Measuring 4IR Responsiveness in Vietnam's Higher Education

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ABSTRACT

This research introduces a new model for university transformation in the context of the Fourth Industrial Revolution (4IR). This new approach, known as the Innovation-driven University, applies criteria and indicators through the University Performance Metrics (UPM). The UPM has three key characteristics: radical mindset changes, holistic innovation facilitations, and ecological and social norm encouragement. Instead of past transformations' entrepreneurial approach, the innovation-driven method redefines universities as ecosystems that innovate for others rather than in isolation. An innovation-driven model facilitates the demands of entrepreneurial spirit, innovative approaches, digital transformation needs, personalized education, and ecological and social norm promotion. It is a new framework to measure innovation in higher education institutions (HEIs) that integrates criteria that respond to the demands of the 4IR. This article assesses UPM's ability to evaluate the 4IR readiness of 10 HEIs in Vietnam. We provide conclusions on the skills HEIs need to develop to prepare graduates for work and life in the 4IR.

Keywords: 4IR, Innovation-driven University, Ecological University, Digital Transformation, University Rating.

Introduction

The world is changing quickly, and old benchmarking models do not sufficiently account for disruptions associated with the fourth industrial revolution (4IR). Quality, access, and sustainability are key characteristics of reputable higher education institutions (HEIs). These qualities are essential for individual learning and human capital formation. As such, academic standards are established in line with relevant geographical accreditation bodies to communicate the viability of awarded credits and degrees. The university is responsible for the academic quality and standards of all degrees in its name. At the same time, the university must ensure that its academic standards are at least as high as those of comparable institutions. Then, when necessary, they can innovate to meet expectations within their constraints. Benchmarking across universities within a country and across international borders allows HEIs to identify and monitor changing standards and performance to maintain quality and improve outcomes, processes, and policies. Based on this benchmarking, the reputation and funding for a given HEI are closely linked to its reputation for quality. In this context, quality evaluation benchmarks, rankings, and ratings play a central role in shaping global higher education standards. These processes verify a given HEI's standing to all relevant stakeholders and enable them to plan and achieve change more efficiently (Stoller, 1995).

This research focuses on how HEIs assess their ability to produce 4IR-ready graduates and innovate. Innovation is understood as relating to processes for developing, adopting, and delivering policies and practices that generate change, efficient practices, new programs, and technology deployment with organizations and their community members. (Comeaux, 2013). Quality higher education is now associated with employability in a disrupted world, and HEIs curriculum, pedagogy, and research respond to these challenges. Countries and universities have an obligation to their students and funders to consider their 4IR readiness (Gleason, 2018; Wissema, 2009; Barnett, 2018; Chung et al., 2020; Chung et al., 2022; Dewar, 2021; OECD, 2017). To become more effective and relevant institutions in this disrupted 4IR era, universities need a benchmarking tool that fully reflects the characteristics and requirements of the graduate, the labor market, and society. New benchmarking metrics and indicators can provide universities with directions for improvement and act as critical drivers of change to address antiquated policies that do not support evolving students or research. The criteria we use to assess quality must change as the world changes.

To address this problem in Vietnam, colleagues at Vietnam National University developed the University Performance Metrics (UPM) (UPM, 2020). UPM is a sophisticated new benchmarking framework that assesses HEI responsiveness to 4IR educational demands. UPM is a score rating system of HEI's quality based on benchmarking references.

The main objective of this rating system is to promote benchmarking among universities against five newly-relevant and innovative 4IR-relevant education characteristics: Entrepreneurial Spirit, Innovative Approaches, Digital Transformation, Personalized Education, and Ecological and Social Norms. Fifty-five universities from the ASEAN region (including Brunei Darussalam, Myanmar, Indonesia, Philippines, Thailand, and Vietnam) and Taiwan have implemented UPM. The

participants expressed their satisfaction with the ratings they received and praised UPM for building a system that could help fulfill their vision of becoming a competitive university at the international level. These participants expressed appreciation for creating a benchmark their students and potential employers could use as indicators of success relative to their local contexts and disrupted world.

This research provides insight into the skills HEIs need to develop in graduates to prepare them for work and life in the 4IR. In this article, we redefine the characteristics of successful HEIs following the UPM approach of innovation-driven universities and use UPM's core indicators to evaluate the 4IR readiness of technological HEIs of Vietnam.

The Evolution of Higher Education

Three Generations of HEIs

In the context of world changes, Wissema provides a detailed description of three different generations of HEIs (2009) and their evolution in recent times. He argues that they are experiencing significant change again and evolving from more traditional research-based and government-funded universities into international know-how hubs, which he calls third-generation universities, or 3GUs. Wissema's framework helps us understand how benchmarking today's institutions also needs to change. In current benchmarking systems, innovation and entrepreneurship are not correctly weighted for their significance if incorporated.

Borrowing Wissema's terminology, we can assess the first-generation universities (so-called 1GUs) as metaphysical places of learning in service to god. Among 1GUs, the university was brick-and-mortar churches, mosques, monasteries, and temples, and teaching was mostly one-way presentations where learners, typically exclusively male, were passive recipients of knowledge. These universities worked to reinforce universal truths and train future leaders of their society in service to god. But these first-generation schools eventually produced what is known today as a liberal arts education. Grounded in the pedagogies of Confusious, Al Ghazali, Plato, Ibn Khaldoon, and modern-day philosophers such as John Dewey in the United States, these schools combined interdisciplinary curriculum and rote memorization, and dialogical learning to inform the modern Liberal Arts model.

The second-generation universities (2GUs), according to Wissema, are the research-oriented universities that emerged in post-industrial societies (such as the Humboldt University of Berlin, founded in 1810). These universities reduced the universal truths to experimental and logical verification of specific theories and hypotheses with a monodisciplinary approach. In these HEIs, specialization was narrow, deep, and siloed in interdisciplinarity. Although there was engaged interaction between faculty and students, the primary function of a 2GU was the transmission of knowledge and foundational research. Second-generation universities also embed the computer in their operational processes and, eventually, the personal computer. Research in 2GUs has been an

essential source of innovation and economic growth. However, there has been little effort to support the application of research for the betterment of society in 2GUs. The development of 2GUs emerged from the idea that universities would generate basic knowledge while companies and institutes would develop applied know-how that could translate into practical and economic solutions (Wissema, 2009). As the importance of innovation and disruptive technologies has become clear with 4IR technologies, governments are less content with funding research for its own sake. Over the last 25-30 years, governments shifted the purpose of funding HEIs. They have become incubators of new science- or technology-based commercial activities for existing firms or startups (Chung et al., 2022).

A shift toward third-generation universities (3GUs) is characterized by governments encouraging HEIs to take an active role in exploiting their knowledge. They are funding research to support activities in the interest of the economy. Thus, universities have become explicit instruments of economic growth in the knowledge economy, and 3GUs have emerged with new economic goals that first-generation institutions did not prioritize. The 3GU might be best described as the entrepreneurial university, which actively supports the creation of value to society by supporting the development of talent, but also techno-starters, and startups. Exploiting know-how is the 3GU objective, as universities are seen as the cradle of new entrepreneurial activity in addition to traditional research and education tasks. In this case, education is pursued to create scientists, scientifically educated professionals, and entrepreneurs.

Redefining the Modern University

While HEIs have been evolving, so too have local societies and the global economy. The 4IR has been altering how we live, work, and relate to one another. The rapid change we see with digital technologies renders obsolete traditional approaches to HEIs. Information is no longer solely controlled by universities; the skills most needed to relate to using information, not where to get it. These changes require a new model for HEIs to make education worthwhile for the individual, the community, and the economy.

The Malaysian Ministry of Higher Education (MOHE, 2018) has identified nine ways that the 4IR has created uncertainty for higher education; these can be reduced into four main areas. First, HEIs are challenged by changing labor market trends due to automation in specific industries. We are already seeing automation of tasks, shifts in part-time employment through the gig economy, and increased demand for lifelong learning and active learning skills. Second, there is an extraordinary demand for digital literacy as technologies change and new software platforms emerge faster than humans can master, requiring new cognitive load management expertise and learning skills (MOHE, 2018). Third, there is a changing landscape for entrepreneurs who need to know how to leverage global platforms to facilitate startups for economic growth and new livelihoods. Finally, human lifestyles and value systems are changing systemically, which has implications for how we personalize education at scale and what humanistic characteristics people choose to foster – such as emotional intelligence and civic engagement (MOHE, 2018).

Drawing on literature from the 4IR and ministries of education across Southeast Asia, we identified three key areas that HEIs can focus on to foster skills and competencies in graduates and against which they can benchmark themselves: (i) radical mindset changes, (ii) holistic innovation facilitations, and (iii) ecological and social norm encouragement. These new capacities could help universities respond to the trends in 3GU and 4IR and position themselves for success. While funding, security, and access issues complicate innovations in curriculum, staff, and infrastructure, 3GUs should be encouraged to reorient their pedagogical approaches based on these three key areas.

Radical Mindset Changes: As Fang, Kand, and Liu note in *Measuring Mindset Change in the Systemic Transformation of Education*, "mindsets as the basic assumption, beliefs, core values, goals and expectations shared by a group of people who are committed to a specific field, and what they will use as rules to guide their attitudes and practice in the field." (Fang et al., 2004, p. 299), Hagen (2002) has highlighted the importance of mindset shifts in order to foster entrepreneurial innovations in HEIs. Currently, many HEIs operate with the initial industrial revolution mindset, whereby humans need to be developed to support the production of goods. Disruptive innovations, and catastrophes are forcing change. Covid-19, which forced emergency remote instruction around the world in April 2020, highlighted that old ways of functioning are outmoded. HEIs are notorious for being resistant to change. However, entrepreneurialism and innovation are mindsets, and mindset changes are essential to developing future-ready graduates and future-relevant research for innovative HEIs.

Holistic Innovation: Innovation is not just the successful introduction of something new based on an invention (or research), but rather, the ability to innovate, recognize and create opportunities, work in teams, take risks, and respond to challenges (Kirby et al., 2011). The innovation we refer to here involves substantial shifts in organizational character to foster more efficient, productive systems and well-educated employable graduates (Smith & Burton, 1998). We refer to "holistic innovation" to include leadership and governance, organizational innovation ecosystems; people and their incentives; innovative teaching and learning; and innovation-driven research (and/or exploitation of knowledge) (Smith & Burton, 1998).

Embracing digital technology to run systems, deliver teaching, and conduct research is part of HEI's holistic innovations. Some have referred to such HEIs as smart universities. South Korea has developed some of the most well-known national initiatives in smart education (Lim & Kye, 2019). Recently, a conceptual model of smart universities proposed digital transformation-oriented higher educational institutions using digital infrastructure (digital legal, digital human resources, digital data, digital technologies, and digital applications) to provide personalized learning services to learners of all generations in the country and around the world.

For the evaluation of the impact of digital transformation and attempts at holistic innovation in HEIs, the UPM establishes eight indicators. These include information analysis and management, digital scholarly resources, learning resource access, interactive learning, MOOC and digital

lessons, blended learning, application of cyber-physical systems, and information ethics. These are introduced in detail in Table 1 below.

Ecological and Social Norm Promotion: As we are now in the Anthropocene, human activity is environmental. The 21st-century university is embedded and interconnected with multiple aspects of the social, cultural, and material worlds. Universities are well positioned to champion the 17 Sustainable Development Goals (SDGs). Not just through supporting SDG #4 - increased access to quality education, but also by explicitly supporting SDG #17, which relates to global cooperation on all the other goals. HEIs need to be innovative leaders in addressing the world's disruptive challenges. The role of an HEI is to apply an ecological lens to lead, strengthen, and enhance the sustainability of our species. Through the curriculum, actions, funding, and internal practices, HEIs can support the achievement of the SDGs by 2030. Innovative HEIs work to foster knowledge and expertise that help address the grand ecological challenges of our earth. And they can produce graduates that can navigate modern complexities by training teachers and students in relevant interdisciplinary areas.

This work is not just about ecological systems but also sustainable societies that are allowed to be civically engaged. Chankseliani and McCowan (2021) have highlighted that not all universities can address the SDGs due to a lack of funding or other local challenges. However, the SDGs cover many aspects of the human and ecological connection. SDG #16 relates to promoting peaceful, inclusive societies, providing access to justice for all, and building accountable and inclusive institutions. Preparing critical thinkers, problem-solvers, and compassionate citizens will support the structures of peace within society. In a fragile world where civil and international conflict is being waged on several continents, the sustainability of society is intrinsically linked to fostering social norms that value peace over conflict.

Characteristics of The Innovation University: A Model for Assessment

Building on the ideas Wissema (2009) shared, this research establishes the model and the way to become an innovation-driven university. For this case, university classifications and the convergence of teaching intensive- and research-oriented-universities to an innovation-driven university model are presented in Figure 1. Here, Types 1, 2, and 3 are 1GU, 2GU, and 3GU, while Types 4 and 5 are excellent versions of 2GU and 3GU. If a Type 1 university wants to develop itself, it first has to create a thorough research base to become a Type 2. As discussed below, Type 1 universities can reach a Type 3 one thanks to non-R&D based innovation (or open innovation). Type 2 universities, however, can facilitate their R&D-based innovation (or pioneer innovation) and collaborate actively with the industry to become Type 3 universities or innovation-driven universities, which include three key characteristics: radical mindset shift, pursuing holistic innovation, and promoting social and ecological norms.

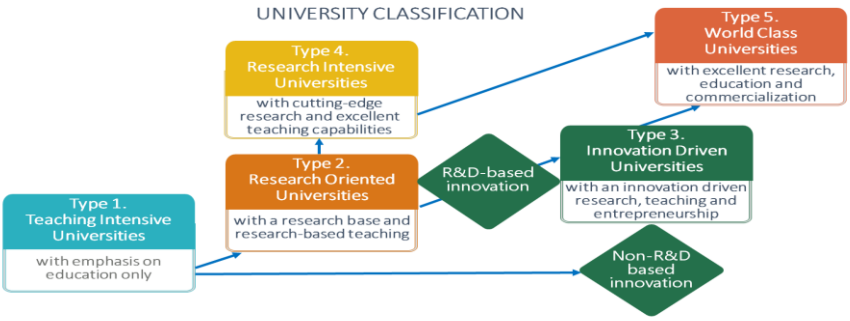

Figure 1: University Classifications and The Convergence of Teaching Intensive and Research Oriented-Universities to An Innovation-Driven University Model.
Source: Developed by Wissema (2009) And Chung et al. (2022).

The model consists of two core clusters, traditional education, and research-based cluster, and a general innovation cluster. There are two optional elements, specific innovation corresponding to the teaching-intensive and research-oriented universities, as depicted in Figure 2. The traditional education and research-based group consist of traditional university components that perform the basic research and education functions, such as faculties, departments, and teaching and learning processes. It is not presented in detail here; below, we focus only on the components and characteristics of the general and specific innovation models applied through the UPM.

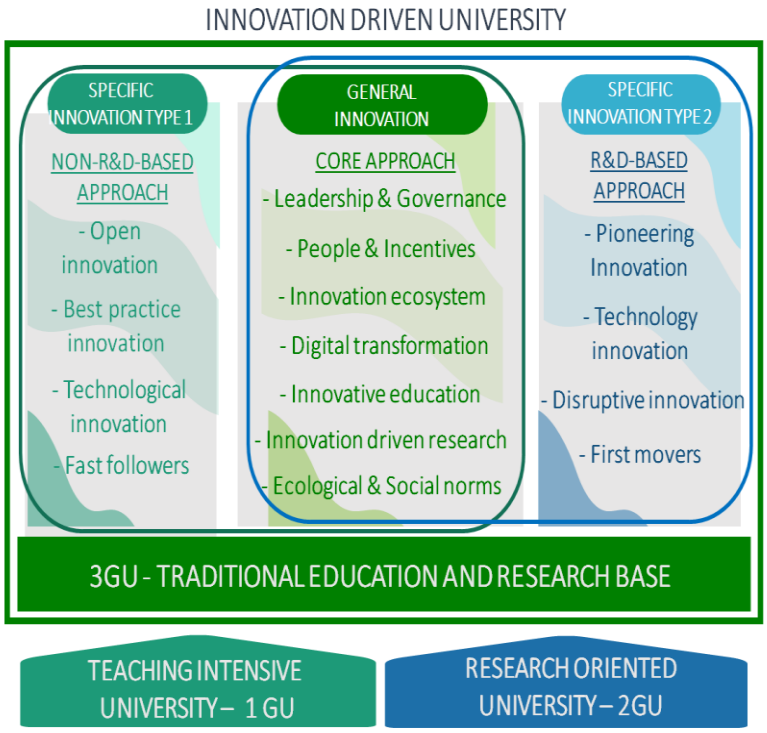

Figure 2. Model of Innovation-Driven University,
Source: Developed by Chung et al. (2022).

General Innovation

The mechanism of innovation development in the university lies in creating the An innovative environment, including all the business development processes of its constituents (research, professionals, infrastructure, and funding), provided well-designed goals are set based on the defined principles (Krasovskiy et al., 2020). The general innovation cluster of a highly-adaptive innovation-driven university includes the following seven components: (1) Leadership and governance, (2) People and incentives, (3) innovation ecosystems, (4) digital transformation, (5) innovative teaching and learning, (6) innovation-driven research, and (7) ecologically focused social norms. These components are discussed in turn below.

Leadership and Governance: Entrepreneurship, innovation, digital transformation, personalized education, and new social norms are the significant elements of this new university strategy. There is a high-level commitment to implementing university innovation strategies and strengthening university culture. In an innovation-driven university, the HEI has an organizational model for coordinating and integrating entrepreneurial activities at all levels (Gibb, 2012; Etzkowitz, 2017). The university has defined its reputational ambitions, articulated in the strategic or corporate plan. The university's corporate plans and core statements specify and make references (through KPIs and goals) to a desired future reputation for the university. A university identity guide is a quality assurance mechanism for visualizing the brand and reputational attributes. All academic and service departments have identified how they can positively contribute to enhancing the university's reputation. Documents, policies, and resource allocation to carry out missions and achieve goals are established and implemented, primarily resource investment for achieving the goals of an innovation-driven university.

People and Incentives: The university invests in the talent development of academic staff and first-year undergraduate students to support its innovation agenda. It raises awareness of the importance of developing innovation abilities among staff and students (Gibb, 20012; the US, 2013). The university actively encourages individuals to become entrepreneurial, provides opportunities to experience entrepreneurship, and supports individuals and groups to move from entrepreneurial ideas to action. Besides creating new mechanisms for breaking down traditional boundaries and fostering new relationships to bring internal stakeholders (staff and students), the university gives status and recognition to collaborators who contribute to the university's innovation agenda.

Innovation Ecosystem: Besides the traditional education and basic research focus, the university innovation ecosystem includes interdisciplinary, project-oriented research centers, which work on transferring knowledge and technology to the business community. In addition, there are creative co-working spaces and startup support systems for faculty, staff, students, and the broader startup community to share ideas, design, construct, and develop new products (Gibb, 2012). A business incubator and/or center for entrepreneurship is a unit that supports individuals and groups

moving from entrepreneurial ideas to action. A center for developing university intellectual property is indispensable for the economic focus.

Although there is no neat patterning concerning the ecological focus of a given HEI, a green and modern campus environment would help the innovation-driven university to be powered ecologically. Indeed, it proposes the atmosphere and ethos of the universities. Critically, the university has strong links with incubators, science parks, and other external initiatives, creating opportunities for dynamic knowledge exchange. The presence of business and industry partners at the university events on campus is a measure.

Digital Transformation: Digital transformation is about more than adopting a learning management system and new student information platforms. It is about expediting time and increasing completion rates of students while bringing in technological changes to lower costs, monitor quality assurance, and enable quality research output. The smart university is described through the V-SMARTH model (Duc et al., 2020). It consists of 6 basic components of digital resources, open-access learning materials, virtual learning environment, individualized education, interactive learning, and digital platforms. These elements come together in three pillars: digitization, digital learning models, and a comprehensive digital transformation process. Digital technology is a necessary and insufficient element to complete innovation. It increases expectations about the availability and flexibility of the learning experience while creating opportunities to respond to challenges in new ways and opening up other opportunities previously unaddressed (Dewar, 2021).

Innovative Teaching and Learning: For the changing landscape of employment and labor market trends and significant technological advances that automate pattern-based work, universities must adapt by providing personalized, technology-enhanced, on-demand learning in multiple modes (Chung et al., 2020; Etzkowitz, 2017; Gibb, 2012). Innovations in teaching and learning involve moving beyond the banking model of education described by Paulo Freire and moving to a model of critical dialogue and student-centered learning, which enables students to get at higher-order thinking skills. Traditional models of information transfers in higher education assume students are empty vessels to be filled up with specific content knowledge to perform a specific job in the labor market. We see now that such education does not develop the requested critical thinking skills for a disrupted work environment. Students need hands-on, real-world experience that taps their prior knowledge and encourages them to fail and try again. Innovations can come within the classroom through faculty development initiatives and cultures of teaching changes, or they can come from the type of education offered.

The degrees and certifications offered by HEIs are shifting in some innovative education circles. There are structural innovations within and across HEIs that can be observed. For example, the marginal change model (jukebox university) is a multi-campus training model with high flexibility, starting with interoperability and personalized training characteristics. It allows students to earn credits in person and online at partner network universities (MOHE, 2018). Students are granted

graduate diplomas and certificates on new modules aligned with the cognitive skills needed in the 4IR. It includes trends for radical changes to how content, skills, and competencies are delivered to learners. COVID-19 has sped up this trend in areas where internet access and affordable data are available. In this case, nano degrees, micro-credentials, and badges are awarded through non-campus university models, and no training programs for defined majors are offered. This business-oriented training model is capturing the interest of a new generation of digital natives and is also a response to the unsustainable cost of attending university in many countries.

Innovations in teaching and learning are also occurring as HEIs take student experience more seriously. Curricular design and pedagogy align with the learning sciences so that teachers and students know their content knowledge, skills, and competencies that can be applied in various contexts. Educators are encouraged to bring their research into the classroom and not create a siloed approach between teaching and research. Assessment methods are used and constructively aligned in such classrooms and university programs to achieve the expected learning outcomes and the teaching and learning objectives. The teaching methods chosen are meant to promote students' understanding of and commitment to life-long learning. Lifelong learning includes key cognitive traits such as curiosity and initiative, a commitment to critical inquiry, information-processing skills, and a willingness to experiment with new ideas and practices. Innovative teaching and learning activities foster student creativity, design thinking, exploration, and an entrepreneurial mindset. The university should be structured to stimulate and support the development of entrepreneurial and digital mindsets and skills while having quality assurance and control procedures in place.

The third area of innovation is a collaboration between governments, HEIs, and industry. The cost and scale of the demands for talent development and scientific advancement require new relationships between these stakeholders. Innovative HEIs are emerging as physical sites for co-location and research collaboration with industry and as brokers of relationships between young entrepreneurs and potential mentors, supporters, and funders. This is further elaborated on as we discuss specific innovations in the R&D space in Section 3.2.

Innovation-Driven Research: Although exploiting know-how becomes the third university mission, intensive, cutting-edge knowledge creation is still important. For this purpose, high-impact publications and patents filed (all fillings, all jurisdictions), patents issued (all jurisdictions), number of licenses, number of licenses to spin-outs, and gross license income received are measured. In particular, the research is mainly transdisciplinary or interdisciplinary, in which scientists, engineers, and designers of many disciplines work together. In contrast, the disciplines are no longer one-to-one related to individuals. These research results benefit the community's socioeconomic well-being (Etzkowitz, 2017; Gibb, 2012).

In addition, university research has an entrepreneurial nature and innovation orientation. Entrepreneurship is no longer seen as a means of enriching yourself at the expense of others. University research activities develop science, technology, arts, social sciences, and humanities.

They can innovate to respond to challenges and opportunities to increase the added value of the economy and social media to advance and realize a strong nation and prosperity. In particular, many young people are interested in creating their own life rather than being a cog in the wheel of a large enterprise. As a result, in addition to seeking industrial employment, students are active in creating new, technology-based firms of their own, and such firms can be very successful. This trend was well-developed in Asian countries.

Ecological and Social Norms: HEIs are ecosystems themselves. They maintain networks, policies, and physical structures that can support sustainable environmental health and inclusive human well-being. It means that many different organizational areas of the institution work together toward a set of collective goals or institutional outcomes. These often relate to research, student success, staff satisfaction, and community engagement. Increasingly, it relates to the role of the HEI in contributing to the awareness of and action around the 17 SDGs (Chankseliani & McCowan, 2021).

The HEI impacts community sustainable development awareness through research, curriculum, community-based learning, and programming. It promotes related social norms (such as activities to pay back, support students in need, and help the poor and people affected by natural disasters). Lastly, information ethics are emphasized, including academic integrity, moral behaviors, and electronic security measures. Part of being an ecologically sustainable ecosystem is being an ethical institution.

Specific Innovation

Specific innovation is the third pillar in our Innovative Higher Education Institutions mapping. This is usually focused on a research-based development approach to innovation where funding is provided, and promotion emphasizes the creation of new technological and software-based capabilities that have applications in the marketplace. There are several forms this can take, including pioneering innovation, best practice innovation, and technological innovation. Each HEI pursues strategies relative to its context, goals, and market segment applicability relative to its mission. Pioneering innovation is often most associated with the term innovation. Pioneering innovation occurs when a brand-new product, service, or method of doing something is introduced into the market. This type of innovation is rare. Everything is a remix, and creating a new product, service, or way of doing something in a completely original form as a first occurrence is unlikely. Pioneering innovation (i.e., R&D-based innovation) is an invention. The HEIs that successfully realize this type of innovation will become the first movers which make disruptive changes in processes, labor markets, and procedures. However, teaching-intensive HEIs prefer open innovations (i.e., non-R&D-based). In this case, they will become fast followers thanks to their higher-end capabilities for technological absorption and innovation, but they will not support R&D and technological generation.

Rating Innovation-Driven Universities in Vietnam

Using the definitions above, we categorized the level of innovation in 10 Vietnam HEIs using the UPM indicators and methodologies, as described below.

Method: Criteria and Data Collection

In attempting to measure the 4IR Responsiveness of HEIs, a UPM rating system was developed (UPM 2020). The main objective of this rating system is to promote benchmarking among universities against five core 4.0 education characteristics: *Entrepreneurial Spirit, Innovative Approaches, Digital Transformation, Personalized Education, and Ethical Values*, which describe well the above-discussed model for assessment of innovation-driven universities. Indeed, the performance evaluation of the UPM involved 52 indicators across eight categories. It covers Strategic Ambition, Education, Research, Innovation, University Ecosystem, Digital Transformation, Internationalization, and Community Services. There are indicators reflecting characteristics of the university as a whole (and include two core clusters of traditional education and research base), general innovation, and specific innovation options). Besides traditional indicators, which often appear in the existing world ranking and rating systems, the UPM rating has further developed 24 new criteria. These are directly related to the elements of 4IR, especially strategic management activities, entrepreneurship and personalized education, innovation ecosystem, sustainable development, and lifelong learning support (UPM 2020, see also Table 1).

In this paper, 32 of the 52 UPM indicators were identified as directly relating to 4IR transformation demands, e.g., instead of the traditional indicators of student employability, the student startup businesses were relevant. The 32 indicators are divided into four subcategories: Education, Research and Innovation, Digital Transformation, and Ecosystem and Actions. Education covers all elements of mindset changes, leadership and governance, people and perspectives, and innovative teaching and learning. The ecosystem and actions subcategory cover elements of the university ecosystem and ecological and social norms. These rated criteria and indicators and their contents are detailed on the UPM rating website (UPM, 2020). We used the data from 10 universities to explore how they measure up relative to the criteria defined and implemented in the UPM (UPM, 2020).

The indicator can express attributes, status, level, or changes in the objects examined, thus serving as the basis for rating. For benchmarking, an indicator is a concrete and verifiable description or a figure concerning the desirable properties of activities. The indicators can be qualitatively or quantitatively measured. The indicators rated by statistical numbers are relative to the average benchmarking points of the top 1,000 universities worldwide according to the ranking. The indicators are assessed qualitatively and holistically on a scale of 1 to 6 based on the ASEAN university network (AUN-QA) quality assurance model. A measure of 4 indicates a good benchmark, whereas a 5 or 6 indicates better than adequate or world-class. The indicator benchmarking points are presented in Table 1.

Rating data were collected from 10 (research-oriented) engineering and technology universities in Vietnam that voluntarily participated in the UPM assessment in the 2020 term. Most institutions have similar sizes, research reputations, and graduate programs. A similar approach was applied to innovation ranking (Hall, 2020). These are Hanoi University of Science and Technology, VNU University of Science, VNU University of Engineering and Technology, Thuyloi University, Transport and Communication University, Hanoi University of Civil Engineering, Hanoi University of Mining and Geology, Hanoi University of Pharmacy, Phenikaa University, and the Hue University of Science. All data were self-reported by the universities according to the UPM criteria and the procedure provided for self-evaluation guidelines. These self-evaluated reports, however, were submitted to the UPM team, then reviewed and confirmed via evidence attached to the report by the UPM assessors. The ten universities' scoring was obtained separately for each university. However, in Table 1, only the minimal, maximum, and average scores are presented for copyright reasons and research purposes. The minimal and maximum scores are considered critical cases, while the average value can give a general view of these participating universities and whole Vietnamese HEIs. These data are presented together with the benchmarking points in Figures 3-6.

Table 1: Rating Data Collected from 10 Engineering and Technology Universities in Vietnam in the Form of Benchmarking Point (Bench. Point), Minimal Achievement (Min. Value), Minimal Achievement (Max. Value), and Average Achievement (Average Value).

No	Criteria and Indicators	Bench. point	Min. value	Max. value	Average value
1	Education				
1.1	21st Century University Alignment	6	5	6	5.2
1.2	Student Centric Policies and Processes	6	4	6	4.7
1.3	Quality of incoming students	24	15	24	19.2
1.4	Size of academic faculty quality	70	34.4	69.7	51.5
1.5	Faculty reputation	20	10.7	25.2	16.6
1.6	4IR Responsiveness in Program Structure and Contents	6	2	7	4.3
1.7	Personalized Learning	6	4	5	4.1
1.8	Student Teaching and Research Assistantship Policies	6	4	6	5.1
2	Research and Innovation				
2.1	Research productivity	1.2	0.5	2.8	1.2
2.2	Research Impact	4.5	3	6	4.0
2.3	Scimago Research Index	4	0	4	1.2
2.4	Nationally Recognized Intellectual Property	25	0	36	8.5
2.5	Globally Recognized Intellectual Property	6	0	4	0.9

2.6	Budget for Research and Innovation	20	8.6	34	16.8
2.7	Start-up Businesses and Spin-off Companies	5	0	10	3.8
2.8	Scimago Innovation Index	4	0	4	1.2
3	Digital transformation				
3.1	Information Analysis and Management	6	4	5	4.3
3.2	Digital scholarly resources	20	1.7	25	9.7
3.3	Learning resource access	5	0.1	22	4.1
3.4	Interactive Learning	2	0	7	2.2
3.5	MOOC and Digital Lessons	5	1	8	2.7

No	Criteria and Indicators	Bench. point	Min. value	Max. value	Average value
3.6	Blended Learning	50	25	50	33.8
3.7	Application of Cyber Physical System (CPS)	2	0	5	1.5
3.8	Information Ethics	1	0	1	0.5
4	Ecosystem and Actions				
4.1	Research, R&D and Innovation Facilities	7	4	6	5.1
4.2	Creative Co-working Space and Start-up Supports	7	3	6	3.9
4.3	Campus Environment	7	3	5	3.8
4.4	Business and Industry Partners	1	1	4.1	2.2
4.5	Life-Long Learning Capacity Enhancement	1	0.2	1.1	0.5
4.6	Impact of Sustainable Development Research	15	5	27	10.7
4.7	Realization of Sustainable Development Research	2	0	2	1.6
4.8	Social Norm Promotion	5	5	15	8.2

Results and Remarks

Education: As shown in Figure 3, individually, some Vietnamese universities of engineering and technology have approached and even exceeded the benchmarking points, especially for the criteria of 4IR strategy alignment, incoming student quality, faculty quality, faculty reputation, and training program expected, learning outcomes, and contents. The university strategy demonstrates the required responsiveness of entrepreneurial spirit, innovation approaches, digital transformation, and personalized education. The program contents and courses are comprehensive and up-to-date and demonstrate responsiveness to the requirements of the 4IR in both generic outcomes (in particular, entrepreneurial and digital mindset and skills) and subject-specific outcomes (related to knowledge and skills of 4.0 technology and solutions). In particular, new launching programs for basic 4.0 technologies such as IoT, A.I., Big Data, Robotics, Digital Economy, and Creative and Culture Industries exist. However, in general, the traditional approaches in organizational structure and strategy implementation, teaching, and learning process are still dominated. Although the

entrepreneurial mindset was determined in the Vietnamese Qualification Framework, its performance remains slow. The advantages of credit-based training are not fully realized, limiting individualization and personalization in training and encouraging cooperation among the university's faculties and other universities and industries. Few students complete their degrees within the expected timeframe. The average proportion of academic faculty staff with a Ph.D. degree to the total number of academic staff is 51.5%, but it is relatively low (34.4%) for several universities. In particular, for some engineering and technological universities with a long history, the quality of students is modest compared to competitor programs abroad. This quality challenge hinders the industrialization intentions of the country because the necessary talent to modernize is unavailable.

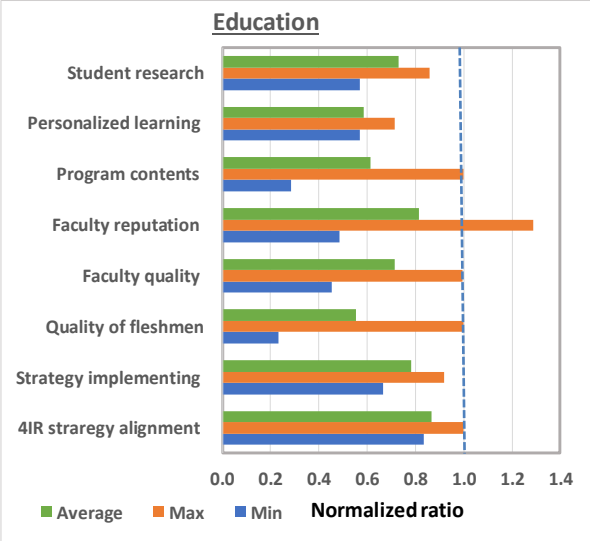

Figure 3. Rating Results for the Indicators of the Education Cluster

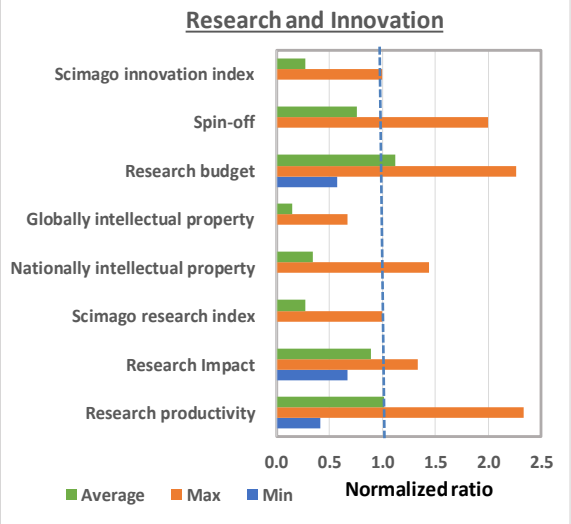

Figure 4. Rating Results for the Indicators of the Research and Innovation Cluster

Research and Innovation: Figure 4 presents the results of the indicators in the research and innovation cluster. Except for the international intellectual property indicator, several universities fulfill and exceed the benchmarking points of the UPM system for research and innovation, particularly for research productivity, research impact, budget, and spin-off companies. These explain why Vietnam has universities in the top 1,000 world universities of Q.S. and Times Higher Education rankings. For the rest, however, the results show poor performance in the Scimago research and innovation index, internal and national intellectual properties, and spin-off companies. It leads to a low average value for those indicators.

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research and innovation index, internal and national intellectual properties, and spin-off companies. This leads to a low average value for those indicators.

Digital Transformation: Figure 5 illustrates the rating results for digital transformation. While the benchmarking points are not high, almost all average values of rated indicators are below these benchmarks. Before the Covid-19 pandemic, many universities were still implementing simple digital strategies, which limited the digitization of paper-based processes and administration services. A complete digital strategy remains absent at most universities, and objectives and KPIs for a digital transformation plan are not defined. Thus, several activities, such as learning resource access and interactive learning, have not been implemented due to a lack of tools. In other cases, data is not available to measure progress. The education programs' online (recorded teaching, live teaching) or/and MOOC courses measured are still limited. Digital lessons are widespread in terms of electronic lectures at the first levels, but the material is rudimentary (such as slide shows and PDFs). Digital classes with recorded teaching and live teaching are rare. The level of application of cyber-physical systems to learning and management is modest. Moreover, information ethics are not entirely ensured, including academic integrity, moral behaviors, and electronic security measures.

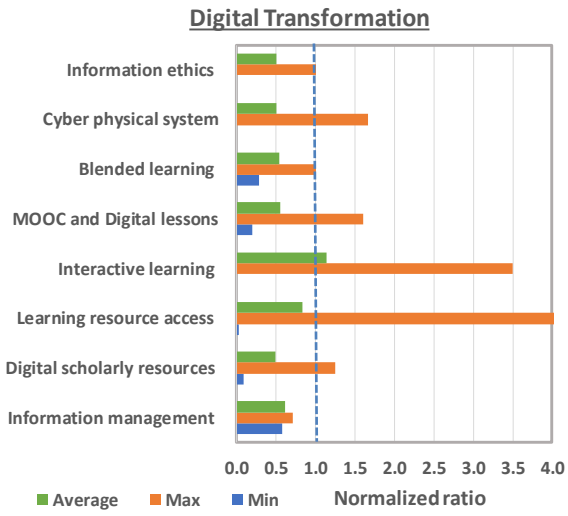

Figure 5. Rating Results for the Indicators of the Digital Transformation Cluster

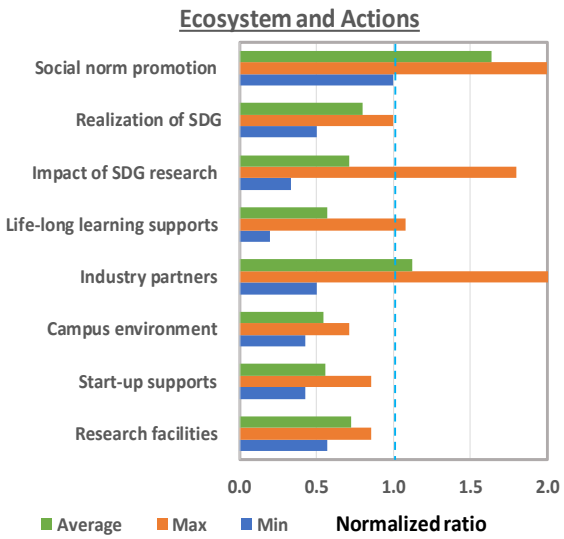

Figure 6. Rating Results for the Indicators of the Ecosystem and Actions Cluster

Ecosystem and Actions: Rating results presented in Figure 6 are indicators of a university's ecosystem and related actions. Compared to the standards of the top 1,000 world universities within the benchmarking exercise, which is understood at the normalized ratio, research facilities, startup support, and campus environment are modest for the ten measured Vietnamese HEIs. While they might use best practices determined by national standards, they are far from performing at the highest global level for these criteria. For instance, institutions have not implemented indicators 4.5

and 4.6 (lifelong learning and research related to SGDs). On the other hand, local community engagement activities are effective. The number of businesses, industries, and organizations that collaborate in student training and research and startup projects, provide funding/grants for customized research, or/and have collaboration in R&D resulting in co-publications and shared I.P. license/industry co-patents is highly established. These universities are vital in promoting university impact on sustainable community development and fostering harmonious social norms. These activities, which attract a wide swath of student bodies, are initiated by student associations.

Conclusion and Recommendations

In this research, the definition of an innovation-driven university is described, and a blueprint is provided to help research-focused HEIs respond to the recent changes in the 4IR. This university model balances the entrepreneurial and ecological characteristics but enables it to strengthen the accountability and autonomy of the university, which is suitable for all five types of universities identified.

Overall, the UPM participated technological universities in Vietnam have a highly qualified and reputable academic staff, are training a large number of students, attract a significant amount of research funding, conduct R&D, are innovation and startup minded, publish many quality articles, and facilitate the production of intellectual properties. However, the university innovation culture is still new. In most cases, HEIs in Vietnam requires a modern and synchronized R&D research environment and excellent startup support. In particular, along with digital infrastructure and mindset changes, the universities need to pay attention to the new concepts and contents of community service activities, in which lifelong learning and sustainable development are priorities.

The 21st century has posed significant challenges for higher education institutions to respond successfully to new demands. A benchmarking tool that fully reflects the characteristics and requirements of the graduate, labor market, and society in the new era will help universities to advance themselves on the higher education landscape of the country and the region, to work out or adjust their strategic approaches and become more effective and relevant institutions. With its five core 4IR education characteristics of entrepreneurial spirit, innovative practices, digital transformation, personalized education, and ecological and social norms, the UPM rating system is suitable to guide and inform university transformations. Moreover, UPM can show the tasks that higher education institutions should perform, as well as priorities and targets that must be reached, to guide their strategic planning. Moreover, benchmarking metrics and indicators can provide universities with directions for improvement and act as critical drivers for universities to move from a closed to a more responsive model.

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