DIGITIZATION INNOVATION IN UNIVERSITY EDUCATION

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ABSTRACT

Covid-19 pandemic and post-pandemic had led to the confrontation of higher education system with enormous challenges. That necessitated the urgent transition from face-to-face –teaching to online -teaching. The change was an innovation in higher education. A comparative study of digital education based on the survey in 2020-2021 in seven different countries was conducted at Shanghai University. The study was based on grey comprehensive evaluation model. In general, developed countries had high comprehensive evaluation value, while Finland, United States of America, South-Korea and Latvia had relatively low grey correlation coefficient in several certain indicators, leading to a sharp drop in the overall score. Romania ranked last while China ranked second as a developing country as well. The study launched a conclusion that research and development personnel, infrastructure funds and university financial investment in digital education had relatively more obvious effects on improving the innovations and quality of higher education system including the leadership system of universities.

KEYWORDS

Learning, Innovation, Higher education, Grey Comprehensive Evaluation Model.

1. INTRODUCTION

Online-teaching opened up as a smart solution for future education. In the field of education, a digital leap had been made in a short notice which has encouraged universities in the development of creative and innovative solutions. Concerns about educational inequality had risen in the process especially in the countries with short prior experience in online education. Same countries had also shorter history of innovation-orientation. Despites the limitations in technological conditions, all possible efforts should have been made when pursuing equality in online-education. The global emergency of the Covid-19 pandemic confronted all people with unpredictable, disruptive situations which had changed the daily lives, economies, political decisions and universities.

Generally, online-teaching has been used to supplement the classroom teaching, which is called “blended learning”. “When there is a risk, there should be an opportunity”, as the saying goes. The late Austrian-American economist Joseph Schumpeter introduced the “creative destruction theory”. (Schumpeter 1991, Kopp 2019) The Covid-19 pandemic was destructive, but it also, in a sense, created some creative destruction. It opened new opportunities and facilities for innovations based on the creative destruction theory. In the best scenario, teachers and students had got some benefits from online-teaching, which equipped them for the future learning and communication. For instance, teachers should have considered the issues such as how to motivate students and encourage them to be proactively participate in real-time video class discussions, how to implement innovative teaching concepts more effectively, how to maintain care and guidance for individual students, and how to share and integrate online-teaching experiences with other colleagues.

Teachers’ creativity and innovation skill with online-teaching can be a vital factor for stimulating students’ autonomous learning, turning the epidemic “crisis” into an “opportunity” whilst reforming teaching and learning innovative concepts. The university management should have provided support in this process and change its operating logic. During this period university leadership system changed at short notice in to the direction of Dynamic operation logic. (Aberg & Stahle, 2012). Throughout history, education has rarely been reformed or benefited from technological advances. Nowadays, with digital teaching allowing real-time interaction, many innovative teaching- and learning-methods can be attempted and implemented. The most

powerful part of this new generation of real-time interactive teaching and learning is that it can simultaneously accommodate in scaling and personalized learning, which traditional classroom teaching cannot do. In traditional large classes, it is difficult for teachers to know how many of the students understand or master the contents of a class. However, if the teaching and learning activities are carried out online in real time, teachers' understanding of students' progress can change. For example, teachers can review the distribution of answers to certain multiple-choice questions. They can recognize the number of students who answered in correctly and where they went wrong through the interactive polling function. During online teaching and learning, it is possible to reduce some of the limitations of traditional classrooms, which gives room to rethink how teachers can turn "classes" into better learning experiences and enhance teachers' mentoring and coaching roles. (Hakkarainen 2004; Karna 2011; Kilpinen 2004)

2. AIM OF THE STUDY

Covid-19 created a digital leap in all around the world, including higher education. The starting point of online education and in innovations varied from country to country and therefore, the changes that took place in the spring of 2020 vary. In some countries, a system for providing e-learning had been acquired on a fast schedule. Teachers had been introduced to new types of teaching, and only then had provision been introduced. The leadership of university had changed. Other countries had expanded only their previous offerings of courses. It was interesting to compare the seven selected countries, China, Finland, Latvia, Mexico, Romania, South Korea and the United States at different levels of online education and to gather experiences of change for operational development and innovation.

There was no return to yesterday, so institutions needed to start from first principles, creating a vision for life after the pandemic, making hard choices based on data, creating new models, realigning priorities and entering a post-covid-19 world not in isolation but collaboration. The aim of this study is to compare the implementation, quality and quantity of online-education by a questionnaire method in seven different countries and see the innovation orientation. The survey was made in 2020-2021 at Shanghai University. (The author worked in that time as visiting professor at Shanghai University.) The countries had been selected on the basis of countries were chosen to represent different continents, different education systems and different level of innovation orientation. The first electronic survey was conducted for the management of every university and the second electronic survey was conducted for the academics including program directors. The third electronic survey in the study was conducted simultaneously for groups of students in business administration.

3. THEORETICAL FRAMEWORK AND RESEARCH PROBLEM

There is no single or core theory which support online education. Research is linked to educational theories, mainly constructivism or exploratory learning. Constructivism is an international concept, so it is used is this research. Exploratory learning is actually a manifestation of constructivism. E-learning is implemented in as an opportunity to individualize teaching and it provides the preconditions for the realization of a constructivist view of learning better than mass-based teaching. The main research problem was as follows: The realization of a constructivist view of learning in e-learning and in innovation at universities in seven different countries. Insightful learning combines intelligence, emotion, creativity and skill of innovation. Learning takes place not only within the human mind, but in interaction with other people. Although more and more different tools are used in learning today, the key is not technology but participatory and inspiring pedagogy. (Hakkarainen 2004).

In the light of the study, the function of human memory was the continuous drawing of conclusions and the development of contexts. When learning new things, the student develops new connections between things. This is also manifested at the brain level, with new synaptic connections between nerve cells being created and extinguished continuously. The details the student learns can be remembered as its own when they relate to some sensible whole. Memory is a very central thing in human thinking and learning. If memory doesn't work, it's impossible to anticipate or plan for the future. In the constructivism, knowledge and learning are related to action. Knowledge does not pass from the outside into the human mind, but each student constructs his or her own knowledge. Understanding cannot be transferred it is always the output of the student's own thinking.

It is the student's own active knowledge construction process, in which the student selects and interprets information based on what he or she has previously learned and expectations. Learning includes, for example, self-perceived questions, self-experimentation, problem-solving, understanding and critical thinking. According to the constructivism, the key to learning is the understanding and thinking. Learning is thus the active interpretation of an individual's observations and experiences and the construction of new meanings associated with them. Learning is situational and based on interaction. Learning requires self-direction, which must be learned and be able to learn. In order to understand the basics of own thinking, the student must grow to see himself/ herself and his/her own actions from the outside and become aware of own assumptions. The student must be able to direct his or her own selective attention to what is relevant to what he or she is learning, and the student must also feel that the questions that arise are important and meaningful to him or her. Only then does learning happen. The results of the work of the different students form the basis for the teacher's own analysis of the matter. Everyone gets to know each other's work, which varies greatly, allowing the course a learning environment where not only student´s own experiences but also other students´ issues came to the fore.

The most important skill of a teacher is to create functional, appropriate learning environments that raise questions in the student´s mind and help him or her construct answers by understanding what is being sought. In the learning environment created by the teacher, appropriate questions arise, the answers to which are sought under the guidance of the teacher on the basis of the student´s own experimentation, understanding and thinking. The teacher trains students' thinking and comprehension skills by giving them the widest possible opportunities to receive feedback on their own operational processes. The learning environment includes situations of uncertainty (confrontations) initiated by the teacher. Through these, the student gets the opportunity to develop their own abilities to learn to learn. The appropriateness of the learning environment should be a conscious goal for all involved in the process. In order for meaningful and in-depth learning to take place, one must take knowledge of one's own and shape one's own internal model of it. (Hakkarainen 2004, Karna 2011)

When we talk about constructive learning, reference is made to this constructive principle of memory. Skills are developed through long-term and goal-oriented training at a variable, gradually decelerating pace. There are occasionally different levels of skill learning, during which a certain aspect of a skill is automating, but overall performance suffers. The development of skills at the highest level means the persistent continuation of practice even after the pace of skill development has slowed down. Peak performance can be achieved by avoiding the formation of rigid routines. The student has to face challenges that break with familiar patterns and force the student to stretch his/her own skills. Simply maintaining the level of performance achieved is not enough. The most difficult of these skills are often thinking skills. In order to develop, the student must constantly and consciously refine both his/her own actions and his/her own thinking. Action and thinking develop intertwined. A well-developed and unified way of acting and thinking is typical of an expert. Self-assessment skills (metacognitive skills) are needed to develop expert thinking. The student cannot get them naturally, because the assessment and development of student´s own internal models and skills requires acceptance that the student does not yet know everything. (Hakkarainen 2004; Karna 2011)

During the pandemic university leadership changed radically. The leadership logic is basically the exercise of power, that is, power is in a way a tool of leadership. Leadership without power already seems contradictory to the idea, and in practice it is impossible. When a university leader invests in the resilience of his or her organization, he or she has to lead according to a Mechanical, Organic, and Dynamic logic - according to the current goal. This division is based on Pirjo Stale's research. (Aberg & Stahle 2012). Power and the use of power are involved all the time, albeit in very different forms. The more knowledge-intensive the organization, the more important it is for the leader and manager to understand how power is combined with results in different ways and how the university is most effectively developed in the long run.

The university's ability to innovate is based on the management of various operating logics. Operational logic refers to the principles, systems and management structures under which the activities of university staff are integrated into cooperation and further into the results of the university. In Mechanical operating logic the most important results are in teaching, degrees, secondly in research results and thirdly in impact with surroundings and society. Second logic is Organic operating logic, which produces flexible development and self-directed learning. It is based on agreed processes, human interaction, motivation and responsibility. The third one is Dynamic operating logic which produces social courage, innovation and attractiveness. It is based on networking, self-organization and strong autonomy of actors. Dynamic operating logic strengthens the university´s innovativeness and proactiveness. In dynamic action, power is paramount, as dynamics do not

emerge without influencers and new perspectives that have the potential to connect creative people to work inspired by bold visions. The task of an innovative leader is to identify these people and create the conditions for them to operate. Strong dynamic operating logic is the university's attraction to innovative staff. (Cheng 2020) New creative and evolving expertise is needed when the operating environment changes and old and proven models do not work. A priori reflection on the preconditions of constructivism in e-learning provided subjects to the theoretical part and the surveys. (Hasan 2020).

4. METHODS

4.1 Data Collection

Data collection of this study was conducted as digital surveys. Target survey-takers were divided into 3 groups: (1) University management: What role did e-learning play in the current strategy of the university? How did they see the change in the future? Management was asked about their views on learning and whether they relate to some general theories or whether they exist at all. (2) Academics including program leaders: Program leaders and academics were asked about their views on learning. It was also asked whether they related to some general theories or whether they existed at all. Academics and program leaders were asked: What kind of experience had they had with e-learning technical solutions, software, content, and guidance? What was the key feedback from academics and program teachers? What were the key successes, what about failures? How did program managers and academics see the connection of e-learning to students working life after graduating? How had been the reactions of the partner companies to e-learning? (3) Students: What kind of experience had they had with e-learning technical solutions, software, content and guidance? How had their studies progressed? What were the key successes, what about failures? How did students see the connection of e-learning to working life after graduation? The collection of questionnaire data played a significant role on the application of the model. The extensiveness and reliability of the data could have ensured the model feasible with practical significance. This study selected managers, students and academics engaged in higher education as investigation object. The survey was conducted from August 2020 to March 2021, collecting data from seven selected countries. A total of 160 questionnaires were issued and collected in this survey. After eliminating 4 invalid questionnaires, 156 valid ones were obtained with an effective recovery rate of 97.50%.

4.2 Variable Description

Based on the existing researches, this study selected 17 indicators from *Scale of e-learning in higher education*, *Input of digital education during the Covid-19 crisis* and *Impacts of e-learning on higher education during the Covid-19 crisis* to accurately evaluate the implementation, quality and quantity of digital education in each country. First, *Scale of e-learning in higher education* reflected the basic development of digital education. Enrollment number of graduate students and number of doctor students could have represented this index. Second, *Input of digital education during the Covid-19 crisis* was the core reflecting the driving force of digital education development under the influence of the pandemic. It was not only evaluated from the indicators of physical capital such as financial investment provided by universities and online education expenditure per capita, but also taken serious considerations of human resources, including number of teachers implementing online-teaching. Among them, number of R&D personnel including innovations in digital education had attracted the special attention in terms of manpower investment in scientific research. Last, *impacts of e-learning on higher education during the Covid-19 crisis* could have reflected the ability of digital education to serve the current community. Wen's article (2013), one of the most cited articles in this field, mentioned that intensity of students' performance evaluation, grade for academics' online teaching skills and grade for managers' digital working efficiency were important indices to measure the significance of digital technologies in higher education. Furthermore, with accordance to Pan et al. (2020), number of temporary forms of academic employment and opportunities for equity, diversity and inclusion could have been selected as impact measurement indicators as well.

Table 1. Parameter List

Primary variable	Secondary variable	Symbol
Scale of e-learning in higher education	Enrollment	X_1
	Number of graduate students	X_2
	Number of doctoral students	X_3
Input of digital education during the Covid-19 crisis	Proportion of e-leaning in higher education	X_4
	Number of teachers implementing online-teaching	X_5
	Number of R &D personnel in digital education	X_6
	Infrastructure funds	X_7
	Financial investment provided by universities	X_8
	Online education expenditure per capita	X_9
	Research funds on digital technologies	X_{10}
	Inherent assets	X_{11}
Impacts of e-learning on higher education during the Covid-19 crisis	Total use frequency of digital technology	X_{12}
	Intensity of students' performance evaluation	X_{13}
	Grade for academics' online teaching skills	X_{14}
	Grade for managers' digital working efficiency	X_{15}
	Number of temporary forms of academic employment	X_{16}
	Opportunities for equity, diversity and inclusion	X_{17}

4.3 Factor Analysis

Due to the considerable number of indicator selection, there might have been high internal correlation between different indicators and unstandardized structure of observation data resulting in inconsistent analysis results. In order to facilitate the subsequent data analysis, it was hoped to reduce the number of variables and improve the model accuracy through factor analysis first. The basic principle was to find out the representative factors that could reflect the overall characteristics in the multi-dimensional variables, and classify the same essential variables into one factor. These unobservable synthetic indicators were public factors. Grey comprehensive evaluation model was based on the entropy weight.

After the dimensionality reduction by factor analysis, grey comprehensive evaluation method was conducted to test. This method assessed the pros and cons of each comparison sequence by calculating the similarity between the comparison sequence and the reference sequence. However, the traditional grey comprehensive evaluation method simply samples the average value of the correlation coefficient of each index when solving the sample correlation degree, which obliterates the heterogeneity between the indexes. While in accordance to the background of this topic, different elements of the data had different significance to the system of digital education. Therefore, it was of great priority to distinctly set the reasonable and scientific weights for these indicators of digital education quality so as to represent different elements' value. To improve the traditional one, this study integrated the entropy weight method and the grey comprehensive evaluation method to analysis the quality of digital education in various countries.

4.4 Grey Comprehensive Evaluation Method

Firstly, it was needed to select the optimal sequence. All the indexes described above were positive indicators which meant that the larger the value, the better the evaluation result was. Therefore, the maximum value of the same index for each evaluation object was taken as the optimal value of the index. While the maximum value of the "Total use frequency of digital technology" was taken as the optimal value of this indicator. The sequence composed of the optimal values of each indicator was called the optimal sequence, and was denoted as $X_0 = (x_{01}, x_{02}, \dots x_{0n})$.

Secondly, to solve the grey correlation coefficient, it was needed to set the comparison sequence and the reference sequence respectively. Continue to the previous step, the optimal sequence was taken as the reference sequence. And the sequence composed of the index values of each evaluation object as the comparison sequence, denoted as $X_i = (x_{i1}, x_{i2}, \dots x_{in})$, i=1, 2, …m. The grey correlation coefficient between the i^{th} evaluation object and the j^{th} index in the reference sequence is denoted as $\gamma_{ij.}$ Here, it was taken ρ as 0.5.

Last step was to calculate the grey correlation degree which reflected the closeness of the comparison sequence to the reference sequence. The greater the degree of association, the closer the comparison sequence was to the optimal value. Therefore, the pros and cons of each evaluation object could have been evaluated according to the degree of grey correlation of each comparison sequence. Taking in to account the heterogeneity between different indicators, different weights are assigned to the indicators according to the relative importance of each indicator. Among them, ω_j was the weight of the jth index. The index weight was determined by the above-mentioned entropy weighting method. Then it was calculated the grey correlation degree of each country based on this.

5. RESULT ANALYSIS

5.1 Evaluation Results

Before factor analysis, it was necessary to judge whether the variables selected are suitable for factor analysis. According to the data, a group of observations with 5 related variables and 12 sample size were obtained for analysis. In order to prevent the occurrence of multi collinearity, it was needed to estimate the correlation between the selected variables before factor analysis. In this study, it was used SPSS 25.0 statistical software to test the collected data. Although the significance level of Bartlett sphericity test was less than 0.01, the value was 0.495, less than 0.6, which did not pass the KMO test indicating that the selected variables were not suitable for factor analysis. (In statistics, Bartlett's test, named after Maurice Stevenson Bartlett, is used to test homoscedasticity, that is, if multiple samples are from populations with equal variances. Some statistical tests, such as the analysis of variance, assume that variances are equal across groups or samples, which can be verified with Bartlett's test. The Kaiser-Meyer-Olkin KMO test is a measure of how suited your data is for Factor Analysis.)

Table 2. Comprehensive evaluation value

Country	Comprehensive evaluation value	Rank
U.S.	0.7709	1
China	0.5387	2
Finland	0.4988	3
Latvia	0.4751	4
South-Korea	0.4192	5
Mexico	0.3786	6
Romania	0.3495	7

5.2 Analysis of Results

It is widely accepted that developed countries tend to have high comprehensive evaluation value, including the United States of America, Finland, South-Korea and Latvia. However, Finland, South-Korea and Latvia have relatively low grey correlation coefficient in several certain indicators such as "Research funds on digital technologies" with heavy entropy weight, leading to a sharp drop in the overall score. These countries are also known as innovation-oriented countries. Notably, Romania ranked last. This is because Romania's digital education penetration is still relatively low. It can be found that the number of enrolled students (number of undergraduates, graduate students and doctoral students) is particularly low. (Liu & Yan 2018)

In general, as a developing country, all digital education evaluation index values in Mexico seemed to be tremendously low. The number of academics implementing online-teaching continued to decrease and their quality could not be guaranteed significantly. On the other hand, what was puzzling is that China ranked second as a developing country as well while the various evaluation index values had a relatively large gap, showing that China had an unbalanced level of resource development when the digital education system had obvious room for improvement. In terms of that, Liu and Ru (2018) demonstrated that for the large number of students in China, the phenomena of uneven distribution in higher education resources were increasingly obvious. For example, the resources of scientific research personnel attracted by various schools and the financial resources invested by the state were uneven. Jiang (2020) discovered that only a few universities were considered to be highly efficient and innovative in digital R&D. Since schools without national key construction projects lack national financial support, the research efficiency was relatively low. In universities the leadership was not moving toward Dynamic operating logic. According to the analysis of China's grey correlation coefficient, it could have been found that the statuses of scientific research (number of R&D personnel in digital education and research funds on digital technologies), university construction investment (infrastructure funds and inherent asset investment) as well as financial investment provided by universities are far below the optimal sequence. Furthermore, the entropy weights of R&D personnel, university financial investment and digital research funding were relatively large.

6. VALIDITY

When evaluating the validity of this study the differences between the target countries and the time of the survey must be taken in to account. The study was conducted at Shanghai University at a time when universities were closed everywhere. The target groups were university management, academics and students. The share of China was higher than in other countries, especially in the target group of students. Management groups, and academic groups were more balanced. However, the study was valuable because the results are indicative and showed a digital leap in developing countries as a result of the pandemic. University management' interest in responding showed that leadership was moving toward Dynamic operating logic.

7. CONCLUSION

Economic and cultural globalization has ushered in a new era in higher education. Because of its immersion in knowledge, higher education plays a particularly important role in global knowledge economies. However, the current Covid-19 pandemic was making it trapped in a development burden. To cope with the challenges posed by this crisis, transformation from traditional face-to-face teaching to online-teaching should have been timely implemented in higher education system. This research offered insightful analysis and established grey comprehensive evaluation model. Although Covid-19 had restricted mobility, the research result promoted the development work and internationalization of higher education institutions, which could serve as a credible reference for the higher education reform. In the future, more cross-border e-earning will be offered and implemented. The expansion of e-learning across national borders implements internationalization in an economic and efficient way. In particular, the study is likely to stimulate discussion with business representatives on issues related to employ-ability as well as on the achievement of lifelong learning objectives.

The case of the digital leap showed how universities in a short time had to change all their operating logics after the Covid-19 pandemic expanded the world. The situations at the universities were very different. Some

countries had already come a long way in developing and implementing online-teaching. The necessary infrastructure was in place in the universities and the staff was able to switch to large-scale online teaching. Some countries were about to start, and the Covid-19 pandemic caused the phenomenon described by Schumpeter. Changes were needed in the leadership of universities, from more Mechanical and Organic logic of actions towards more Dynamic logic of actions. It means changes from basic decision-making to innovative solutions for teaching and research. The change was made in a very short time. In 2022, it is generally stated that there is no going back. However, the teaching of expropriation is returning, at least in part, to those countries where it is possible. Similarly, the face-to-face innovation of research teams is gradually returning to universities.

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