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LIFELONG LEARNING MANAGEMENT FOR ENGINEERING SPECIALISTS IN CONTEXT OF INDUSTRY 4.0

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The issues of lifelong learning are relevant in the current context of educational development in Ukraine. The paper indicates a meaningful content of such concepts as "lifelong learning", "continuing vocational education and training" and "adult education" formed during the development of the European discourse in the field of vocational education and training but has a definite difference. It is noted that the concept of 'lifelong learning' allows the professional to build an educational trajectory that fully corresponds to their professional and educational abilities and needs. The issues of lifelong learning for engineering specialists in the context of Industry 4.0 are of great importance. The transition to Industry 4.0 requires engineers to continuously improve their knowledge and skills due to rapid technological changes. The authors of this article developed and proposed a theory-practice IDEFØ model of lifelong learning for engineering specialists based on the Structured Analysis and Design Technique (SADT). The model provides a visual description of lifelong learning processes and aims to increase their efficiency in organizations.

Keywords: lifelong learning, engineering specialists, Industry 4.0, Structured Analysis and Design Technique (SADT), IDEFØ model.

УПРАВЛІННЯ БЕЗПЕРЕРВНИМ НАВЧАННЯМ ДЛЯ ФАХІВЦІВ ІНЖЕНЕРНИХ СПЕЦІАЛЬНОСТЕЙ В КОНТЕКСТІ ІНДУСТРІЇ 4.0

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Питання навчання впродовж життя набуває особливої актуальності в умовах сучасного розвитку освітньої системи України, що інтегрується у європейський освітній простір та орієнтується на потреби ринку праці. У статті окреслено змістовне наповнення базових понять «освіта впродовж життя», «неперервна професійна освіта і навчання» та «освіта дорослих». Показано, що ці терміни сформувалися у процесі розвитку європейського дискурсу у сфері професійної освіти і навчання, однак мають певні концептуальні та функціональні відмінності. Автори наголошують, що поняття «освіта впродовж життя» дозволяє фахівцю самостійно вибудовувати освітню траєкторію, яка повністю відповідає його професійним здібностям, освітнім потребам та стратегічним цілям особистісного і кар'єрного розвитку. Особливу увагу приділено питанню навчання впродовж життя для представників інженерних спеціальностей у контексті переходу до Індустрії 4.0. В умовах швидких технологічних трансформацій інженери стикаються з необхідністю постійного оновлення компетентностей, засвоєння нових знань та вдосконалення практичних навичок. Безперервна освіта стає запорукою їхньої конкурентоспроможності, мобільності та готовності до роботи в умовах цифровізації виробничих процесів.

У статті розроблено та запропоновано теоретико-практичну IDEFØ-модель організації безперервної освіти для спеціалістів інженерного профілю на основі методології структурного аналізу та проектування (SADT). Представлена модель забезпечує візуальний опис основних процесів навчання впродовж життя, визначає ключові елементи взаємодії між учасниками освітнього процесу, джерелами знань та очікуваними результатами. Вона спрямована на підвищення ефективності функціонування системи неперервної освіти як на рівні окремих організацій, так і в ширшому контексті професійної підготовки інженерів у національній та міжнародній освітній системі.

Ключові слова: безперервна освіта, спеціалісти інженерних спеціальностей, Індустрія 4.0, технологія структурного аналізу та проектування (SADT), модель IDEFØ.

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INTRODUCTION

Development of vocational education and training requires multidirectional, because this problem is multidimensional and involves different approaches, which can complement each other. At the same time, the issue

of preparing specialists for self-realisation in professional activities, comprehensive personal development, individual approach to the subjects of educational activities and building individual trajectories of professional development is relevant [1]. Solving these problems is particularly important in the context of Industry 4.0 formation [2].

Industry 4.0 is characterized by the widespread spread of digital technologies in all areas, changing the methods of production, learning and communication in society. This process is leading to the creation of new jobs that require not only technical skills but also self-learning abilities, analytical thinking, and creativity. In the field of education, there is a need for continuous skill improvement, which is encapsulated in the concept of lifelong learning. As noted by S. Chakrabarti, P. Caratozzolo, B. Norgaard, E. Sjoer, the ability to adapt, ease of acquiring knowledge, and gaining skills relevant to Industry 4.0 are especially important for engineering specialties [3].

One of the key features of lifelong learning in an Industry 4.0 environment is the need to renew knowledge and skills as technology advances. Engineering professionals must constantly update their competencies to remain competitive in the labour market. Lifelong learning in Industry 4.0 requires engineers to be flexible, responsive, and continuously striving for development. Consequently, modern educational programs should be adapted to meet the new requirements of the labour market. This includes incorporating the study of Industry 4.0 technologies such as fintech, Internet of Things, cloud computing, virtual reality, blockchain, etc.

LITERATURE REVIEW

The content of the concept of lifelong learning is being shaped as the pan-European discourse on vocational education and training develops. Related (but not synonymous) to the concept of lifelong learning in Europe are usually the concepts of continuing vocational training and adult education.

However, there is a difference between them. In modern literature, the following combinations of terms are used to define the concept of lifelong learning "adult education"; "continuing education"; "further education"; "recurrent education" as lifelong learning by alternating learning with other activities, mainly work; "permanent education"; "lifelong education"; "lifelong learning". The European Commission has combined various education and training initiatives into a single Lifelong Learning Programme [4].

This programme replaced the vocational training and distance learning programmes that existed before 2006. Lifelong learning has been recognised as one of the main components of the European social model by the Council of Europe. Such learning is not limited to education; it is also a critical factor in the areas of employment and social security, economic growth and competitiveness.

The concept of "lifelong learning" was defined by the English academic R. H. Dave. He defined "lifelong learning" as a process of completing personal, social and professional development of individuals throughout life in order to improve the quality of their own personal lives and their social environment [5].

H. Dava, who sees it as a process of personal, social and professional development of individuals throughout their lives in order to improve the quality of both their personal lives and their social environment. The definition of lifelong learning is given in the European Commission document "Making the European Lifelong Learning Area a Reality": "Lifelong learning is a set of learning activities undertaken throughout life, with the aim of improving knowledge, skills and competences for personal, civic and social development and/or for employment" [6].

During the twentieth century, lifelong learning became a political and economic prospect for the general population. To this day, documents are created and implemented to implement it in all areas of society. For example, lifelong learning initiatives were adopted in the second half of the twentieth century by the United Nations Educational, Scientific and Cultural Organisation in its global Education for All campaign [7].

The main differences between the concepts “lifelong learning”, “continuing vocational education” and “training, adult education” are presented in Table 1.

Table 1

The main difference between the concepts lifelong learning, continuing vocational education and training, adult education

Term	Description
Lifelong learning [8]	Lifelong learning activities undertaken by an individual for personal, social or professional reasons, the results of which are reflected in improved knowledge, innovation, skills, competences and/or qualifications
Continuing vocational education and training [9]	Education and training which follows initial education and training or entry into the labour market and which aims to help citizens: improve or update their knowledge and/or skills; acquire new skills for career advancement or retraining; continue their personal or professional development
Adult education [10]	General or vocational education which follows basic vocational education and which is provided to adults in order to achieve professional or personal goals

UNESCO (1976) aimed to transform the global education system by developing skills beyond formal education, including support for non-formal learning opportunities. The organisation stated that education should be "universal and extend learning opportunities to children, youth and adults" [11].

Thus, UNESCO's global initiative is based on a humanistic perspective. Continuing vocational education and training (CVET) takes place after completing specific initial/basic vocational education and training (IVET) necessary for professional activity and provides the opportunity to improve knowledge, skills, and competencies, acquire new competencies, and pursue career development.

Continuing vocational education and training is a complex and multifaceted concept covering a wide range of interrelated economic, pedagogical, psychological and social issues. An analysis of academic sources shows that the term “professional development” has become widely used in practice and is increasingly being considered by academics and practitioners.

Transformations in the technological sphere lead to corresponding changes in education, as the requirements for employees' qualifications increase [12]. B. W. Shanahan, J. Organ emphasise the need for advanced training and lifelong learning to acquire skills in demand in the labour market [13]. A survey of 218 law specialists revealed that 45% are oriented toward lifelong learning. Personal determinants play an important role in motivating lifelong learning [14]. Technological changes in the digital society affect many areas of specialist training. For example, lifelong learning is essential in medical student training. One of the main ways to develop these skills is through independent learning [15]. Undergraduate nursing students with independent learning abilities have also shown a strong orientation toward lifelong learning [16].

Lifelong learning fosters the development of key qualities in learners. H. Ekşi, M. Özgenel, and E. Metlilo found a significant positive relationship between success motivation and lifelong learning. Additionally, success motivation positively influences the tendency toward lifelong learning [17]. A survey of chemical engineering students during the COVID-19 pandemic determined that factors such as openness to learning and curiosity are important for the realisation of lifelong learning [18]. T. Deveci notes that lifelong learning skills helped first-year students reduce the negative impact of COVID-19 [19]. Implementing the concept of lifelong learning requires maintaining continuous communication among students throughout the knowledge acquisition process. Survey results indicate that Chinese students prefer using mobile resources for lifelong learning [20].

Based on surveys of students in Spain, Mexico, and Chile, E. García-Toledano, A. Gracia-Zomeño, P. Farinho, and L.M.C.M. Picado emphasise the importance of lifelong learning in developing personal, social, and learning-to-learn competences among university students. They argue that students must develop competences beyond the knowledge gained during the learning process [21].

Many countries, including South Korea, have recognized the need for lifelong learning and are actively implementing its basic principles in response to the technological changes of the 4th Industrial Revolution and an aging society [22]. An example of successful implementation of the lifelong learning concept is the experience of Graz University of Technology in Austria, where this approach has proven effective in the automotive sector [23]. N. Ismail, H. A. Rahman, A. M. A. Rifa'i, M. M. Mazalan [24] note that lifelong learning programs have a positive impact on the quality of education in the context of the 4th Industrial Revolution in Malaysia.

It should be noted that lifelong learning in the Industry 4.0 environment helps employees adapt to changes and maintain competitive positions in the labor market. Additionally, continuously updating knowledge and skills amid dynamic technological changes allows engineering specialists not only to master new technologies but also to increase productivity and efficiency.

PURPOSE OF THE ARTICLE

The aim of the study is to develop and implement a theory-practice IDEF model of lifelong learning for engineering specialists based on the Structured Analysis and Design Technique (SADT).

RESULTS

One of the aspects hindering the development of the system of professional development of employees is the lack of motivation to improve their professional level and the absence of a system of incentives and motivation for professional advancement.

According to a survey of Ukrainian enterprises of various industries and forms of ownership conducted in previous years, 20.2% of the enterprises surveyed cited insufficient interest of employees in professional development as a reason for employers' investment in vocational training.

Another factor is that employers are reluctant to invest in vocational training because the effectiveness of these investments is difficult to assess from a qualitative point of view, while it is much easier to calculate the costs.

Personnel training allows solving the main tasks both in the interest of the organisation - improving the efficiency and quality of work, and in the interest of the individual - raising the standard of living, motivating to improve, creating an opportunity to realise their abilities.

The survey [25] revealed the respondents' opinion on who should support employees in their professional development and compared it with the actual data on who actually provided them with support in their professional development (Fig. 1).

As a result, we can see that the respondents' opinion about who should provide support in their professional development is somewhat different from the actual situation of assistance in professional development. Thus, 41 (out of 54) respondents believed that the head of the department should provide support in professional development, while

in fact only 33 respondents received this support from the head of the department.

The situation is similar with the training and personnel department. 19 respondents believed that professional development support should be provided by the training and personnel department, but only 12 respondents received it from this department. The general manager of the enterprise provides support in professional development to employees. Thus, out of 18 respondents who believed that the general manager should provide such support in professional development, 16 employees actually received it.

This is almost one hundred per cent. The situation is different with the team of the division. Here we see that the team of the unit provides active support in the professional development of colleagues. Thus, 14 respondents received support in their professional development from the team, although they believed that the team should provide it to only 10 people.

To implement the concept of lifelong learning in the context of Industry 4.0, the authors propose using the SADT approach. The business model for lifelong learning for engineering specialists, with detailed structuring of business processes, is presented in Fig. 2. The proposed model consists of a set of hierarchical actions that transform an object. These actions are graphically represented as business processes, along with arrows indicating input, output, control, and execution mechanisms.

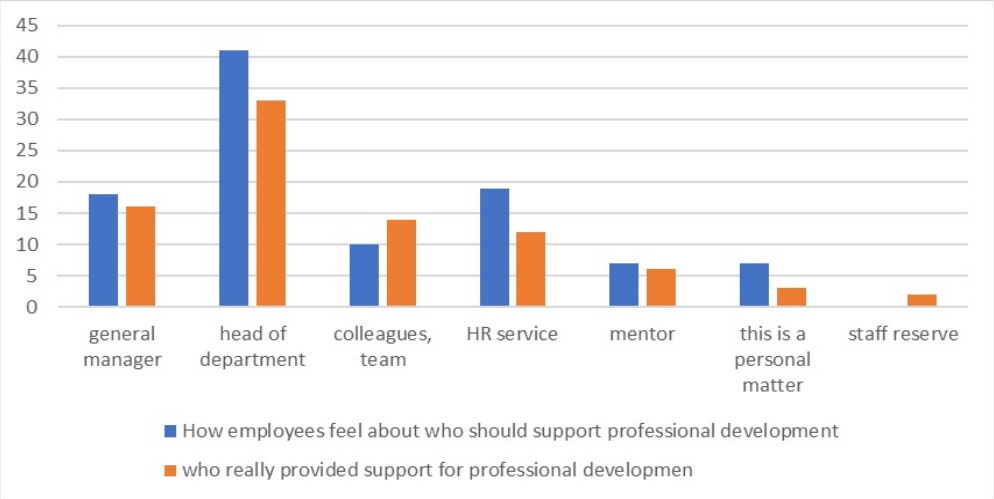

Fig. 1. Who, according to the respondents, should provide support and create the necessary conditions for professional development, and who actually contributed to their professional development

The description of blocks A1 - A4 of the lifelong learning model for engineering specialists, as shown in Fig. 2, is presented below.

A1. Assessment of Current Skills and Needs

This stage involves analysing the current knowledge and skills of engineers and identifies areas where additional training and professional development are needed. In an Industry 4.0 environment, assessing the current skills and training demands of engineering professionals becomes particularly important. With the advancement of technology and digital innovation, the requirements for engineering professionals are constantly changing. Engineers must be ready to work with new software products, be able to analyse large amounts of data, and use modern equipment and technology.

The stage includes setting learning objectives based on career and necessities for professional activity in the Industry 4.0. The result is the development of an individualized training plan, which includes selecting appropriate courses, seminars, trainings, and other educational resources. Training should focus on the practical application of acquired knowledge, as well as on developing creativity and the ability to innovate.

A2. Basic and Advanced Training

This stage involves the learning and practical application of acquired knowledge. Modern engineers must have technical knowledge and skills, as well as the ability to work with large amounts of data, software, and artificial intelligence systems. Training can take place in both online and face-to-face formats, as well as using practical assignments, masterclasses, trainings and case studies. The stage includes: participation in basic courses and trainings to update and deepen knowledge; learning new technologies, methods and tools that are relevant to the current engineering specialisation in the context of Industry 4.0; constantly monitoring the latest trends and innovations in the industry; participation in conferences, webinars and other events to share experiences and gain new knowledge. Upon completion of the training, engineers are required to apply the acquired knowledge in practice to consolidate it and improve their professional skills.

A3. Practical Training of Engineers in the Conditions of Industry 4.0

Practical training of engineers in the context of Industry 4.0 is a key element for the successful functioning of modern technology enterprises. Engineers need not only theoretical knowledge but also practical experience working with technologies such as artificial intelligence, the Internet of Things, robotics, and production automation.

Training for engineering specialists should include lectures, seminars, practical classes, masterclasses, internships, and work on real projects. This stage includes: participation in projects that allow applying the acquired knowledge in practice; inclusion of real tasks and cases in the learning process to consolidate new knowledge; regular monitoring and evaluation of progress in achieving the set goals; adjustment of the training plan depending on the results obtained and changes in professional needs.

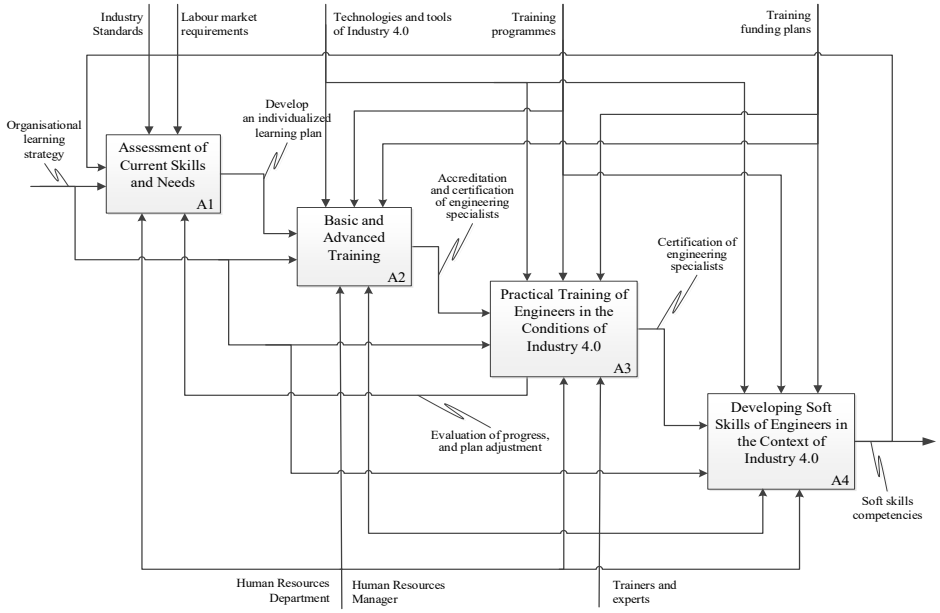

Fig. 2. IDEFØ lifelong learning model for engineering specialists

A4. Developing Soft Skills of Engineers in the Context of Industry 4.0

It is important for engineers to have not only technical knowledge, but also to be able to co-operate, communicate effectively and solve problems in a team, to be able to express their thoughts clearly and effectively, to listen and understand colleagues, and to have skills of constructive criticism. In addition, in the context of Industry 4.0 it is necessary for engineers to be able to quickly and effectively find solutions to arising problems and be ready for non-standard situations. The result of soft skills development includes improved communication skills, empathy, teamwork, conflict resolution, decision-making and time management skills.

After completing the stages, an analysis of the learning results is conducted, forming the basis for developing a plan for further action. Engineers receive feedback from teachers and experts, helping them improve their knowledge and skills in the future.

The further continuation of the engineers' learning within the lifelong learning concept framework raises the issue of ensuring the effective interaction of all educational process stakeholders, uppermost, universities and employers.

In today's conditions there are structural changes, the content of education, technologies and means of education are modernised, new relations between higher education institutions and enterprises are formed, whose main task is to ensure the quality of education of competitive specialists demanded by the labour market.

CONCLUSIONS

The concept of lifelong learning recognises the need and opportunity to acquire, at each stage of life, the blocks of information that a person needs to support his or her active life and self-fulfilment. Improving the quality and effectiveness of the education system will allow faster adaptation to constantly changing social processes and will help to meet people's needs for skills and competences that meet today's requirements.

The proposed in the article theory-practical IDEFØ model of learning for engineering specialists based on structural analysis and design metrology allows to implement lifelong learning programme in practice. The practical significance of this methodological approach to organizing lifelong learning is multifaceted:

Assessment of Needs: It allows for assessing the existing need for the development of skills and knowledge of engineering specialists in response to the challenges of Industry 4.0.

Identification of Weaknesses: It makes it possible to identify "weaknesses" in organizational learning and direct resources toward their elimination.

Forecasting Requirements: It enables forecasting the need for training and resources to achieve programme outcomes.

In order to fulfil advanced technological tasks, it is necessary to train specialists based on the integration of education, science and industry. This challenge to the system of higher vocational technical education, accompanied by a fast pace of life and fierce competition on the international labour market, can be adequately met by training

competitive technical specialists who meet the modern requirements of production in the context of Industry 4.0. The process of training such specialists should involve scientists, researchers and teachers from higher education institutions as well as engineers and specialists from research institutions and manufacturing enterprises.

Successful integration of education and Industry 4.0 requires collaboration between educational institutions, businesses, and public authorities. It is important to create partnerships to adapt training programmes to market needs, provide internships and apprenticeships for engineering students, and encourage continuous updating of knowledge and skills in working professionals. Lifelong learning in an Industry 4.0 environment is a necessity for a successful career in today's world. With technology constantly evolving and new professions emerging, keeping your knowledge and skills up-to-date is crucial. Continuous learning allows you to stay current with the latest trends and technological innovations, as well as adapt to the changing work environment.

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