Exploring the Readiness for Digital Transformation in a Higher Education Institution towards Industrial Revolution 4.0

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Abstract—Digital transformation process in higher education institutions in the industry revolution 4.0 has raised important challenges for how a digital university (university 4.0) is effectively deployed. In Vietnam, the government and the ministry of education and training started a plan to transform leading universities into digital universities. The first question for this process is which key factors of the university are affected by the digital transformation. And what the readiness in human resources of the university for the digital transformation. Therefore, this study aims to analyze the characteristics of the digital university model to identify the criteria for assessing the availability of the digital transformation process. This study contributes to a better understanding of four basic facets of the digital university: Education Program, Learners, Training Services, and Governance. A survey-based quantitative study for the readiness of digital university was conducted among the students and the staff of Hanoi University of Science and Technology, Vietnam. The results of this study allow us to introduce a readiness framework for digital transformation as a reference for the other higher education institutions. Also, we can partly confirm that the trend of digital transformation is indispensable for universities in Vietnam, contributing to the improvement of higher education quality and international integration in the context of industrial revolution 4.0.

Keywords—Digital transformation, digital university, smart university, university 4.0.

1 Introduction

Under the impact of the Fourth Industrial Revolution (4IR), digital transformation takes place in all areas including higher education, bringing new challenges, and opportunities for the development of higher education. Following this new trend, the wave of digitalization is happening strongly in Vietnamese education, especially in higher education institutions. However, the digital transformation is a long-term process, going through many stages, requiring many resources to participate and the support of regulatory agencies, institutions, and policies. As a result, several questions that relate to the effectiveness of digital transformation as well as the fundamental factors that should be considered when participating in the digital transformation process, have been increasingly emerging. Therefore, the assessment of readiness for the necessary changes to adopt digital transformation in higher education institutions is a demanding goal. To this end, we studied a typical digital transformation model implemented at Hanoi University of Science and Technology (HUST) to assess its readiness for extracting a readiness framework as a reference for other higher education institutions.

In Vietnam, HUST with the mission of being the leading university, always pioneers in industrial revolutions to provide the quality labor resources adapting to the changes in science and technology. Then the digital transformation has been implemented at HUST since the beginning of 2010s; in the HUST campus, almost all the management points have been computerized. This article is to investigate the readiness of HUST in the context of digital transformation through the survey with the target objects as management staff, lecturers, and students of different majors. Such readiness is assessed through a set of criteria extracted from the analysis of typical digital university models that have been introduced in contemporary studies. Accordingly, the contributions of this study are as follows:

- Choose the typical model of digital university and analyze the key features of the digital university
- Propose the criteria for assessing the readiness for digital transformation
- Deploy a survey in HUST for assessing the digital transformation effects

The remainder of the paper is organized as follows. Section 2 provides a literature review. Section 3 describes the methodology. Results and discussion are presented in Section 4.

2 Literature Review

In this section, we provide a detailed investigation of the reference models of the digital university, by which the appropriate criteria for assessing the readiness in the digital transformation process of a specific university *i.e.*, HUST, will be extracted.

2.1 Model of digital university

The 4IR took at first in the World Economic Forum in 2016 at Davos, Switzerland that led our world to a revolution of changes in the way we live, work and relate to one another (Schwab, 2016) and "The response to its must be integrated and comprehensive, involving all stakeholders of the global polity, from the public and private sectors to academia and civil society" (Salmon, G., 2019) [1-2]. In IR4.0, there are many emerging technology breakthroughs such as robotics, IoT, 3-D printing, nanotechnology, big data, Artificial Intelligent, and much more that require human resources with adequate digital and data literacy. The transformation in the education sector can be done quickly in the huge influences of those emerging technologies. Therefore, IR4.0 makes the new dynamics of education innovation, then, obviously, university, in the charge of training employment skill and employability for the industry, should be changed deeply into University 4.0 according to Education 4.0 and IR4.0. Lapteva, A. and Efimov, V. (2016) define that Uni 4.0 is a very open environment that includes a hub of communications such as information, social, activity-related then it connects various external participants with students and professors [3]. Uni4.0 serves itself as a platform for training, education, and deploying research, project, development of new practices as an "intelligent park". University 4.0 responds to IR 4.0 in this study is identified as a smart university model. As the results, the complex reality of the University 4.0 includes:

- The development of digital technology integrated into smart instructional strategies for "implementation of knowledge into reality"
- The deployment of communication networks as connectives
- The learning ecosystem as an open and innovation platform.

In 2019, Hoang, M.S. *et al.* proposed the model of the university in the context of the 4IR that was formed by the three key factors: digital technology, connectives theory, and learning ecosystem [4]. In the context of IR4.0, the combination of these three factors opens educational technology as the core of University 4.0. The educational technology platform will create positive changes in the important parts of University 4.0 such as learners, training services, educational programs, and governance.

University 4.0 or Digital University, which possesses smart education, in which this concept is defined by IBM as an interdisciplinary, learner-centered education system, connecting educational institutions and provide [5]:

- Adaptive learning programs and good learning conditions for learners
- Collaborative teaching and learning technology and digital resources for lecturers and learners
- Computerized management process, classroom activities are monitored and reported
- Regularly update information about learners
- Online learning resources for learners everywhere.

Thus, according to the above specification of IBM (2012) or Hoang. M.S *et al.* (2019), measuring the readiness of the university to meet the requirements of the

industrial revolution 4.0 is measuring the responsiveness of the following key factors: Education program, Learners, Training Services, and University Governance.

2.2 Characteristics of digital university

The criteria for assessing the digital transformation in the university are extracted from analyzing four fundamental facets of the university: Education Program, Learners, Training Services, and Governance.

a) Education programs

The education program is usually called the term "curriculum" that began to appear in 1820, but it was not until the nineteenth century that the term was commonly used in the educational field in the United States and some countries with developed education (Pratt 1994) [6]. The term curriculum, broadly defined, includes goals for student learning (skills, knowledge, and attitudes); content (the subject matter in which learning experiences are embedded); sequence (the order in which concepts are presented); learners; instructional methods and activities; instructional resources (materials and settings); evaluation (methods used to assess student learning as a result of these experiences); and adjustments to teaching and learning processes, based on experience and evaluation [7]. In determining "the design of a twenty-first-century curriculum" the Ministry Of Education (MOE) not only consulted national and international experts, but also participated in the Organization for Economic Cooperation and Development -OECD's Future of Education and Skills: Education 2030 project, and the Students' Voice initiative (Cabinet of the Secretary of State for Education, 2017). As a result, the process of digital transformation must make the education programs in university meet the social needs, integrate goals for student learning, be flexible, be achieved by all students, and be designed according to personalized learning as well. Armed with an education program that meets these criteria, digital schools will affirm its functions, providing a human resource suitable to the requirements of Industry 4.0 [8-9].

b) Learners

UNESCO's studies on the competence of graduates adapting to IR 4.0 in 2016 identified six groups of competencies: innovative and creative thinking, social skills, personal skills, global citizenship, ICT knowledge and skills, other skills (lifestyle, religion, ...) [10]. The report of the OECD on education and skills for the future to 2030 also shows that, in the future, learners will need to apply their knowledge in many uncertain and developing situations. For this, they will need a range of cognitive and metacognitive skills (critical thinking, creative thinking, self-regulation, etc.); social and emotional skills (empathy, cooperation, ...); and practical and physical skills (using new communication and technology devices, etc.). Moreover, the research of A. Danielewicz-Betz and T. Kawaguchi in 2014 pointed out that the first and third personal skill of engineering students is the communication skills and the goal-setting skills [11]. Communication skills are also listed in another research of

Stefan Vorbach in 2019 [12]. Learners 4.0 should be proactive in making the overall program plan and building a schedule for specific learning activities. Moreover, learners should be developed their research capacity, creativity, and service-oriented. Finally, learners must develop emotional intelligence, problem-solving ability, decision-making, critical thinking, and cooperation for success.

c) Training services

Applying digital technology, University 4.0 will build student-centered models to make learners have the opportunity to experience a better and more comprehensive in university. In university 4.0, training services will support learners throughout the learning process. Learners are connected with academic advisors; pay tuition bills more easily; provide a convenient way to schedule appointments with counselors; check and submit financial assistance; provide stronger job board; connect current students with alumni. As a result, learners have the opportunity to experience a better and more comprehensive university. The University of Edinburg (in Haywood, J., 2018) was the first university-wide initiative with educational technology that began with a program called "Email for All" (in 1992), then a well-developed eLearning infrastructure (1998-2003-2010), Massive Open Online Courses–MOOCs (2012) and now Open Education (since 2015) [13]. Moreover, as a smart university, Uni 4.0 uses predictive analytics to identify learner's support services when they encounter academic problems. A smart learning environment (SLE) can record every detail of students' learning behavior; It allows different stakeholders such as instructors, learners, lecturers, researchers, educational institutions to obtain important and valuable information through the analysis of these behaviors. All information gathered about students' learning behaviors and their interactions with different contexts were analyzed to identify the situation. Also, learning analysis systems (LAS) are often provided in learning management systems (LMS). Therefore, SLE analyzes and measures, evaluates course performance, and predicts student success (in Sahar, Y. et al., 2016) [14-15]. On the other hand, using a digital learning environment, training services in Uni 4.0 support the solutions to personalize learners, providing personalized learning experiences. Individualized education reinforces the flexibility of the educational system and implements customized learning associated with future personal and professional interests by blending the teaching in a defined curriculum (face-to-face and online) with individualized instruction (competence, roadmap, interests, needs, etc.) or mobile teaching. Even more, universities 4.0 have started to apply random teaching-learning methods, students can study anytime, anywhere, with different teaching-learning methods through ICT platform and educational environment provided to integrate micro-nano certifications (in Nguyen et al., 2020) [16]. In particular, individualized education can support lifelong learning very effectively. Therefore, educators in Uni4.0 can take advantage of learners 'data from learning management systems to counsel the entire educational process, maximizing learners' lifetime value [17].

To conclude, in a socialist-oriented market economy, Vietnam's education has been very open and integrated, always aiming to meet learners' needs from the perspective that learners are at the center of the education process.

d) University governance

In higher education research, university governance is viewed from both broader (Neave and van Vught, 1994) and narrower perspectives (Tight, 2012) [18-19]. University governance in the context of digital transformation evaluated on numerical university criteria must have the ability to set up the admission strategies, attracting the enterprise's fund for science research, having technology-enhanced public-private partnerships, and transforming the training model as a business model. Firstly, universities always declare their vision for their role in society to provide quality training to the community. A very general implication concerns the importance of appropriate "advertising" of institutional requirements and emphases during the admissions process; students select a college/university for many reasons, but those who come to the campus with a good idea of what is offered and an accurate view of what they can gain from their educational experience will very likely be more positive about attending (Barbara E. Moely Vincent Ilustre (2011) [20]. Secondly, public-private partnerships in education entail a model of financing and education provision where public and private sectors share the costs and risks of education provision in a manner that involves 'a contracting mechanism used to acquire a specified service, of a defined quantity and quality, at an agreed-on price, from a specific provider, for a specific period [21-22]. Moreover, a public-private partnership in the context of autonomous universities leading to comprehensive cooperation: marking the participation of WoW in training program evaluation, vocational practice guidance, sharing of training and recruitment fees graduate students. Therefore, these are the basic criteria that need to be evaluated at the first stage of digital transformation at a specific university to analyze and gain experience for the next phase of digital transformation and provide lessons for other universities.

3 Methodology

3.1 Research design

To measuring the readiness for reaching University 4.0, we conducted a survey that focuses on studying the four basic elements of higher education in readiness to transform to university 4.0, which include Education Program, Training Services, Learners and Higher Governance according to the Uni4.0 model (Hoang. M.S, 2019) and the smart education framework (IBM, 2012). The factors of Education Program are measured by the meeting of social requirements; brevity, flexibility, and completeness of educational program; the integration of training methods; the learners' individualization in the training process. The factors of Learners are measured by Self-setting the Learner's mission; Self-planning the total learning activities; Learners' capability of scientific research; Learners' Social Skills. The factors of Training Services are measured by Supports in Learning Process; Individual Learning Experiences; Lifelong Learning Services; Stakeholders 'Support; Learning Counseling. The factors of Governance are measured by Admissions Strategy; Attracting investment from busi-

nesses; Public-private partnerships; Business model of training services. These key factors and associated criteria for readiness assessment are tabulated in Table 1.

Table 1. Key factors and their criteria

Key factors	Criteria
Education Programs	1.Meet social needs 2.Integrate goals for student learning (skills, knowledge, and attitudes) 3.Be short, flexible, and achieved by all students 4.Be designed according to personalized learning
Learners	5.Be proactive and have an individual mission 6.Have a schedule for their learning activities 7.Do scientific research 8.Have social skills
Training Services	9.Support all time 10.Give personalized experiences 11.Improve lifelong learning 12.Make stakeholders network 13.Do effective counselors' system
Governance	14.Have admission strategies 15.Attract enterprises fund for science research 16.Have technology-enhanced public-private partnerships 17.Transform training model as a business model

3.2 Population and samples

The survey was conducted at Hanoi University of Science and Technology in the academic year of 2019-2020. There are 1,379 lecturers and lab teachers; 28,912 students at HUST in the year 2017. In our survey, the staff was from 24 schools and departments at HUST; the students were from 18 disciplines training in HUST. To determine the sample size, the authors used Yamane Taro's (1967) simplified formula, see the proportion in Equation (1) [23].

$$n = \frac{N}{1+N \cdot e^2} \tag{1}$$

For calculating the minimum sample size of the staff, with the population size (n_1) was 1.379 and the acceptable sampling error (e) was 0.1 (10 %), corresponding to a confidence level of 95 % and p = 0.5 (see Equation (2)).

$$n_1 = \frac{1379}{1+1379 \cdot 0.1^2} = 93.24 \tag{2}$$

The minimum sample size (n_1) should therefore be 94, which accounted for 6.81 % of the 1,379 lecturers and lab teachers in HUST during the period of the study.

For calculating the minimum sample size of the students, with the population size (n_2) was 28,912 and the acceptable sampling error (e) was 0.1 (10 %), corresponding to a confidence level of 95 % and p = 0.5 (see Equation (3)).

$$n_2 = \frac{28912}{1+28912 \cdot 0.1^2} = 99.65 \tag{3}$$

The minimum sample size (n_2) should therefore be 100, which accounted for 0.34 % of the 28,912 total students in HUST during the period of the study. The authors designed questionnaires by using Google Forms and distributed them randomly through the local email system of HUST. Then 117 responses of the staff were returned, 896 responses of the students were returned. In which, there is 49.57 % of this staff (58 teachers/117 in total) working in IT or IT-enhanced departments, and 43.41 % of these students (389 students/896 in total) studying IT or IT-enhanced disciplines (Information Technology, Electronics, and Electrical disciplines). Of the 119 staff, 61.54 % were male and 38.46 % were female. In particular, of the staff 71.79 % had a doctor's degree; 24.78 % had master's degrees and 2.57 % had engineering/bachelor's degrees. The highest percentage of staff (56.41 %) has their working experiences from 10 to 19 years. The second-ranked percentage of staff (23.93 %) has their working experiences for more than 19 years. There are 11.97 % of the staff having their working experiences from 5-9 years and only 6.48 % of the staff having working experiences for less than 5 years. Of the 896 students, 80.96 % were male and 19.04 % were female. In this survey, there are 4.24 % of the students in the first year, 33.04 % in the second year, 38.84 % in the third year, 15.07 % in the fourth year, 6.07 % in the fifth year, and 1.67 % over study-time. The percentage of students in this survey attained at an outstanding GPA is 2.34 %, at an excellent GPA is 6.81 %, at a good GPA is 36.27 %, at medium GPA is 34.38 %.

3.3 Data collection

Firstly, the questionnaires collected the personal factors of the respondents through email transmission. The personal factors of staff included Gender, Ages, Qualification, Specialty, Years of Experience, the personal factors of students were Gender, Ages, Specialty, Grade Point Average. Then, according to the framework for Digital University, there were four key factors included Education Programs, Learners, Training Services, and Governance in University were measured in Readiness Model for HUST4.0. Opinions of respondents in readiness for HUST4.0 were measured by Likert-type scale questions that include strongly agree (5), agree (4), neutral (3), disagree (2), and strongly disagree (1).

3.4 Research instruments

Collected data were analyzed using IBM Statistical Package for the Social Sciences –SPSS 20.0. All data is analyzed through the following steps: (1) evaluate the reliability and scale values using the Cronbach's Alpha coefficient; (2) *t*-independent sample test is used to find the difference in the viewpoint between staff and students or IT staff and non-IT staff on the readiness of HUST 4.0; (3) Analysis of one-way variance (ANOVA One-way) is used to analyses the readiness for digital conversion at HUST among 3 groups of academic staff (PhD. Master and Bachelor/Engineer). Descriptive statistics such as mean, standard deviation (SD), percentages, and frequency were used to determine the readiness of HUST 4.0. When using Cronbach's Alpha coefficients to evaluate the reliability of data in 17 criteria related to the readiness for digital transformation at the initial level, Cronbach's Alpha value is 0.892 out of 1013 survey samples. This result shows that the data is highly reliable.

4 Results and Discussion

4.1 Readiness in education programs

a) Education programs meet social needs

As seen in Table 2, this criterion was evaluated at the highest value (mean equal to 3.82; standard deviation about 0.723). The main reason is that HUST has set up the mission of developing and perfecting training programs to train learners' competence that meeting the requirements of practicality and modernity, approaching international standards in program structure and content; ensure the integration, consistency of the program and the connection between the training levels since 2017 [24]. It is similar to Thiep L.Q. *et al.* wrote about the development and innovation of Vietnamese higher education from 1954 to 2006 like "Higher education is not only included as part of the government development strategy but also have to meet the needs and forecasting influences of society" [25].

b) Education programs integrate learning goals for students

Assessment of the ability to integrate educational purposes for learners has shown positive results (in Table 2, mean and standard deviation equal to 3.41 and 0.833 respectively). Those have proved that HUST's program advancement is making encouraging signs. However, to improve the satisfaction of students, the program should be enhanced continually. Indeed, the recent higher education program at HUST has been updated since 2017. Specifically, the structure of the school's curriculum would integrate Mathematics and General Science (32 credits), basic professional and core knowledge (48 credits) with additional knowledge such as Language, Social Skills, Political and Legal Theory, Technical Writing, and Presentation Skills. Furthermore, at the end of the third year, students could choose intensive orientation courses that suit their future careers after graduation. Besides, students would have an internship semester in the company before doing a dissertation. Thus, training programs are geared to offer the learning goals for students, from general training to the orientation of career training.

c) Education programs is short, flexible, and achieved by all students

The degree of flexibility and responsiveness of learners in HUST's higher education program has been highly appreciated (in Table 2, mean and standard deviation equal to 3.78 and 0.731 respectively), thanks to applying ICT to the process of training and student management. In the digital transformation process, HUST has implemented blended learning since 2018 so that the program could be flexible and achieved by all students in their self-paced learning paths. Moreover, the Management Information System and Training System was built and used in HUST in 2007 for training under the credit system from the school year 2007-2008. Initially, the training management software just had several key functions such as student database management, academic registration, and graduation registration. However, due to the increasing number of student accounts (storing account information of graduated students of the school year 2007-2008), the University had to build a new web portal

(ctt-daotao.hust.edu.vn) ensured the readiness and flexibility for students to select and register courses to accumulate appropriate credits for future careers (on website http://dk-sis.hust.edu.vn).

d) Educational Programs is designed according to personalized learning

With many different personalization measures based on the process of digital transformation, students and staff also highly appreciate the degree of personalization of the training program that they are following (in Table 2, mean and standard deviation equal to 3.5 and 0.830 respectively). Firstly, the Management Information System also helps students selecting class and time following individual schedules; help students proactively shorten or extend the study time at the University... Secondly, with a flexible training program, fixed subjects, and training options, students can improve their skills and supplement their lack of knowledge. Thirdly, the academic advising system, international scholarship system & enterprise scholarships are always ready for students to select subjects and career orientation to promote the passion and strengths of each student. Fourthly, it is the implementation of blended learning from 2018-2019 onwards that enable students to experience personalized learning in many courses in the school's curriculum.

Table 2. Opinions about readiness in education programs for HUST4.0

Education Programs	Mean	Standard deviation	Order
Meet the social needs	3.82	0.723	1
Integrate goals for student learning (skills, knowledge, and attitudes)	3.41	0.833	4
Be short, flexible, and achieved by all students	3.78	0.731	2
Be designed according to personalized learning	3.50	0.830	3

4.2 Readiness in learners

a) Learners are proactive and have an individual mission

The impact of digital transformation on student activeness has been highly regarded (in Table 3, mean and standard deviation equal to 3.71 and 0.805 respectively). The process of digital transformation in educational management and teaching organization has changed a lot of studying methods. In particular, learners can convert his or her study condition to plan the registration of necessary courses as well as being perfectly adequate for their ability in the next term. The registration process has 2 stages including enrolling in courses and registering for classes. The students who are warned of academic results at levels 1 and 2 would be limited resisted credits in the next semester. Besides, they need to have a more appropriate study plan in the next semester if they do not want to be forced to leave school. Thus, each student would have different learning goals and put more effort to reach them.

b) Learners have a schedule for their learning activities

Criteria for students to build their learning schedules are most valued in the group of related criteria for learners (in Table 3, mean and standard deviation equal to 3.87 and 0.783 respectively). Through the registration system in each semester, learners could make their timetable for learning activities. These activities have been formed since 2007 because all training programs were developed according to the credit system and each student had to plan their studying schedule before the new semester comes. Since 2009, each student has had an account to access the Student Information System to build their learning plan and register their subjects for next semester, see the learning results. This is similar to Astin, A.W's point of view, it is said that "Universities should arrange their resources to create more opportunities for students to participate in a full range of experiences to gain the necessary skills and academy competencies" [26]. He also said that the way students use their time is the most important variable in this equation, more important than their basic characteristics or where they attend college. So, in the first phase of the digital transformation program that allowed students to make study plans, the total number of students warned of bad results was quite large, about 4.081 students/year in the semester 20162 (15 %), so far the total number of students warned of bad results has decreased significantly with 3.744 students / 1 year in the semester 20172 (12.9 %) and the rate of students graduating early with an excellent degree has increased in the academic year 2019-2020.

c) Learners do scientific research

HUST has been highly evaluated on stimulating students to research (in Table 3, mean and standard deviation equal to 3.75 and 0.824 respectively). As a matter of fact, as a university focusing on researching, HUST encourages students to take part in Labs to have more opportunities of experiencing professions, improving the researching capacity of individual students right as they are undergraduate. With much effective training and research cooperation programs, HUST always prioritizes science research and technology transfer cooperation. The annual conference for students' scientific research in HUST is organized every year that attract a lot of students and make many chances for students to do scientific research. In recent years, HUST has emphasized students researching with high review by international publication (ISI, Scopus). There have been many researching products by students which have been transferred technologically to produce in reality (such as bike with electric engine, driverless garbage truck, a self-propelled robot that can collect information, identify voices and interact with humans, Electric vehicles with navigation assistance technology using a compass, economical vehicles – proposal of the school year 2019 - 2020…).

d) Learners have social skills

The social skills of learners are evaluated at the lowest value (in Table 3, mean and standard deviation equal to 3.69 and 0.842 respectively). In fact, at HUST it is quite the same as being described by George D. Kuh about American students at the beginning of 2000. He supposed that there were over 40 % undergraduate students in the USA at that time following part-time higher education because the majority of them lived outside the university, having limited time at the campus as well as having lim-

ited access to many opportunities of studying and developing characteristics like participating in social activities, interchanging at the university. Besides, there are more extra subjects and in-depth study. The students also enjoy the convenience of online learning registration or via the telephone. Therefore, students gradually limit their direct contact with friends and teachers, leading to low social skills. As a result, improving their soft skills is needed for training essential labor resources in the era 4.0 then the supplement subjects for social skills are added in the training programs at HUST now.

Table 3. Opinions about readiness in learners for HUST 4.0

	Total Staff		
Learners	***Mean***	***Standard deviation***	***Order***
Be proactive and have an individual mission	3.71	0.805	3
Have a schedule for their learning activities	3.87	0.783	1
Do scientific research	3.75	0.824	2
Have social skills	3.69	0.842	4

4.3 Readiness in training services

a) Training services support students all time

The capability of supporting all-time at HUST is evaluated at the first level in the criteria of training services (in Table 4, mean and standard deviation equal to 3.70 and 0.812 respectively). The main reason is that training services in HUST have changed effectively during the digital transformation process. By using the digital system such as Information Site for Training, Student Work for Counselors, Student Network for Alumni, Training management for Teachers, etc., all students and staff can access the system, view information, help each other's if they needed in every time and everywhere.

b) Training services give students a personalized experience

Education service allows learners to have learning experience individually, which has been highly evaluated (in Table 4, mean and standard deviation equal to 3.54 and 0.777 respectively). This result was obtained thanks to digital transferring. HUST has exploited the Internet system by connecting Wi-Fi. The intranet systems have been encompassed (LAN, Wi-Fi), operated stably and continuously 24/7, connected with high-speed Internet. At least, primary ICT service systems of e-University (e-information portal, e-mail, e-office, e-learning) have been monitored for information security. The service has allowed learners to experience individual learning as private learning, learning can take place anytime, anywhere depending on learning needs.

c) Training services improve lifelong learning

The survey results showed the supporting lifelong learning for learners has been evaluated the lowest among the indicators of education service (in Table 4, mean and standard deviation equal to 3.22 and 0.9 respectively). The difficulties HUST meets in

the obligation of improving lifelong learning capacity in learners are the same as the viewpoint of Norris, D. M [27]; O'Donnell, J.J [28], Ogilvy, J. [29] and Pace, C. R. [30]. This is the duty of complicated higher education and challenging due to the requirement of addressing lifelong learning ability as well as continual learning, non-stop learning. Thus, the survey results showed that the supporting lifelong learning for learners has been evaluated the lowest at HUST is natural. This is similar to the sharing of George D. Kuh about almost all the universities in the USA at the beginning of the year 2000 that it was not held to assist students to promote these kinds of abilities. Therefore, to support lifelong learning is needed to improve more, indeed after the students graduate and need to improve their skills for their career. Hence, this will be one of the duties needed to be improved in the process of digital transferring at HUST in the years to come.

d) Training services make stakeholders network

The effectiveness of the forming process of stakeholders at HUST has been evaluated at a quite high level in comparison with other criteria (in Table 4, mean and standard deviation equal to 3.64 and 0.816 respectively). Deriving from the actual situation of the Vietnamese economy which is similar to the USA in the 2000s through George D. Kuh's analysis, the essence, structure, and activities of workforces nowadays are very different from what graduate students have been prepared traditionally so far [25]. Intellectual groups now account for about one-third of the workforce, which reflects the changing property of the profession. It is predicted that around 60 % of the entire workers act as self-control, without being monitored. 50 % of the labor will be temporary workers as labor contracts or a part-time job. Thus, an information network from related sides should be built at the university to provide students with social information on the future world of work, which is a duty of higher education. At HUST, the direct support from stakeholders such as families, businesses, social organizations through the website for alumni and information. This explains the high evaluation of these criteria at HUST.

e) Training services do effective counselors' system

A learning consultation system is always an important part of training credits. In education services, the learning consultation system has been the second highly evaluated (in Table 4, mean and standard deviation equal to 3.67 and 0.833 respectively). This result was obtained by HUST having research programs applied new education technologies to the process of analyzing learner data, bringing about consultations and support in time to help learners be more successful in the period of higher education. As the point of view in Lam Quang Thiep and et al., most of the undergraduate students between 18 and 22 stuck with learning and spent much of their minds on a social relationship and developing their characters, especially during the first 1 or 2 years at university. Thus, universities should develop and make use of learning consultation systems school mentality consultation systems effectively, especially through the support of digital transferring and technological applications like Chatbot, Big Data, AI.

Table 4. Staff's opinions about readiness in training services for HUST 4.0

Training Services	Total Staff		
	Mean	***Standard deviation***	***Order***
Support all time	3.70	0.812	1
Give personalized experiences	3.54	0.777	4
Improve lifelong learning	3.22	0.900	5
Make stakeholders network	3.64	0.816	3
Do effective counsellors' system	3.67	0.833	2

4.4 Readiness in governance

a) Have admission strategies

As an autonomous university, to ensure the quality of input and maintain the revenue from tuition, enrollment is always a top priority task. However, in Vietnam, as N.Q. Thanh *et al.* (2019) in many groups of universities that employ autonomy, the lowest autonomy of lecturers taking part in campus administration is the very activity of determining the campus yearly enrollment scale [31]. The participating level only reaches the highest score as 0.72 point. There were even lecturers of the groups of university owning the level of participation at 0.01 point. On the contrary, this study shows that having admission strategies was the most highly evaluated (in Table 5, mean and standard deviation equal to 4.2 and 0.690 respectively) among the elements of managing the campus autonomously. Learning the lesson from international experience, the university attracted enrollment successfully thanks to a strategy of advertising enrollment and commit to education quality with public reports (Barbara E. Moely Vincent Ilustre (2011) [20]. The industrial revolution 4.0 requires universities to have education orientation actively, building curriculums that meet the demand of a suitable profession (Pham Van Quyet, 2019) [32]. The HUST digital university model has also created an online recruitment channel with the support of stakeholders, spreading HUST's brand to potential customers (high school students and their parents).

b) Attract enterprises fund for science research

The research results show that Attract enterprises fund for science research stands the second (in Table 5, mean and standard deviation equal to 4.09 and 0.689 respectively). The role of enterprises is important in education activities and researching at a university. We require the university to look for a campus operation budget by attracting and selecting students and by doing research rather than by lobbying (Tran Thi Bich Lieu, 2008) [33]. It is the trend of stakeholders more and more taking part in campus administration structure (Pham Thi Thanh Hai et al., 2018) [34]. HUST has created a nice environment and attracted enterprises and companies to participate in doing research, transferring research, and sponsoring studies.

c) Have technology-enhanced public-private partnerships

Have technology-enhanced public-private partnerships stands the third (in Table 5, mean and standard deviation equal to 3.97 and 0.704 respectively), as the survey data reflected: higher education privatization is one of the new trend having a great impact on higher education system in many countries, even changing the traditional mindset on the university (Daniel Levy, 2006) [35]. Therefore, it is supposed that each major in each context had different stakeholders participating (sponsors, non-government organizations, resource using units). As the general trend of higher education in nowadays context, HUST performs toward a digital basis and mutual development with all stakeholders.

d) Transform training model as a business model

The transform training model as a business model has been evaluated as the lowest among all content (in Table 5, mean and standard deviation equal to 3.83 and 0.8 respectively). As Tran Thi Bich Lieu (2008) the characteristics of campus business are only within management activities but not in academic activities [33]. Vietnam is proceeding with higher education reform, university administration reform. Therefore, although there has been a policy of renovating university administration, performing the Transform training model as a business model has not been highly evaluated at HUST.

Table 5. Opinions about readiness in governance for HUST 4.0

	Total Staff		
Governance	***Mean***	***Standard deviation***	***Order***
Have admission strategies	4.20	0.690	1
Attract enterprises fund for science research	4.09	0.689	2
Have technology-enhanced public-private partnerships	3.97	0.704	3
Transform training model as a business model	3.83	0.800	4

4.5 Comparison between non-IT staffs and IT staffs for the readiness of HUST4.0

Comparing the two average values of views of two groups of non-IT staff and IT staffs using the *t*-test of the value Sig. In the Levene test lower than 0.05 (see Table 6), the variance between the two groups of IT-related professionals and the common staff is different, we will use the *t*-test results in Equal variances not assumed. As a result, other criteria have the value Sig. In the Levene test higher or equal to 0.05, the variance between the two groups of specialized IT-related officials and ordinary staff is not different, we will use the *t*-test results in Equal variances assumed.

Table 6. Levene test between non-IT staff and IT staff

	Levene's Test for Equality of Variances	
	F	***Sig.***
Learners had a schedule for their learning activities	7.273	.008
Learners had social skills	4.888	.029
Governance attract enterprises fund for science research	12.708	.001
Governance applied technology that enhances public-private partnerships	5.945	.016

See the results of the *t*-test in Table 7, if the value Sig. in testing $t < 0.05$, we conclude that there are significant differences in the average value between the two groups of staff in IT and non-IT majors in eight criteria. The analyzed results prove that there is a difference in evaluation grades between staff specializing in IT and other fields. As expected, the tendency shows that IT staff have a higher level of readiness for digital transferring than a staff of other fields (p-value < 0.05). This result is quite consistent with previous studies showing that IT staff have a higher attitude and are more ready for digital transferring. This also reflects the advantages of professional skills influencing the level of readiness for accepting technology changes or receiving new administration systems from staff. Staff with good IT and technology background have a higher level of readiness for digital transferring than staff who are lacking IT knowledge. This also implies that it is necessary to pay attention to IT skill training programs for staff to conduct campus digital transferring successfully. Meanwhile, it is required that the selection, development of technology systems need to be considered carefully appropriately with current systems and staff capacity in the university.

Table 7. The *t*-test between non-IT staff and IT staff

	Equal variances not assumed Sig. In the Levene test < 0.05		**Equal variances assumed Sig. In the Levence test ≥ 0.05**	
	t	***Sig. (2-tailed)***	***t***	***Sig. (2-tailed)***
Education Programs integrate goals for student learning (skills, knowledge, and attitudes)			-2.581	.011
Learners are proactive and have an individual mission			-2.168	.032
The learner had a schedule for their learning activities	-2.886	.005		
Learner did scientific research			-2.224	.028
Learner had social skills	-2.604	.010		
Governance has admission strategies			-2.492	.014
Governance attracted enterprises fund for science research	-3.059	.003		
Governance had technology-enhanced public-private partnerships	-3.452	.001		

4.6 Comparison among groups of academic staff (Ph.D., Master, and Bachelor / Engineer) for the readiness of HUST4.0

The results showed that the statistical quantities describing the significance level are less than 0.05 in ten criteria listed in Table 8 so the variance of the readiness levels for HUST conversion in these ten criteria among the three rolling groups (classification by qualification) is statistically different.

ANOVA analysis among three groups of different officials on degrees shows the results that there are 10/15 criteria with sig. < 0.05, indicating that there are differences between the three groups in terms of readiness for digital transformation at HUST independently, not due to random factors. Differences in views between different qualified staffs suggest that the education process promotes awareness of the importance of digital transformation and the application of ICT in the teaching process. The higher the qualifications, the more officers understand the need for digital transformation in education, especially higher education. Highly qualified staff will be the key team to promote and implement digital transformation in the school and they will promote the strengths of digital technology in providing training, teaching, and management services at the university.

Table 8. ANOVA - Analysis of one-way variance in readiness for digital conversion at HUST among 3 groups of academic staff (Ph.D., Master, and Bachelor/Engineer)

		Sum of Squares	df	Mean Square	F	Sig.
Programs meet the social needs	Between Groups Within Groups Total	2.959 52.585 55.543	2 113 115	1.479 .465	3.179	.045
Programs are short, flexible, and achieved by all students	Between Groups Within Groups Total	5.880 59.112 64.991	2 113 115	2.940 .523	5.620	.005
Programs integrate goals for student learning (skills, knowledge, and attitudes)	Between Groups Within Groups Total	5.389 64.499 69.888	2 113 115	2.694 .571	4.720	.011
Programs are designed according to personalized learning	Between Groups Within Groups Total	3.944 71.668 75.612	2 113 115	1.972 .634	3.109	.048
Learners are proactive and have an individual mission	Between Groups Within Groups Total	5.908 74.781 80.690	2 113 115	2.954 .662	4.464	.014
Learners have social skills	Between Groups Within Groups Total	4.428 79.115 83.543	2 113 115	2.214 .700	3.162	.046
Services give personalized experiences	Between Groups Within Groups Total	3.888 71.112 75.000	2 113 115	1.944 .629	3.089	.049
Services make stake holders network	Between Groups Within Groups Total	7.095 63.594 70.690	2 113 115	3.548 .563	6.304	.003
Services do effective counselors' system	Between Groups Within Groups Total	4.682 56.884 61.565	2 112 114	2.341 .508	4.609	.012

Governance has technology-enhanced public-private partner-ships	Between Groups Within Groups Total	4.707 76.905 81.612	2 113 115	2.354 .681	3.458	.035 5

5 Conclusion

In this study, the four key factors of the digital university are analyzed according to the typical models of the digital university. For certain context in Vietnam, we choose the model of university 4.0 (see Son H.M 2019) and the smart education framework (see IBM, 2012) to set up the conditions for surveying HUST. According to levels in the smart-university of the IBM model, the number of staff and students in HUST attend in this survey is suitable for the initial level of smart education in the digital university. So, if analyzing the results of the survey, we will get an overview of HUST's maturity at the initial level of the digital university. As a result, the survey starts at building the criteria for the assessment of the readiness of digital university. In our research, the criteria for assessing the readiness of university are extracted from the characteristics of the digital university so the framework for the assessment of readiness was built in detail. By assessing the staff's and students' opinion about the readiness of HUST for digital transformation, we believe that under the impact of digital transformation, four key factors including Education Program, Learners, Training Services, and Governance need to be fundamentally changed, creating the core values for higher education institutions. This value chain will look forward to the goal of improving the quality and effectiveness of higher education in the fourth industrial revolution. Based on the model of the digital university, HUST staff and students have highly evaluated the readiness of digital transformation. These core staff and students will be the key factors to spread out the strength of digital transferring to other staff and students in the entire university. Hence, the preparation for the next periods in the progress of digital transferring is possibly and effectively implemented, bringing HUST to a typical digital university model of Vietnam, as the expectation of the Ministry of Education and Training as well as the campus current workforce and students. Otherwise, these results prove that building the digital university should start from developing the conceive and actions in universities' human resources for digital transformation in university. We hope that this analysis of initial lessons in digital transformation at HUST will be useful for transferring digital university to other universities and contribute to the improvement of higher education quality in Vietnam adapting to the development of education 4.0.

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