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Updating of higher education curriculum for future engineers during the COVID-19 pandemic

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ABSTRACT

Higher education is immersed in unpredictable environments and is facing challenges during the Coronavirus Disease 2019 (COVID-19) pandemic. It needs to adapt to external changes constantly, especially to the level of development of science and technology as the most important component of education courses for future engineers are facing development difficulties within achieving their goals as the core of higher education. Curriculum serves as basis for realization of goals of higher education and curriculum for future engineers needs updating. The paper analyzes dilemma of updating of higher education curriculum for future engineers within its content and structure. During the learning process students participated in curriculum renewal and accelerated the upgrading of curriculum content and structure. Finishing the course, students conducted reflection, improved their understanding during the reflection process continuously that helped them to develop the habit of lifelong learning. The authors propose to expand teaching methods for the courses, to adapt engineering courses to the needs of economic development during the COVID-19 pandemic, to strengthen students' interaction and participation, to supply multiple participation in curriculum "customization" countermeasures to update higher education curriculum for future engineers.

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1. INTRODUCTION

Throughout the history of human development there will always be changes in higher education within social, economic, and industrial changes. Higher education is both an opportunity and a challenge because of new changes during the Coronavirus Disease 2019 (COVID-19) pandemic. It needs to adapt to external changes constantly, especially to the level of development of science and technology as the most important component of education.

Education for future engineers is facing transformation and upgrading, that requires using new methods within its continuous advancement [1]–[5]. Demands for future engineers have changed, and new demands have been put forward for higher education curriculum for future engineers during the COVID-19 pandemic. Higher education provides society with engineers that meet actual needs according to the theory of

supply in higher education, thereby promoting social development effectively. Supply and demands for higher education curriculum for future engineers are compatible with social development when the supply in higher education is compatible with the structure of demands and quality of education of future engineers. It promotes the development of higher education at the same time. The basis of higher education is curriculum which implements educational goals of the students. Connection with the students and the external environment is realized through curriculum. Therefore, curriculum should focus on the requirements and changes during the COVID-19 pandemic [6]–[9].

Updating of higher education curriculum for future engineers is connected the quality requirements which reflect comprehensive and diversified characteristic for courses. The lagging content of the curriculum is mainly reflected in the fact that there is a large time lag from the cutting-edge achievements of scientific research to the content of the curriculum [10]–[13]. The current curriculum content cannot meet the needs of industries effectively. The curriculum lags have changed significantly due to the lack of industry promotion. Unreasonable curriculum structure is mainly reflected in the current curriculum structure based on departments, disciplines, and majors. The poor availability of interdisciplinary curriculum resources results in obstacles to interdisciplinary curriculum learning. Curriculum should be divided into different modules to make the knowledge relatively separate at the same time. There is a lack of systematic cognition, professional knowledge is too narrow, cross-integration of knowledge is poor, and there are great difficulties in interdisciplinary innovation.

2. METHOD

Updating of higher education curriculum for future engineers during the COVID-19 pandemic can be analyzed from the two aspects such as course content providers and course content requester. Course content providers of higher education include teachers directly and other indirect course providers. Teachers have high level of qualifications; they are more experienced in developing higher education curriculum for future engineers. At the same time, teachers do not have a thorough understanding of needs of engineering industry due to the lack of practical experience of working at enterprises. Moreover, universities are striving to create research-oriented institutions. Although awareness of teachers' applicability of the curriculum has improved, they have insufficient experience in working together with enterprises to improve the content of the curriculum [14]–[18].

Course content provider include two-way linkage between "going out" and "bringing in" in order to promote the curriculum updates. "Going out" means that university teachers go out and provide training and consulting services to companies. "Bringing in" means introducing outstanding corporate talents in order to teach courses and give lectures to students. It should be focused on increasing the proportion of young teachers and enhancing the activity of university teachers. Those measures will promote rationality of quantity and structure of curriculum, foundation for innovation of higher education curriculum content, and guarantee training courses services for enterprises. Enterprises should become cradle of knowledge within those changes gradually [19]–[22].

Good learning environment at universities helps scholars to produce knowledge according to their own interests. Enterprises have a short production cycle and fast update frequency of knowledge and technology that can improve economic benefits of enterprises driven by economic interests. Therefore, universities and enterprises are engaged in knowledge production. Each of them has their own advantages, they should promote linkage and transformation of knowledge among enterprises and universities. Teachers can understand practical difficulties of enterprises in employing and educating people.

Universities use experience in the design of course content in order to promote the update of it by providing training services for enterprises within the process of interactive consultation. In general, "going out" and "coming back" are more helpful in guaranteeing the course update. Therefore, we adhere to the principle of "going out" and "bringing in" as the supplement. It promotes upgrading of higher education courses through two-way linkage.

It is very important to pay attention to indirect providers of course content and provide upgrade of courses in all aspects. Many graduates believe that curriculum of the main subjects they contain more theoretical courses and fewer practical courses. It indicates that reform of teaching curriculum content of universities is imperative [23]–[25]. These conditions promote position of indirect curriculum content providers. It pays attention to the professional ability of indirect course providers, increases the ratio of professionals, optimizes the structure of personnel of enterprises, and lays a solid foundation for the upgrading of the curriculum structure [26], [27].

It is important to mention that "intelligent" elements are applied in the curriculum which rely on the course content in order to promote the "intelligence" of the course structure, to supervise and to promote the optimization of the educational process, to force the speed of the course updating and upgrading according to the relevance of professional disciplines [28]–[32]. At the same time, it is necessary to provide regular

training of the personnel of enterprises in order to improve their business capabilities, to provide guarantee for the promotion of diversified linkage, to promote the upgrading of curriculum content and structure, and to increase the adaptability of higher education curriculum content and structure due to the situation during the COVID-19 pandemic. Direct requester of higher education such as students, parents, and indirect requester such as companies serve as course content requester. Requirements for courses are quite different from those of previous ones due to the demands of industry. If timeliness of the existing curriculum content does not meet the needs of students, it will result in low attention to the content of the curriculum and reduced recognition. If teaching method is still based on classroom teaching as the main teaching method, students' participation will be poor, and the curriculum content cannot be updated effectively.

Although enterprises face difficulty of employing people and high cost of preparing of graduates, it is difficult to participate in updating of the course content and adjustment of the course structure. Although students face employment difficulties, although parents are stakeholders in higher education courses, it is also difficult to participate in the updating of higher education courses and the adjustment of course structure. Those aspects affect higher education curriculum, which, in its turn, affects adaptability of higher education courses during the COVID-19 pandemic [33]–[36].

3. RESULTS AND DISCUSSION

Experimental work was conducted in 2021. Students of the specialty "information systems and technologies" of National Research University of Information Technologies, Mechanics and Optics and Southern Federal University and participated in the study. The total number of students was 135 (68 participants were in experimental group, control group included 67 participants). Age range of the students was from 20 to 22 years. Education of future engineers in control group was realized according to the standard curriculum.

3.1. Process of updating educational curriculum

Realization of experimental work in experimental group included process of updating of higher education curriculum for future engineers. It included the following countermeasures which assisted to break through difficulties of the development of higher education courses during the COVID-19 pandemic:

- Adaptation of higher education courses to the needs of economic development during the COVID-19 pandemic
- Development of overall idea of curriculum reform of integrated thinking
- Re-integrating and upgrading the course content
- Following the innovative professional courses
- Adding information courses according to the industrial needs systematically
- Diversified expansion of teaching methods in order to strengthen students' interaction and participation
- Conducting research from course content providers and course content requester

3.2. Realization of experimental work

It was particularly important to achieve "education through fun" with the help of information technology and through intelligent design of the curriculum. Teaching place was not restricted, course content was shared through online methods in time in order to achieve better interaction among students and teachers. Students prepared courses by themselves and use micro-classes within social networks. Teachers played a guiding role, allowing students to master the latest content and to update knowledge during the preparation process. Students' ability to share knowledge was improved, which was beneficial in the future. Students' ability to improve self-regulation and timely cultivation of information and knowledge in the workplace also helped teachers to guide better and to help the students.

Teachers played the role of "catalyst" in this process, helping the students "to learn by doing" that meant to be able to adapt to the speed of iterative update of knowledge in time. During the learning process students participated in curriculum renewal actively and accelerated the upgrading of curriculum content and structure. Finishing the course, students conducted reflection, improved their understanding during the reflection process continuously that helped them to develop the habit of lifelong learning. It also helped to improve ability of thinking, to adapt to the rapid development of society, and finally to adapt to the requirement development. The purpose of the initial stage of the experiment was to determine the initial level of professional competence of future engineers before updating of curriculum and after it. Professional competence of future engineers consists of three components such as technological, project, and analytical. Structure of professional competence is reflected in Table 1.

Table 1. Structure of professional competence

Component	Characteristic
Technological component	- Ability and skills of application of modern information technologies and software, in solving problems of professional activity; - Ability and willingness for effective solving tasks of professional activity based on information culture using information and communication technologies and taking into account the basic requirements of information security; - Ability and willingness for selecting platforms and instrumental software and hardware for the implementation of information systems.
Project component	- Ability and readiness for searching, analyzing and synthesizing information; - Determining the range of tasks within the framework of the goal and choose the best ways to solve them, based on the current norms, available resources and restrictions.
Analytical component	- Ability and willingness for managing his/her time, building and implementing a trajectory of self-development based on the principles of education throughout life.

3.3. Outcomes

The practical implementation of education of future engineers was carried out in the form of an analysis based on Likert scale. The results of the study are presented in Tables 2 and 3. Thus, we have the following results:

a. High level of formation of professional competence of future engineers in the experimental of all components began to predominate in the experimental group at the end of the experiment, while in the control group, medium and low levels remained were the main characteristic of the control groups at the end of the experiment.
b. There was an increase in all components of the formation of professional competence of future engineers in the experimental group. Most of the students of the experimental group have knowledge and understanding of the basic and specific functions and capabilities of educational resources, a structured and systematic idea of the possibilities of using educational media information and media products in professional activities.
c. The majority of students of the experimental group showed high level of student's ability and skills of application of modern information technologies and software, in solving problems of professional activity; ability and willingness for effective solving tasks of professional activity based on information culture using ICT and taking into account the basic requirements of information security; ability and willingness for selecting platforms and instrumental software and hardware for the implementation of information systems. They revealed ability and readiness for searching, analyzing, and synthesizing information; determining the range of tasks within the framework of the goal and choose the best ways to solve them, based on the current norms, available resources, and restrictions. Students of the experimental group revealed ability and willingness for managing time, building, and implementing a trajectory of self-development based on the principles of education throughout life.

The results of experimental work on education of future engineers in control and experimental groups revealed that in the experimental group the level of professional competence of future engineers is higher than in the control group that proves the effectiveness of experimental work.

Table 2. Level of professional competence of future engineers in the experimental and control groups at the beginning of the experiment

Professional competence	Experimental group			Control group		
	Low level (%)	Middle level (%)	High level (%)	Low level (%)	Middle level (%)	High level (%)
Technological component	41.2	38.2	20.6	40.3	38.8	20.9
Project component	55.9	27.9	16.2	38.8	37.3	23.9
Analytical component	42.7	33.8	23.5	41.8	29.8	28.4

Table 3. Level of professional competence of future engineers in the experimental and control groups at the end of the experiment

Professional competence	Experimental group			Control group		
	Low level (%)	Middle level (%)	High level (%)	Low level (%)	Middle level (%)	High level (%)
Technological component	13.2	36.8	50.0	41.8	38.8	19.4
Project component	8.8	26.5	64.7	34.3	43.3	22.4
Analytical component	10.3	22.0	67.7	32.9	37.3	29.8

4. CONCLUSION

Higher education institutions should provide a basic training framework and give a certain degree of flexibility to the basic training goals, allowing students to participate in them. Higher education institutions should also form a normalized mechanism for students to select courses. Students become "keepers" of knowledge and course content within this process, they participate in upgrading of course content and structure, and solve the problem of mismatch between course content supply and course content demand effectively. Teachers play a guiding role in this process, making the content and format of the course more vivid, and playing the role of teaching each other.

Participation in "customization" of courses has revitalized standardized professional training, enriched students' autonomy, and diversified course choices. Retaining of students' autonomy in choosing courses, perfecting the system of students' participation as the main body of "preparing lessons", allowing students' participation in the course content customization process help higher education to adapt to the COVID-19 pandemic changes. Higher education institutions should create platforms and channels for knowledge exchanges between students and enterprises that gives an opportunity to form a mechanism of linkages between specialties and industries. This ensures that indirect requester of courses will be able to influence the decision-making of the "course market" directly or indirectly in order to adapt to COVID-19 pandemic changes.

Higher education adapts to the process of development of higher education curriculum for future engineers during the COVID-19 pandemic actively. Although this process is full of challenges, it can achieve new development in the process of reform, seeking industrial development and getting balance point with higher education reform according to its own development laws and adaptability. New challenges have been raised to the knowledge interaction, production, and innovation of human society within the process of updating of higher education curriculum for future engineers during the COVID-19 pandemic. Curriculum serves as basis for realization of goals of higher education. Multiple participation in the process updating of curriculum will promote development of higher education courses breaking through its development dilemma from the perspectives of course providers and requester. At the same time, it is necessary to consider the actual situation and to form a unique higher education reform response system gradually within the process of higher education curriculum updating.

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