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Industry 4.0 and Development of Teaching Competencies for Students in Universities of Education in Vietnam

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ABSTRACT

In the context that Vietnam is actively approaching Industry 4.0, teacher training institutions, including universities of education, are taking various approaches and seeking methods to develop pedagogical competencies for students in order to meet the requirements of this revolution. However, thoroughly understanding the nature and the impacts of Industry 4.0, thereby applying its advantages in development of teaching competencies for pedagogical students, is still a question that needs answers from domestic and foreign educators. The article compiled 18 references related to this issue, then analyzed and synthesized, discussed the opinions and viewpoints of each author, and recommended a number of measures to develop teaching competencies for students in universities of education to meet the requirements of Industry 4.0: identifying goals of competency training for students; developing training programs towards the formation of teaching competencies to meet the requirements of Industry 4.0; innovating the integrated training aimed at the required professional competencies of teachers 4.0.

KEYWORDS: Industry 4.0; education 4.0; teachers 4.0; teaching competencies; teaching competency development methods.

1. FOREWORD

In any era and any country, human resources are a key factor and driving force of socio-economic development. The rapidly growing Industry 4.0 has brought new challenges to education in general and higher education in Vietnam in particular that requires utmost efforts to keep up with the times and to be able to participate in the "knowledge economy" process. Industry 4.0 has been having profound impacts on education and teacher training [1]. In particular, the development of teaching competencies for students has received considerable attention from educational experts and education managers. There have been many research works on this issue. Author Ha Thi Lan Huong had a research article on developing a framework of pedagogical competencies 4.0 for students [2]. However, the author has not deeply researched each teaching competency. Directly discussing the training of teachers 4.0 in universities of education, authors Nguyen Hoang Doan Huy and Nguyen Thu Ha published results of researching the preparation of universities of education in the transformation to higher education 4.0 and the development of information technology and communication competencies for pedagogical students [3,4]. Articles titled *Measures to develop teachers' professional competencies in the form of organizing learning communities in high schools* [5] and *With Regard to the Connection between Pedagogical Schools and High school in Teacher Training and Retraining in Vietnam* [6] contributed a voice to effective and feasible measures to improve the quality of high school teachers in a close relationship with teacher training activities at pedagogical schools, which emphasized the role of information technology in fostering and developing teaching competencies for teachers. A number of works focused on researching changes in teachers' role and position in the new context to determine the criteria for training teachers 4.0 in pedagogical schools. There are works that affirm the change in teachers' role from a teacher to a designer, an advisor who helps learners adjust the quality and value of information sources, new knowledge, and a competent expert who is open-minded, able to criticize independently, actively collaborate among learners with what they know, and a provider of understanding in the form of a bridging scaffold [7]. The role of teachers in the 21st century becomes complicated in a rapidly changing world where knowledge is virtually unlimited. Teachers should orient toward technology and be responsible not only for their own teaching but also for their students' learning. Accordingly, teachers need to meet curriculum standards to enhance learners' creativity, curiosity and learning motivation; and need to ensure a safe classroom environment. However, the problem of promoting technological change in education

without posing a risk to human values still has no solutions [8]. The question is what competencies in general and what teaching competencies in particular that pedagogical students should have to be able to take on the role of teachers 4.0 after their graduation. The article focuses on researching the impact of Industry 4.0 on education, recommending measures to develop teaching competencies for students in teacher training institutions. In particular, it focuses on determining the goals of competency training for students; developing training programs towards the formation of teaching competencies to meet the requirements of Industry 4.0; innovating the integrated training aimed at the required professional competencies of teachers 4.0.

2. RESEARCH METHODS

The article applies the theoretical research method. This method is used in researching works and documents on the current situation of teaching competencies of students in universities of education. At the same time, this method is used in theoretical and practical researches on Industry 4.0, the impacts of Industry 4.0 on education and teacher training institutions; researching results of scientific topics to determine the current situation of students' teaching competencies; identifying components of teaching competencies for students in universities of education and recommending measures to develop those competencies in the context of Industry 4.0.

3. RESULTS AND DISCUSSIONS

3.1. Industry 4.0 and its impacts on education

3.1.1. Industry 4.0

The term "Industry 4.0" originated from a project in the high-tech strategy of the German Government. It promotes the computerization of manufacturing that leads to a digital production platform. The fourth industrial revolution (also known as Industry 4.0) is a revolution built on the third industrial revolution on digital and electronic revolution (computers, telecommunications technology and Internet) that appeared in the middle of the last century. The specific characteristic of Industry 4.0 is the fusion of technologies and the blurring of boundaries among physics, digital field and biology with a focus on the deeply interdisciplinary development of artificial intelligence, robotics, Internet of Things (IoT), materials science, biology, wireless mobile technology, etc. All of these components are connected to each other through a **digital platform**, which is the key element of Industry 4.0 [9].

The speed of the current breakthroughs of Industry 4.0 is unprecedented in history. Compared to the previous 3 industrial revolutions, Industry 4.0 is developing at an exponential rate. Moreover, it is disrupting almost every industry in every country. The breadth and depth of these changes portend the transformation of the entire production, management and governance systems of human society.

3.1.2. Impacts of Industry 4.0 on education and teacher training institutions

a) Impacts of Industry 4.0 on education

The emergence and integration of new technologies, artificial intelligence and the internet of things lead to new economic fields and new professions that have a profound impact on education in all aspects such as management, environment, contents, methods and forms of education and training. A number of main impacts of Industry 4.0 on education can be mentioned as follows:

- The educational mission has changed: The education system is required to prepare a workforce that can move more easily among professions, among fields of activity and among different cultures rather than training them for a specific profession, in a specific time and place.

- Innovation of educational goals: Industry 4.0 sets new requirements for human resource preparation that leads to many changes in the education system to adapt with such requirements. The educational goal is to develop human resources to meet the requirements of the economy in Industry 4.0 with priorities on *competencies and qualities such as creativity, entrepreneurship, digital competency, and competencies of using virtual reality technology devices, leadership competency, self-learning competency, cooperation and social emotions, qualities of global citizens*, etc.

- Training and research on new professions, integration of fields: The impacts of Industry 4.0 require the education to have open programs that quickly adapts to new needs of the labor and job market, learning programs that allow learners to learn on mobile devices, store and access from anywhere on cloud computing software, and learn with games to attract learners. Educators and educational leaders emphasize that one of the important changes of education 4.0 is interdisciplinary integrated teaching, which combines two or three majors and subjects, to help students learn across fields; to provide human resources for new professions; to train and nurture talents [10].

- New requirements for competencies of research and training human resources:

+ Leaders 4.0: In addition to traditional competencies, leaders 4.0 are people with a perspective 4.0: creative, responsive, flexible.

+ Teachers 4.0: Understand the goals of developing human resources 4.0; capable of integrated teaching, using information technology and communication (ICT) in teaching.

+ New requirements for teaching facilities and environment: Teaching facilities in the 4.0 era are mainly digital media, smart devices (robots, 3D printing) and virtual reality environment; Wi-Fi connection, connection of educational levels, integration of fields, public and private combination, global connection to create creative and entrepreneurial educational ecosystems [11]. Outstanding is

the trend of using robots to support teaching activities and administrative management [12,13]. In addition to the virtual teaching environment and aids, it is necessary to attach much importance to real teaching and educational environments so that learners can experience real people, environments, and things in life, and solve life's problems for the interests of the community.

- To change standards and criteria for evaluating and ensuring educational quality, aiming at standards and criteria for digital schools, smart schools, and creative innovation capabilities of universities; to use automation and intelligence in assessment and accreditation. However, researches also show that education and training quality assurance in Industry 4.0 needs to aim at development of competencies for learners, online assessments, application of intelligence in various forms of assessment and parallel assessment throughout the learning process [14].

b) Impacts of Industry 4.0 on teacher training institutions

Higher education institutions in general and pedagogical training institutions in particular are facing many opportunities and challenges due to the impacts of Industry 4.0. Education is facing a big challenge of transforming from traditional teaching methods to innovative teaching methods. If students continue to teach with traditional methods after their graduation, they cannot create citizens suitable for the 21st century. Therefore, teacher training institutions should ceaselessly innovate their training activities to adapt to the innovations of Industry 4.0; train students to graduate with competencies 4.0 such as: creative competency, competency to adapt to changes, leadership competency, career development competency, integrated and differentiated teaching competencies, competency of integrating pedagogy and technology in teaching, etc. To do this, teacher training institutions should innovate their models of training pedagogical students to become teachers 4.0. This new educational model must emphasize the development of a 4.0-oriented educational vision and philosophy; development of standards for pedagogical students 4.0, then development of programs and organization of training processes aimed at forming and developing students' competencies.

3.2. A few words about the current situation of teaching competencies of students in some universities of education

3.2.1. Teaching competencies of students of pedagogic universities

In the opinion of author Tran Ba Hoanh, in the work titled *Teacher Issues - A Theoretical and Practical Research* [15], teaching competencies consist of three basic components: Knowledge about the field of activity (competence of knowing); Skills to conduct activities (competence of doing); and Psychological conditions to organize and implement such knowledge and skills in a unified structure and clear orientation (competence of expression).

In 2012, the High School & Intermediate Professional School Teacher Development Project - Ministry of Education and Training issued undergraduate output standards of pedagogical major blocks for high school teacher training with 8 standards; Teaching competency standards include 9 criteria: (1) Knowledge of interdisciplinary, supplementary, and foundational sciences; (2) Knowledge and skills of subjects to be taught in high schools; (3) Competency to develop programs of subjects; (4) Competency to apply methods, means, and forms of organizing subject teaching activities; (5) Differentiated teaching competency; (6) Integrated teaching competency; (7) Competency to make and realize teaching plans; (8) Competency to test and assess learning outcomes; (9) Competency to develop and manage teaching documents. Accordingly, universities of education, based on the above standards, have set output standards for their graduates, including standards of teaching competencies [16].

3.2.2. A few words about the current situation of teaching competencies of students in some universities of education

To provide a few words about the current situation of teaching competencies of graduates from universities of education, we conducted a study on the results of the ministerial-level educational science research project no. B2011-17-CT04 by Nguyen Thi Kim Dung et al. on the teaching competencies of students in universities of education [17].

The author administered a questionnaire survey to 278 final-year students of Hanoi National University of Education, Thai Nguyen University of Education - Thai Nguyen University, Tay Nguyen University, Tay Bac University, Da Nang University of Education - Da Nang University, Ho Chi Minh City University of Education, School of Education - Can Tho University, University of Education - VNU Hanoi and 119 young teachers (fresh graduates from universities of education) at the Departments of Education and Training of Hanoi city, Ho Chi Minh city, Son La province, Da Nang city, Can Tho city. Specific results on the level of mastering some component competencies of teaching competencies are as follows:

Table 1: Level of mastering some component competencies of teaching competencies

No.	Component competencies	Young teachers		Students	
		Average	Standard deviation	Average	Standard deviation
1	Integrated teaching, differentiat	2.58	0.946	2.70	0.997

	ed teaching				
2	Use of teaching - educational facilities, equipment	2.97	0.868	2.88	0.938
3	Testing, assessment of learners' learning outcomes	3.09	0.801	2.92	0.874
4	Efficient development, management, and use of teaching documents	2.63	1.068	2.72	0.992
5	Application of information technology in teaching and managing documents	3.03	0.895	2.80	0.939

Source: *Figures of surveying young teachers and final-year students of the project no. B2011-17-CT04*

The above table shows that the component competencies are mostly near and close to level 3 (the highest level is 4) for both final-year students and young teachers. However, the general trend is the relatively high consistency in low-level component competencies related to the difficulties that they encounter in high school reality such as integrated teaching competency, differentiated teaching competency; competency to develop and manage teaching documents.

When they were asked about the difficulties that final-year students and young teachers encountered in teaching practice through interviews, the majority of young teachers and final-year students said that, in terms of teaching competencies, they were having difficulties in organizing integrated teaching and differentiated teaching; in using teaching aids and applying information technology in teaching; in conducting competency-based testing and assessment of learning outcomes; in developing and managing their teaching documents.

In short, all difficulties that final-year students and young teachers encounter are related to the competencies to meet the requirements of the current general education innovation, especially in the context of meeting the requirements of Industry 4.0. It is especially important that those difficulties are related to the level of mastering the component competencies of teaching competencies. These are the competencies that young teachers and final-year students are weak and lacking and need to perfect.

3.2.3. Recommendation of some component competencies of teaching competencies for students in universities of education to meet the requirements of Industry 4.0

Based on our research on the current situation of teaching competencies of students in universities of education along with the impacts of Industry 4.0 on teacher education and training, we recommend a number of component competencies of teaching competencies for students in universities of education to meet the requirements of Industry 4.0 as follows:

1. Develop curriculum and didactic materials	
Knowledge	***Skills***
(i) Analyze the basic theory of chapter design and development. (ii) Analyze subjects to be taught in high schools; methods to design and develop subject-based curriculum (subject-based curriculum, modules; programs of classes, educational levels, etc.). (iii) State the role, nature, structure, and requirements of textbooks (types of textbooks used for the implementation of subject-based curriculum, structure of textbooks, etc.). (iv) Analyze relationships between programs and learning materials, especially textbooks.	(i) Analyze and comment on a subject-based curriculum to be taught in high schools. (ii) Design a subject-based curriculum for a class to be undertaken in high schools. (iii) Determine forms of organizing, methods, and means of learning for students corresponding to a program (subjects, lessons, sessions, and learning items in a session); conditions for students to implement this program. (iv) Analyze and indicate the connection between a specific subject-based curriculum and its relevant textbooks. (v) Analyze and comment on a textbook related to a specific subject-based curriculum.
2. Integrated teaching competency	
(i) Present and analyze the nature of integrated teaching, analyze the trend of integrated teaching, thereby realize the necessity of integrated teaching of sciences in schools. (ii) State methods and	(i) Comment on current subject-based curriculum in high schools according to integrated criteria. (ii) Analyze the integrated teaching ability of a topic, a part, a chapter in a subject curriculum. (iii) Compile and

forms of integrated teaching. (iii) Analyze the requirements and capabilities of integrated teaching of subjects. (iv) Present the principles of developing a comprehensive integrated teaching program. (v) State the conditions to ensure the integrated teaching.	implement an integrated teaching plan for a topic, a lesson, ... (iv) Create a matrix to indicate the integrated knowledge content in a subject-based curriculum in high schools.
3. Differentiated teaching competency	
(i) Analyze the core contents of differentiated teaching (ii) State forms and methods of differentiated teaching according to learners' psychological and cognitive characteristics and in the principle of selecting appropriate forms and methods for different learners. (iii) Analyze program contents, forms of organizing differentiated teaching - teaching by career-oriented division; (iv) Present trends of differentiated teaching in the world. (v) Analyze applications of information technology and communications in differentiated teaching.	(i) Comment on and format current subject-based curriculum in high schools according to differentiation criteria. (ii) Use results of surveying learners to choose appropriate teaching forms and methods for different learners. (iii) Set criteria for a differentiated teaching program. (iv) Design subject teaching programs for differentiated subjects according to criteria and levels of differentiation. (v) Design and implement a lesson plan that takes into account the different characteristics of students' abilities, cognition, attitude, etc.
4. Competence to apply information technology in developing, managing, and exploiting teaching documents	
(i) Present types of documents, the meaning of each type, ways to create, manage, exploit and use each type of teaching documents. (ii) Present some software in creating, managing and using teaching documents.	(i) Develop and update necessary information to teaching documents. (ii) Use some software to create, manage and use learner documents. (iii) Exploit information in teaching documents for the teaching process.

3.3. Measures to develop a number of component competencies of teaching competencies for students in universities of education to meet the requirements of Industry 4.0

3.3.1. Necessary knowledge in the formation of teaching competencies for pedagogical students to meet the requirements of Industry 4.0

a) *Knowledge about curriculum and didactic materials development*

Curriculum development knowledge and skills are trained to form the curriculum development competency. The curriculum development competency is the core professional competency of a modern teacher, because thanks to it, teachers develop their expertise and professionalism in the teaching profession and it aims to create effective teachers. The curriculum development competency helps teachers develop and implement a curriculum at both micro and macro levels; helps teachers actively participate in creating and developing a curriculum. Without this competency, it is difficult to have effective educational activities that are compatible with different, changing and developing social contexts.

The curriculum development competency needs to be formed in pedagogical students by equipping them with both theory of curriculum development and methods of curriculum creation. Both domestic and foreign researches agree that this competency is necessary and consider it a fundamental innovation factor. To gain this competency, the teacher training program needs to have theoretical contents about the curriculum, curriculum development and design skills, curriculum development models and methods, curriculum development processes, organization of researches for curriculum development, the relationship between the curriculum and textbooks and the competency to implement the curriculum in educational and teaching practice.

b) Knowledge about integrated teaching and differentiated teaching: Both educational trends of advanced countries in the world and the orientations of Vietnamese general education in this period to meet the requirements of Industry 4.0 appreciate the integrated and differentiated teaching competency of teachers. To gain this competency, it is necessary to equip future teachers with theories on integrated and differentiated teaching, content designing skills, curriculum, integrated and differentiated teaching topics, methods and forms of organizing integrated and differentiated teaching, etc.

c) Knowledge about developing, managing, and exploiting educational and teaching documents (referred to as learner documents): Knowledge about types of documents, meaning of each type, ways to create, ways to manage and exploit each type of educational - teaching documents.

d) Knowledge about assessment of teaching & education results

The assessment competency in education is formed on

the basis that students are equipped with knowledge about and skills of testing and assessment in education, the quality of education, the motivation of education and teaching; assessment process, methods, forms, and objectives; assessment tools; design and preparation of assessment tools; information collecting and processing and use of results obtained from testing, assessment, etc.

Training knowledge and skills to assess educational outcomes is valuable as an element of teacher training innovation only in thoroughly grasping the fact that the ideology of testing and assessment is a method of receiving feedback for teachers and learners approach the identified goals. Thus, testing and assessment must integrate contents, goals, methods, and motivation of the teaching process. Accordingly, process assessment (developmental assessment) and summative assessment (output assessment) must be closely combined with each other.

3.3.2. Integrated training innovation aimed at required professional competencies of teachers 4.0

First is *the integration among fields of knowledge, among modules, between theory and professional practice*. The modules are carefully arranged and closely connected together based on a solid theoretical foundation of "learning to be able to teach students 4.0 after graduation". Such integration will have the dual effect of both professional skills and profound basic knowledge. *Basic science modules* should be deemed as an element of pedagogical science when basic science is oriented to the formation of subject teaching competencies in high schools. Usually, the duration of specialized scientific knowledge training accounts for over 60% of the training program. When it is integrated with pedagogical knowledge, there will be a rich and diverse source of pedagogical knowledge, skills and competencies.

The essence of this method is that training is not only designed according to the logic of content but also according to the logic of professional competencies. A teacher's professional competencies are not simply the addition of knowledge units but must be the integration of three blocks of knowledge: specialized knowledge, pedagogical knowledge and skills, and cultural and social knowledge, ethics, responsibility, professional values in the era of Industry 4.0. The environment where the integration process takes place is high schools, and the integration mechanism is to teach students through the act of teaching and educating students.

Training with integrated methods is conducted in the following orientations:

- *Design of curriculum, textbooks, and organization of training activities must be under close management* (monitoring) and coordination of activities among lecturers of different modules, between pedagogical lecturers and high school teachers, and among training units. Each subject needs to fully focus on specific aspects of the curriculum and the overall model of future teacher competencies in the period of Industry 4.0.

- *Modules, textbooks*, and lecture outlines need to have integrated exercises and topics depending on the characteristics and potential contents. Case studies are developed with the highest integration efficiency when they are based on selective materials from curriculum contents, textbooks and educational activities of high schools. These are exercises that require students to apply obtained knowledge to solve teaching and educational situations in reality in high schools. Therefore, students also have many opportunities to interact with professional practice in high schools that makes it more convenient to train professional competencies.

- *The integration possibility is proportional to the length of time, volume and contents* of training content units. This needs to be taken into account when the curriculum is designed according to the credit system. It can be overcome in many ways, including the preparation of cross-credit, cross-module, and module topics for participants in teaching as a basis for organizing teaching activities. Experience from other countries shows that maybe after students accumulate enough credits for a certain capacity, certain training course, they need to be testes and re-assessed with test questions that require integration.

- *Integrating roles for lecturers and high school teachers*: Teaching staff directly attending classes at university are also responsible for guiding intern teachers and sometimes they even participate in teaching students and teachers in practical schools. And vice versa, high school teachers can also participate in teaching practice hours for students at university and guide intern teachers, etc. This brings different elements in the curriculum through the integration of roles. The vocational training experience of lecturers and high school teachers where linking training responsibilities with pedagogy is decisive in integrated teaching to form professional competencies for pedagogical students.

- *Make the best of theoretical lessons in combination with practical activities.*

This is the trend of striving in many countries from the results of researching and applying pedagogical practice. Take practical teaching and general education situations to organize theoretical learning activities. The percentage of practice hours must be at least 50%, which is half of the theoretical hours in each module. Effective integrated teaching takes place in the pedagogical environment of high schools, so there should be a mechanism and method to link responsibilities of pedagogical schools and high schools.

4. CONCLUSION

Every revolution poses challenges to teacher training institutions that require them to innovate to meet the requirements of the revolution. Industry 4.0 has influenced and impacted education; making education 4.0 transform from

serving the knowledge economy to the creative economy. Education 4.0 will be marked by a big change in training goals, shifting from imparting knowledge to the masses to enlightening (unleashing potential, competencies, and motivation) and empowering innovation to each individual.

Regarding the requirements for teachers 4.0, universities of education need to focus on developing competencies for pedagogical students, including teaching competencies to meet the requirements of Industry 4.0. Accordingly, it is necessary to take specific measures such as Identifying goals of competency training for students; Developing training programs towards the formation of teaching competencies to meet the requirements of Industry 4.0; Innovating the integrated training aimed at the required professional competencies of teachers 4.0. In addition, it is necessary to invest more in advanced educational technology, apply online training, network connection to foster professional competencies for students, teachers, and intern teachers in an expanded and unified network system nationwide and globally. It is the only way to continue developing new national strategic solutions for training and fostering teachers in an open direction that combines initial training and continuous training; teacher training at pedagogical schools must be associated to teaching and learning practices in high schools; continue innovating advanced teaching and learning methods; perfect the management of teachers and schools; improve benefits for teachers who are qualified understand technology applications; strengthen international integration, cooperate with leading pedagogical training institutions in the world and in the region; honor the teaching profession and heighten the innovation of teachers' role; establish mechanisms and policies, facilitate the attraction and drastic use of available foreign investment sources for teacher training to improve teaching competencies in the digital era.

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