CEIFS is able to monitor and evaluate the success of individual projects and, based on the results, modify, develop, evolve or terminate them.

The agile approach to learning and development means fostering collaboration, adaptability and a focus on innovative problem solving to meet the needs of the workforce. The methodology is rooted in the principles of agile software development, which is becoming increasingly popular in training programmes across a wide range of industries.

At the heart of the CoVE's agile training model lie the needs, resources and delivery capabilities of its partners. Airbus Helicopters, for example, is one of the original partners that came together to form CEIFS and has been heavily involved in the RotorSkills 4.0 programme. It has developed a specific offer for the technician level required by the French aerospace industry. The strength of the agile method is that it has strong support from employers because it responds quickly to a real need, and thus offers students a real prospect of employment. On the other hand, this approach is perhaps best suited to large employers who have the resources and future vision needed to invest in and deliver these joint programmes with an educational institution. However, programmes such as RotorSkills 4.0, described in more detail below, also offer tangible results in a timely manner for the thousands of SMEs that support regional industrial giants such as Airbus Helicopters.

CEIFS' project-based and agile approach emphasises communication and collaboration. It is particularly well suited to the rapidly evolving industries supported by CoVE, such as the area of microprocessors. Funding provided for the development of pedagogical tools (e.g. the Martian Robot which is part of the I-NOVMICRO project described below). CEIFS-funded projects also integrate equipment such as the latest in 3D metal printing machines at educational partners and provide access to apprenticeships at some of the region's most digital industrial companies where students train on industry-owned equipment. In summary, the campus' agile methodology is particularly well suited to training programmes for rapidly evolving industries and represents a valuable conceptual approach for organisations seeking to provide effective and relevant training for their current and future employees, as well as for regional workforce needs.

The CoVE seeks to strengthen projects by bringing together actors with the capacity to generate new initiatives. They have relationships that help to spread good practices between different educational actors. The magic ingredient is the trust that the CEIFS is able to build between partners through its governance and leadership.

As the governance and programming of CoVE is project-based, describing specific initiatives that the CEIFS has underway and how the learning programmes work and integrate with industrial partners is the easiest way to understand the innovative aspects of the pedagogical approaches at play.

inSitu

The development and use of digital learning platforms is an aspect that has been used consistently in the past and became an even more central role during the pandemic. Students mentioned that it was easy to find all the information about assignments as well as the calendar of activities on the platforms used by the different partner institutions.

A concrete example is the learning management tool inSitu. It is an integrated digital platform to facilitate learning and training in work situations. InSitu allows the networking of all relevant actors (i.e., students, teachers and employers) to facilitate a strategic and interactive approach to course

management at UIMM Sud. Through the integration of reference systems within inSitu it is possible to link situations encountered by students to an activity/skills matrix. This allows for an organised and integrated evaluation by the tutors and trainers who are able to assess student progress more accurately.

The inSitu tool, which was launched in the context of the above-mentioned Bachelor Technician project in digital engineering, was implemented jointly with the Lycée Jean Perrin as a CEIFS partner. The fact that Lycée Jean Perrin is now also using inSitu is a key piece of evidence of the transfer of CEIFS activities between the training centres, schools and universities involved.

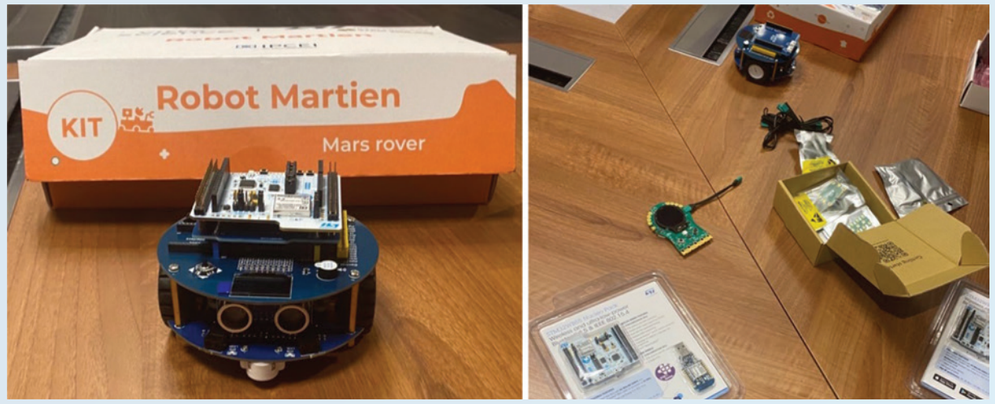
I-NOVMICRO

The I-NOVMICRO project aims to modernise training in the fields of microelectronics and electronics to meet the recruitment, training, and development needs of employers. The pedagogical approach involves the use of 60 training modules, and it aims to train 1 680 young people under the age of 26 years during the 5-year project. It brings together 11 CEIFS partners and has a budget of EUR 2.5 million. The Région Sud is the second most digitalised region in France with more than 160 organisations in the sector, anchored by STMicroelectronics. The I-NOVMICRO project uses three training sites located in Gardanne, Istres, and Aix-en-Provence. They provide training for a variety of target groups including employees of companies in the sector and job seekers, although the major focus is on students in baccalaureate to graduate programmes. Near the training centre in Istres the project aims to create a clean room — a controlled environment where pollutants such dust and airborne microbes are filtered out, typically to create ideal conditions for the manufacture of (micro)electronic products. I-NOVMICRO also contributes to the development of teaching and technological platforms as part of a digital pedagogy 'from silicon to services' through 'STM32 Education'. STM32 is a family of 32-bit microcontroller integrated circuits designed and manufactured by STMicroelectronics.

Part of the project is already being tested by the *Marie Madeleine Fourcade High School in Gardanne*, a CEIFS partner. STMicroelectronics provides half of the funding for its seconded technician and the CoVE covers the other half of the funding as a grant for this person who works as a kind of director of ICT education at the high school. This electrical engineer helps to implement the programme at the high school and other participating schools. The miniature microelectronic boards and peripherals used in I-NOVMICRO help provide hands-on experience in programming and using robots (i.e. digital machines that are built with the help of robotic components, such as microcontroller units). STMicroelectronics provides training robots free of charge to schools, which benefit by introducing students to the French-Italian, Swiss-headquartered company. The robots also help to train the future electrical engineers and technicians needed to deploy their systems. Their design uses the latest technology, which students can also use and control via their mobile phones.

However, many of STMicroelectronics's robots are not suitable for young people just starting to work with digital tools. So STMicroelectronics, with funding from CEIFS, has developed simpler robots.

FIGURE 5. I-NOVMICRO EQUIPMENT



Images: DTI

The robots work more like a game console, with plug-and-play connections and interfaces that are easier for first-time users. The ones used in high schools have attractive and aspirational names such as the Mars Rover (see Figure 4). By 2022, the new robots were working but the control software was still being developed as part of the project's work programme. To create this software, STMicroelectronics has partnered not only with companies such as Microsoft, but also with French SMEs active in the digital education sector, such as the Paris-based Vitta Science. The software will allow the robots to be programmed, but to also be controlled without programming. The aim is to enable students to visualise the programming/functions performed by the robot in order to support digital learning.

In general, the I-NOVMICRO project is expected to have an impact young people and to further promote the industrial and digital transformation of companies in the Région Sud. And the project might not have happened without CEIFS. Before working with the CoVE, STMicroelectronics had many interactions with different parts of the French government that did not result in concrete actions and got bogged down in bureaucracy. They found CEIFS to be the right entity through which to connect with the education system, because it was flexible, had shared values and was willing to cooperate.

ROTORSKILLS 4.0

This project aims to support the transformation of the aerospace industry, and more specifically the helicopter industry, through the creation of 'agile' training courses. It is a programme that relies heavily on apprentices and hands-on experimentation with professional training equipment. RotorSkills 4.0 is anchored at Airbus Helicopters, one of the largest companies in the Région Sud. In addition to Airbus, there are more than 190 companies in the aeronautics industry that also need

of skilled workers for production and development. In total there are over ten thousand jobs in the helicopter industry in the region. The RotorSkills 4.0 project includes 9 partners from education and industry and has a budget allocation of EUR 3.2 million for this 3-year project which builds on previous editions.

Through this project there are over ten training courses related to four technical platforms, all of which are modular and share the CEIFS governance module, which allows students to have multiple on-ramps and off-ramps to different programme offerings as well as a way to continually build skills. More than a thousand young people under the age of 26 have benefited from the programme, as have 920 employees.

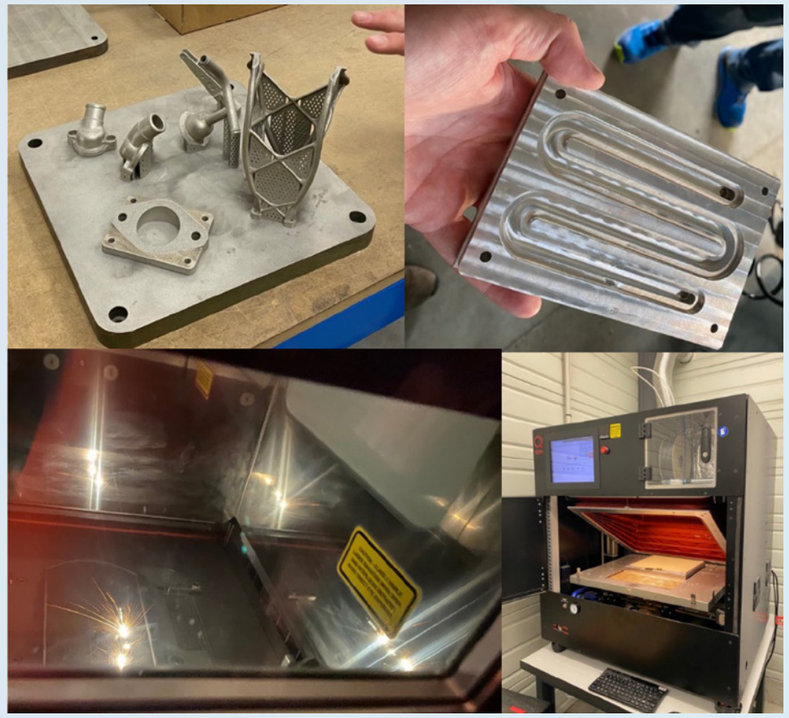
The training is for specialised aeronautical professions, and complementary courses are offered at two locations. The programme begins with CAP-level training in structures and avionics and can lead to completion of the aeronautical Bac Pro, with a specialisation in avionics, structures, or systems. With the possibility of an additional year, the programme can be further focused on the maintenance of turbine aircraft, piston aircraft, and helicopters. The Aeronautical BTS programme trains senior technicians at baccalaureate level plus 2 years of specialised training in activities such as diagnostics, technical support, and customer support through more than ten digital training paths linked to four main technical areas related to rotorcraft. It covers key areas such as maintenance and production, as well as areas such as data and cyber security, and how to support the green transition through a Master's programme in Frugal-tech.

TEAM HENRI-FABRE

One of the most interesting and innovative full partners of CEIFS is the TEAM Henri-Fabre. It is a joint innovation centre dedicated to the industry of the future, which can be described as a technology, competitiveness and business accelerator. Originally established in 2015, additional funding for the innovation centre was secured in 2017, when CEIFS and TEAM Henri-Fabre won a Future Investment Programme (PIA) from the French government's financial institution *Caisse de Dépôts et Consignations*.

The TEAM Henri-Fabre Technocentre offers students, entrepreneurs and industrial companies a range of services, from training to support for innovation. The Technocentre's workshop is dedicated to showcasing the future of advanced manufacturing and industrial prototyping. It teaches 3D printing with plastic, but also with metal and advanced polymers, as shown below.

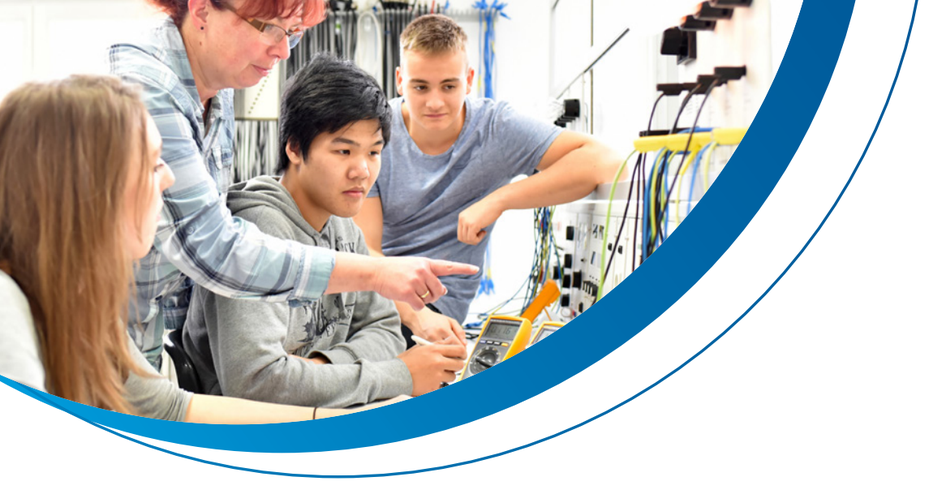
FIGURE 6. ADVANCED MANUFACTURING AT TEAM HENRI-FABRE



Images: DTI

The Innovation Centre's approach to supporting the industries of the future is carried out in an experimental and prototyping space covering more than 3 000 square metres in total. For example, using 3D metal printers students learn manufacturing techniques that are key to local industries, such as Airbus Helicopters, which, like the Innovation Centre. is based in Marignane, France. By pooling the resources of the various partners and funders of TEAM Henri-Fabre, it is possible to develop and implement projects that could not have been financed alone by either the industry or education partners alone.

A number of CEIFS partners are involved in the development and use of TEAM Henri-Fabre, including Arts et Métiers, CFAI Istres, CIPEN, and Académie Aix Marseille Provence. The project partners have invested in new technical platforms to support the delivery of skills in demand in the region. TEAM Henri-Fabre trainers have designed and delivered training on and through digital tools that allow easy access, rapid implementation and individualisation of learning through modules adapted to initial and continuing vocational training. The training pedagogy for this collaborative project was made possible by the CEIFS network which integrates technical, educational and



multi-level public and intersectoral partners. During the case visit for this study, one of the trainers presented how 3D metal printing can produce the types of parts needed for rotorcraft, which operate at extreme temperatures and have a lot of vibration. In this type of industry there is a distinct advantage in reducing the potential failure rate of parts due to welding irregularities.

Advanced manufacturing equipment has been installed not only at the TEAM Henri-Fabre site but also at the sites of all partner institutes. This has enabled more advanced training for the students and a pathway for students to be continually challenged and trained on increasingly advanced systems as they master each level and piece of equipment.

At TEAM Henri-Fabre, students learn how to build prototypes, use advanced equipment and interact with cutting-edge industry partners. At the Technocentre, students from different educational levels and institutions work in a shared laboratory space. The biggest test of its success is whether the equipment installed and distributed, and the expertise disseminated, actually match the educational programmes and employment opportunities in the region. There is evidence that the innovation centre has been at least somewhat successful in this regard. TEAM Henri-Fabre's achievements include the creation or reinforcement of 52 training courses, which have trained more than 1 200 young people, employees, and job seekers in the use of high-tech digital tools.

4.2 SUPPORTING EFFICIENT AND EFFECTIVE GUIDANCE FOR VET STUDENTS

CEIFS aims to avoid any single points of failure in students' progress by taking a portfolio approach to students across its educational partners. As the education of students is the domain of the individual institutions, what the CoVE provides a way for partners to interact with each other and learn more about what other institutions in the region are doing for their students. The aim is to provide multiple on-ramps or entry points into programmes as well as off-ramps or exits within a more unified regional approach. Off-ramps, such as exit points for students with certified qualifications or degrees, can provide students with apprenticeships that can eventually lead to full-time employment. On-ramps allow students to return to the VET system, if they have failed in a programme, or allow for them to diversify their learning experiences to suit their needs and aspirations.

This was exemplified by a young woman who was interviewed during the study visit who told the story of attending a higher education programme during the pandemic, which she said was, 'quite difficult and I didn't like it'. She then came to CEIFS partner Jean Perrine to study for her BTS (*Brevet de technicien supérieur*), a higher technician certificate at EQF level 5. She says that she was 'really happy to be on the course, and that maybe the BTS programme was what I should have been doing all along.' She went on to say that after leaving high school, she 'really didn't know what to do, it was all very vague, and a lot of people change the sector they work in.' She added that she had been told that '75% of the B1 level students at the university she attended did not stay', emphasising the importance of having different educational pathways.

The BTS programmes in which the interviewed student is involved with are designed to provide students with the technical skills and knowledge needed for specific professions, such as business, engineering, healthcare, and information technology. These may be shorter courses, qualifications or certificates that lead to employment outcomes or act as a stepping stone to higher education degrees. Although perhaps not fully realised, much of the vision behind the CEIFS initiative is being realised. Most importantly, the integrated approach of the CoVE have several overall benefits, including:

- Greater accessibility: Having multiple on-ramps, students can easily enter the VET system, regardless of their previous educational experience or circumstances. This leads to increased accessibility and opportunities for students to develop the skills they need to succeed in the world of work.
- Flexibility: The ability to choose multiple off-ramps gives students the freedom to leave a programme and explore other options if they find it is not a good fit. This results in a more flexible and responsive education system that adapts to the changing needs and interests of students. Again, this depends on the guidance that they receive at their institution, but through CEIFS, individual institutions are more likely to be aware of other educational opportunities in the region.
- Reduced risk: Several programmes use a virtual employability guarantee for students (e.g. the technician programme as a part of RotorSkills 4.0 between the UUIM Sud Training Centre and Airbus Helicopter where the administrators claimed to have almost full employment of graduates of this Baccalaureate + 2-year programme). Furthermore, because CEIFS operates across a network of entities, no single setback for or shortcoming of a single institution or unanticipated sudden change in economic conditions is likely to affect the overall education and training outcomes for the Région Sud. This result is a more resilient education system.
- Improved outcomes: The ability to choose from multiple programmes and on-ramps and off-ramps gives

students a wider range of options and increases their chances of finding a specific programme that is a good fit, leading to higher job satisfaction, greater job security, and higher earnings. This also helps to meet the changing demands of regional skills needs, and supporting regional economic development.

CEIFS focuses on enabling operational efficiency with a regional VET framework by supporting innovative multi-institutional programmes. It is involved in programmes such as Forindustrie[9], which is described as an 'extraordinary universe' created to introduce industry to secondary and vocational school students and other job seekers. Designed and produced in the Région Sud with the support of more than 50 institutional and industrial partners, this new interactive online platform was accompanied by digital events inviting students to live a digital adventure from November to December 2022 in French industries. More than 12 000 students and several hundred job seekers took part. The digital platform provided a unique opportunity for young people to navigate and interact on a virtual archipelago with hundreds of different types of jobs. It also engages students by offering the winning educational institutions (those with the highest participation) the opportunity to experience a real, fully-funded field trip experience to one of the region's major employers as part of the initiative's prizes. It is also unique in that it involves not only students, but also teachers and job centre staff, as well as industry speakers who explain their day-to-day activities. This is an example of innovative use of digital technology to connect students with real-world careers advice at a regional level.

9 See more on Forindustrie here.

5. CONCLUSION – KEY LEARNINGS ABOUT THE DIGITAL TRANSITION AT CAMPUS D'EXCELLENCE INDUSTRIE DU FUTURE SUD

This case study has examined the approach to, strategy for, and pedagogical practices related to the digital transition at the Campus d'Excellence Industrie du futur – Sud. CEIFS is an association made up of a federated network of actors supporting a decentralised regional skills ecosystem which is made up of multiple actors, such as educational institutions, training organisations, regional authorities and industry players. Each of the CoVE's public and private partners bring specific key resources and added value to facilitate an integrated regional vocational training offer that responds to the territorial development needs of the Région Sud in France.

CEIFS is a good practice in the way it reinforces existing courses from specialised technical secondary schools to master's level programmes with state-of-the-art equipment and links to industry and research through sectoral programmes (e.g., within aeronautics, energy, (micro-) electronics and industrial automation). Its governance structure allows for a unique project-based and agile approach to vocational education and training programmes, where learners can follow tailor-made pathways that build on the previous levels and educational programmes they have attended.

The CoVE is part of the French Campus des Métiers et des Qualifications programme and has been certified with a label of excellence for the training it provides. CEIFS aims to lead the digital transition through the variety of training programmes and qualifications it offers, providing young people with relevant skills for careers in highly digitalised sectors.

In this context, the key success factors for CEIFS in supporting the digital transition through VET include:

- Responding to competitive public calls for proposals and implementing specific projects that have digitalisation as a key component. These projects provide strategic resources and the support of the Campus' network, which helps each individual organisation to be more effective.
- Supporting a vocational and higher education system that provides multiple 'on-ramps' and 'off-ramps' to avoid single points of failure, further learning, gaining certification and the acquisition of recognised digital skills through educational programmes that meet the needs of students.
- Adopting an agile approach to learning and development promotes collaboration, adaptability and innovative problem solving to meet future and current regional workforce needs.
- Providing digital tools that enable students to create physical prototypes and simulate results using the same type of equipment and software used in industry.
- Focusing human resource expenditure on supporting partner organisations through project-based programming that integrates different educational institutions.
- Reinforcing the mission and vision of each partner and their views on digitalisation, with representatives from each organisation also involved in governance.
- Strengthening the role of industry and regional stakeholders who are key to ensuring that the digital skills delivered in the education programmes have clear links to the world of work.
- Benefiting from world-class industry partners, such as Airbus and STMicroelectronics, and working on collaborative tools and projects to acquire the latest technology and machinery to support digital education.
- Using various French national and regional government programmes to help deliver digital tools and pedagogical support, such as the national course certification agency.

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ANNEX A: CAMPUS CERTIFICATES & DEGREES OFFERINGS

UPPER SECONDARY TECHNOLOGICAL PROGRAMMES (BTN)

The Technology Baccalaureate or BTn (*baccalauréat technologique*, BTn) is a 3-year school-based technological study programme that combines general education in year 10 with specialised technological subjects in years 11 and 12 and is organised around different fields and activities. At the end of the BTn students graduate with the EQF level 4 and most BTn, students enrol in professional bachelor programmes or undergraduate higher technician studies.

UPPER SECONDARY VOCATIONAL PROGRAMMES (BAC PRO & BTS)

Upper secondary VET is provided by both public and private schools and offers flexible pathways for students. General education (mathematics, history and geography, science, French and English) is combined with VET subjects (at least 50% of the total programme) and a work placement of between 12 and 22 weeks, depending on the qualification. In the first year, basic skills (French language and mathematics) are combined with a set of skills common to 14 occupations. The second year is devoted to career guidance and project-based individual or collective multidisciplinary work. This 2-year programme leads to an EQF level 3 professional skills certificate (*certificat d'aptitude professionnel*, CAP), which certifies the student as a qualified worker in 180 specialisations in industry, commerce and services, and nine specialisations in the agricultural sector.

The 3-year programme also requires students to complete an apprenticeship leading to an EQF level 4 vocational baccalaureate (*baccalauréat professionnel*) or Bac Pro, which provides qualifications in 100 occupations. The Bac Pro also provides access to advanced technical programmes. Graduates with a CAP or Bac Pro may follow a 1-year programme to obtain a specialisation certificate (*mention complementaire*), at EQF level 3 in 20 specialisations or level 4 in 30 specialisations. CAP graduates can also follow a 2-year programme to obtain the EQF level 4 qualification. Upon completion of a Bac Pro programme, students receive a vocational baccalaureate and are qualified for entry-level positions in their chosen field or can continue their education with a specialised vocational degree such as the BTS.

The Higher Technician Certificate (*Brevet de technicien supérieur*) or BTS at EQF level 5 is designed to help students enter the labour market immediately and is organised around competence units. BTS programmes are designed to provide students with the technical skills and knowledge needed for specific professions, such as business, engineering, health care, and information technology. Upon completion of a BTS programme, students receive a Higher Technician Certificate and are qualified for entry-level positions in their chosen field or can continue their education with a specialised university degree. The BTS programmes are offered by public and private vocational schools and are recognised by employers and universities. BTS degrees are one of the most common pathways for many of the CEIFS students as many of the programmes are related to technically-oriented programmes.

PROFESSIONAL BACHELOR PROGRAMMES

Professional bachelor's degrees are at EQF level 6 (*licence professionnelle*). These vocational programmes are delivered through universities and aim to ensure the immediate integration of students into the labour market. There are 173 specialisations (*mentions*) in a variety of sectors, including agriculture, industry and commerce or social services. Students work on theoretical and practical subjects with a compulsory work placement and an individual or collective project (*projet tutoré*) accounting for at least one third of the total credits of the programme. As with most bachelor's programmes, the total duration is usually 3 years. There is a degree of flexibility in that students in professional reorientation can have their previous academic or professional learning recognised when enrolling in a professional bachelor's programme. Thus, it is also possible to complete the programme in 1 or 2 years, depending on how the adapted programme is organised (60 or 120 ECTS points). Students who graduate with a professional bachelor's degrees can also continue with a master's degree in the same field of stud.

UNIVERSITY BACHELOR OF TECHNOLOGY (BUT)

The university bachelor of technology (*Bachelor universitaire de technologie (BUT)*), which was introduced in 2021/22 as part of the professional bachelor pathway reform, offers an EQD level 6 degree. These degrees are part of the public higher education sector and, in the case of the CEIFS, are delivered in partnership with the Institutes of Technology (IUTs) located throughout the Région Sud. These courses are more accessible to students living in areas further away from the main institutions involved in the CEIFS. University Bachelor of Technology students are selected from general and technological baccalaureate degree holders. Two thirds of the BUTs are defined by the national

framework curricula and one third can be adapted to the social and local economic environment and/or the learning needs and pathways of the students. BUT programmes include a project assignment of 600 hours and a work placement of between 22 and 26 weeks.

The structure of the VET system in France is designed to allow for progressive specialisation and individualised pathways such as those for bachelor or BTS graduates undergoing professional reorientation to enter a bachelor or BUT programme. Graduates can also enter a professional master's programme that builds on the undergraduate degree.

PROFESSIONAL MASTER PROGRAMMES

Professional Master's programmes are offered by public or private higher education institutions in the fields of engineering, business and management. Master's degrees require a 120 ECTS credits over four semesters. To be admitted, a student must have a bachelor's degree or a validation of prior learning (*validation des acquis de l'expérience (VAE)*). Courses include theoretical, methodological and applied elements, as well as including one or more work placements. They also require scientific research such as the completion of a dissertation or other original research work. Students must also have good working knowledge of a foreign language. A Master's degree (EQF level 7) provides access to high-level jobs that requires 5 years of post-baccalaureate education, as well as access to doctoral studies.

ANNEX B: CASE STUDY BACKGROUND

This report is based on desk research, seven group interviews and several individual interviews with a range of stakeholders involved in the CEIFS. As mentioned below, the interviews were conducted with the management, teachers and students from the relevant educational institutions, and with representatives from the regional government and enterprises in partnership with the CEIFS. Several one-on-one interviews were also conducted with the Director for Communications, Marketing & External Relations of the Association Campus d'Excellence Industrie du futur – Sud.

INTERVIEW PARTICIPANTS

Group interviews with teachers/ trainers/learning designers:

- Several group interviews were conducted at different locations (see below) with the following interviewees:
  - a trainer from BTS Electrotechnics at the UIMM Sud Training Centre, Istres;
  - a university professor at Arts et Métiers (ParisTech) - Director of GIS Smart, Engineering School Arts et Métiers, Aix-en-Provence (Grande École / University);
  - an educational engineer, Engineering School Engineering School Arts et Métiers, Aix-en-Provence (Grande Ecole / University);
  - an educational engineer for digital training and learning designer and producer of hybrid and distance e-learning courses at Arts et Métiers, Aix-en-Provence (Grande École / University);
  - an engineer at the high school seconded from STMicroelectronics, Marie Madeleine Fourcade High School, Gardanne;

- a teacher in engineering sciences (also in charge of international relations) at Jean Perrin High School, Marseille;
- a teacher at the BTS CPI and lecturer for the bachelor's projects in digital engineering, Jean Perrin High School, Marseille.

The group interviews focused on pedagogy, digital tools, and the conditions for good digital teaching by drawing on the experiences of teachers, learning designers and professors. At the Grande École, the Engineering School Arts et Métiers, Aix-en-Provence, two learning designers were interviewed, in addition to the lead professor in the programmes related to the CEIFS. At the UIMM Sud Training Centre in Istres, one teacher presented the smart city systems and digital learning equipment for engineering and robotics, and discussed the research question. The UIMM Sud Training Centre in Istres also presented an external consultant who supports teachers and the administration. At the Jean Perrin High School, Marseille, the teacher in charge of the course for the students involved in the research was interviewed, along with a teacher who spends half of his time teaching and half of his time working on administrative and outreach issues at the Association Campus d'Excellence Industrie du futur – Sud.

Group interview with the management

- The interview was conducted with:
  - the Director for Communications, Marketing & External Relations, Association Campus d'Excellence Industrie du futur – Sud;
  - the Research and Development Manager, Training Center UIMM Sud, Istres;
  - the Director for Communications and External Relations, Training Center UIMM Sud, Istres;
  - the senior consultant for professional training (working with the UIMM Sud – Istres Training Centre, for example on the inSitu digital learning management system);
  - the Director for Professional and Technological Training, Marie Madeleine Fourcade High School, Gardanne;
  - the Teacher of engineering sciences (also in charge of international relations) at the Jean Perrin High School, Marseille;
  - the President Association Campus d'Excellence Industrie du futur – Sud;
  - the Director of the Jean Perrin High School, Marseille;
  - the Director of Professional and Technological Training, Jean Perrin High School, Marseille.

The group interview with the management focused on CEIFS' approach to governance, resources, networking and the focus on digitalisation and workforce skills.

Group interview with regional government:

- Interviewees were:
  - The Director for International Relations at Région académique Provence Alpes Côte d'Azur, (Regional Academic Directorate for European and International Relations and Cooperation – Marseille)
  - a representative from regional government responsible for the Campuses of Trades and Qualifications and strategic partnerships in Région Sud.

The CEIFS has close links to the regional educational authority (the Rectorat) and the regional government for the Région Sud / Provence Alpes Côte d'Azur region and the interview focused on the links and resource support for CEIFS from the regional authorities.

Group interview with students:

- The group interviews were conducted at several educational partner institutions (see below). The following students were interviewed:
- apprentices and trainees, Training Center UIMM Sud – Istres, Marignane;
- a student at the Engineering school Arts et Métiers, Aix-en-Provence;
- students at the Marie Madeleine Fourcade High School, Gardanne;
- students, Jean Perrin High School, Marseille.

The group interview involved groups of three students enrolled in the different educational institutions under the CEIFS umbrella, with the exception of the Engineering School Arts et Métiers, Aix-en-Provence, where one student, formally representing the student body, was interviewed. The students talked about the online learning platforms, and the software programs and technical equipment that they use, the benefits and challenges of digitalisation, the digital skills they have acquired, etc.

Group interview with (internal and external) partners:

- An engineer with responsibility for Industrial Strategy & Innovation at TEAM Henri-Fabre, Marignane;
- the Operational Director of TEAM Henri-Fabre, Marignane;
- the Vice President and Head of Social Policies and Industrial Relations/Head of Human Resources France of Airbus Helicopters Division – Airbus Group;
- the Regional delegate PACA & Human Resources Airbus Helicopters Division – Airbus Group;
- the Human Resources International Coordinator, Airbus Helicopters Division – Airbus Group;
- the HR Group Programme Manager for STMicroelectronics in charge of the microelectronics/electronics sector development of CEIFS;
- the Head of the International Relations Mission of the Center for Studies and Research on Qualifications.

The group interview with internal/external partners was conducted with, among others, representatives of two companies — Airbus Helicopters, full partner within the CEIFS, and STMicroelectronics, which does not have full partner status in the CEIFS Association, but is part of its Board. The interviews were conducted at different locations. An additional group interview was conducted with a member of the

research body on qualifications, which is also a member of the CEIFS Board.

In-depth individual interviews:

- Several individual interviews were conducted with the Director for Communications, Marketing & External Relations, Association Campus d'Excellence Industrie du futur – Sud.

CEIFS has a very lean structure with two full-time staff — one part-time advisor and the President who is also a member of the Board of Directors of the EDF energy company and President of the Mediterranean Industry Association. The Director General of CEIFS had to be excused from the study visit at the last moment due to a private matter.

The Director for Communications, Marketing & External Relations, Association Campus d'Excellence Industrie du futur – Sud, spent four days transporting the ETF representative and the DTI researcher around the region, as meetings were scheduled in seven locations for a total of four to discuss CEIFS in-depth in one-on-one interviews on a wide range of topics.

CASE II

HELSINKI BUSINESS COLLEGE, FINLAND

1. HELSINKI BUSINESS COLLEGE

The Helsinki Business College (HBC) is located in two buildings in Pasila in the Finnish capital, Helsinki. The school, which has 3 200 students and 135 staff, offers programmes in business and information and communication technology (ICT). The HBC is the largest Finnish college teaching subjects in these fields. The school has an annual turnover of approx. EUR 18 million.

The Helsinki Business College Ltd is a limited liability company owned by the Helsinki Chamber of Commerce and the Finnish Business College Foundation. Its purpose is to provide secondary vocational education and versatile training to meet the needs of the business community in the metropolitan area. HBC's mission is 'To be a place where future professionals grow' and its vision is 'The best learning partner for your future'.

FIGURE 7. HELSINKI BUSINESS COLLEGE

Image: DTI

1.1 INTRODUCTION TO THE DIGITAL TRANSITION AT HBC

The Helsinki Business College is a pioneering vocational education and training (VET) provider in the digital transition. The school has been using learning management systems for more than a decade to organise teaching and learning activities and, after COVID-19, has also taken a big step into digital pedagogy and the use of digital learning tools and content. This has led to the HBC taking on the role of coordinator for the national requirements for VET ICT programmes.

Today, the HBC strives to use digital pedagogical methods to make teaching and learning as relevant, flexible and engaging as possible for both young students and adult learners. Moreover, it has been continuously involved in the development of digital development to expand the school's digital profile and enhance the digital skills of its teaching staff.

This case report describes evolution of the digital transition at the HBC, as well as signature digital activities and initiatives of the institution.

1.2 VET IN FINLAND

The official goal of Finnish education policy is to ensure equal educational opportunities for all and to further ensure that everyone complete at least upper secondary education. About half of the students who complete their basic education continue to upper secondary VET education. Beyond the young, continuous competence development is a key element in Finnish VET, with more than half of VET students aged between 20 and 60 years (Finnish Ministry of Education and Culture, 2019a).

The national and local authorities are responsible for funding VET as part of the national budget. Workplace-based VET is also publicly funded. Except for learning materials, VET is free of charge to students, who are also entitled to free meals and subsidies for school transport. Students may be charged a reasonable fee for further and specialist qualifications. Full-time students can apply for student grants and loans (ibid).

VET also has a very positive public image in Finland. 84% of Finns said that they had a positive opinion of VET in 2019, and 96% agreed that people in VET learn skills that the employers need. Furthermore, 84% of Finnish VET students said that they were very satisfied with their studies (compared to an EU average of 72%). In terms of continuing education, 64% of Finns agreed that it was easy to continue from VET to higher education (compared to an EU average of 54%) (Cedefop, 2019a).

2. MANAGEMENT AND ORGANISATION OF THE HELSINKI BUSINESS COLLEGE

Before exploring how the HBC uses digital tools in teaching and the organisational aspects of its work, it is important to take a step back and review the institution's fundamental approach to digitalisation and the digital transition.

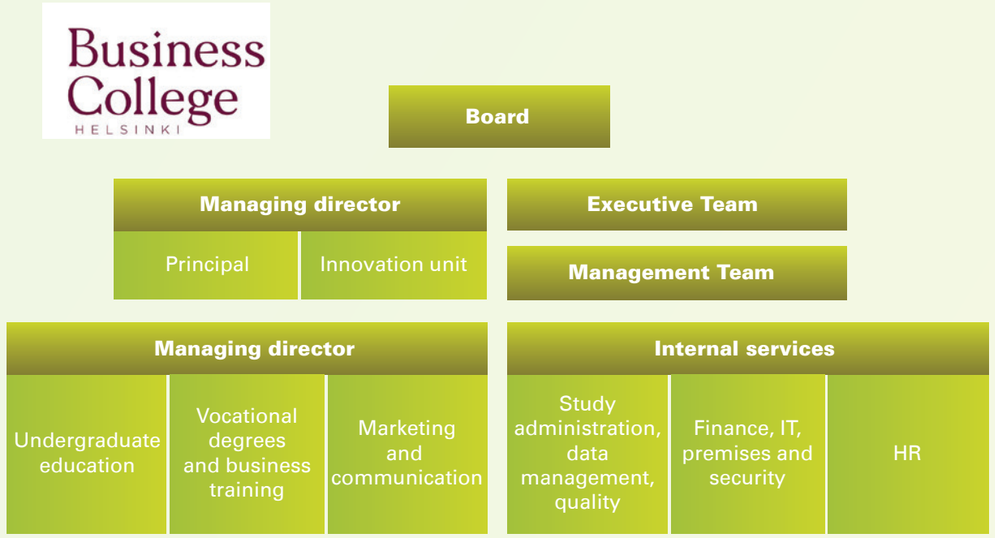
HBC's leadership insists that digital is a tool and never an end in itself. Digital activities are only implemented to the extent that they add value for the school's students, staff or external stakeholders. It is a testament to the success of HBC's digital transition that the college has found different ways to implement digital tools to strengthen the learning environment, facilitate relationships with businesses and make it easier to organise teaching.

2.1 ORGANISATIONAL STRUCTURE

HBC is governed by a school board whose members represent important societal stakeholders. There are members from the Helsinki Regional Chamber of Commerce, from the Finnish Chamber of Commerce, from the Finnish Institute of Occupational Health, from the Confederation of Finnish Industries and Microsoft Finland. The school is supervised by the Finnish National Education Agency.

The organisational structure of the school's management is shown in Figure 8. The implementation of digital strategy, including participation in international digital projects such as the DIHUB, is managed by the Innovation Unit.

FIGURE 8. ORGANISATIONAL STRUCTURE OF THE HBC



Source: Helsinki Business College, internal document

2.2 MANAGEMENT OF DIGITALISATION

Ultimately, the responsibility for HBC's digital transition rests with the school's principal. Digitalisation is one of the five core areas of HBC's main strategy, which deals with the process of digitalisation and the handling of issues related to digitalisation. HBC also has an innovation unit that is responsible for the overall project management of the most advanced digitalisation projects.

HBC's main strategy, including its strategies for digitalisation, is updated annually. There is no separate budget for the digitalisation strategy. It is monitored annually in a special development evaluation session where the results of the previous year are presented and the current issues (including digitalisation) are discussed. HBC's strategy for future digitalisation follows this model of annual review.

Looking ahead to the next 5 years of digitalisation, HBC expects hybrid and online teaching to become more important. In addition, the demand for other services related to VET providers, such as employment services, is growing and requires cloud-based solutions. Against this background, the HBC expects that intelligent AI features will increasingly become part of digital processes.

2.3 AUTONOMY

HBC follows national guidelines for learning outcomes of courses and training programmes. However, these guidelines still leave HBC with a lot of room to do things in its own way. For example, HBC management considers itself autonomous in terms of the learning management systems used by the school, the digital learning content of courses and training programmes, the digital tools used and taught, and the digital pedagogy in general. 'Wilma' is a mandatory nation-wide online program that deals with formal aspects of student information, as described in section 4.2.1. Otherwise, VET providers are free to use the software they prefer.

Because of HBC's positive experience with the digital transition — and because it is the largest ICT qualifications VET provider in Finland — the school is now the coordinator for national requirements in VET ICT programmes. This means that HBC staff help formulate the national guidelines for IT VET in Finland. In this way, HBC is able to test new digital tools and approaches to digital pedagogy that can then be implemented nationally.

2.4 FUNDING AND ACQUISITION

The financing of the basic IT infrastructure is part of the IT department's budget, together with laptops, cloud services, service platforms etc. The IT department collects the needs of all HBC units for the next year in the budgeting process. In

addition, each department has its own budget from which additional resources for digitalisation can be allocated if a need arises. This is also done on an annual basis, and the final decision on the budget is made by the Board of the school.

2.5 THE IMPORTANCE OF HARDWARE

Both students and teachers agree that the perhaps the most important factor in HBC's digital transition relates to physical hardware. When students begin their studies at HBC, they are given a personal laptop. During their studies, the laptop is the property of HBC, but once they have obtained their qualification, the students take ownership of the device.

The laptops are pre-installed and students also receive free licences for Microsoft 365 (also known as Microsoft Office). The software is provided by Microsoft free of charge for educational purposes. When they graduate, the school deletes these programmes from the laptop as it cannot pass on licences to third parties.

These laptops are a cornerstone of the digital transition at HBC. They put all students on an equal footing and provide equal access to all of the school's learning management systems and digital tools. In addition, by licensing and installing of key software from the outset, students can focus immediately on learning how to use these programs.

The computers are paid for by HBC through the funding the school receives from the government, but it is HBC's own decisions on the allocation of these resources.

2.6 ORGANISATION AND TRAINING OF TEACHERS

Teachers at HBC are organised in six teaching teams based on the subjects they teach. Within these teams, teachers help each other develop pedagogical solutions, including digital solutions. As teachers face similar challenges, peer learning is an important part of strengthening digital pedagogy.

HBC's human resources department oversees digital literacy training. The HBC has outsourced this service to external providers who offer digital literacy courses online. Every employee is offered the opportunity to receive training. Supervisors agree on training needs and activities during their annual individual meetings with all employees who are encouraged to use new digital tools in their work.

The key to HBC's continuing digital transition is to keep teachers interested in new digital solutions and eager to develop their own skills. Due to the high demand for ICT experts in Finland, it is not easy to recruit qualified teachers in ICT subjects, as the school cannot match the higher salaries offered in the private sector. Rather than recruiting new digital skills, it is therefore important to continuously develop the digital skills of existing staff.

An important way to keep teachers engaged and open to the digital transformation and new digital solutions is through development projects, such as DIHUB, described in section 3.9, and national competitions, such as the national skills competition 'Taitajaa'[10].

10 For more information on the competition, see: https://taitaja2023.fi/en/

These projects increase motivation and provide motivation for the school to spread and be recognised for its excellence. Teachers also learn from businesses through regular interaction with them during students' work placements and when businesses contribute to teaching at HBC, as described in Chapter 4.

2.7 DIGITAL SUPPORT

Digitalisation depends on its support system. At HBC, digital support takes two main forms.

Among HBC staff, 'main users' are designated for all common programmes (the innermost circle in the onion model) and some programmes used for specific tasks (circle 2.a. in the onion model). These key users keep up to date with their designated software programme and can provide guidance to other staff members. They thus become the local point of contact for IT challenges relating to specific programmes. The main users have time allocated for this task. This is reflected in their work plan, which is agreed to by their supervisor.

For students and for more general IT issues, HBC has a helpdesk, which is open Monday to Friday from 9am to 3pm and provides telephone and email support during the same hours. The students who run the helpdesk are not paid, but the job serves as an exercise

FIGURE 9. A VISIBLE SIGN MARKS THE LOCATION OF THE IT HELPDESK

Image: DTI

that can be incorporated into their studies. There are teachers who monitor the activities.

In addition to supporting students and staff, the IT helpdesk serves as a learning environment for ICT students, where digital services are developed and innovated for the different projects. For example, the final outcomes of the DIHUB project are maintained and further developed with the help of the IT helpdesk students and the supervising teachers.

The students interviewed underlined the importance of the existence of the helpdesk. As more elements of teaching become digitalised, students need quick access to IT help when problems arise.

In addition, students are served by the artificial intelligence-based chatbot BCbotti following a series of pilots launched in the autumn of 2022. The chatbot can answer basic questions and direct students to further information.

2.8 A DIGITAL PHYSICAL ENVIRONMENT

The HBC seeks to inspire students to engage with various digital tools both in class and in their free time.

For example, HBC has a studio room fully equipped with microphones, a mixer, headsets and other equipment, all installed in a casual room with a couch and colourful decor. These facilities can be used to record

FIGURE 10. STUDIO ROOM AT THE HELSINKI BUSINESS COLLEGE

Photo: DTI

podcasts—either as an assignment for a class, or in students' spare time as hobby projects. In this way, the HBC facilities independent learning among students by providing them with digital hardware that they might not otherwise have access to.

The HBC also has a gaming room equipped with a gaming desktop PC with two monitors, a headset, remote controls for video consoles, beanbags to sit on, and a variety of trinkets with pop culture references to phenomena such as Star Wars and Minecraft. The room is designed to allow students to relax and play with digital tools while situated in a fun and different environment that supports rather than stigmatises gaming culture.

Finally, the HBC has installed several office phone booths around the campus. These acoustic phone booths encourage users to make video and phone calls at any time without having to find a quiet room or leave the building. Acoustic phone booths are also small enough to be used in normally wasted spaces such as corridors or under stairs. Teachers can use them for short meetings, digital student consultations, or even for classroom teaching to relieve some of the pressure on physical facilities for distance learning.

FIGURE 11. GAME ROOM AT THE HELSINKI BUSINESS COLLEGE

Image: DTI

FIGURE 12. ONE OF THE SEVERAL OFFICE TELEPHONE BOOTHS ON CAMPUS

Photo: DTI

2.9 DIGITAL PROJECTS – DIHUB

The HBC has been active in applying for European funding in order to develop the skills of teachers, improve the quality of digital pedagogy, strengthen the school's network with other VET providers and relevant businesses, and to position HBC as an international leader in the digital transformation of VET. HBC's efforts to support these digital projects were initiated by the school itself, according to HBC management. It is not something that has been imposed on the school by the Finnish government.

The DIHUB, an EU-funded development project initiated and coordinated by the HBC, was implemented over the period 2019–2023. It was one of the first five pilot projects funded, which received funding under the new initiative of the Centres of Vocational Excellence in 2018. The DIHUB comprised of a cluster of five interconnected nodes with 11 partners, including the HBC, together with other higher education institutions and SMEs.

The DIHUB revolved around the creation of a digital platform with courses and networking tools for students related to cloud computing and cloud technology. These courses and tools include but are not limited to cloud technology skills, cloud computing job opportunities, and IT development tools for cloud computing. In short, the product of DIHUB was a platform full of digital resources for learning cloud-related topics, intended for use by other VET providers in Finland and internationally.

An example of the role of the DIHUB platform role in learning and teaching was the funding of a practical business project for students. The students developed a cloud service using Microsoft 365 for a company that runs restaurants in Porvoo and Tammisaari. The aim of the project was to develop a cloud-based system for the company that would reduce the use of purchase invoices, receipts, contract forms, order confirmations, sticky notes, PDFs, and image files.[11]

11 See 'Restaurant company takes the leap into the cloud with the help of students', DIHUB Website, https://dihubcloud.eu/2021/12/21/restaurant-company-takes-the-leap-into-the-cloud-with-the-help-of-students/

FIGURE 13. ROLL-UP PROMOTING THE DIGITAL INNOVATION HUB

Photo: DTI

The DIHUB platform also contains tools for SMEs and teachers, such as digital education and training, networking with VET providers, and DACUM analysis.[12]

The DIHUB-project's platform is the first service platform to provide cloud technology services to VET providers (secondary and higher education), learners and SME's globally. At the end of the project, an ICT teacher from HBC was selected to continue to maintain and develop the service platform together with two students from the ICT programme. Several digital twins of the service platform have been created by HBC staff, where students can develop and test new features. If these student projects prove useful, their features can be integrated into the main version of the service platform and become a standard part of it. In this way, DIHUB is both a digital content platform and a digital learning tool, as students can interact with it and practice their own computing skills through the platform. The service platform uses a Microsoft SharePoint solution. As HBC uses Microsoft products and services, Microsoft provides the platform free of charge to educational institutions.

The DIHUB is a key way for HBC to disseminate its excellence in digital transformation. Other secondary and higher education institutions at international level have recognised the DIHUB as a unique service platform and shown interest in its creation, maintenance, and update. The HBC has applied for EU funding to continue the DIHUB project. The aim is to extend the initiative to data management and data analysis via the cloud. This application is supported by 17 partners.

12 See https://dihubcloud.eu/activities-and-results/

2.10 ORGANISATIONAL LEARNING AND DISSEMINATION

The HBC learns about new approaches and digital tools through national and international networks, especially in projects where digitalisation is the core element. In addition, the HBC shares a campus with the University of Applied Sciences, and this geographical proximity supports the collaboration between the two institutions. For example, the University of Applied

Sciences was one of the key partners contributing to the DIHUB project.

HBC disseminates its knowledge and excellence in many ways. HBC's role as initiator of new development projects in the area of digitalisation, similar to DIHUB, is one way of disseminating excellence. In addition, when development projects are underway, social media and special hashtags are used to draw attention to the digital activities. In addition, HBC has channels to the Finnish National Education Agency to inform it about the latest developments at the college. This helps to spread HBC's experience throughout the country.

3. DIGITAL CONTENT AND PROGRAMMES

The HBC offers vocational upper secondary qualifications as well as further vocational qualifications, specialist vocational qualifications and short courses. An overview is set out in the tables below.

The **two basic qualification programmes** are the Vocational Qualification in Business and the Vocational Qualification in Information and Communications Technology. Both programmes are taught in Finnish and English for young and adult students. The table below shows the list of specialisations that the students in these programmes can choose from:

TABLE 1. OVERVIEW OF SPECIALISATIONS IN THE TWO BASIC QUALIFICATION PROGRAMMES AT HELSINKI BUSINESS COLLEGE

VOCATIONAL QUALIFICATION IN BUSINESS	INFORMATION AND COMMUNICATIONS TECHNOLOGY
Marketing & content production	Game programming
Projects/events/service design	Web programming
Sales/logistics	Cyber specialist
Financial services	IT support
Financial management services	Cloud IT support
Entrepreneurship	

In addition, the HBC offers a range of **further vocational qualifications** and **specialist vocational qualifications,** as summarised in table 2:

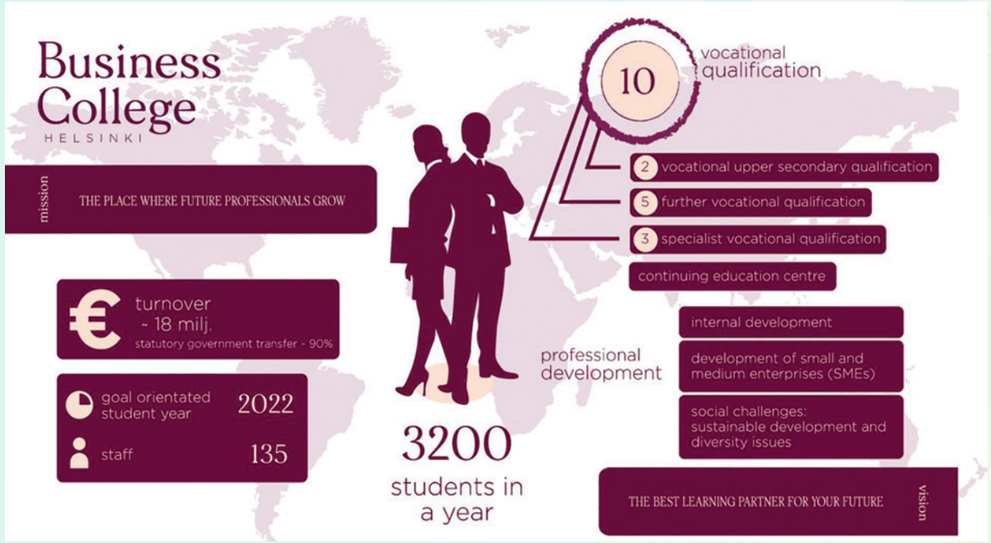
TABLE 2. OVERVIEW OF FURTHER AND SPECIALIST VOCATIONAL QUALIFICATIONS AVAILABLE FROM THE HELSINKI BUSINESS COLLEGE

FURTHER VOCATIONAL QUALIFICATIONS	SPECIALIST VOCATIONAL QUALIFICATIONS
Financial management (with five different paths) Sales and marketing Professional qualification for immediate supervisor work	Leadership and Business Management Leadership and Business Management in Cyber Security Specialist vocational qualification in Financial Management Specialist vocational qualification in Human Resources Specialist vocational qualification in Information and Communications Technology

Finally, HBC offers the following **Short Courses** that can subsequently be taken in order to obtain a qualification:

- Coder Training, Angular & Net (in Finnish)
- Coder Training, Java & Angular (in Finnish)
- Coder Training, React & Drupal (in English)
- Cloud service specialist (in Finnish)
- Training in identity and access management, IAM, (in English)
- Preparatory Vocational Course for further study at the Universities of Applied Science.

FIGURE 14. TRAINING PROGRAMMES AT HELSINKI BUSINESS COLLEGE



Source: 'Helsinki Business College in a Nutshell', Helsinki Business College, hand-out, 29 September 2022

3.1 DIGITAL SKILLS – THE ONION MODEL

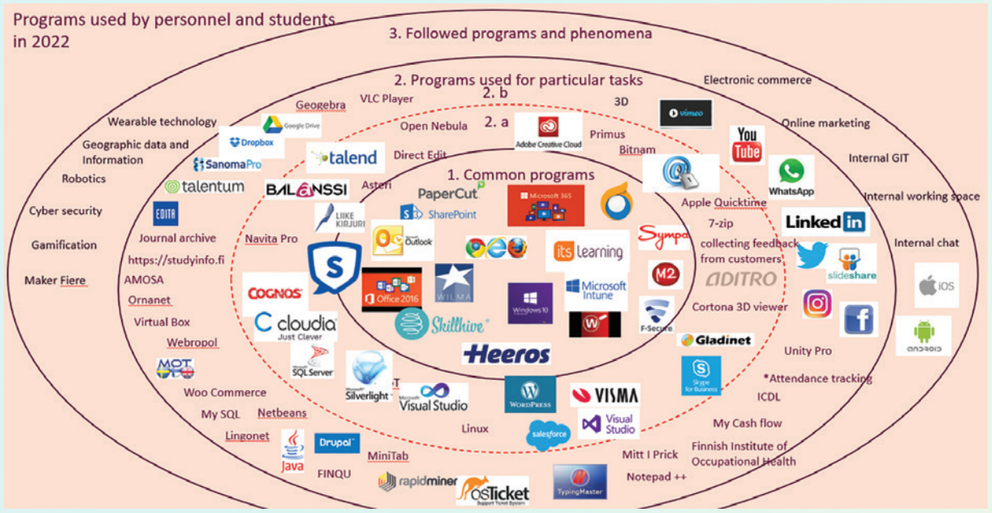
HBC's approach to digital skills relating to specific software programmes can be visualised in an onion model.[13] The IT department has designed and presented the model to the managing board.

The innermost circle of the onion model contains the '**common programmes'** used by everyone, both students and staff at the HBC. These are the basic working tools (e.g. Microsoft Office), as well as HBC's learning management systems and national systems. Everyone must have basic knowledge of how to use these programs, and the HR department organises training in their use.

The middle circle contains '**programmes used for specific tasks,**' as described in section 2.b. Employees have the opportunity to be trained in the use of these programs. For the programs in section 2.a, technical support is provided by the school's IT department and user support is provided by the school's designated main user — a member of staff who is given special responsibility and time for a particular digital tool. For the programs in section 2.b., technical support is the responsibility of the user himself/herself and there is no main user support on campus.

13 The information below is based on the hand-out entitled The Onion Model of Programs Used at BC Ltd of the Helsinki Business College, dated 30 September 2022.

FIGURE 15. HBC'S ONION MODEL OF DIGITAL PROGRAMS



Source: 'The Onion Model of Programs Used at BC Ltd', Helsinki Business College, hand-out, dated 30 September 2022

The outermost circle contains the '**Followed programmes and phenomena'.** These are interesting software and trends that may move closer to the core of the onion in the future. Everyone follows the new software, trends, and phenomena to the extent required by their work tasks and needs. The testing of software is agreed on with the school's IT department, but there is no technical main user support. Training in a specific programme is agreed with the supervisor of a particular member of staff.

Supervisors and the IT department are responsible for evaluation and approval, wherever a programme is to move from one layer to another. This process, however, is usually initiated by a teacher who discovers and tries out a new digital tool and then proposes its wider implementation.

HBC staff use the metaphor of an orchestra to describe the onion model. There are certain 'instruments' that are mandatory in an orchestra. These are the common programmes. But individual members of the orchestra can also bring new instruments into the orchestra to play a solo or decide whether the new instrument should be incorporated into the orchestra's ensemble.

3.2 DIGITAL TOOLS IN TEACHING

One of the first tools young students at the HBC are introduced to is the basic Microsoft Office suite, which is both a learning tool and a tool used in industry: MS Word, Excel, and PowerPoint. Students are introduced to these digital tools at a relatively advanced level as they are used in most subjects taught. Students in business programmes learn these tools through a dedicated course called 'Tools for Work'. There is no specific tools on these tools for adult students.

The HBC strives to make its teaching as practical and close to real-life business as possible. This means that students use the same digital tools as those used in the industry, such as Photoshop, Canva, and InDesign for graphic presentations, and social media, and Instagram or TikTok for promotional products. The students interviewed said that they were impressed with the way the HBC tries to make the exercises feel real by using the same digital tools as those used in industry.

The specific digital tools taught depend on the subject. Some courses, for example short-track courses, focus on specific IT languages. Others are more open to digital tools, and the choices made will depend on the teacher team. Teachers have autonomy in choosing the digital tools they consider most appropriate for their classes. As mentioned before, the general rule is to make the classes as close to reality as possible. Teachers therefore use the same digital tools as those used in industry whenever possible.

Chapter 4 describes in more detail how the digital tools are incorporated into the broader framework of digital pedagogy at the HBC.

4. PEDAGOGICAL APPROACH

The digital transition is evident in many different aspects of pedagogy at the HBC. Digitalisation can be seen in both the tools used for teaching, the digital learning content of the courses, and in the ways in which the HBC connects with external partners, namely companies.

4.1 COVID-19 AND BEYOND: LEARNING DIGITAL TEACHING

Like so many other schools, teachers at the HBC were thrown headlong into remote teaching when the COVID-19 lockdowns hit. At the time, there was little guidance on how to best teach digitally as few teachers had any experience. The mantra was 'just do your best and make it work', which led to a trial-and-error approach.

In retrospect, teachers and management wish that more effort had been put into staff development in relation to distance learning. A more thorough discussion of the issue, including the challenges of digital pedagogy, could have resulted into stronger teaching and a more cohesive staff.

Today, teachers at the HBC have a high degree of autonomy in their digital pedagogy. The school does not have a teaching strategy for digital pedagogy for teachers to follow. This underlines the importance of an ongoing dialogue between teachers and between management and teachers in relation to digital transition. New, digital ways of working require adaptation by all staff. Staff dialogue is important to ensure a coherent approach and share best practice. A high degree of staff autonomy allows teachers to both learn from each other and enjoy the freedom to design their classes as they see fit.

4.2 LEARNING MANAGEMENT SYSTEMS

The HBC uses several learning management systems to organise teaching and interaction with students. The systems that students engage with are collectively referred to as the 'e-campus.' This term includes 'Itslearning' (described below), the students' intranet, and its mobile version, 'Tuudo'. All the instructions, services, links, materials, events and other news, HBC's social media feeds and student stories are collected in the students' intranet and Tuudo. The two learning management systems are tailored to HBC's needs in collaboration between the responsible process owner (HBC staff) and the external service provider.

The management of HBC highlights two advantages of implementing learning management systems from a management perspective. Firstly, having all the documents in central learning management systems makes them much easier to access and organise. In this way, digitalisation saves staff time. Secondly, digitalisation saves a lot of paper, which helps the HBC in its efforts to become a greener office.

The learning management systems also facilitate communication within staff teams, between management and teachers, and between management/ teachers and the students. Digitalisation also means that documents are less likely to be misplaced, and all parties always have access to the communication history.

However, teachers and students have also identified a challenge: HBC's use of multiple learning management systems, as described below, can sometimes be confusing. Many LMSs have built-in communication services, which means that students may find themselves communicating with their teachers on several different platforms at the same time, with different types of communication on the different platforms. For example, formal paperwork and personal information may be handled in one system, which is more secure, while informal feedback or questions between teacher and student may be handled on another. In addition, different teachers tend to prefer different communication channels.

4.2.1 WILMA

Wilma is the Finnish national study management system for students, teachers and parents. In Wilma, students plan their studies, choose their courses, access grades and credits, report absences from school, read announcements, and communicate with teachers. Teachers plan and grade studies, register credits and absences, and communicate with the students and their parents. Parents access the study credits of their children (or other dependants), monitor and report absences, communicate with teachers and read messages and announcements from the school. Workplace supervisors monitor and report the progress of their students and communicate with teachers. The system uses processed information for planning the studies and curricula and for reporting statistics. Wilma is also the user interface for booking classrooms and meeting

rooms.[14] In addition, students can use Wilma as a catalogue of workplace opportunity.

In 2020, Wilma was used by 98% of all Finnish elementary schools and nationwide for general upper secondary school enrolment.[15]

4.2.2 ITSLEARNING – HBC'S WEB ENVIRONMENT

While Wilma handles the formal aspects of student-institution interaction and administration as described above, Itslearning is the primary tool for teacher-student interaction and the learning management system used by teachers to organise their classes.

Students can log in to Itslearning using their personal Business College credentials, which are the same as those they use to log in to Wilma. In Itslearning students are added to the courses marked in their timetables. Teachers add all assignments and materials to their courses so that students can access all materials in one place. Students can submit assignments on Itslearning, and the teachers grade them online.[16]

Teachers provide students with instructions for Itslearning as students at the beginning of their studies at the HBC. Students can also download an Itslearning app on their smartphones to log in to their own courses, study and complete assignments. The app alerts students when their teacher has updated course content or sent a message.

As an 'e-campus', Itslearning also allows teachers to advise students online and gives students easy access to remote student administration services. The HBC has been using different learning management systems for more than 10 years, and the systems have been continuously developed with new and improved features.

4.3 ONLINE TEACHING PEDAGOGY

Online teaching brings both new opportunities and new pedagogical challenges. Teachers at the HBC have found that these challenges affect both students and teachers.

Students found it harder to stay motivated during online lessons and teachers found it more difficult to keep students engaged. The risk is not only that students pay less attention during lessons, but also that they more generally 'disappear' from the programmes altogether. The challenge is therefore to ensure a continuing sense of connection between the student and the training programme.

For online teaching, this means more activities, more breaks, and more variety. To keep students engaged in distance learning, the teacher needs to switch between different pedagogical tools to ensure that students remain active learners. For example, in marketing classes, HBC teachers instruct students to visit shopping centres and analyse practical examples of marketing on site. In this way, students are motivated by practical exercises and are also physically active.

14 See https://wilma.omnia.fi/

15 See 'Cooperation between school and home, City of Helsinki website, https://www.hel.fi/helsinki/en/childhood-and-education/comprehensive/cooperation/wilma/

16 See 'Itslearning web environment', HBC website, https://en.bc.fi/student-services/learning-environments/itslearning-web-environment/

Age is an important factor in student motivation, HBC' staff have found. Young students are taught as much as possible in physical classrooms during the first semesters of their programmes. In contrast, adult programmes are taught primarily through Microsoft Teams. Adult students are more motivated and distance learning is more flexible. The HBC does not offer hybrid teaching. Classes are either physical or digital, but not both. This choice has been made to tailor teaching to the specific format.

Motivation in digital pedagogy was also a challenge for the teachers. HBC teachers report that it can be demotivating to teach on screen, especially when students do not have their cameras switched on. In addition, working days tend to become more monotonous and longer when both teaching and preparing for teaching are done in front of a screen. Teachers therefore had to consciously introduce more variety in their work to maintain their own motivation as well as a physically healthy working environment.

Another challenge was also to work out where to physically teach remote classes. Remote teaching requires a space that is undisturbed, free from personal effects and with adequate lighting. Such rooms were in short supply at the HBC, and the lack of proper infrastructure to organise teaching locations proved a challenge for HBC's teachers and administration.

One positive aspect of remote teaching is that it is much easier to invite guest speakers. At the HBC, university teachers enhance classroom teaching through the use of Microsoft Teams. The digital format is much more convenient for the external teachers and makes them much more willing to contribute their insights. For students, the university lecturers provide external validation of the material taught, they provide research-based knowledge of the subject areas and they help create variety in the pedagogical methods used.

As remote distance learning offers both new possibilities and pedagogical challenges, HBC faculty have reported the need to think about distance learning and hybrid teaching well in advance. Courses should not simply be moved from off- to online without the underlying pedagogy being adjusted accordingly. When preparing new teaching materials, teachers at HBC now consider how the subject can be taught digitally and what practical exercises might support digital classroom teaching. Excellent distance learning requires that teaching materials are constructed with distance learning in mind. This may require more detailed descriptions of subjects that are not taught in the classroom with the teacher present or more practical exercises to keep students engaged and interacting with each other.

HBC is even piloting a course for adults that is entirely online and where all assignments are done in Itslearning. The course has received many applications and its remote nature allows students to participate from all over Finland, not just Helsinki. The project is still in the pilot phase, but if successful, it could pave the way for HBC to offer more courses that are taught fully online.

4.3.1 ONLINE VIDEOS

Teachers at the HBC now regularly combine 'live' teaching, whether remote or in a physical classroom, with online videos. These videos are usually provided by Itslearning for younger students and

LinkedIn Learning[17] for adult students. LinkedIn Learning is also used for younger students and staff training purposes due to its extensive coverage with more than 17 000 online courses and generally high quality. Teachers can also purchase or create videos for their courses. In general, teachers have their pedagogical independence and can organise their lessons as they see fit.

Using videos from external sources, such as LinkedIn Learning, has several advantages. The videos often have presenters who are well known and highly regarded in their field, and videos can go in more detail on very specific topics that may be of interested to only a few of the students. Teachers can thus target the videos used for teaching purposes to individual students.

The extent to which video is used in the classroom depends on the subject and the number of quality videos available online. It is up to the teacher to decide, but in general the use of online videos at the HBC has been increasing.

One limitation of videos is the lack of communication between teacher and student. Students cannot ask teachers questions about the videos. Therefore, HBC teachers need to take extra care to facilitate student questions when relying on videos.

4.3.2 ONLINE STUDENT COUNSELLING

Digital communication tools can also make student counselling much more flexible, as the student and teacher no longer need to be in the same place. Teachers at HBC describe digital counselling as a great way to improve the availability of student counselling. When it is done digitally, students are more likely to seek more frequent but shorter counselling sessions, which helps to address students' problems quickly. Today, about half of all student counselling sessions are conducted digitally through Microsoft Teams or Zoom.

One of the challenges of the digital transition is the question of availability. With online communication, some students expect teachers to be always available, just as they can message their friends whenever they want to. For teachers, this can be a challenge to a healthy work-life balance. Teachers at the HBC deal with this challenge in different ways. Some HBC teachers have set up online 'office hours', where they are available for student enquiries. At set times each week, they are available in a Microsoft Teams meeting, where students can come and go as they please. Teachers report that students make frequent use this service Some teachers prefer to meet with students on an ad hoc basis, using either Microsoft Teams or even the social messaging and communication application WhatsApp for shorter meetings. Other teachers prefer to answer student questions immediately in writing, regardless of the time of day. This gives the students the information they need quickly, and it means the teacher does not forget to get back to the student later.

The teachers at HBC agree that different approaches to availability can work and that teachers need to find a system that works for them individually. However,

17 LinkedIn Learning is an online skill-building solution by Microsoft that is integrated into the company's social networking platform LinkedIn. See more information on the solution here: https://learning.linkedin.com/

as more communication becomes more digital, finding time to concentrate and focus on tasks becomes more of a challenge due to the many possible interruptions. The increased availability can therefore challenge for teacher's ability to concentrate and work without distractions.

4.4 CLOUD TEACHING

In HBC's ICT programme, cloud technology has become an important topic for teaching and pedagogy. ICT teachers report that the HBC now invests little in any new hardware for teaching. Instead, students interact virtually with virtual machines, such as when programming a digital twin of a particular type of machine rather than having the physical hardware available in the classroom. In addition, instead of using locally stored data, all HBC data is now cloud-based. In this way, both the administration and the pedagogy of HBC use cloud technology.

This emphasis on cloud technology is also seen in HBC's DIHUB project, described in Chapter 3, which helps other VET providers use and teach cloud technology, and helps student find cloud-related job opportunities and development tools. The DIHUB has created a platform of cloud-related materials, which HBC students and teachers are still using today.

The majority of the students indicated that the pilots conducted as part of the DIHUB project were very useful in acquiring new knowledge and skills. Students also indicated that they gained new practical knowledge or improved their existing knowledge related to the use of cloud solutions in their field.

There is a special cloud technology pathway for the ICT students at the HBC. The HBC does not require any additional resources to run the cloud programme itself, as new hardware is not required, but training teachers and collaborating with SMEs does require some additional resources, especially as cloud technology is developing so rapidly. This underlines the importance of having a designated main user among the staff (as described in section 2.7), who is responsible for, interested in and kept up to date with software related to cloud technology.

The HBC involves companies in cloud-related teaching in a number of ways. SMEs provide cloud development projects for the students, as described below. Large cloud technology providers such as Microsoft and Google are also involved in cloud teaching. These companies have produced tutorial videos on their own cloud tools. Some of the basic courses are free, but there is a fee for the more advanced courses that lead to certification.

4.5 COLLABORATION WITH BUSINESS

Just as distance learning enables more guest lecturers from universities, the digital format also makes it easier to get companies to participate in classroom activities. CEOs of various Finnish companies have visited HBC digitally to tell students about their individual stories and their companies. Since CEOs talk to the students about topics they know by heart there is no travel involved, it is easy to get these business representatives to participate in the classroom. For the students, this provides inspiring input and a window into the realities of

business in Finland. Microsoft Teams and Zoom are used to host these meetings.

Digital tools can also be used to facilitate remote company visits. Having an entire class of students visit a company can create logistical challenges in terms of transportation, calendars, and possibly security. At the HBC, students visit companies digitally through guided video tours.

In addition, HBC teachers conduct digital evaluation meetings with workplace instructors to save time. This makes it easier for teachers to stay in regular contact with students' workplaces. When providing information on work placements, businesses use the national WILMA system directly.

Companies' requirements for digital skills and knowledge vary widely. The HBC reports that smaller companies are often less familiar with the digital world and digital opportunities. They are surprised by what they can do with digital tools. As a result, HBC's students often have a better understanding of digital opportunities than the companies they interact or have work placements with. This, in turn, provides companies with one of the most important benefits of having students from HBC in work placements: the students bring new knowledge about digitalisation.

In contrast, larger companies are often more advanced in their use of digital tools. These companies can provide instruction to HBC students (and teachers) in the latest digital solutions and the necessary digital skills. This is highly motivating for the students, as they get a practical insight into the digital skills they need to acquire in order to be relevant to businesses.

Some companies go further in their engagement with HBC and provide students with assignments based on their actual needs, such as marketing a product. Students here use digital tools, either free software (such as the social media application Instagram) or programmes for which the school owns an educational license (such as the design software InDesign) to develop solutions, which they then present to the companies. This type of practical exercise has several advantages. For students, it is a fun and relevant way to learn and to market themselves to companies. For teachers, it provides new inspiration for the classroom. And for companies, the students may come up with solutions that can be implemented. In addition, companies use these projects to identify potential future employees among talented students. This concept was initially developed as part of DIHUB and has become part of the Cloud Technology curriculum. Today, it is today used deliberately in both ICT and business programmes, and classes are planned around it.

For companies, working with the HBC is attractive because it helps provide access to skills, which the companies do not yet have in-house. Providing work placements for students allows the companies to test whether they need certain skills and save money on expensive consultants. When the students bring new and relevant skills to the table, the companies can then hire them.

By working with the HBC, companies also gain access to a network of other companies involved in the digital transition. In particular the DIHUB project has created an ecosystem where business partners can meet each other and representatives from the education sector. Stakeholders can register on the DIHUB service platform. There are plans to create a mobile application for DIHUB to enhance collaboration between stakeholders.

In general, the HBC collaborates with more than 1 000 companies/ organisations in the field of vocational learning and skills demonstration. All contractual aspects of the business collaboration are handled in Wilma.

4.5.1 DIGITAL DIARIES

Students in work placement are instructed to keep digital diaries on the Itslearning platform during their work placement. Students write about their work placement experience once a week, and teachers can read and comment on these diaries. Students can thus stay in touch with teachers during their work placement and receive advice. By using Itslearning, HBC teachers can access all student diaries using a single platform (instead of physical paper or having to sorting through emails) and easily monitor student progress.

5. CONCLUSION – KEY LESSONS FROM THE DIGITAL TRANSITION AT THE HBC

To reiterate the approach of HBC management and teachers to digitalisation: digital tools and approaches should always be a tool for learning, never an end in themselves. In this sense, digitalisation can bring many advantages to VET providers, including in terms of the organisation of teaching, relationships with companies and the material taught.

The programmes taught at HBC are highly regarded in Finland for equipping students with relevant digital skills. This is done by ensuring that the digital tools used for teaching are the same as those used in industry, making exercises feel as real and relevant to students as possible. Digital tools are also used to build closer links with companies and make it easier for them to contribute to teaching, for example through short guest lecturers via Zoom or Microsoft Teams. The key is to reduce the amount of time involved in such collaboration for both teachers and business representatives. Finally, by exploring cloud-based technologies and software programs in the DIHUB platform, HBC has created a vast resource for itself and other VET providers to enrich ICT teaching with cloud-related material.

Digital transition at the HBC was already under way before COVID-19. It had by then been using digital learning management systems for more than 10 years. But the pandemic provided a strong push to more digitalisation, which the school is still adapting to. At the time, the HBC did not have a well-developed strategy in place; instead remote teaching experiences were shared among staff members. Today, teachers have a great deal of autonomy in deciding when and how to use (or not to use) digital tools in the classroom. The key is to maintain an openness towards new digital solutions in line with industry requirements and practices.

All of this requires appropriate hardware and software to be successful. One of the most important, if not the most important, factor in HBC's digital transition is that students are provided with new computers with pre-installed software and are then supported by the school's IT helpdesk. The computers provide equal opportunities to students and assure teachers that all students have access to the necessary material and software for teaching and learning.

On the management side, most decisions about digital tools and investments are proposed by specific supervisors, teams of teachers, the IT department and individual key users of software programmes. These can then formulate their budgetary needs for consideration by the principal and the school board on an annual basis.

All in all, the HBC is a good example of how to manage the digital transition in VET. At the HBC, digital transition is an ongoing process, where new digital tools, platforms, and teaching methods are continuously being developed and tested to enhance the learning outcomes of students and improve the organisational flow of teachers and management.

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ANNEX

This report is based on desk research and a two-day visit to the Helsinki Business College (HBC) in Finland on 3 and 4 October 2022.

As part of the mission, four group interviews were conducted with teachers and management of the Helsinki Business College. Towards the end of the visit, a plenary discussion was held with most of the interviewees.

INTERVIEW PARTICIPANTS

Group interview with teachers/trainers:

- Four teachers were interviewed.

The group interview focused on pedagogy, digital tools, and the conditions for good digital teaching, drawing on the teachers' respective experience, etc. Two of the teachers taught information and communication technology (ICT), and two taught economics.

Group interview with the management:

- The Principal of the Helsinki Business College, the Director of Finance, the Deputy Managing Director and the Development Manager were interviewed.

The group interview with management focused on HBC's approach to both national and EU guidelines on digitalisation, the school's strategic model for digital competencies, digital innovation hub projects, etc.

Group interview with students:

Five international students enrolled in HBC's business programme were interviewed. The students spoke about the software programmes they use, the benefits and challenges of digitalisation, the new digital skills they have acquired, etc.

Group interview with external partners:

- The interviewees were one of the Managing Director at CRnet Oy, an independent consultant (via Microsoft Teams), and a development specialist at the HBC.

The group interview with external partners included representatives from two external companies and one member of HBC management. CRnet Oy has contributed to HBC's green transition efforts by helping the school to measure and report its carbon footprint. CRnet also keeps an online database with sustainability news that is accessible to the students. Ms Päivi Korhonen is an independent consultant who assisted the HBC in the digital hub project and shared some of her external views on the project and its challenges.

Plenary discussion

The plenary session was attended by most of the participants from the previous group interviews and by the representative of an external partner (Earthster) who was unable to attend the previous group interview. Earthster helps organisations conduct life cycle analyses, and the company representative had previously worked with the HBC in a position at the cloud service provider Cloudriven. The plenary discussion topics were broad and focused on the key learnings of the participants and the collaboration between the school and external companies.

CASE III

SHENZHEN POLYTECHNIC, CHINA

1. INTRODUCTION

This chapter contains several sections that provide background information relevant to the case study at hand. First, Shenzhen Polytechnic (the institution) is introduced. Other sections outline the Chinese vocational education and training (VET) system and describe the national policies relevant to digitalisation.

1.1 SHENZHEN POLYTECHNIC

Founded in 1993, the Shenzhen Polytechnic is a large institution comprising 19 faculties, including the *School of Electronic and Communication Engineering* and the *School of Artificial Intelligence*, with more than 1 400 full-time teachers and more than 33 000 full-time students.[18] It has six campuses with a total surface area of 3 006 320 m^2. The institution is primarily funded by the Shenzhen Municipal Government. The institution's annual investment in capital construction and education over the past 3 years has exceeded RMB 2.5 billion, equivalent to more than EUR 3.47 million.

The Shenzhen Polytechnic is a public higher technical vocational education (TVET) institution that offers higher vocational education diplomas equivalent to EQF levels 4 and 5, but no bachelor's or higher degrees.

Located in Guangdong Province, the school has always had a digital approach and mindset. The sections below describe the school's digital initiatives and its pedagogical approach to digital learning.

18 Shenzhen Polytechnic. About SZPT

FIGURE 16. MAIN CAMPUS OF SHENZHEN POLYTECHNIC

Image: Shenzhen Polytechnic

The factors that have helped drive digital transformation at the Shenzhen Polytechnic include:

- A robust and deep collaboration with leading Information and Communication Technology (ICT) companies which, among other things, support the school in identifying relevant and current skills needs, but also provide cases and assignments based on challenges from the real world of work.
- An overarching digital strategy outlined in separate action plans for the digital transformation and artificial intelligence, respectively. These action plans contain specific goals for the whole institution and blueprints for their achievement. They help to ensure that the entire school is aligned with the digital transformation, while maintaining an ongoing focus on developing the digital mindset of teachers, leaders, and students.
- The use of up-to-date equipment and software helps ensure that the programmes offered at Shenzhen Polytechnic are relevant for the labour market, as students are taught to operate the same hardware and software that is used by the leading companies in the industry.
- A pedagogical approach that emphasises practical, hands-on cases and assignments while incorporating elements of gamification.

1.2 VET IN CHINA

In China, the focus on VET was revived the 1980's, with the VET system expanding significantly since then (Benchmarking, Center on International Education, 2015). In 2018, 15.9 million Chinese students were enrolled in secondary VET institutions.[19]

China's formal VET system of China is under the responsibility of the Ministry of Education, while the Ministry of Human Resources and Social Security

19 UNESCO-UNEVOC. Dynamic TVET Country Profiles – People's Republic of China

is responsible for non-formal VET. The Ministry of Education is also responsible for the overall funding of the system. However, new regulations have been introduced that encourage the sharing of financial costs (and benefits) with the private sector (UNESCO-UNEVOC, 2018). The Chinese government has implemented various policy initiatives to incentivise the financial involvement of private actors in vocational education and training. These include tax incentives for enterprises that invest in VET.[20]

A recent reform of the Law on Vocational Education of the People's Republic China has upgraded the status of VET, as the law now emphasizes that VET has the same important status as general education.[21] This is motivated by the fact that it is an important part of the national education system and human resource development, and an important way to cultivate diverse talents, inherit technical skills, and promote employment and entrepreneurship.[22]

The policy reform also meant changing and updating the Chinese educational system. Before the reform, there were two types of junior general secondary schools and junior vocational secondary schools, and two types of senior secondary schools: senior general secondary schools and senior vocational secondary schools.

Students who graduated from junior secondary vocational schools most often became farmers and low-skilled workers, although they can take an entrance exam and continue their education in upper secondary school. However, the most common pathway was for students to enter senior secondary schools after completing junior secondary general school (Benchmarking, Center on International Education, 2015).

After the reform, the distinction between general and vocational secondary schools has been eliminated, while the law now encourages traditional secondary schools to offer courses in vocational subjects.[23] This means that the distinction between general and vocational education only exists in non-compulsory education.

In addition, the educational system offers different pathways to vocational education. The most popular are the specialised vocational upper secondary schools, which offer 3-year certificate courses. This course type is also offered by Shenzhen Polytechnic.

Private sector involvement is a key aspect of China's political strategy to improve and develop the vocational education system.

In recent years, VET development has received more attention from the Chinese government. Official statistics from the Chinese Ministry of Education show that funding for improving the quality of vocational education and training increased significantly from 2014 to 2018 from RMB 1.14 billion to RMB 1.87 billion.[24] In addition, a national action plan from 2014 states that the government aims to create a modern demand-driven VET system by 2020 (Mercator Institute for China Studies, 2015).

However, vocational education in China has faced serious challenges for many years. Among other things, technical and vocational education and training has been perceived as less attractive than an academic degree by young people. An important step towards improving the perception of VET is outlined in China's National Medium and Long-Term Plan for Education and Development (2010–2020). In the plan, the Chinese leadership stresses the importance of a more active role of private enterprises in the VET system in order to provide students with more practical experience (UNESCO-UNEVOC, 2018). This means that different stakeholders, including private enterprises, are encouraged to share the costs and benefits of VET programmes. In addition, the national government has recently increased its focus on adapting VET to the demands of the Fourth Industrial Revolution in order to keep track of the widespread impacts of digitalisation.

In September 2020, the Chinese Ministry of Education, together with other governmental agencies, published the Action Plan for Improving the Quality of Vocational Education, which sets out broad goals for China's vocational education sector for the years 2020–2023. The plan sets out a series of tasks and objectives that are aligned to the five overarching goals for VET in China. The goals revolve around improving the overall quality of VET and the standards for the vocational education system at the national, provincial and institutional level. One of the overarching goals is to establish a chain of responsibility for vocational education that ensures that both government, industry and educational institutions are responsible for VET.[25]

20 See, for example, Koty, 2021.

21 China Briefing, 2022. Vocational Education in China: New Law Promotes Sector's Growth

22 Wiki Source. Vocational Education Law of the People›s Republic of China

23 China Briefing, 2022. Vocational Education in China: New Law Promotes Sector's Growth

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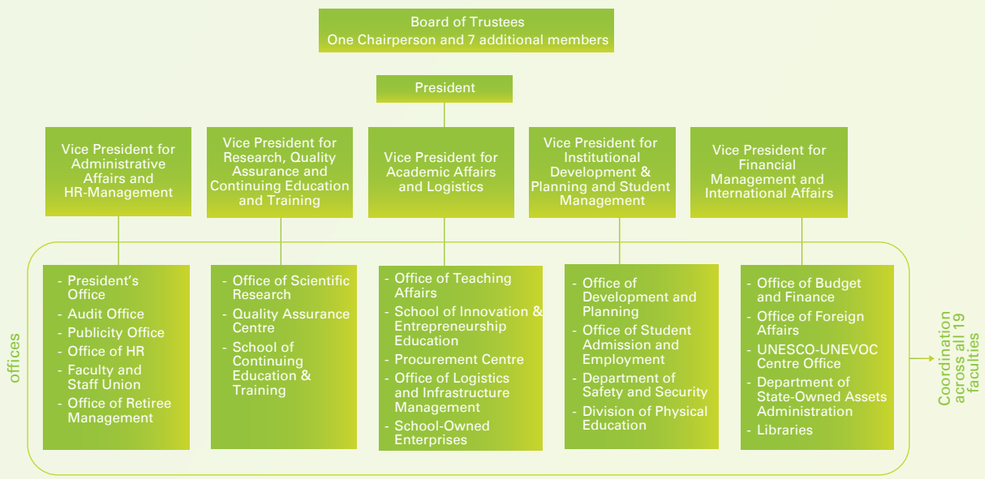
2. MANAGEMENT AND ORGANISATION OF SHENZHEN POLYTECHNIC

2.1 ORGANISATIONAL STRUCTURE

The institution is governed by a board of 8 trustees who represent senior college leaders and key administrative managers from the Shenzhen Polytechnic. Together with the school's President and five Vice Presidents they form the leadership of the Shenzhen Polytechnic. Each Vice President has overall responsibility for a number of offices (see Figure 3), which are responsible for coordinating all of the school's 19 faculties. In addition to the faculties where digitalisation is part of curricula, the Shenzhen Polytechnic also houses a number of other faculties, including the School of Economics, the School of Management, and the College for Elderly Healthcare, among others.

The management and organisation of the digital transition at the Shenzhen Polytechnic has been an important aspect of the school's digital success. The school's leadership has placed a strong focus on involving the entire institution in the digital transition by developing, among other things, an ambitious digital action plan that involves leaders, teachers and students. The strategy and digital transition are influenced and supported by both the national and local government. The sections below explain the key aspects of how the digital transition is organised at Shenzhen Polytechnic.

FIGURE 17. ORGANISATIONAL STRUCTURE OF THE SHENZHEN POLYTECHNIC



Source: internal document

2.2 THE IMPORTANCE OF THE DIGITAL STRATEGY AT SHENZHEN POLYTECHNIC

The Shenzhen Polytechnic is a digital school at heart and seeks to integrate digitalisation in all its faculties and their activities. The digital transition is systematically promoted throughout the institution. This is achieved through the integration of digital tools that support the learning experience and the use of the digital infrastructure (such as online platforms) available to both students and staff. The Shenzhen Polytechnic takes a holistic approach to the digital transition, believing that it is important to consider digitalisation in all institutional and educational aspects in order to be successful.

According to the management of Shenzhen Polytechnic, it was crucial that digital transition was a large-scale institutional project. All aspects and all teachers and administrators were involved. Everyone has to be aligned and share the same goals. It may be necessary to change the mindset of teachers who have been used to teaching in the same way. The same is true for their students who come from high schools without digital tools and online learning.

Because staff attitudes are so important to the success of a large-scale transition, the school's action plans have been important tools in driving digitalisation. The Shenzhen Polytechnic has formulated two action plans embedded in regional and national strategies for digitalisation, which specify the institution's goals and how they will be achieved. These are the Artificial Intelligence Action Plan and the Digital Transformation Action Plan. The plans act as a roadmap for Shenzhen Polytechnic's

TEXT BOX 1. SELECTED GOALS OF 'THE ARTIFICIAL INTELLIGENCE ACTION PLAN' AND 'THE DIGITAL TRANSFORMATION ACTION PLAN'

Artificial Intelligence Action Plan

- Facilitating Intelligent Institutional Governance and Decision Making
- Strategic Planning of AI-related Programmes
- Setting up an AI Curriculum Resource Database System
- Increasing the Level of Teacher Training
- Facilitating the Reform of the System of Teaching Materials
- Accelerating the Reform of Teaching Methods
- Strengthening basic research and development of AI applications
- Building a Technical Service Platform
- Improving the Framework of AI System for a Smart Campus
- Setting up the AI Big Data Centre

TEXT BOX 1. (CONTINUED)

Digital Transformation Action Plan

- Promoting quality in talent cultivation
- Deepening the integration of industry and education
- Improving teachers' digital skills
- Adopting emerging EdTech and digital pedagogies
- Cultivating students' digital literacy and skills
- Upgrading social engagement with digital technologies
- Engaging in digital technology innovation
- Strengthening global digital engagement
- Enhancing digital governance
- Consolidating digital infrastructures

(Source: Internal documents)

digital development. setting ambitious goals that ensure that the school's management, teachers and students are all moving in the right direction. The text box below contains some of the goals set out in the Artificial Intelligence and Digital Transformation Action Plans.

The digital initiatives in the action plans concern all parts of the institution. They have affected the Office of Planning and Administration and the Office of Teaching Affairs, as well as practical aspects such as the Office of Logistics and Infrastructure, making the digital transition all-encompassing and systematic.

2.3 GOVERNMENT SUPPORT AND SOCIETAL FACTORS THAT DRIVE THE DIGITAL TRANSITION

The Shenzhen Polytechnic is a pioneer among Chinese TVET institutions in formulating action plans for both digital transformation and artificial intelligence and has developed numerous digital learning resources. In addition, the institution has developed 5G smart campus infrastructure that enables students to engage in digital and online learning. The school's digital focus stands on the shoulders of the national policy focus on the digitalisation of Chinese society.

China's governance mechanism entails a top-down approach. Therefore, the Shenzhen Polytechnic's action plans can be seen as blueprints of how the institution intends to achieve the national, provincial, and municipal development goals.

The Shenzhen Polytechnic considers political support very important for the successful digital development of the school. The focus on digitalisation by the national and provincial governments and the allocation of resources by governmental actors have been important in the process of ensuring a successful digital transition. For example, the Shenzhen Polytechnic has received substantial financial support from the Shenzhen Municipal Government to support the digitalisation of the school. The city government has supported the implementation of the 5G smart campus infrastructure and also provides a stable subsidy to the Shenzhen Polytechnic.

FIGURE 18. CLASSROOM TEACHING AT THE SCHOOL OF ELECTRONIC AND COMMUNICATION ENGINEERING

Image: Shenzhen Polytechnic

In addition to the political focus and will to move the Chinese society in a more digital direction, the leadership of the Shenzhen Polytechnic points to several societal drivers that have driven the need for a digital transition of VET. These drivers include, in particular, the development of the digital economy and technological advances in China. From Shenzhen Polytechnic's perspective, the digitalisation of society will continue at an increasing pace, as this development has been supported and embraced by both national and regional digital strategies.

2.4 DISSEMINATION OF DIGITAL EXCELLENCE

Each year, the school organises the Belt and Road international Conference on TVET, an annual event that brings together experts and scholars from different countries to discuss the future of VET. In 2022, the theme of the conference was 'New Connotation, New Value, New Mission'.

In addition, the school offers institutional support to other TVET Institutions. The Shenzhen Polytechnic has assisted up to 200 providers of technical VET from 13 disadvantaged provinces in China by sharing its promising and proven solutions. The shared knowledge includes the school's governance philosophy, teaching methods and learning models. In addition, the institution also provides counterpart capacity building on campus to TVET leaders and other key personnel.

A prime example of Shenzhen Polytechnic's knowledge sharing is that since 2014 the institution has sent a management team to Ji'an

FIGURE 19. INSTITUTE OF INTELLIGENT MANUFACTURING

Image: Shenzhen Polytechnic

College to participate in its institutional management. Ji'an College is a TVET institution in the Jiangxi Province. These efforts have helped the partner institution to become a model TVET provider in its province in just a few years.

As a result, the Shenzhen Polytechnic takes great pride in disseminating its knowledge and helping other VET providers to promote the national VET standard.

2.5 THE DIGITAL INFRASTRUCTURE OF THE SCHOOL

Shenzhen Polytechnic's infrastructure is quite comprehensive and superior to that of other institutions in the region in terms of software and hardware. Students are provided with state-of-the-art equipment to support their learning experience, ensuring that what they learn is relevant and up to date for the current labour market. This is important and a priority for Shenzhen Polytechnic, as the (ICT) sector evolves so rapidly that both knowledge and equipment quickly become outdated.

The school has various digital learning environments, including smart classrooms equipped with cameras that can record the lessons for students who are unable to attend and three virtual reality (VR) simulation training centres. The VR simulation centres include both VR glasses and VR software tools, allowing students to enter a relevant virtual environment and experience professional practices and their outcomes in the virtual setting.

The digital infrastructure of Shenzhen Polytechnic is also supported by the integrated platform called iSZPT. The platform is the entry point for virtually everything from online learning resources to administrative functions for both students and staff. The activities handled through the platform include:

- information sharing (e.g. announcements, publication of policies and plans, mailbox, internal news, etc.)
- financial affairs (e.g. procurement and applications for reimbursement)
- education management (e.g. student management, examination matters, quality assessment, etc.)
- online resources (e.g. online library and databases)
- R&D services and support functions (e.g. application for logistical and ICT support).

The general features of the platform and the overall framework of the school's digital infrastructure are shown in Figure 6 below, and include, in addition to the functions supporting administrative tasks for students and staff, a data resource platform and big data analysis.

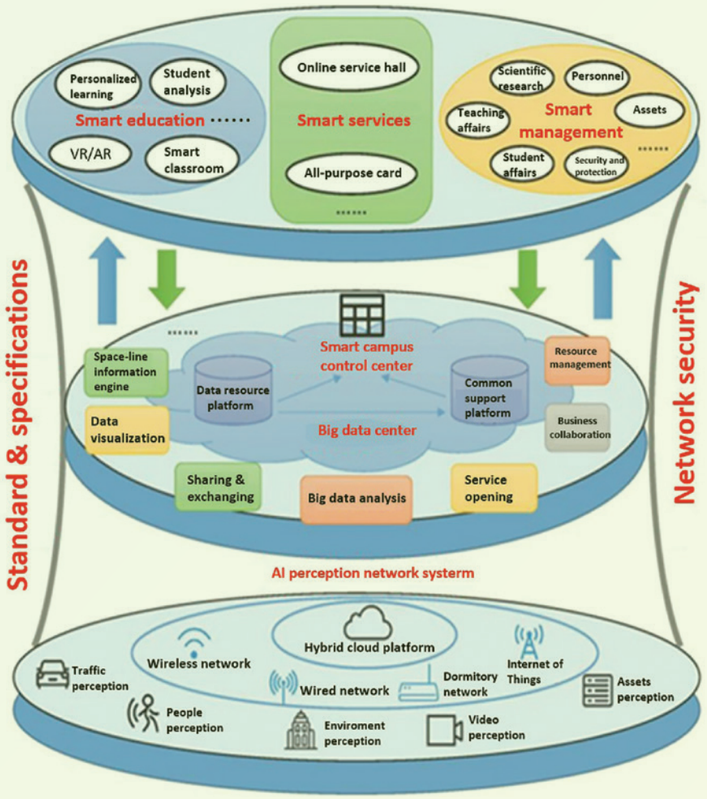
Students at Shenzhen Polytechnic are very enthusiastic about the platform, as it gives them greater flexibility and more opportunities to learn. The institution has allocated a total of EUR 793 187 for the development and integration the platform.

The 5G infrastructure is also seen as an important part of being a digital institution that supports the use of digital tools and digital learning, ensuring that online learning can be applied throughout the institution. This is important in order to ensure that the digitalisation encompasses all the different faculties at the Shenzhen Polytechnic. The initial investment in the 5G infrastructure was funded by private sector telecoms, such as China Mobile, China Telecom and China Unicom. The Shenzhen Polytechnic enjoys their 5G services and pays them service fees.

Another important part of the digital infrastructure is the online learning platforms used to facilitate digital learning. Unlike the iSZPT, these online learning platforms are more specific and have been developed to for particular faculties or subject areas. Some of the platforms and software used at the Shenzhen Polytechnic have been provided by the school's industry partners such as Huawei and Tencent.

For example, the Shenzhen Polytechnic has designed a blockchain platform, which is used by students on the Blockchain programme.

FIGURE 20. OVERVIEW OF THE DIGITAL INFRASTRUCTURE AT THE SHENZHEN POLYTECHNIC



Source: Internal document

Blockchain technology has been gaining increasing attention as it enables the secure exchange of information. It involves recording transactions in a transparent and distributed database that is simultaneously available to all participants in a dedicated network of computers. This form of distributed database means that the power to update a blockchain (i.e. the record of transactions) is shared among the participants. This ensures a permanent, immutable and transparent record of data and transactions, making it possible to exchange anything of value.[26]

The blockchain platform developed by Shenzhen Polytechnic allows the students to write code directly on the platform, where teachers can see it immediately and give instant feedback. This particular platform also provides a ranking of the code, turning an

26 McKinsey, 2022. What is a blockchain?

FIGURE 7. DIGITAL FACILITIES PROVIDED BY HUAWEI

Image: Shenzhen Polytechnic

assignment into a kind of internal game among the students.[27]

In addition, the online learning platforms, such as the blockchain platform, allow students to learn anywhere and anytime, thus giving them a welcome increase in flexibility, for example in case of illness or COVID-19 lockdowns. The platforms are also being used by the teachers to provide students with extracurricular materials. Similarly, the platforms allow teachers and students to interact and have discussions online, while students can also go online and replay recorded lessons when doing their homework.

27 This aspect will be further elaborated in the section about Shenzhen Polytechnic's pedagogical approach.

2.6 THE IMPORTANCE OF CLOSE COLLABORATION WITH THE PRIVATE SECTOR

An important element in the successful blossoming of Chinese VET is the close collaboration between VET providers and enterprises. Shenzhen Polytechnic has prospered from this priority of the Chinese Ministry of Education and has established collaborations with industry-leading enterprises from the ICT sector. Amongst others, the school has close relations to Huawei and Tencent.

2.6.1 A CLOSE RELATIONSHIP MAKES FOR A MUTUALLY BENEFICIAL COLLABORATION

Collaboration is a key factor in Shenzhen Polytechnic's digital excellence, and relationships are constantly being nurtured and developed. It is essential

for Shenzhen Polytechnic to collaborate with top ICT companies in order to remain relevant to students and the labour market. Collaboration is a top priority for Shenzhen Polytechnic and its industry partners, such as Huawei and Tencent. The overarching reason for the long-standing and fruitful collaboration is that it is mutually beneficial (see Figure 8 and the textbox below). Industry is influencing the education of tomorrow's workforce, ensuring that they have the skills to create value in the ICT sector. In addition, by providing digital infrastructure and expertise to students, companies serve a greater good by supporting China's overall digital literacy.

Huawei states that it minimises the risks of hiring when it knows that students come from the Shenzhen Polytechnic, as the company participates in curriculum development and works to ensure that students have relevant certifications before they enter the labour market.

On the other hand, the Shenzhen Polytechnic benefits by always having a very direct assessment of what is required of the students now and in the future, which helps the school to create highly relevant programmes that address the current trends and digital skills needs of the ICT sector. The following table summarises the school management's view of the importance of collaborating with business partners.

The Shenzhen Polytechnic holds frequent meetings with its industry partners. For example, meetings between Shenzhen Polytechnic and Tencent take place on a weekly basis (either online or face-to-face). This happens not only at management level, but also with teachers. They meet regularly with company representatives to discuss the implementation of different initiatives and curriculum development.

The Shenzhen Polytechnic and its industry partners have developed a strong relationship. Interactions can also take the form of short, informal conversations and meetings. For example, the school management and teachers sometimes use the messaging application WeChat together with representatives from their industry partners to exchange ideas and views on relevant challenges. This means that there is an ongoing and mutually supportive communication and that both parties are alerted to new trends and challenges that one or more of the partners is looking to address. This helps each party to better understand the other's mindset, to understand challenges from the other's perspective, and to identify points where collaboration is relevant.

FIGURE 8. ILLUSTRATION OF THE MUTUALLY BENEFICIAL COLLABORATION BETWEEN SHENZHEN POLYTECHNIC AND ITS INDUSTRY PARTNERS

深圳職業技術學院 SHENZHEN POLYTECHNIC ⇄ Industry partners: HUAWEI, Tencent 腾讯

Benefits	Activities	Benefits
▪ Relevant programme content and curricula ▪ Continuous knowledge about the demand for skills	▪ Teacher training ▪ Certifications ▪ Identification of future skill needs ▪ Development of teaching materials ▪ Case competitions	▪ Recruitment of talents ▪ Branding of the enterprises ▪ Increased revenues

Source: Danish Technological Institute

'The collaboration between Shenzhen Polytechnic and our industry partners like Huawei and Tencent is a powerful force for the digital transformation of our institution. By working together with leading enterprises, we are more capable to identify emerging trends in the industry and the derived skills needs. The collaboration also gives us better conditions for developing relevant teaching and learning resources.

The key to making such a collaboration work, is to make it mutually beneficial for both parties. For our partners, the opportunity to impact what is taught and how its taught is valuable, as it makes the future employees better equipped to solve the problems of tomorrow.'

(Source: Interview)

Wenming Yang
Coordinator of UNESCO-UNEVOC Center, Shenzhen Polytechnic

2.6.2 POLITICAL PRIORITY HELPS BUILD FRUITFUL COLLABORATIONS

Both the Shenzhen Polytechnic and its industry partners believe that their collaboration is facilitated by a favourable policy environment. Collaboration between VET providers and the industry is a priority for the Chinese government, which means that both parties are encouraged to pursue partnerships. As already mentioned, this is done by encouraging public-private partnerships and by offering tax breaks to private actors who fund vocational training. The Shenzhen Polytechnic predicts that such collaborations will grow stronger in the future as China continues to promote the digital transformation and the national government has published new strategic goals to support the digitalisation of education.

Collaboration between the Shenzhen Polytechnic and its industry partners (such as Huawei and Tencent) covers multiple activities. The most important ones and their link to the pedagogical approach and programme content are discussed in the following chapters.

2.6.3 TEACHER TRAINING

The upskilling of teachers in VET is a national policy goal in the Chinese vocational education system. The aim is to improve the quality of the national VET system and its supply of skills, and to make it a more attractive educational choice for young people. The Chinese government has set a target that half of all teachers should be 'dual-qualified', i.e. have both academic and practical teaching skills.[28]

Teacher training is also an important priority for Shenzhen Polytechnic and is part of the school's Digital Action Plan. Some of the relevant professional development initiatives include: the implementation of continuous teacher performance evaluation and the participation of teachers in relevant skills competitions.

The institution has also set up a framework to ensure the coordination of teachers' professional development. Each school/faculty has a pedagogical coordinator who is responsible for organising weekly workshops and regular training in the use of educational technologies.

The institution's industrial partners are also central to efforts to improve teachers' digital skills. Teacher training often takes place in the companies. Teachers at the Shenzhen Polytechnic frequently visit industry partners to receive training on the latest software and other topics, as it is crucial for the quality of the education that teachers are up to date with the latest developments in the sector. For example, every year the teachers from the AI School and the ICT School of Shenzhen Polytechnic visit Huawei to learn about the company's certification courses so that the school can offer the certifications to its students.

28 The Australian Government; Department of Education, 2020. China announces vocational education action plan for 2020–2023

3. DIGITAL CONTENT AND PROGRAMMES

Shenzhen Polytechnic places great emphasis on the development of digital skills and education. This is evident from the extensive list of ICT-related programmes that the institution offers its students.[29] Programmes in artificial intelligence, mechatronics and digital media arts are among the options available at the school.

3.1 DEVELOPMENT OF TEACHING MATERIALS AND CURRICULA

As already mentioned, collaboration with, and input from, industry partners (such as Huawei and Tencent) is a cornerstone of the preparation and development of digital content at the Shenzhen Polytechnic. This ensures that the digital skills taught at the school are relevant and up to date in terms of ICT skills demands. In addition, the curricula are constantly updated in order to capture and incorporate emerging trends and developments within the ICT sector.

In addition to receiving input from industry partners on their current and future skills needs, the Shenzhen Polytechnic also has a systematic digital approach to collecting data that can inform decisions on the development of subjects and programmes. Through a consulting company, the Shenzhen Polytechnic interviews and surveys alumni and ask them about the skills needed in their current job position and industry. This practice helps to ensure that skills gaps are identified and addressed by the institution.

Based on this, the school's teachers develop teaching materials that address

29 See Annex A.

FIGURE 9. TEACHING SITUATION AT THE SCHOOL OF ARTIFICIAL INTELLIGENCE

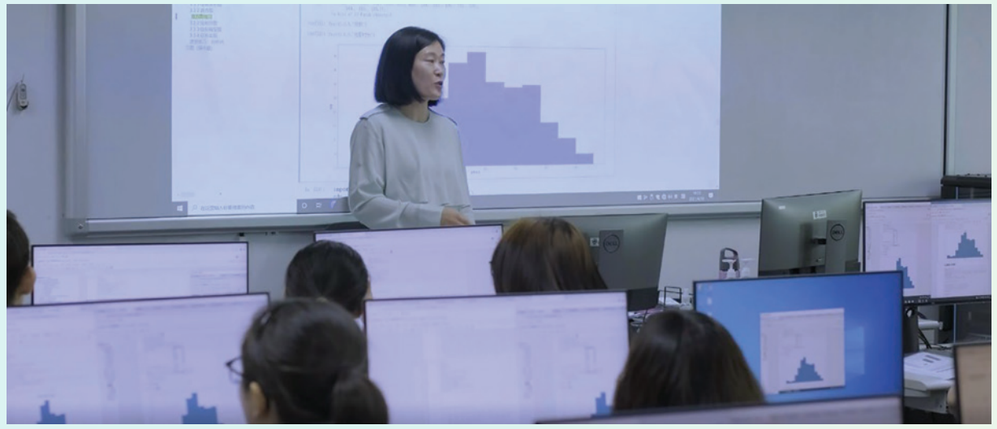


Photo: Shenzhen Polytechnic

the need for digital skills. And the digital skills of teachers are continually assessed and improved to ensure that they are qualified to teach emerging skills. As mentioned in section 2.6.3, the Shenzhen Polytechnic has a systematic practice that ensures the professional development of the teachers.

Example: Shenzhen Polytechnic's School of Artificial Intelligence

An example of the importance of digital content and educational programmes is Shenzhen Polytechnic's School of Artificial Intelligence. The School of Artificial Intelligence was established in 2019 after restructuring the former School of Computer Engineering. This school offers seven different programmes,[30] and more specifically:

- Virtual Reality Application Technology
- Cloud Computing Technology Application
- Software Technology
- Computer Application Technology
- Big Data Technology
- Artificial Intelligence Technology Application
- Blockchain Technology Application

Another interesting example of a highly digital programme at the forefront of the technological development is the school's blockchain programme. This major was established in 2021 and Shenzhen Polytechnic students have already achieved good results in national skills competitions. The programme equips students with the necessary skills to work in financial technology or with the development of intelligent manufacturing technology.

30 Shenzhen Polytechnic, School of Artificial Intelligence

As already mentioned, the faculty has developed a blockchain platform to support the teaching and learning of the subject. Some of the features of the platform, along with the pedagogical thinking behind it, are presented in Chapter 4.

Example: Shenzhen Polytechnic' School of Electronic and Communication Engineering

Another example of a digital faculty at the Shenzhen Polytechnic is the School of Electronic and Communication Engineering. The school has an excellent reputation and its students have won several national prices in skills competitions. It offers the following seven majors:[31]

- Electronic Information Engineering Technology
- Modern Communication Technology
- Computer Network Technology
- Internet of Things Application Technology
- Mobile Internet Application Technology
- Information Security and Technology Application
- Integrated Circuits Technology

More interesting, however, is the Integrated Circuits Programme, which was established in 2021 to meet the demands of the continued rapid growth of China's electronics industry and cultivate the high-quality technical and professional talents urgently needed by the entire integrated circuits industrial chain. The programme is another example of Shenzhen Polytechnic's rapid response to industry needs.

31 Shenzhen Polytechnic, School of Electronic and Communication Engineering

4. PEDAGOGICAL APPROACH

A key word for the pedagogical approach of Shenzhen Polytechnic is practice orientation. The school makes great efforts to organise curricula, lessons and assignments around real-world cases.

Much of this is done with the help of Shenzhen Polytechnic's industry partners. For the ICT-related programmes of Shenzhen Polytechnic, the school works (often and systematically) with companies to co-develop the courses and teaching materials. As a result, some of the engineers from these companies are involved in course development.

It is worth noting that many students from Shenzhen Polytechnic tend to have limited experience with digital learning tools that support a less teacher-centred approach before entering the school. When new students come from high school, they are mostly used to teacher-centred learning in the form of traditional blackboard lectures. Therefore, the use of digital tools in school is new to many of the new arrivals at the Shenzhen Polytechnic. However, it is important to note that not all learning at the Shenzhen Polytechnic is digital, as the school believes in hybrid teaching as its overall approach (so that students receive a mix of both online and offline resources).

As a result, collaboration with leading ICT companies (discussed in section 2.6) is also deeply embedded in the school's pedagogical approach. School assignments and extracurricular activities are often embedded in real-world business challenges or software used by the industry partners. This link to leading companies has an impact on student motivation. The fact that school assignments become practical, in the sense that students see that the skills they are acquiring are directly applicable

FIGURE 11. USE OF VR TECHNOLOGY AT THE SHENZHEN POLYTECHNIC

Photo: Shenzhen Polytechnic

in ICT, means that students become more engaged in the tasks.

Often, the company-based assignments are accompanied by visits to the company's premises, which also supports student engagement by allowing them to learn from real employees in positions similar to those they will hold in the future.

The Shenzhen Polytechnic believes in maintaining a strong link between the education at the school and the real-world challenges of the real world, which is why hands-on projects involving companies are given high priority. As a result, the curricula of all educational programmes at Shenzhen Polytechnic are designed and developed by an Educational Programme Steering Committee, which consists of both teachers from the school and private sector experts from the industry.

Most of the curricula of the school's educational programmes are delivered in either a simulation centre or an industrial training centre and attempt to create conditions that simulate those of the real world. Shenzhen Polytechnic estimates that about 50 per cent of the time in an educational programme is spent on assignments and cases from the real world or provided by industry partners.

The school also places great emphasis on cultivating students' innovative skills and organises their participation in various skills competitions. The school also has close industry partnerships with Huawei, Cisco, China Unicom and others.

4.1 GAMIFICATION

Another important component of the pedagogical approach at Shenzhen Polytechnic is the gamification of the learning experience. This approach

has been shown to foster intrinsic motivation, make learning more engaging and increase students' knowledge retention as compared to traditional schooling (Putz, et al., 2020). This pedagogical understanding has been made more accessible through digital learning tools.

An example of how Shenzhen Polytechnic's uses gamification in training programmes is the blockchain programme at the School of Artificial Intelligence. On the faculty's blockchain platform, students can be assigned tasks, such as writing a piece of code, and the platform instantly provides a score and ranks the student's work. Using a scoreboard, the students can see their rank and relative success with the task. This competitive indicator of the student progress is designed to motivate students and deepen their engagement. In this way, the assignment also becomes a small internal competition, which several students have described as motivational for their learning.

In addition to the autogenerated score and ranking, the teachers can also assess the code right away and provide feedback to the individual student.

4.2 SKILLS COMPETITIONS

Skills competitions play an important role at Shenzhen Polytechnic. They can be organised by the institution itself or they can be international competitions organised by other VET providers or industry partners. Skills competitions can also be organised in collaboration between these types of stakeholders, for example, with teams of teachers and industry representatives based on real-world work challenges and linked to the learning objectives defined in the curriculum.

A recent example of a case competition involving students from the Shenzhen Polytechnic is the national final of the Computer Programmer Competition, which took place in the framework of the National Industrial Vocational Skills Competition 2022. This competition included both students and employees from the Shenzhen Polytechnic. Both students and teachers excelled in the competition and won first prizes.

The competition served as an effective way to promote the widespread application of new-generation information technology and to promote the training of skilled students. In addition, participation in this type of competition also supports the national policy goal of building a large pool of knowledgeable, skilled and innovative workers.[32]

Students from the Shenzhen Polytechnic also participated in international skills competitions, such as the 2022 BRICS Skills Development and Technology Innovation Competition – BRICS Future Skills Challenge.[33] In 2022, a team of Shenzhen Polytechnic students from the Virtual Reality Technology Application programme won first prize in the field of mixed reality resource development.[34]

The Shenzhen Polytechnic sees such competitions as an opportunity to further promote teaching and learning, and as to share and develop innovative new ideas among students.

Teachers at the school always encourage the students to take part in skills competitions. This is seen as a great way to engage the students in the different topics so that (at the end) they learn and master the required digital skills. Representatives of the industry partners, such as Huawei and Tencent, also help to coach the students prior to their participation in certain skills competitions.

4.3 EXTRACURRICULAR ACTIVITIES

Many of the mandatory assignments in the digital programmes at Shenzhen Polytechnic are accompanied by extracurricular activities, such as additional voluntary assignments or reading material. The extracurricular activities are published on online platforms. The platforms provide a great opportunity for individualised learning by allowing students who want to dive deeper into the subject matter to go beyond the mandatory educational content. The use of digital platforms also improves the efficiency of learning.

However, the students must also have a great deal of self-discipline to take advantage of the many opportunities the platforms offer. The Shenzhen Polytechnic provides a lot of resources to students along with extracurricular activities, but the students need to take advantage of these opportunities.

There are many examples of training programmes where the teachers and their students communicate informally on the messaging application WeChat. This can help the teachers to get a better idea of the students' learning status by participating in and observing the group chat. Teachers share business-related knowledge and information in the form of new standards or articles related to the relevant industry, which is intended to inspire and motivate students.

32. Shenzhen Polytechnic, 2022. AI Teachers and Students Won Good Results in the National Vocational Skills Competition
33. BRICS Future Skills Challenge are hosted by BRICS Business Council – an association of the BRICS countries Brazil, Russia, India, China and South Africa
34. Shenzhen Polytechnic, 2022. Students of Virtual Reality Application Technology Won the Gold Medal in the BRICS Skills Development and Technology Innovation Competition

5. CONCLUSION – KEY LESSONS FROM THE DIGITAL TRANSITION AT THE SHENZHEN POLYTECHNIC

Importance of ensuring that everyone is aligned and on board with the digital strategy

According to the management of the institution, it was crucial that the digital transition was a large scale institutional project. It is important for the leadership to ensure that the transition is systematically promoted across all faculties and staff. Shenzhen Polytechnic's approach has been holistic in the sense that all aspects, and all teachers and administrators, have been involved. A big part of this is changing the mindset of the teachers and students.

This means that the digital transition requires qualified leaders and teachers who can ensure that everyone is aligned and working towards the same goals. This is why the institution also points to the action plans as an important factor in ensuring this this.

Partnerships with the ICT industry to help make programmes and content relevant

Collaboration between VET providers and the industry has been a policy focus of China's national government for a number of years, and the Shenzhen Polytechnic is a prime example of the benefits of strong relationships with the ICT sector.

Industry partnerships with Huawei and Tencent, amongst others, have strengthened the relevance of the programmes and content taught. Collaborations cover teacher training and the identification of relevant and current skills needs in the ICT sector. Real-world cases and the use of software used by real companies have also proven to be highly motivating for students at the Shenzhen Polytechnic.

Gamification and skills competitions are good pedagogical tools when using digital teaching methods

Shenzhen Polytechnic has found that gamification enhances the learning experience and is a good way to increase student motivation. As a result much of the digital skills teaching at the Shenzhen Polytechnic involves small games or internal peer-to-peer competitions. Similarly, it is a priority for the school to involve students in skills competitions, often supported to some extent by the school's industry partners.

The Shenzhen Polytechnic has found that digital tools and online learning are highly compatible with the concept of gamification, as intelligent assessment tools, for example, allow instant scoring and ranking of both objective and subjective assignments.

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ANNEX A: ICT-RELATED PROGRAMMES

List of ICT-related programmes at Shenzhen Polytechnic

- Programmes in ICT & Electronic Engineering
  - Electronic Information and Engineering Technology Programme
  - Mobile Internet Application Technology Programme
  - Internet of Things Application Technology Programme
  - Computer Network Technology Programme
  - Information Security and Management Programme
  - Communication Technology Programme
- Programmes in Artificial Intelligence
  - Artificial Intelligence Technology Service Programme
  - Computer Application Technology Programme
  - Software Technology Programme
  - Cloud Computing Technology and Application Programme
  - Big Data Technology and Application Programme
  - Virtual Reality Application Technology Programme
- Programmes in Mechatronics
  - Intelligent Building Engineering Technology Programme
  - Mechanical Design and Manufacturing Programme
  - Mechatronics Technology Programme
  - Electrical Automation Technology Programme
  - Intelligent Control Technology Programme
  - Industrial Robot Technology Programme
- Programmes in New Energy Vehicles
  - Automotive Electronic Technology Programme
  - New Energy Vehicle Technology Programme
  - Intelligent Transportation Technology Application Programme
  - Automotive Application and Maintenance Technique Programme
  - Operation and Management of Urban Rail Transit Programme
- Programmes in Digital Media Arts
  - Animation Production Technology Programme
  - Digital Media Art Design Programme
  - Animation Design Programme
  - Game Art Design Programme
  - Radio, Film and TV Production Programme

Source: Internal document of the Shenzhen Polytechnic

CURRICULUM EXAMPLE FROM THE ARTIFICIAL INTELLIGENCE TECHNOLOGY SERVICE PROGRAMME

Curricula in this programme include general education curricula, professional education curricula and practical training, with a total of 140 credits.

1. GENERAL EDUCATION CURRICULA

General education curricula are divided into compulsory curricula, elective curricula and minor curricula, with a total of 51 credits, of which 37 credits are for compulsory curricula and 14 credits are for elective curricula.

1.1 Compulsory general education curricula

The compulsory general education curricula comprise nine curricula: Ethics and Laws, Foreign Languages, Practical Writing, Physical Education and Health, Career Planning and Employment Guidance for College Students, Innovative Thinking, Psychological Health Education, and Situation & Policy, Safety, ICT Literacy and other curricula.

1.2 Elective general education curricula

The elective general education curricula are divided into five modules: Language Literature & Cultural Heritage, Scientific Spirit & Life Care, Social Science & Modern Society, Artistic Creation & Experience, and Innovation & Entrepreneurship and Pluralistic Practice, including a total of 100 curricula. Students are required to select at least 2 modules and earn 14 credits in these elective curricula.

1.3 Minor curricula. About 20 minor curriculum clusters are offered by the Shenzhen Polytechnic. Students may obtain a minor certificate after earning 15 credits in a curriculum cluster. Students who select a minor curriculum cluster may be exempted from 14 minor curriculum credits. The Shenzhen Polytechnic publishes a minor curriculum selection guidebook each academic year.

2. Professional education curricula

The professional education curricula in this programme include professional basic curricula, professional core curricula, and professional advanced curricula, with a total of 89 credits. The three parts are structured around and include the subjects listed below.

3. Digital Teaching and Learning

This programme promotes the transformation of teaching methods and tools against the background of artificial intelligence. With a student-centred spirit, it creates a teaching and learning model based on autonomous, ubiquitous and personalised learning, and promotes online and offline hybrid teaching and learning, seamless mobile-based learning, and a hands-on learning model based on 5G + VR/AR/MR.

The programme establishes a new form of education digitalisation, with a teaching environment as the guarantee, teaching resources as the foundation, teaching platforms as the support, teaching models as the core, standards and norms as guidelines, and information literacy as the approach. Based on the information-based curricula, and guided by the engineering projects, the programme builds a bridge between curriculum teaching and work positions, relying on a talent training mode that integrates curricula, certificates and competitions.

After defining the core skills and training goals of the curriculum, the curricula are framed and modularised. These factors work together to support the teaching objectives. At present, a teacher from this programme has won second prize in the Guangdong Province Information-based Teaching Ability Competition. From 2012 to date, the programme has won more than eight national first and second prizes in various national university student leagues.

TABLE 1. PROFESSIONAL FOUNDATIONAL CURRICULUM STRUCTURE

NAME	CREDITS	HOURS/WEEK
Introduction to AI	2	2
Java Programming Fundamentals	4	4
Web Design and Production Technology B	3	3
Engineering & Applied Mathematics	4	4
Python Language and Application	4	4
Computer Application Basic Training	1	24
Advanced Office Software Application Training	1	24
Data Structure	4	4

Source: Internal documents, Shenzhen Polytechnic

TABLE 2. PROFESSIONAL CORE CURRICULUM STRUCTURE

NAME	CREDITS	HOURS/WEEK
Java Object-oriented Programming	3	3
Object-oriented Programming Training	1	24
Database Management and Application C	3	4
Intelligent Data Application A	4	4
Machine Learning Practice	4	4
Basics of Deep Learning	3	4
Artificial Intelligence Vision	4	4
General Practice of Artificial Intelligence	2	24
Graduation Internship	16	24

Source: Internal documents, Shenzhen Polytechnic

TABLE 3. ADVANCED CURRICULUM STRUCTURE

NAME	CREDITS	HOURS/WEEK
Artificial Intelligence Data Acquisition	3	3
Structured Machine Learning Project	2	24
iOS Object-oriented Programming Basics	4	4
Mobile Application Development 2	4	4
Network Operating System (Linux)	2	2
Software Testing Technology	3	3
Natural Language Processing	3	3
Advanced Depth Learning	2	2
Data Analysis and Application	2	2
Mac iOS Application Development (1)	3	3
Enterprise Application Development	3	3
Intelligent Algorithm Containerized	1	24
Software Testing Practice	1	24

Source: Internal documents, Shenzhen Polytechnic

ANNEX B: CASE STUDY BACKGROUND

This report is based on desk research and interviews with the management, teachers, students and external partners of the Shenzhen Polytechnic. Due to COVID-19 restrictions in place at the time when the case study was conducted (18–20 October 2022), all four group interviews and the plenary discussion with most of the interviewees were conducted online.

A programme officer from the UNESCO-UNEVOC Centre at Shenzhen Polytechnic facilitated the ensuing dialogue and provided additional information and documentation.

PARTICIPANTS IN THE INTERVIEW

Group interview with teachers/trainers:

- Four teachers from the Shenzhen Polytechnic were interviewed. Two of them taught at the School of Electronic and Communication Engineering of Shenzhen Polytechnic and two taught at the School of Artificial Intelligence.

The group interview focused on the benefits of digital tools as perceived by the teachers, and the conditions for good digital teaching. It also covered the benefits of participating in national competitions and the opportunity for teachers to learn from the top enterprises of the region.

Group interview with the management:

- The interviewees were the Provost of the Shenzhen Polytechnic and the UNEVOC Centre/UNESCO Chair Coordinator.

The group interview with the management focused on Shenzhen Polytechnic's experience of becoming a digital school and the school's digital infrastructure, which ensures a systematic and aligned digital transition for all parts of the school. In addition, the group discussed the school's approach to identifying the ongoing needs for new digital skills, which includes working in closely with the private sector.

Group interview with students:

- Six students enrolled in the Shenzhen Polytechnic's School of Electronic and Communication Engineering and School of Artificial Intelligence were interviewed. The students from the two faculties had different majors, including blockchain, telecommunications, and cloud computing.

They talked about the digital tools they use and their benefits. The students found that using digital tools gave them more hands-on experience, which they enjoyed. Finally, they expressed great satisfaction with the industry collaboration and the opportunity to meet and learn from top companies.

Group interview with external partners:

- The interviewees were a representative from Huawei Technologies Co., Ltd. And a representative from Tencent, as well as the Shenzhen Polytechnic's UNEVOC Centre/UNESCO Chair Coordinator

- The interview focused on the cooperation between the companies and Shenzhen Polytechnic. Both business partners expressed that the cooperation is mutually beneficial.

Plenary discussion:

- The plenary session was attended by most participants from the previous group interviews (except the students).

The plenary discussion topics were broad and focused on key learnings, the management of the digital transition, advice for other VET providers, potential pitfalls in school digitalisation and the cultivation of fruitful relationships.

CASE IV

TEMASEK POLYTECHNIC, SINGAPORE DIGITAL TRANSITION

1. INTRODUCTION

This introductory chapter presents background information relevant to the case study at hand. It first introduces the Temasek Polytechnic and School of Engineering and further sections outline the VET system in Singapore, describing the national and regional strategies of relevance to its digital transition.

1.1 TEMASEK POLYTECHNIC AND THE SCHOOL OF ENGINEERING

Temasek Polytechnic (TP) is a post-secondary vocational education institution and statutory board under the responsibility of the Ministry of Education in Singapore.

The Temasek Polytechnic (TP) was established in 1990 and has grown into a large education institution with more than 13 000 students and more than 1 400 staff. Today, the TP offers 36 diploma courses in six schools, as shown below. A polytechnic diploma course is equivalent to a bachelor's degree at a Fachhochschule, which is equivalent to EQF level 6.[35]

The TP is the third polytechnic to be established in Singapore. As an industry-focused institution, polytechnic graduates in Singapore are sought after for employment or well prepared for further education. Students at the TP typically receive a diploma in a specialised field of study after completing 3 years of academic studies and an industry internship.

35 See Cedefop's categorisation of Bachelor programmes at Universities of Applied Sciences leading to EQF level 6.

FIGURE 21. MAIN CAMPUS OF TEMASEK POLYTECHNIC

Image: Temasek Polytechnic

Polytechnics in Singapore admit most of their students after secondary school, usually at the age of 16–17 years, i.e. after 10 years of formal education. For example, students who have completed the Singapore-Cambridge General Certificate of Education (Ordinary Level) can apply for admission to the TP. The 2-year programme prepares students aged 15–19 years to be proficient in one or two languages, mathematics, science and humanities.[36]

36 The GCE O-Level It is jointly examined by the Cambridge Assessment International Examination, the Singapore Ministry of Education, and the Singapore Examination and Assessment Board with the latter offering more information on GCE O-Level here.

TP's pedagogical approach emphasises a practical and skills-based education approach (PSE) which focuses on providing authentic learning to prepare students for and in the world of work. The curriculum is developed in collaboration with industry partners, and TP's technical facilities simulate real work environments, allowing students to develop practical skills and experience.

Internships are a cornerstone of the polytechnic education system. Typically lasting between 12 and 26 weeks, TP's internship programme exposes students to work in the industry they will be working in after graduation. The TP has an industry network that gives students

access to a wide range of companies and academic institutions, both in Singapore and abroad.

1.1.1 THE SCHOOL OF ENGINEERING

The case study visit took place at the School of Engineering and focused on two centres: the Integrative Built Environment Centre (IBEC) and the Advanced Manufacturing Centre (AMC).

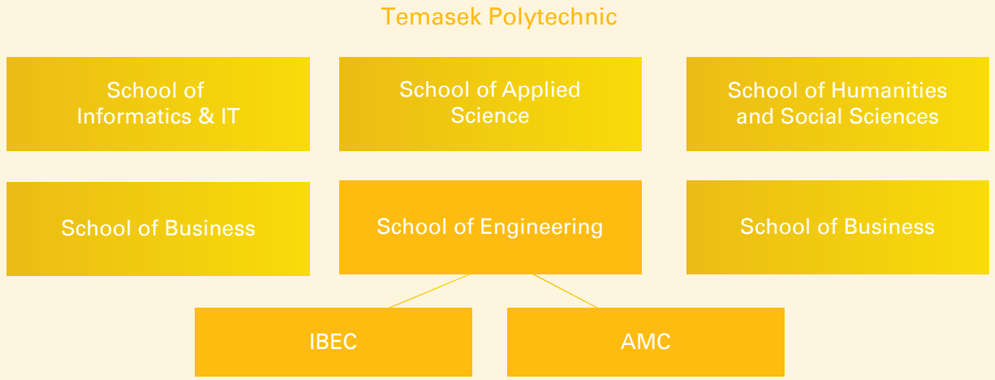
The School of Engineering and its two centres were selected for the case study because they are significant examples of the integrative use of digital tools to support learning at the Temasek Polytechnic. The two centres are introduced below.

The Integrative Built Environment Centre (IBEC) was established on 7 January 2022 as an important part of TP's support for the Singapore Green Plan and the BuildSG movement, a centre that promotes multidisciplinary teaching and learning.[37] By providing training in the latest technologies, the IBEC seeks to advance the nation's drive for sustainable development and the transformation of the built environment sector. The centre covers a wide range of related fields, specialising in areas such as digital architecture, intelligent building systems and smart facility management. The centre has a broad scope and can be accessed by both students in pre-employment training and students in continuing training. By providing training in the latest technologies, the IBEC seeks to advance the nation's drive for sustainable development and the transformation of the built environment sector.

The Advanced Manufacturing Centre (AMC) is an applied and skills-based training centre in the field of advanced manufacturing, which involves the use of innovative and advanced technologies to improve products and processes by enhancing the cyber-physical integration of manufacturing. For example, the AMC houses a complete end-to-end 'live' smart factory on campus, which is based on AI and data-driven. The centre can be accessed by both pre-employment and continuing training students. The AMC has industry partnerships, offering opportunities to work on proof-of-concept projects and providing consultations to companies to support their digitalisation and Industry 4.0 transformation.[38]

37 Temasek Polytechnic, 2022. Temasek Polytechnic Launches S$2.3m Integrative Built Environment Centre

FIGURE 2. THE SIX SCHOOLS OF THE TEMASEK POLYTECHNIC



Source: TP website

1.2 VET IN SINGAPORE

This section provides a brief introduction to the national VET context and outlines how VET is governed and funded in Singapore. As the term Technical Vocational Education and Training (TVET) is typically used in the context of the national education system, it is also used in the following sections. The figure below shows the Singapore education system, including the post-secondary TVET system.

The TVET system in Singapore is shown in Figure 2. Polytechnics offer TVET programmes at ISCED levels 5 to 8. The duration of the programmes is 3 years, and the entry requirements are GCE O-Level, GCE A-Level, PFP, or a completion of a programme at an Institute of Technical Education.

The post-secondary TVET system in Singapore comprises eight institutions: three technical education institutes, which mainly offer vocational training at certificate and higher certificate level, and five polytechnics, like the Temasek Polytechnic, which offer 3-year diplomas of para-professional training, and advanced and specialist diplomas. The term para-professional means that the graduates work as technical assistants, for example, assisting engineers or other professionals.

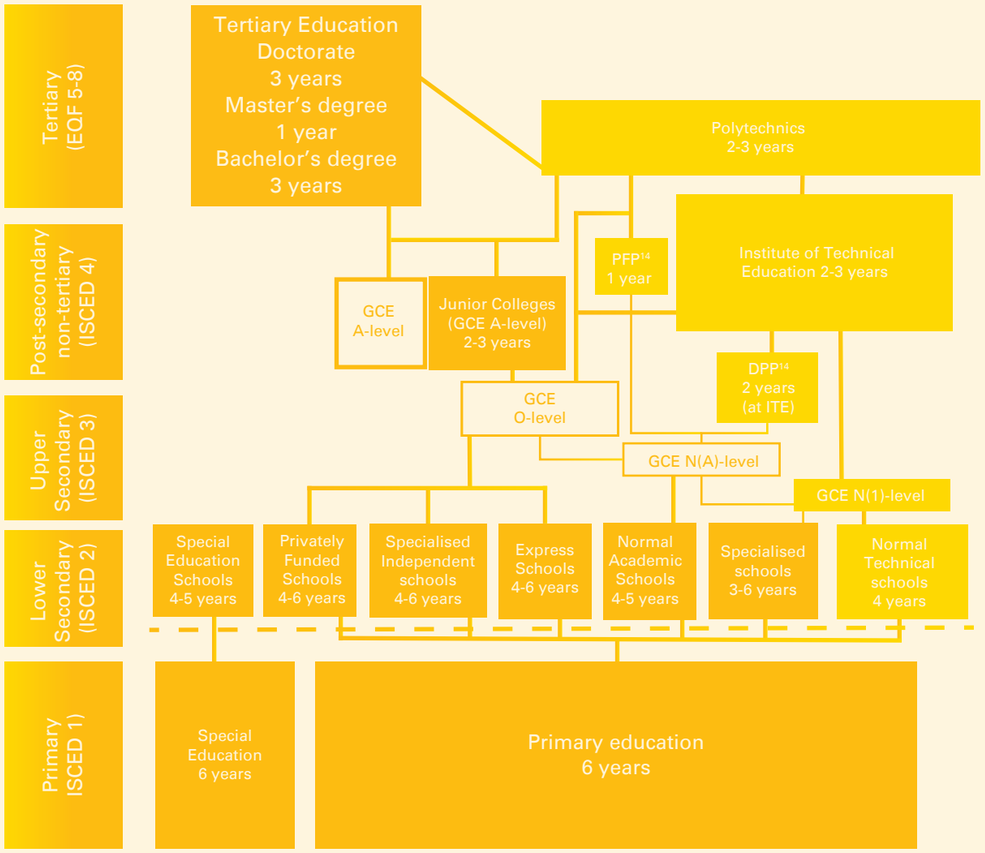
The participation rate in post-secondary TVET is comparatively high at 65% of school leavers, with all entrants having at least 10 years of schooling before entering TVET (Varaprasad, 2022). Approximately 40% of the entrants to the polytechnics are graduates of general schools (holding additional certificates to meet admission requirements). Others enter polytechnics via different educational pathways, such as after completing their GCE A-levels at junior college or graduating from a technical education institute.

1.2.1 GOVERNANCE

The governance of Singapore's TVET system and the delivery of skills that address the needs of the labour market and businesses are based on close collaboration between government institutions, employers, industry associations and trade unions. This collaboration takes place through a detailed network of committees and is guided by an Industry Transformation Roadmap for each industry sector. The constant and rapid changes in the labour market pose a fundamental challenge to TVET institutions in terms of faculty readiness, curriculum change, and the upgrading of facilities. For this reason, TVET institutions, such as the TP, have close links with industry, which develops and implements the training programmes together with the institutions. The government, through

38 Temasek Polytechnic. Advanced manufacturing @ TP.

FIGURE 22. STRUCTURE OF THE SINGAPORE EDUCATION SYSTEM



Source: UNESCO-UNEVOC, 2020

its various economic and workforce agencies, is actively involving the private sector in the transformation and restructuring of industry, and TVET institutions are a key component in this effort.

Based on the country's profile prepared by UNESCO-UNEVOC (2020), the key legislation and government agencies that govern the TVET system in Singapore are as follows:

The National Manpower Council, comprising the Ministry of Trade and Industry (MTI), the Ministry of Manpower (MOM) and the Ministry of Education (MOE), is responsible for national skills manpower planning and training. The MOE oversees the implementation of policies introduced by SkillsFuture Singapore (SSG), a statutory board under the Ministry of Education (MOE). Thus, in Singapore, the government is the main provider of education and training, and the educational institutions are governed by government-appointed boards. However, the institutions are relatively autonomous and have the power not only to offer the programmes but also to award their own qualifications. This means that they both set and implement the national standards for education and training.

SkillsFuture Singapore (SSG). SSG drives and coordinates the implementation of the national SkillsFuture movement. The SSG Board provides guidance and advice to the SSG Management on all matters within the purview of the SSG, including its policy, regulatory and promotional functions. It also reviews and approves SSG's strategic plans and budgets. The SSG Board members have diverse backgrounds, including trade unions, and the private and public sectors. This enables the SSG to draw on its diverse experience and a variety of perspectives. Working with leading sectoral agencies, employers, and unions, the SSG co-develops medium-term workforce and skills plans for each key sector to support industry growth and productivity efforts. These Sectoral Workforce Strategies identify sector-specific workforce and skills requirements over a period of 5 years and outline a holistic set of measures to address these needs.

Workforce Singapore Agency (WSG). The Agency oversees the transformation of the local workforce and industry to meet ongoing economic challenges. It promotes development, competitiveness, inclusiveness and employability at all levels of the workforce. The Board and the management of the Workforce Singapore Agency have established a framework to ensure strict adherence to good corporate governance practices. The board provides guidance and advice to the management on all matters within the remit of competence of the WGA, including its policy, operational and promotional functions. The Board also reviews and approves WGA's strategic plans and budgets. The Board members are drawn from a variety of backgrounds, including trade unions and the private and public sectors, to provide a diversity of experience and perspectives.

Industry Transformation Maps (ITM). In 2017, the government rolled out roadmaps for 23 industries to address issues within each industry and deepen partnerships between government, business, industry, trade associations and chambers (see also section 1.3.1).

The Future Economy Council (FEC) has overall responsibility for the implementation of the Industry Transformation Maps (ITMs). To this end, the Council has six sub-committees, each having responsibility for overseeing a group of ITMs within the same broad cluster of industries. The ITMs are grouped into six clusters – manufacturing, built environment, trade and connectivity, essential domestic services, modern services, and lifestyle. Each ITM sets out a growth and competitiveness plan, which is supported by four pillars: productivity, jobs and skills, innovation, and trade and internationalisation.

The Skills Framework, which is an integral part of the Industry Transformation Maps is jointly developed by employers, industry associations, trade unions, and the government for Singapore's workforce. The Skills Framework provides key information

on individual sectors and employment, career pathways, occupations/job roles, and existing and emerging skills required for the identified occupations/ job roles. It also provides a list of training programmes for the upgrading and mastering skills. The Skills Framework aims to provide a common skills language for individuals, employers and training providers. This facilitates the recognition of skills and supports the design of training programmes for skills and career development.[39]

1.2.2 QUALITY ASSURANCE FRAMEWORK

In addition to the overall governance of the VET system described above, the Ministry of Education has established a detailed quality assurance framework in 2007. The ITE Quality Assurance Framework (IQAF) and the Polytechnic Quality Assurance Framework (PQAF) have been established to ensure that ITE and the systems and structures of ITE and Polytechnics for resource allocation, human resource management and other organisational processes are properly aligned to enable them to achieve their mission.

The Quality Assurance Frameworks are based on 5-year assessment cycles with the following main steps:

1. Each institution conducts an institutional self-assessment against 25 institutional objectives in five areas: Governance and Leadership, Management and Strategic Planning, Teaching and Learning, Industry Linkages, and Service.
2. The institution submits its Institutional Self-Assessment Report (ISAR) to the MOE prior to the site visit.
3. An External Review Panel (ERP) commissioned by the MOE will then conduct a 5-day EV (site visit). The review will culminate in a qualitative report (EV Report) which will confirm good practice and identify areas where improvement action is required or recommended.
4. Quality improvement projects: The institution will then submit action plans with clear milestones to address the areas identified for improvement in the EV Report. A progress report on the action plans and issues raised by the EV at the annual Performance Review Forum with the MOE must also be submitted.

(Source: UNESCO-UNEVOC, 2020)

1.2.3 FUNDING

TVET is funded from three main sources: government funding, student fees and the private sector.

Government funding

The Ministry of Education (MOE) provides development and funding to all educational institutions, including TVET institutions such as the Institute of Technical Education and the five polytechnics. The total amount of development funds varies depending on the annual needs of each institution. These needs vary greatly depending on the type and level of education. However, the general trend is that the expenditure of TVET institutions, including the expenditure per student, is continuously increasing. For example, in 2015, the amount spent on a TVET student per year was about SGD 12 000 (about EUR 8 300). In general, students enrolled in TVET courses are required to pay fees. Under certain programmes, such as the Continuing Education and Training Pillar 3, courses at higher education institutes are subsidised by the government (up to 70% of the course fee) for Singaporeans and permanent residents. The remainder of the fee can be paid through the Skills Future Credit, a government-backed initiative that supports individuals in their pursuit of lifelong learning.

Private funding

In addition to government funding, contributions there are also contributions from the private sector. For this purpose, the Temasek Polytechnic General Education Fund[40] was established in 2003, to:

- provide scholarships, bursaries and other assistance to students;
- support education-related projects/ activities for students;
- support student and staff exchanges with industry and other institutions;
- bring renowned experts, lecturers and speakers to TP;
- provide seed funding to establish centres of excellence in strategic areas of teaching and research;
- promote the continuous training and development of staff;
- do all things necessary or appropriate to promote and fulfil the mission of TP.

The Temasek Polytechnic General Education Fund receives donations from individuals, companies, and organisations, supplemented by matching grants from the MOE. It also receives interest earnings from the investment of funds.

1.3 NATIONAL POLICIES WITH SIGNIFICANCE FOR THE DIGITALISATION OF VET

1.3.1 SMART NATION

The main national policy initiative related to Singapore's digitalisation is 'Smart Nation', a strategy launched by the government in 2014. Smart Nation is an overarching strategy with the overall aim of transforming Singaporean society into the next phase of nation-building. The overall goal is to embrace digitalisation and the benefits it brings. This transformation covers key areas – health, transport, urban solutions, finance, and education (Smart Nation and Digital Government Office, 2018).

To facilitate Singapore's transformation, the government has outlined broad plans to transform the economy, government and society through the 1) Digital Economy Framework for Action; 2) Digital Government Blueprint, and the 3) Digital Readiness Blueprint. These three elements are interlinked as the Digital Government will provide the environment and drive the enablers to

39 Further details can be found here.

40 For more information, see TP's 2018/2019 report on the fund.

shape the Digital Economy and a Digital Society. A Digital Economy will work closely with the Digital Government to support the digitalisation of government service delivery and build industry capability for future transformation needs.

The government's vision is to digitalise every industry and business, increasing productivity and efficiency to drive economic growth. The Industry Transformation Maps (ITMs) mentioned above are part of the efforts to deliver this vision under the Future Economy Committee. The ITMs are supported by Industry Digital Plans to facilitate digitalisation in selected industries. Each Industry Transformation Map integrates productivity improvement, skills development, innovation, and internationalisation. Developed and implemented in partnership with industry partners, the ITMs are intended to guide the digitalisation of each sector.[41]

1.3.2 THE EDUCATIONAL TECHNOLOGY PLAN

With regard to **the education system**, the Smart Nation strategy emphasises that digital technology enables self-directed and collaborative learning, creating new opportunities for learning. The Ministry of Education has launched the Educational Technology Plan (EdTech Plan), which sets out a 10-year vision with a horizon from 2020 to 2030 for the digitalisation of the education system, including TVET. The EdTedch Plan emphasises the overall vision, reinforcing the aim of ensuring that over the next 5 to 10 years, educational technology will help make education become more:

- self-directed, by developing pedagogies, tools, and structures to help students develop intrinsic motivation and take ownership of their learning. In addition, self-directed digital learners use technology for learning and can navigate the digital space safely and responsibly as they think, apply and create digitally.
- Personalised, by creating learning experiences that are tailored to the pace, path and needs of each learner.
- Connected, by developing collaborative learning experiences and connecting students' learning to the community and the world. Connected learners means that they continuously learn by collaborating with their peers, the community and the world. They are also able to connect a range of online and offline sources of information.
- People-centred, by using a data-driven understanding of how students' interests, attitudes and motivations can optimise learning.

The Singapore Student Learning Space (SLS) is one of the EdTech Plan key initiatives.[42] It aims to transform the learning experience of Singaporean students through the purposeful use of technology that enables them to engage in different modes of learning, including self-directed and collaborative learning. All principals, teachers and students in the national school system have access to the SLS. It is an online learning portal that provides equal access to high quality curriculum-aligned resources in key subjects from primary to pre-university level. The SLS also provides teachers with a range of tools to customise and create a meaningful learning experience that caters to diverse learning needs.

The EdTechPlan also sets out objectives for teachers to create physical and virtual learning environments that empower students to learn. Teachers need to be skilful practitioners who can facilitate active learning by leveraging technology to mediate learning interactions between students and content, their teachers, their peers, and the community. To improve teachers' competencies and encourage lifelong learning, the Ministry of Education has introduced 'SkillsFuture for Educators', a professional development roadmap for teachers. The initiative provides opportunities for developing skills different areas, including themes such as e-pedagogy, differentiated instruction and inquiry-based learning (Ministry of Education, 2020).

41 The Singapore Ministry of Trade and Industry offers further information on the Industry Transformation Maps.

42. See more information here.

2. MANAGEMENT AND ORGANISATION OF TEMASEK POLYTECHNIC

This chapter outlines the organisational structure and management of the Temasek Polytechnic and the way in which it translates the trends of digitalisation in the economy into educational programmes.

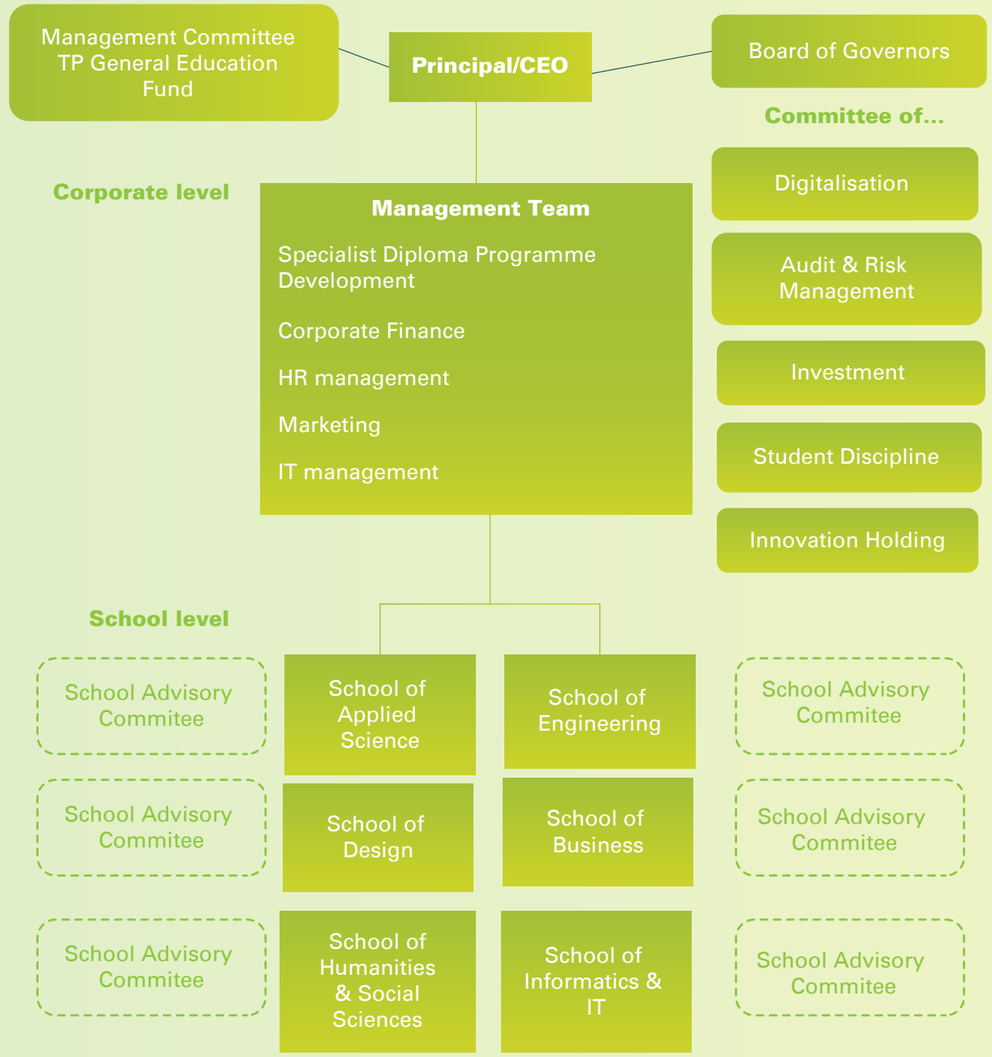
2.1 ORGANISATIONAL STRUCTURE

The Temasek Polytechnic (TP) is a large organisation with corporate and school level management. Management at the corporate level involves overall management of TP's programme development, finance/budgeting, human resources management, IT management and marketing. At the CEO level, the management is overseen by the Board of Governors, which represents government institutions/ministries, industry/sector organisations, experts/researchers, government agencies and other stakeholders. In addition, a number of committees are established at the corporate level and at the school level (School Advisory Committees). The committees represent relevant government institutions and industry associations and companies in the field. The numerous committees reflect the fact that the management of TP is based on close collaboration with the industry partners and other external stakeholders in order to ensure the industry-relevance of TP's skills provision.

The implementation of programmes and courses is managed at school level and centre level. In summary, the organisation and implementation of the digital transition is a 'top-down' process, which involves all three management levels of the TP, as follows:

1. At corporate level, decisions are made about programme development, digitalisation goals and the

FIGURE 23. ORGANISATIONAL STRUCTURE OF TEMASEK POLYTECHNIC



Source: Temasek Polytechnic, 2022

digitalisation of educational activities. Hence, corporate management of TP is the *decision maker* for digitalisation trends that need to be addressed in the curriculum.

2. At school level, the management is the *implementer* and initiator of new digitalisation-related learning activities and projects.
3. At centre level, for example the Advanced Manufacturing Centre (AMC) and the Integrative Built Environment Centre (IBEC), the management is the *collaborator and implementer* that manages the details of the implementation.

Overall, the management of the digital transition is described by the management as a multi-stakeholder collective effort, involving industries, government management and staff. Subject development is managed by Subject Leaders, while Project Managers curate major projects for students in various digital fields.

2.2 TEMASEK POLYTECHNIC'S DIGITALISATION GOALS

The key elements of Temasek Polytechnic's approach to digitalisation are as follows:

The TP addresses the digital transformation of the economy/ society in partnership with the industry to develop industry-relevant digital skills. Management describes the Temasek Polytechnic as addressing the digital transformation of the economy and society through a combination of curriculum development in partnership with industry and research initiatives. The digitalisation of programme content and the integration of digital technologies into the curriculum is a continuous process led by *the institutional management in close collaboration with industry.* The development of curriculum content and the skills/competences for a given programme/course is done through a technical committee that includes representatives from Temasek Polytechnic and industry organisations.

TP offers a range of digital programmes and courses that focus on wide range of digital technologies, including artificial intelligence (AI), building management systems, cybersecurity, data analytics and visualisation, digital twin, augmented/virtual reality (AR/VR), Internet of Things (IoT), and building management systems. Programmes focused on these technologies provide students with the knowledge and skills needed to succeed in the digital economy and to contribute to the digital transformation of society. In addition to the partnership with industry, government strategies, such as Smart Nation and Industry Transformation Maps for each industry sector, are used as crucial guiding element for TPs digital programme content and curricula (as explained in more detail in section 2.3.1).

TP's pedagogical approach focuses on the use of digital tools that support practice-based skills acquired through self-directed, collaborative learning. TP emphasises a digital learning environment that enhances self-directed learning by using pedagogy, tools and structures that help students develop intrinsic motivation and take ownership of their learning. A key digital tool in this regard is the Learning Management System (LMS) 'POLITEMall', which is used as a platform for the sharing of learning materials and collaboration between teachers and students. According to the management interviewed, the Ministry of Education's EdTech Plan has been translated into a learning approach at the TP that gives a high priority to self-directed and collaborative learning and other core pedagogical elements. The Temasek Polytechnic also uses the EdTech Plan as a point of reference that informs its decisions on the pedagogical approach and the use of digital tools in learning. For example, the EdTech Plan emphasises the importance of using technology to personalise student learning and enhance student engagement. As a result, the school incorporates digital tools, such as the Brightspace learning management system, online assessment tools, and gamified learning experiences into its curriculum to support student-centred learning. In summary, by using the EdTech Plan as a reference, The Temasek Polytechnic can ensure that its approach to the use of technology in learning is aligned with the broader goals and objectives of the Ministry of Education, and that it is well positioned to support student learning and success in the digital age.

According to management, another key area in which the Temasek Polytechnic is addressing the digital transformation is research. The Polytechnic has a research programme that focuses on advancing digital technologies and exploring their impact on society and the economy. The Temasek Polytechnic conducts research on the development of emerging digital technologies, such as security surveillance, IoT, building management systems, artificial intelligence, and the impact of these technologies on various industries and sectors. The Temasek Polytechnic also partners and collaborates with businesses and organisations in the technology sector through dedicated projects and student internship programmes. These partnerships provide students with practical, hands-on experience in the digital economy and help TP to stay at the forefront of digital technology development.

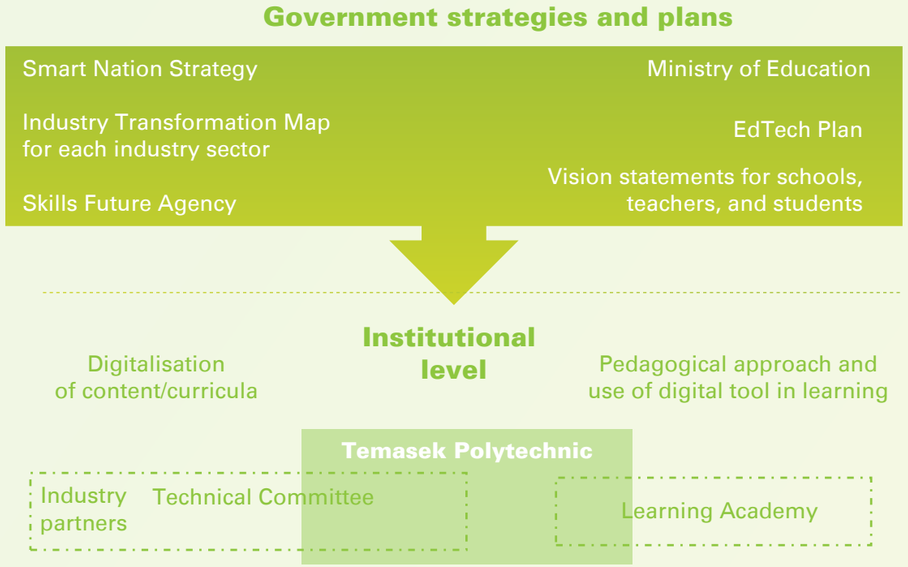
2.3 LEVERAGING GOVERNMENT STRATEGIES AND PLANS

The model in Figure 5 (see below) shows that the digitalisation of VET at Temasek Polytechnic is the result of a combination of government strategies and the training provider's collaboration with industry partners at the institutional level. Similarly, the pedagogical approach and the use of digital tools in the learning environment is shaped by a combination of the government's EdTech Plan and the Learning Academy (see section 2.4) at the institutional level. The Ministry of Education mainly influences the 'pedagogical approach and the use of digital tools in learning', while the Skills Future Agency and Industry Transformation Maps (ITM) mainly influence the 'digitalisation of content'.

In addition, the TP management have provided the following examples of how the Smart Nation Strategy is used by the Polytechnic to decide on the content of digital technology in education programmes.

- Smart Mobility: This theme focuses on creating a more seamless transport experience through new travel options and better access to real-time transport information.

FIGURE 5. DIGITALISATION OF VET AT THE TEMASEK POLYTECHNIC AS A RESULT OF GOVERNMENT STRATEGIES AND INDUSTRY COLLABORATION



Source: Developed by the author

- Smart Living: Improving daily living in our homes through smart devices.
- Smart Health and Wellness: Delivering better health services and wellness applications for seniors and citizens through the effective use of information technology.
- Digital Services: Improving government operations and service delivery through technology.

2.3.1 INDUSTRY TRANSFORMATION MAP (ITM)

Another key government driver for the content of the TP digital programme are the Industry Transformation Maps for each industry sector described above. The ITM for the construction sector has established a vision of an advanced and integrated sector with widespread adoption of leading digital technologies. In the TP, the ITM is used as the policy reference for the Architectural Technology and Building Services Diploma Programme. This is a 3-year course that equips students with the multi-disciplinary skillsets necessary to design and manage smart and sustainable buildings. Similarly, the Integrative Built Environment Centre (IBEC) at TP covers a wide range of related fields, specialising in areas such as digital architecture, intelligent building systems and smart facility management — areas identified in the Industry Transformation Map (ITM) for the Built Environment sector.

Management describes how the TP uses the Industry Transformation Maps (ITM) for each industry sector to inform decisions about digital content in education programmes. The ITM provides a comprehensive overview of each industry sector and outlines the key transformation trends, challenges and opportunities for each sector. Different government agencies are driving the different sectors. For example, Infocom Media is a government agency related to the ICT sector. Agencies also drive the development of industries. Government agencies are represented in various platforms and 'eco-systems' of agencies, educational institutions and business organisations that form sectoral chambers.

Management believes that ITMs provide valuable insights into the evolving digital landscape for each industry sector and help to identify the skills and competencies that are likely to be in demand in the future. This information helps the Temasek Polytechnic to design education programmes that are aligned with the current and future needs of the industry, and to incorporate relevant digital content and technologies into its curriculum, including AR/VR, digital twin, data analytics and visualisation, IoT, electric vehicles, etc.

2.4 IMPLEMENTATION OF DIGITALISATION

The organisation and implementation of the digitalisation is a 'top-down' process that involves all three levels of management of the TP.

1. The management of the TP is the decision maker as to which digital trends are to be addressed in the curriculum.
2. The management of the School of Engineering is the implementer and initiator of new digital learning activities and projects.
3. Management at centre level, for example the Advanced Manufacturing Centre (AMC) and the Integrative Built Environment Centre (IBEC), is the collaborator and implementer that manages the details of implementation.

Overall, the management of digitalisation is described by TP's management as a collaborative multi-stakeholder effort involving industry, government management and staff. Subject development is managed by Subject Leaders, while Project Managers curate major projects for students in various digital areas, such as digital twins, AR/VR, IoT, building management systems and more.

The Learning Academy

At the institutional level, the Learning Academy is a key body that oversees the pedagogical approach and teaching staff capabilities. It delivers and conducts professional development programmes for TP's staff in areas such as learning-teaching, the use of technology for learning, including e-learning, and learning analytics. The Learning Academy also provides continuing professional development (CPD) opportunities by guiding teaching staff in their teaching. The TP has a strong tradition of industry placements for teachers. On average 10% of the teaching staff is involved in CPD industry placements (some of which lasting several months).

The Learning Academy also conducts research in the effectiveness of student learning initiatives in areas such as self-directed learning, problem-based learning, technology-enhanced learning, and learning analytics.

The Learning Academy oversees the pedagogical approach in all schools, for example in all five polytechnics. However, each institution has a 'mini-Learning Academy' (5–6 people), which supports and reviews the pedagogical approach and the use of digital tools. The 'mini-learning academy' oversees development and adaptation of educational content and the use of digital tools. At the institutional level, the Learning Academy carries out a continuous evaluation and quality control of the institution's pedagogical approach and e-learning environment. At the end of each semester, the Learning Academy asks each school to select a subject for evaluation. The evaluation includes an e-learning scorecard, which assesses the effectiveness of e-learning based on various criteria. At the end of the evaluation, a representative from the Learning Academy meets with the staff to discuss each criterion. In dialogue with the teachers, they identify strengths, weaknesses, and areas for improvement.

3. DIGITALISATION IN CONTENT AND PROGRAMMES

This chapter focuses on how digitalisation is integrated into the education programmes at the Temasek Polytechnic (TP). It examines both educational content and curriculum development, and the professional development of teachers and trainers in relation to digitalisation.

3.1 EDUCATIONAL CONTENT

The digital transformation of the economy and society is translated into digital content that is integrated into TP's education programmes for innovative digital careers. The Singapore government's Smart Nation Plan, Singapore Green Plan 2030, and Industry Transformation Maps inform the key focus, priorities, strategies and outcomes of TVET in Singapore. The process of developing new digital programmes at the TP uses the Industry Transformation Map (ITM) for each industry sector as an overall 'vision' or 'roadmap' from which the relevant programmes are derived. For example, the interpretation of the digitalisation of the economy and society is based on government analyses, strategies and roadmaps, which have been developed for 23 industries in partnership between the government, enterprises, industries, trade associations and chambers.

For example, the ITM for Construction has the following strategic vision:

'An advanced and integrated sector with widespread adoption of leading technologies, led by progressive and collaborative firms well-poised to capture business opportunities, and supported by a skilled and competent workforce offering good jobs for Singaporeans. The ITM identifies Integrated Digital Delivery (IDD),

Design for Manufacturing and Assembly (DfMA), as well as green building as key transformation areas to address the challenges faced by the sector.'

(Source: Building and Construction Authority, 2017)

At the TP, this vision has been translated into a 3-year course, the 'Architectural Technology and Building Services Diploma Programme'. This course equips students with the multi-disciplinary skillsets required to design and manage smart and sustainable buildings for tomorrow's cityscape. Students will also learn how technology is used in sustainable architecture and systems design in today's digital economy.

TABLE 1. EXAMPLES OF INNOVATIVE, DIGITAL QUALIFICATIONS OFFERED AT TP AND THEIR PLANNED INTAKE IN 2023

TITLE	CONTENT	SCHOOL
Diploma in Computer Engineering (T13)	Knowledge and skills in emerging fields, such as the Internet of Things (IoT), data analytics, artificial intelligence, augmented and virtual reality and smart manufacturing. Software design and application development process.	School of Engineering/ Planned intake 2023: 100
Diploma in Applied Artificial Intelligence (T69)	Fundamental concepts of AI, its application, and smart application development. Knowledge of AI with subjects, such as machine and deep learning. The programme provides the necessary skills to develop smart applications useful for commercial enterprises, healthcare, education, transportation, and manufacturing.	School of Informatics & IT/ Planned Intake 2023: 50
Diploma in Integrated Facility Management (T28)	Knowledge and skills in managing the amenities, aesthetics, and functionality of large facilities. Multidisciplinary subjects related to building science, business management, and facility design and planning. Industry-relevant certifications like BizSAFE Levels 2 and 4 (Risk Management, Workplace Safety and Health Management).	School of Engineering/ Planned Intake 2023: 75

TABLE 1. (CONTINUED)

TITLE	CONTENT	SCHOOL
Diploma in Biomedical Engineering (T38)	Training in biological techniques and biomedical instrumentation, including BioMEMS (Biomedical Micro-Electro-Mechanical Systems), intelligent wearable healthcare sensors and smart healthcare devices using artificial intelligence. The programme provides insight into the principles of engineering and digital electronics, and fundamentals of designing medical devices for use in hospitals.	School of Engineering/ Planned Intake 2023: 95
Diploma in Electronics (T65)	Skills in robotics, circuit analysis, user interface design, data analytics, AI, electronics prototyping and avionics. The programme provides skillsets in emerging technologies and their applications in various fields, such as healthcare, assistive technology, and green innovations.	School of Engineering/ Planned Intake 2023: 50

Source: Internal documents

Another example is the Built Environment Industry Transformation Map[43] (ITM) — a 'vision' that focuses on integrative planning and design and advanced manufacturing and assembly, and has served as the basis for the Advanced Manufacturing Centre and the 3-year diploma course in 'Integrated Facilities Management', accredited by the International Facility Management Association.

The process of developing a new programme typically involves the top management of the TP for Specialist Diploma Programme Development and school level management (e.g. School of Engineering), which will be involved as the provider of the diploma. The TP management and industry representatives then form a technical committee where they develop proposals for a syllabus of the basic content of the programme. The draft proposals will be discussed with the Skills Future Agency and the Ministry of Education.

The table below contains some examples of the innovative digital qualifications offered at the TP and their planned intake in 2023.

43 More information is available here.

3.1.1 DIGITALISATION OF PROGRAMME CONTENT IN COLLABORATION WITH THE INDUSTRY

As mentioned above, the digitalisation of programme content and the integration of digital technologies into the curriculum is an ongoing process led by the institutional management in close collaboration with the relevant industry. For example, the subject 'Fire and Life Safety' course is accredited by the Singapore Civil Defence Force. In parallel, subjects related to security and surveillance are developed in collaboration with the Singaporean security industry. Examples are described in more detail below:

Example 1: Integrated facility management

The Skills Lists developed by the Skills Future Agency are used as basic building blocks for the formulation of skills/competences for a programme, e.g. facility management. The external industry partner interviewed, the Singapore International Facility Management Association (SIFMA), describes the development of relevant skills for a particular programme, for example integrated facility management, as taking place in a technical committee with representatives from SIFMA, some SIFMA-certified companies and the TP. As an industry partner, SIFMA is in

FIGURE 6. TRAINING FACILITIES FOR THE 'REFRIGERANT HANDLING FOR CHILLER' COURSE AT TP

Image: DTI

contact with a wide range of certified companies, which ensures that the programme is based on deep and up-to-date insight into the use of technology and the needs of these companies. The school presents its draft syllabus based on the Skills Future Agency's framework and asks: 'Is this what you want in the industry?' The of the programme is then negotiated with SIFMA and associated companies in a process that typically involves 5–6 technical committee meetings. During the meetings the syllabus is progressively refined and circulated for comments from trade associations and certified companies.

Example 2: Temasek Polytechnic launches a course on the handling of chiller refrigerant

The opportunity to develop new courses and programmes can come from various industry partners or government institutions. For example, the idea to offer a new course on the reprocessing and reuse of refrigerant gas, a highly potent greenhouse gas emission, came from the National Environment Agency when a new regulation was introduced, which requires companies to reclaim and reuse refrigerant gas. It was recommended that a company with technical expertise in chiller gas reuse should contact TP to develop a dedicated training course for companies. Many companies did not know how to comply with the new regulation.

In October 2022, a requirement was introduced for the companies handling the installation, maintenance or decommissioning of water-cooled chillers to employ at least one certified chiller technician to carry out or supervise water-cooled chiller maintenance work that involves the handling of refrigerants.

The course, which was developed jointly by the National Environment Agency and the TP, is designed to provide refrigeration technicians in the refrigeration and air-conditioning industry with the essential knowledge and skills to correctly handle refrigerants during installation, maintenance, and decommissioning works carried out on water-cooled chillers.

The course is delivered jointly by TP lecturers at IBEC and industry experts who are experienced in refrigerant handling. IBEC houses a 'live' chiller system that cools the centre and doubles as the main training facility.

Industry also involved in providing learning materials

The industry is also involved in providing learning materials and tools, particularly digital training tools. The TP management believes that by partnering with schools and educational institutions, the private sector can play a key role in supporting and enhancing student learning, and preparing students for success in the workplace. In addition, private sector companies can benefit from their involvement in education by developing relationships with schools and students, and building a talented and well-trained workforce for the future.

The management provides some examples of private sector involvement:

The School of Engineering and the Centre of Advanced Manufacturing have set up a physical training space for additive manufacturing, developed in collaboration with OMRON Electronics and other industry partners for initial and continuing TVET students . Another example is the Lufthansa Training Centre, which was jointly established by

the Temasek Polytechnic and Lufthansa Technical Training. This partnership has created a physical training space on aerospace maintenance for initial and continuing TVET students. In addition, the School of Engineering and Lufthansa Technical Training have developed a physical training space on aerospace maintenance for these students.

3.1.2 STUDENTS AND TEACHERS USE SPECIFIC SOFTWARE FOR EACH SUBJECT

All technical areas related to manufacturing, construction and building management are becoming increasingly digitalised. Students described how architectural design subjects are massively digitalised, meaning that about 90% of programme content is related to digital software tools. One students said: 'For each specific subject, there is a specific software programme that is used as a tool'.

Examples: Revit and rendering software

For example, students in Architectural Building Design use **Revit**, a software programme used to design, document, visualise and deliver architectural, engineering and construction projects. Students describe the software programme as very effective for developing complex technical drawings that previously required very time-consuming drafting. Revit also supports collaborative work, as the software includes several different ways to work with other students who are also using it. One student explained that multiple Revit models can be linked together, allowing a group of students to work in context. Digital tools can therefore help students to assess and comment on each other's work and challenge each other's thinking.

In addition, Revit includes an internal feature called Dynamo — a graphical programming interface that allows students to customise the building information workflow. Teachers instruct the students to use Revit at all phases of construction projects, detailing its functions 'layer by layer' as they design the building from inception to construction. Students are also taught how to conduct the 'SAP analysis', which is a multidimensional analysis of the building.

Similarly, lecturers describe describe using specific building performance modelling software to model, for example, energy use, airflow simulation and other aspects of relevant buildings. Architectural rendering software allows users to create two and three dimensional images of an architectural design. Rendering tools are becoming more advanced and now include capabilities for augmented reality, which adds digital elements as a layer on top of a live view, and virtual reality, which provides a fully immersive experience that excludes the physical world.

The process for deciding which digital tools to include in curricula

The management interviewed have explained that decisions about which specific digital tools to include in curricula are based on industry surveys and industry feedback in the school's advisory committee. Information from these sources identified Revit as the domain tech software used in Integrated Planning & Design throughout the entire building lifecycle. The decision to use specific digital tools is made at school level, at the school delivering the course. The decision typically involves the school management, the head of the centre, the domain expert, and the tutors. A key criterion for integrating a particular software tool into the programme is that it is widely known and used in the industry. Teachers often return from company placements with experience of which software programmes are most widely used.

3.1.3 STUDENTS ACQUIRE DIGITAL DEVELOPMENT SKILLS

As described above, students acquire advanced skills in the use of specific digital software programmes, such as Revit, in specific courses/subjects. In addition to advanced user skills, the students also acquire digital development skills as they learn the basic principles of programming. In fact, it is a requirement for students at the School of Engineering to learn how to code and acquire basic programming skills. Students learn coding in a dedicated course in their first year. In this introductory course, they are introduced to basic constructs of programming and learn to write simple code using the programming language Python.

3.2 PROFESSIONAL DEVELOPMENT OF TEACHERS

The digitalisation of programme content and the learning environment makes it very important that teachers are equipped with up-to-date digital skills and knowledge about their subject.

Teachers are entitled to 100 hours for professional development per year and their continuing professional development is funded by the educational institution (the Temasek Polytechnic at school level) based on its government funding and grants that are allocated on an annual basis. In addition, the educational institution (e.g. the Temasek Polytechnic's School of Engineering) can apply to the Ministry of Education (MoE) for additional funding for the professional development of teachers.

The MoE offers many different programmes that are customised to meet the needs of the teachers at all levels. These include the Singapore Instructional Mentoring Programme, the Teacher Work Attachment Programme and the Outstanding Educator-in-Residence Programme. In addition, the MoE organises teacher-led learning communities and conferences to share developments in pedagogy, curriculum and assessment. Looking to the future, the MoE has launched the ambitious 'SkillsFuture for Educators' plan (as mentioned in section 1.3.2), which aims to upgrade the competences of teachers (Ministry of Education, 2020). In addition, the Temasek Polytechnic teachers who wish to undertake an internship with a company outside the school, can apply for funding from the Teacher Work Attachment Programme, with the support of the school principal.[44]

The management and TP's Staff Capability Development Department have the following processes in place to ensure that the teachers at centre level have the necessary up-to-date knowledge in their subject area:

- Professional development
- Subject-specific certifications
- Collaboration with industry experts
- Incorporation of digital content into the curriculum
- Regular evaluation and assessment.

44 See also Min, A. H., 2022. Sending teachers on work attachments outside the education sector requires a collective effort: Chan Chun Sing

In addition, the school management encourages the participation of lecturers in local/international competitions as a means of benchmarking skills against other higher education institutions. Management believes that by implementing these strategies, the centre can ensure that teachers have the knowledge and skills they need to teach their subjects effectively, including an understanding of how digital content and technologies relate to their subject area. Another success factor identified by the management is that the lecturers have a good tradition of collaboration and knowledge sharing. Teacher collaboration is based on a division of tasks/roles, where each teacher has specific areas of knowledge and expertise.

The learning management system POLITEMall that is used at TP has a separate module called 'Professional Development'. Aimed at teachers, it presents several tools, courses and development activities that the teachers can sign up for as part of their professional development.

According to the students interviewed, the lecturers are generally good at e-learning and have improved their skills in this respect during the COVID-19 pandemic. The lecturers interviewed confirm that undergone a training process which has given them the confidence to produce short videos and online tutorials to make the teaching more exciting and activating. They explained that POLITEMall contains many good tools and instructions on how to develop good teaching practices that involve the learners and make them active.

The JP-CETL Projects & Initiatives sub-menu, which is also integrated into the POLITEMall learning management system, presents courses and initiatives offered by the Joint Polytechnic Academy for Educators, which was established in 2022 as a central academy dedicated to developing and enhancing the teaching and learning skills of polytechnic educators. It offers a range of Joint Polytechnic Teacher Capability Development programmes and certifications, such as the Certificate in Teaching and Learning for Polytechnic Educators, the School Leadership Move-In Programme, the Teaching and Learning Mentor Move-In Programme and the Course Leadership Move-In Programme, among other programmes and initiatives supporting the continuous professional development of teachers.

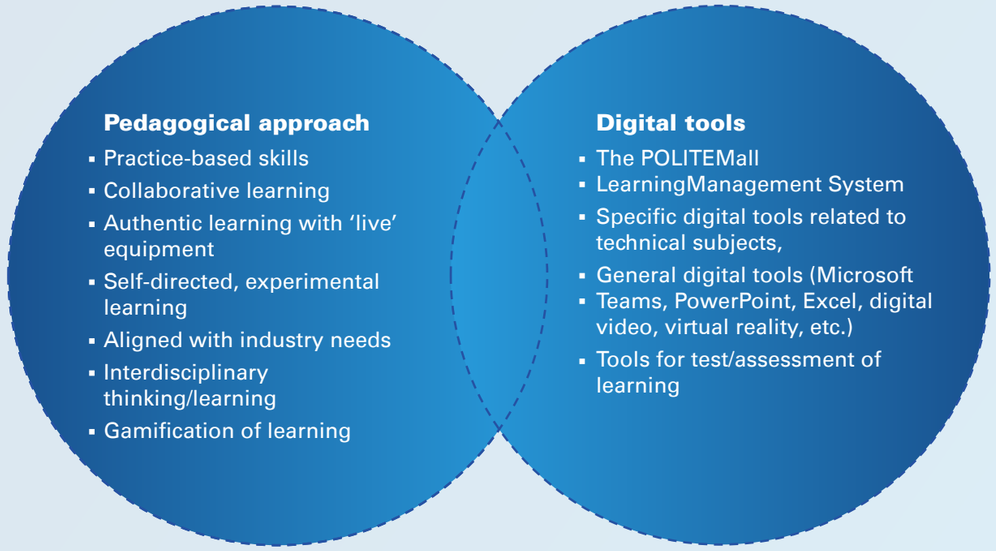
4. PEDAGOGICAL APPROACH

This chapter sets out an analysis of the Temasek Polytechnic's pedagogical approach — how digital tools and the digital learning environment support this approach — and how the digital learning is experienced by the students and faculty.

The Temasek Polytechnic's pedagogical approach is based on a Practice-based and Skills Education (PSE) framework, which emphasises authentic learning to prepare pre-employment students for the world of work. In terms of continuing education for adult learners, the aim is to ensure that the education is highly relevant to industry and that it can be delivered part-time and in a variety of learning modes (face-to-face, e-learning or blended learning).

The figure below illustrates that TP's pedagogical approach focuses on the development of practice-based skills acquired through self-directed learning, and that the skills are aligned with industry needs. The digital tools support the learning processes and the pedagogical approach. The digital tools include (1) the learning management

FIGURE 7. PEDAGOGICAL APPROACH AND THE DIGITAL TOOLS APPLIED AT TP



Source: Author's elaboration

system POLITEMall, which is used as a platform for learning materials and collaboration between lecturers and students; and (2) specific tools/software related to specific technical subjects, for example Revit, which is used to design, document and, visualise architecture and construction projects.

4.1 PRACTICE-BASED SKILLS ACQUIRED THROUGH SELF-DIRECTED LEARNING

TP's pedagogical approach emphasises that students develop practice-based skills that are aligned with industry needs. The following sections describe key elements of this pedagogical approach.

Authentic 'live' experience with energy equipment and digital data extraction

Temasek Polytechnic's use of the energy supply and energy management equipment in its own buildings allows the student to experience a 'live' and realistic work environment. For example, the solar panels on the roof of the building are connected to a classroom full of sensors, monitoring equipment, oscilloscopes, inverters and software, which allow students to analyse and optimise solar energy supply. Solar panel data is used as part of a diploma course

FIGURE 8. MONITORING OF THE SOLAR PANELS ALLOWS STUDENTS TO MEASURE HOW EVEN MINOR DAMAGE TO THE SOLAR CELLS AFFECTS THEIR EFFICIENCY. THE SOLAR PANELS ON TP'S ROOF ALSO ALLOW FOR EXPERIMENTATION WITH DIFFERENT ENVIRONMENTS, SUCH AS PAINTING THEM WHITE TO INCREASE SOLAR REFLECTION UNDER THE PANELS, WHICH CAN INCREASE THEIR ENERGY YIELD

Photos: DTI

in Clean Energy and in adult learner courses (Continuing TVET).

At the same time, IBEC's buildings are used as a 'living laboratory' where energy use, temperature, humidity, lighting, and many other functions are monitored in a building management system. The system allows for data to be reviewed and extracted for educational purposes, as shown in in Figure 9 below:

FIGURE 9. FLATSCREEN DISPLAY AND A CLOSE-UP TO THE RIGHT SHOWING THE BUILDING MANAGEMENT SYSTEM USED AT THE IBEC

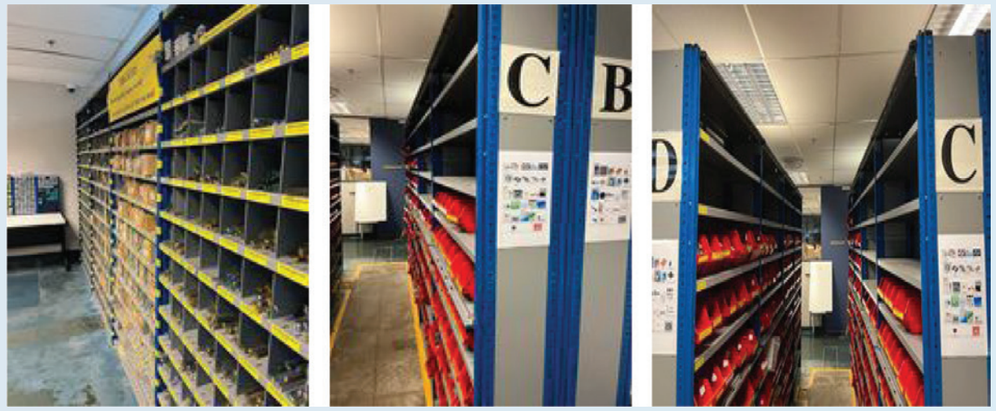
Photos: DTI

The practice-based, experimental and self-directed learning is well reflected in the students' work on their own engineering projects. When they develop their technical equipment for experiments, they collect what they need in libraries of technical spare parts.

Students' projects integrate experiments with sensor technology and software programs for data analysis.
During the visit we were introduced to student projects that experimented with various environmental aspects related to building management, construction and optimisation of energy supply and energy use. For example, one project experimented with solar panels producing solar energy combined with algae production. All parameters of the energy production were monitored with appropriate sensor technology to extract data for process documentation and analysis.

Temasek Advanced Manufacturing Centre is 'at the forefront' of applying technological equipment for Industry 4.0
The Advanced Manufacturing Centre (AMC) has adopted a consistent pedagogical approach to advanced manufacturing that enables hands-on training in a realistic environment. The centre houses an end-to-end 'living' factory that produces high-mix low-volume products and uses a multidisciplinary experimental learning pedagogy. The centre uses technology and equipment to train skills in AI, robotics and automation, industrial Internet of Things, big data analytics, 3D computer-aided design and modelling, additive manufacturing, augmented reality, and cybersecurity, among others.

FIGURE 10. 'LIBRARY OF SPARE PARTS' WHICH STUDENTS CAN USE IN THEIR OWN ENGINEERING PROJECTS



Images: DTI

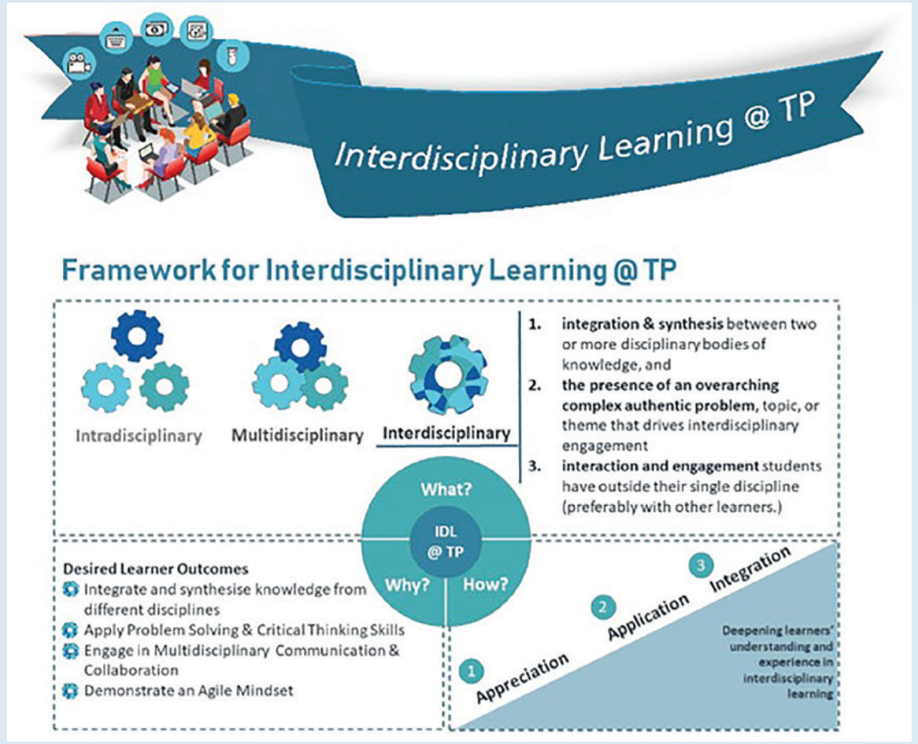
4.2 MULTIDISCIPLINARY LEARNING

The TP also emphasises multidisciplinary or interdisciplinary learning which typically means that students develop projects in collaboration with students from different subjects, courses, centres or schools.

The IBEC focuses on interdisciplinary learning and encourages collaboration between students, staff members and industry partners from different areas of engineering, design and IT. The multidisciplinary projects can be between students from any of the schools at the TP. It all depends on how the subject of a given project can be related to different fields. Contacts and interactions between different schools can be initiated by students or teachers, in some cases through social media, where students present updates on project activities. In some cases, teachers can enhance multidisciplinary projects by giving the students tasks that require collaboration with other schools.

The framework shown in Figure 11 shows the rationale of TPs interdisciplinary learning framework.

FIGURE 11. INTERDISCIPLINARY LEARNING AT THE TP



Source: Temasek Polytechnic

It shows that interdisciplinary learning is used when working on complex, authentic problems that require the synthesis of different disciplinary bodies of knowledge and where there are no clear solutions. The desired learner outcomes involve integrating knowledge from different disciplines and in doing so learners develop a deeper understanding of a problem and critical thinking skills.

In the final interview, the management of the School of Engineering emphasised that interdisciplinary thinking is an important pedagogical approach. When students are paired and work together across different disciplines, they work, learn and propose solutions together. They also see how knowledge from each field enhances the final solution. Interdisciplinary learning involving several schools and external industry partners is supported by digital tools (the LMS POLITEMall, Microsoft Teams, social media and other platforms). The POLITEMall supports interdisciplinary learning by providing students with assignments, quizzes and videos that can enhance learning. In addition, digital communication tools, such as Microsoft Teams, are often used for group work to facilitate peer-to-peer learning and discussion.

Example of interdisciplinary learning

The management's approach is that interdisciplinary learning should be rooted in industry-based projects, where external industry partners have a development project or problem to solve. For example, Project 3R was an industry collaboration project with LDR Pte Ltd, which involved the design and development of a mobile learning application that enables students to learn mathematics through outdoor activities and quizzes. In addition to learning mathematics, the students also learn interesting facts about Singapore's Changi Airport. Another example is the Smart self-Disinfecting Lift, an interdisciplinary collaboration between staff and students from the Diploma in Architectural Technology & Building Services and the TP Clean Energy Research Centre. The team has developed an intelligent lift equipped with a UV-C lamp that uses intelligent sensors to activate it when the lift is empty, disinfecting the lift's interior by killing airborne and surface pathogens. Similarly, in an ongoing project, IBEC students and staff work with NEC experts to delve deeper into smart security analytics. They will learn to assess, collect, organise, process and analyse still images and video surveillance data and sources (Temasek Polytechnic, 2023).

4.3 BUILDINGS AND EQUIPMENT USED TO ACQUIRE HANDS-ON EXPERIENCE

In 2018, all of TP's buildings were scanned using 3D laser technology. All building data has been converted into virtual data available for projects. The scanned data has been incorporated into relevant subjects, such as Security Surveillance, IoT, Energy Monitoring Systems and Solar Photovoltaic Systems, among others. The data is used within a range of programmes, including Architectural Technology and Building Services, Integrated Facility Management and Common Engineering. It has also been incorporated into one or more modules as laboratory experiments.

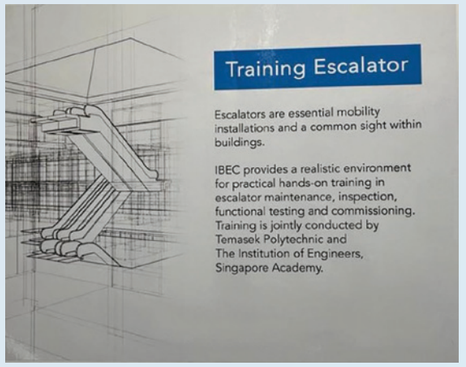
Subsequently, in 2021 the TP installed more than 3 000 sensors across its campus to extract real-time data that can identify potential faults and predict changing conditions. These insights will allow the educational institution to make adjustments to its operations in order to improve efficiency and reduce its carbon footprint. The data collected from the 3 000 sensors is fed into a digital twin, a virtual replica of the physical campus. Data from the air conditioning and mechanical ventilation systems will be monitored to keep temperature and humidity at healthy levels. Data from the various mechanical and electrical systems will be aggregated on the facilities management platform, enabling Temasek Polytechnic to track energy use and identify opportunities to reduce costs and carbon emissions.

A key pedagogical element at the IBEC is putting together various systems and machinery that are commonly found in buildings to give students hands-on experience of operating buildings. These include a refrigerator system, lift and escalator installations, security processes using artificial intelligence, and an electric vehicle laboratory.

FIGURE 12. 3D LASER SCANNER AT THE IBEC ENABLING 3D SCANNING OF BUILDINGS

Image: DTI

FIGURE 13. INFORMATION MATERIAL ON TP'S TRAINING ESCALATOR



Source: internal documents

The IBEC, for example, has opened one of its escalators for educational purposes and offers a course to become a certified lift and escalator inspector. Similarly, TP's rooftop solar energy panels are monitored from a large control room that doubles as a laboratory, where students can use digital sensor data for projects.

In the IBEC's control room, students can monitor all the building's systems for energy distribution, air conditioning, lighting, heating etc. (Figure 14 below).

FIGURE 14. MONITOR ROOM IBEC

Source: DTI's consultant took a picture during visit, September 2022

4.4 DIGITAL LEARNING TOOLS

The following sections describe the main digital tools and how they support the pedagogical objectives.

The scope of the digital learning tools is generally open to all categories of learners at the Temasek Polytechnic. The online courses are open to students in initial and continuing TVET. The same applies to TP's Learning Management System and the 'proof of concept space' described below, which is also available to external stakeholders, such as industry partners.

4.4.1 THE PROOF-OF-CONCEPT SPACE

A 'proof-of-concept' is evidence obtained from a pilot project implemented to demonstrate the feasibility of a product idea, business plan or project plan. A proof-of-concept is used to generate positive results before a product is ready for full-scale development. The proof-of-concept process, whose main objective is to provide a realistic test of a given concept or product before full-scale development, can use digital tools such as digital simulation, augmented/virtual reality and other digital technologies. Management was asked how they would describe the pedagogical approach of the proof-of-concept room. According to the management, the room is a digital tool that can enhance creative thinking and experimental learning, where knowledge and insights are developed through a trial-and-error process that tests the feasibility of solutions. At the same time, it is a digital tool that can help companies build brand awareness, engage with the community, recruit talent and advance their research and development efforts together with the school. It is also a pedagogical approach that facilitates collaboration between the school and business, benefiting both students and businesses.

With funding from the government and industry partners, the AMC has established the Proof of Concept Space, which provides advanced facilities for proof-of-concept projects for industry partners wishing to test and develop new ideas and products. Proof-of-concept projects are available in the following areas: intelligent automation and manufacturing control, connectivity and industrial IoT, robotic systems integration. Students are also involved in proof-of-concept projects as part of their final year major project and internship programme.

The proof-of-concept space can be used by learners in Pre-employment Training (PET) and Continuing Education and Training (CET). Private companies can benefit from the room in research and development: schools can offer companies access to cutting-edge research and development facilities, as well as opportunities to collaborate with faculty and students. This can help businesses stay ahead of the competition and improve their products and services.

The proof-of-concept room is an advanced and innovative learning space that requires highly skilled teachers and trainers. The management of the School of Engineering was asked how teachers and lecturers are recruited and what steps are taken to ensure that their knowledge is up to date. According to management, this is mainly done through networking and collaboration with other institutions. As described in section 3.2 above, TP's management encourages continuing education by providing incentives and opportunities for lecturers to attend conferences, workshops, and

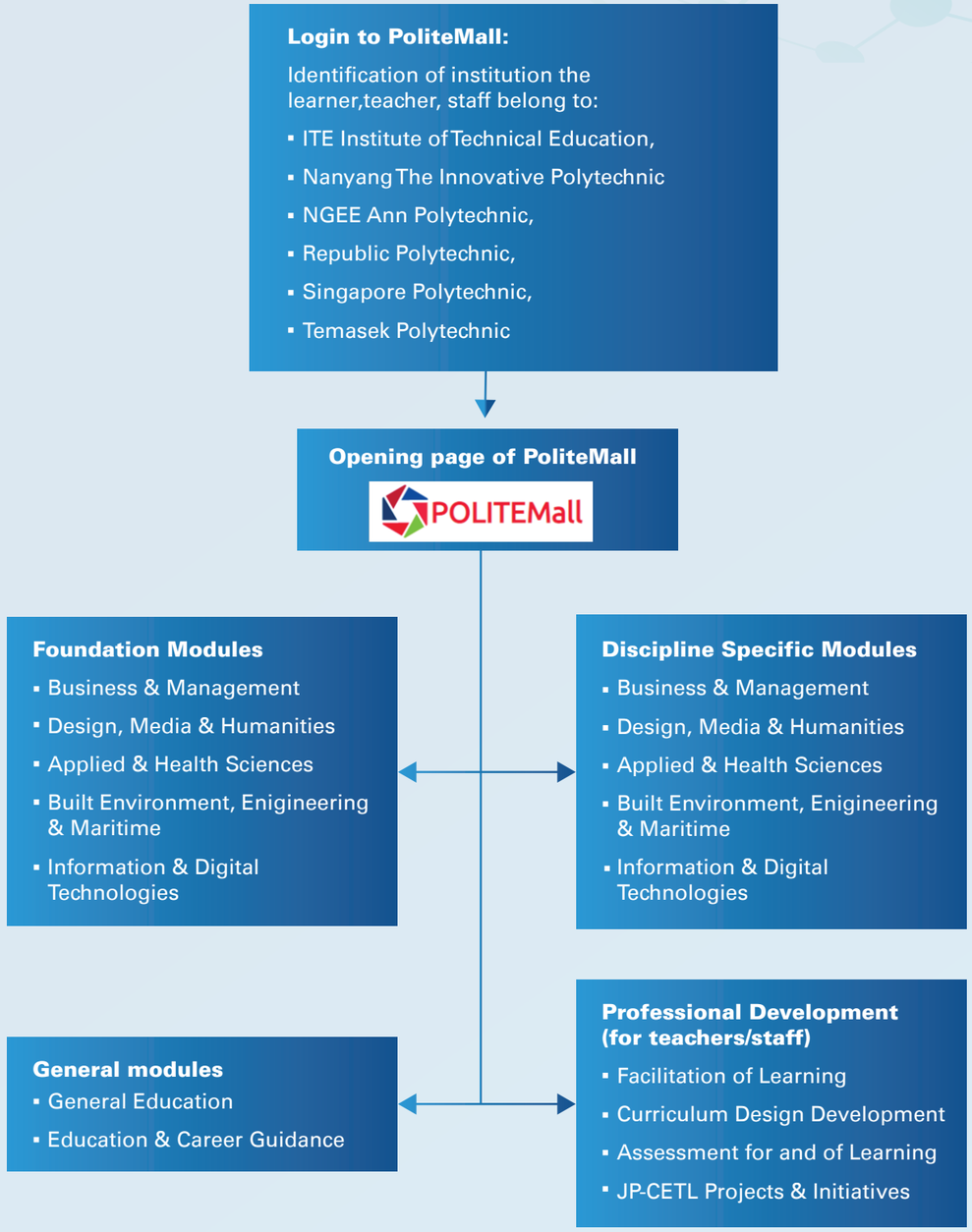
other professional development events. The school provides in-house training and workshop sessions on new teaching methods, technologies, and other relevant topics. The TP also encourages teachers and trainers to collaborate and share knowledge and experience. The institution is also open to internal transfers and encourages existing staff members to support the needs of other departments. With the full support of the school, access to resources and technology is provided to ensure that staff have access to the latest resources and technology to support their teaching and professional development.

4.4.2 THE LEARNING MANAGEMENT SYSTEM

POLITEMall, the widely used Learning Management System at the TP, is managed by an administrator based at TP's Learning Academy who works closely with the Joint Polytechnic and ITE (Institute of Training and Education). The LMS has been developed by several polytechnics (Nanyang Polytechnic, Ngee Ann Polytechnic, Republic Polytechnic, Singapore Polytechnic, Temasek Polytechnic) and the Institute of Technical Education. These six institutions are collectively known as 'POLITE', and they own and maintain the LMS. The lecturers interviewed describe the POLITEMall as a 'repository' because it acts as a platform where they store all the resources they use for teaching, including tasks, notes, instructional videos, recorded lessons and other material.

The figure below shows the main elements of the POLITEMall:

FIGURE 15. OVERVIEW OF THE LEARNING MANAGEMENT SYSTEM AT TP



Source: Author's elaboration

The students access all digital content on the POLITEMall via a personalised ID. The digital content is owned by the Temasek Polytechnic, which manages the copyright agreements with publishers. The educational institution is also responsible for concluding agreements with publishers and authors for the use of books and articles for educational purposes. Responsibility for ensuring the quality of digital content lies with the school offering the course and its local Learning Academy unit. Interviews with the management of Temasek Polytechnic indicate that this 'unison' platform is seen as an advantage because it allows for simplicity and 'economies of scale' in updating the platform and handling technical problems.

As shown in Figure 14 above, learners and teachers/staff face the same layout and main sub-menus in the LMS. However, the Professional Development menu is for teachers only. Here teachers can find tools and courses on how to improve their teaching activities.

POLITEMall is a central digital platform containing many different functions that all students and teachers have access to. Through personalised access, the students use the platform to access learning content and assignments to be prepared before class. All materials distributed by the teacher are usually placed on the LMS. After the lesson, the student can access the recording and review the lesson, if necessary. Similarly, the lecturer can post tasks and assignments for the students to work on after the lesson.

POLITEMall supports self-directed learning

The LMS also enables collaborative work between the students in a given class or programme/course. Students can be paired or grouped by the teacher in advance, or the students may break out in groups themselves.

When the students collaborate via the LMS, they do so via a channel that is only accessible to students in the group. The channel allows the students to exchange messages and files with each other in the group. Collaboration on POLITEMall is supported by the 'Blackboard Collaborate', an integrated video conferencing tool within the LMS, which enables real-time online engagement and real-time chat, audio and video conferencing.

Real-time collaboration can also include interactive whiteboarding and file sharing capabilities, including 'breakout rooms' for more intense collaboration in sub-groups. Blackboard Collaborate also provides access to recordings of sessions for review. Interviews with students and teachers indicate that around 80% of lessons are recorded.

To support the learning process, the lessons on POLITEMall also include online quizzes with multiple-choice questions to be answered to see whether the students have mastered the content. If a student answers too many questions incorrectly, this can help identify gaps in their knowledge.

Interviews with students and lecturers indicate that the LMS is seen by both parties as an excellent platform that supports a progressive learning process, both individual and collaborative. The POLITEMall is a digital tool that is well suited to support the pedagogical approach of 'flipped classroom' and 'self-directed learning'. Temasek Polytechnic defines 'flipped classroom' as a type of blended learning where students can explore new topics on their own, while classroom time is used to focus on the application of new knowledge and higher level outcomes. Content is first introduced, usually in the form of videos which students can watch and review on their own. Then, during face-to-face teaching, the focus is on the student, with the teacher acting as a facilitator. Learning content on their own helps students to become more independent and self-directed.[45] Although students are expected to be self-directed, they must meet an attendance requirement and attend at least 85% of the lessons in each subject on the platform.

Assessment of e-learning with quizzes and 'gamification'

POLITEMall was seen a very useful learning enabling tool during the COVID-19 pandemic, as the previous integration of the LMS meant that the TP was very well prepared for e-learning. During the pandemic, the Learning Academy monitored and improved the quality of tutors' e-learning activities. In particular, the Learning Academy has helped tutors to provide well-structured recorded lessons and more engaging e-learning to ensure that students did not get bored during online lessons. Some students find that they need to take a break when online classes last more than two hours. Breaks and variation of individual and collaborative activities are important to prevent students from becoming mentally absent.

The tutors interviewed describe that all the results of assessments/quizzes are stored in POLITEMall, with the LMS tracking the progress of each student. In addition, the inventory of all the test results allows for evaluation and improvement of teaching practices and pedagogical approaches. Each quiz takes about 10 minutes to complete. The quiz is an element in the LMS. When students take the quiz online, the integrated use of a custom browser locks down the virtual 'test environment', meaning that students cannot cheat, e.g. by finding answers to test questions on the internet.

4.5 LEARNING MATERIALS AND INTELLECTUAL PROPERTY RIGHTS

The POLITEMall learning management system provides a wide range of digital teaching and learning materials. These include student workbooks/handbooks, e-books, lab sheets, tutorial sheets, e-resources including e-books, external website or video links, staff-created videos, and simulation applications.

The teaching and learning materials are largely created by TP staff and are owned by the TP. In some cases, e-materials may be used from publishers such as McGraw-Hill. In these cases, the TP pays for the user licences. In other cases, some may use training materials provided by companies, with the necessary agreements signed between the TP and the companies concerned.

45 Enhancing Your Learning @ TP Engineering School | Temasek Polytechnic

Recently, the polytechnics have started to develop e-teaching and learning materials that are offered for sharing across the polytechnics through the LMS. These materials usually cover basic concepts which will meet the needs of most polytechnics.

There is also a quality assurance system for the learning materials. Management mentions that a subject review takes place every 2 years. Each centre has a Subject Leader who is responsible for a particular subject and reviews the learning materials. Regarding the quality assurance of e-learning, the TP has developed an e-scorecard system. This is used to assess the effectiveness of e-learning based on various criteria. For example, the e-scorecard is used to check the quality of POLITEMall content, layout, ease of navigation and identification of relevant information for students as well as learning activities on the platform. The 'Design, Delivery and Technical Framework' provides guidelines for the development of e-lectures. The framework and the e-scorecard system mentioned above represent tools and provide guidance to help educators, but their use is not mandatory.

4.6 LOOKING TO THE FUTURE: METAVERSE

The Temasek Polytechnic believes that it has created a well-functioning digital learning environment, which supports its pedagogical approach of self-directed learning of practice-based skills that relevant to industry. Looking to the future, however, the digital transformation is far from complete and has only just begun. Within the School of Engineering's focus areas, such as construction, design, and building and energy management, the TP sees a great potential for digital technologies related to the development and use of virtual, three-dimensional plans and environments. Consequently, the TP expects the digital transition to continue towards the metaverse as the next digital technologies paradigm.

The Metaverse is a 3D-enabled digital space that uses virtual reality, augmented reality, and other advanced Internet and semiconductor technologies to enable people to have life-like personal and business experiences online. The 3D-enabled digital space can be displayed in a mask and then the viewer can walk around or work in the virtual space. The metaverse offers unique opportunities for the construction industry and architecture, as the internal spaces and functions of buildings, such as the power grid, can be shown to the viewer in 3D. People can interact virtually with 3D models. In the Metaverse, architects usually re-imagine existing structures such as buildings in the digital realm.

TP's management believes that the metaverse will have a great pedogogical potential, when students are working inside a building, as they will be able to move around the building virtually and see different layers of equipment and the parts and functions of the building. Looking to the future, the Temasek Polytechnic's management also mentions that they are focusing on the government's recent digital economy forecasts. For example, the Skills Demand for the Future Economy Report 2021 by SkillsFuture Singapore. According to the report, nearly 30% of new job opportunities globally will be in data, artificial intelligence (AI), engineering and cloud computing. With the rapid advancement of digitalisation and digital services driven by AI, Internet of Things, cybersecurity and 5G, old paradigms and business models are being challenged. Therefore, the management will continue to follow its approach of close collaboration with the industry to ensure the industry relevance of its skills and education programmes (SkillsFuture Singapore, 2021).

5. CONCLUSION – KEY LESSONS LEARNED FROM TEMASEK POLYTECHNIC'S DIGITAL TRANSITION

Temasek Polytechnic's digital transition has two strands: digital content in educational programmes and digital tools for learning

The two institutions visited, the Advanced Manufacturing Centre (AMC) and the Integrative Built Environment Centre (IBEC), are related to industries are becoming increasingly digitalised. According to students, about 80–90% of the content in training programmes/courses is related to specific software tools and programmes that they use when working in building design, energy management and other areas. As a result, the digital content of the programmes is continuously updated in close collaboration with external partners in technical committees as the TP places high priority on providing practice-based skills that are relevant to industry. Industry placements are often provided to both students and teaching staff to ensure close links with the industry.

The other strand of the digital transition concerns the digital tools that make up the digital learning environment. The TP has developed a digital learning environment that supports the institution's pedagogical approach of providing practice-based skills developed in self-directed learning and collaboration with other students through separate digital channels. The POLITEMall learning management system supports these individual and collaborative learning processes, as the platform allows the students to access and work with content before and after class, and to review the recorded lessons. The 'gamification' of e-learning has increased student engagement and motivation.

The TP has adopted a consistent approach to digitalisation by 'digitalising itself'.

In addition, the IBEC has turned its entire solar energy supply system and internal building equipment into a 'live' laboratory to give students a hands-on look at sustainable building operations using digital monitoring tools. This includes a cooling system, lift and escalator installations, security processes using artificial intelligence and an electric vehicle laboratory. In addition, all buildings have been 3D scanned and converted into digital data that can be fed into digital twins and other replicas of the physical campus. The students and teachers interviewed believe that the close access to technical equipment and 'real' digital data is a great benefit to the learning process.

Government support and policy strategies are important for digital transition.

When asked: 'How did you manage to achieve digital excellence?', the management replied: 'Government support!'. Government strategies and plans are seen as an important guiding factor for the institution's digital transition, as all of TP's digital initiatives and curriculum content are aligned with the government's Smart Nation strategy. The government's Industry Transformation Maps for each industry sector are a key driver for TP's digital programme content. For example, the relevant ITM is used as a policy reference for the diplomas in Architectural Technology and Building Services. Similarly, the Integrative Built Environment Centre covers a wide range of related domains, specialising in areas such as digital architecture, intelligent building systems and smart facility management (which are all areas identified in the Industry Transformation Map (ITM) for the Built Environment sector).

In terms of learning environment digitalisation, the Ministry of Education is seen as a key government supporter of educational technology. The Ministry's current Educational Technology Plan guides the development of a technology-enriched school environment for teaching and learning.

According to the management, another important factor in digital transition is that the teaching staff has an open mindset to lifelong learning. All teachers must be motivated to update their knowledge and understanding of a particular industry and be willing to learn new things on an ongoing basis.

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ANNEX

This case study is based on desk research and a two-day visit to Temasek Polytechnic, Singapore. During the visit, the author of the study was given guided tours of the Integrative Built Environment Centre (IBEC) and the Advanced Manufacturing Centre (AMC) at the School of Engineering. As detailed below, four group interviews were held with Temasek Polytechnic's management, students, teachers, and external partners. In addition, a plenary discussion was held, which was attended by most of the interviewees.

INTERVIEW PARTICIPANTS

Group interview with management:

- The interviewees were a course leader, the head of IBEC, a senior academic mentor and a lecturer.

The interview focused mainly on the digital transition and how learning management platforms and other digital tools were used in the digital learning environment. The interview also focused on how the sustainability and the green transition are integrated into curriculum and the use of technical equipment in this regard.

Group interview with teachers:

- The interviewees were two managers, a senior lecturer and a lecturer from the School of Engineering.

The interview focused on how they use the learning platform and other digital tools in their teaching, and how their competences are updated by the learning academy. The interview also focused on how the teachers collaborate and how teaching is assessed through annual tests.

Group interview with students:

- Six students enrolled in IBEC and AMC courses were interviewed.

The interview focused mainly on their experiences of the digital learning environment and how they use digital tools and various software programmes in the courses. The interview also focused on how different aspects of sustainability, for example energy use optimisation, are integrated into the courses and assignments.

Group interview with external partners:

- The Managing Director of A-GAS, the Honorary Secretary of IFMA (International Facility Management Association) and the Director of IFMA's Secretariat were interviewed.

The interview focused on how the external partners' collaboration with the TP on defining the content and skills objectives of various courses. The IFMA and TP had collaborated on the content and skills goals of the facility management education programme. A-GAS had collaborated with TP in defining the course content on the reuse of gas from TP's refrigeration system, which has become mandatory due to recent national legislation .

Plenary discussion:

The plenary discussion focused on some of key findings and observations from the visit. The participants were mainly the interviewees mentioned above.

ABBREVIATIONS

AI	Artificial intelligence
AMC	Advanced Manufacturing Centre
AR	Augmented reality
Bac-Pro	Vocational baccalaureate
BTn	Technology baccalaureate
BTS	Higher technician certificate with a baccalaureate
BUT	University Bachelor of Technology
CoVE	Centre(s) of Vocational Excellence
CEIFS	Campus d'Excellence Industrie du futur Sud
CAP	Professional skills certificate
DTI	Danish Technological Institute
ECTS	European Credit Transfer System
ETF	European Training Foundation
EQF	The European Qualifications Framework
FTE	Full time equivalents
ICT	Information and communications technology
IBEC	Integrative Built Environment Centre
IOT	Internet of Things
ITM	Industry Transformation Map
LMS	Learning Management System
MOE	Ministry of Education
OPCO	Sector-specific skills operators (*opérateur de compétences*)
PACA	Provence-Alpes-Côte d'Azur
RMB	Renminbi (the official currency in China)
SMEs	Small and Medium-Size Enterprises
SLS	Singapore Student Learning Space
SSG	SkillsFuture Singapore
VET	Vocational Education and Training
TVET	Technical and Vocational Education and Training
VR	Virtual Reality