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Methodological Approaches to the Development of Engineering Skills in the Field of Electric Transport through Practice-Based Learning

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Abstract: *The purpose of the article is to analyze the scientific and methodological literature in accordance with the chosen topic, methodical approaches to the development of engineering skills in the field of electric transport through practical training, as well as to organize the list of engineering skills that a specialist in the field of electric transport should possess and to study how it is possible to develop them with the help of practical (STEM education). Methods, the main research methods used by us while working on this article are: analysis, synthesis, generalization, systematization of thematic scientific literature for the last five years (2020-2024). A methodical approach to the development of engineering skills in the field of electric transport through practical training, which is currently extremely effective, in demand and, accordingly, widely used in a number of countries around the world (Germany, the USA, China, and others) is STEM education. This technology allows you to work*

independently, in pairs and in small creative groups. Thus, on the one hand, it provides an opportunity to work independently and build your own personal and professional development trajectory, and on the other hand, it allows you to develop teamwork skills. In addition, this series of training methods provides an opportunity to develop leadership qualities at the personal level, that is, to take responsibility for one's own life, work, well-being and, if necessary, to be responsible for the team by leading it. Allows to develop general or, in other words, technical skills such as creative abilities, thinking, communication skills, develop communicative flexibility and the ability to resolve conflicts, develop assertiveness, adaptability, the ability to learn and live comfortably in human society. At the same time, work independently and grow personally. So, according to task 1, STEM education allows you to develop the following technical/general competences: the ability to communicate, work in a team, at the same time, if necessary, work independently, that is, it allows you to develop an assertive personality, develop the ability to study, explore the world throughout life and adapt to changes in society, live successfully in it. Develop the ability to manage both in personal life and in team management. With regard to task #2, educational project activities and solving problem tasks will help to develop all these skills for specialists working with electric transport.

Keywords: *practice-based education, engineering competencies, electric mobility, technical skills development, experiential learning, STEM education.*

Методичні підходи до розвитку інженерних навичок у сфері електротранспорту шляхом практичного навчання

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Анотація: *Мета статті полягає в аналізі науково-методичної літератури відповідно до обраної теми методичні підходи до розвитку інженерних навичок у сфері електротранспорту шляхом практичного навчання, а також упорядкуванні переліку інженерних навичок, котрими повинен володіти спеціаліст зі сфери електротранспорту та дослідження того як можливо їх розвинути за допомогою практичного (STEM-навчання). Основними методами дослідження, використаними нами під час роботи над даною статтею є: аналіз, синтез, узагальнення, систематизація тематичної наукової літератури за останні п'ять років (2020-2024 роки). Маємо наступні результати. Методичний підхід до розвитку інженерних навичок у сфері електротранспорту шляхом практичного навчання, котрий нині є надзвичайно ефективним, затребуваним й, відповідно, широко використовується в низці країн світу (Німеччина, США, Китаї та інших) – STEM-освіта. Ця технологія дозволяє працювати самостійно, у парах та малими творчими групами. Таким чином з одного боку вона надає можливість працювати самостійно та будувати власну траєкторію розвитку як особистісну так і професійну, а з іншого дозволяє розвинути навички роботи в команді. Крім того ця низка методів навчання надає можливість розвинути лідерські якості на особистісному рівні, тобто взяти на себе відповідальність за власне життя,*

роботу, благополуччя та відповідати, при потребі, за команду, очоливши її. Дозволяє розвинути загальні або інакше кажучи технічні навички такі як творчі здібності, мислення, комунікативні навички, розвинути комунікативну гнучкість та вміння вирішувати конфлікти, розвинути асертивність, адаптивність, вміння навчатися та комфортно жити в людському суспільстві. При цьому працювати самостійно та особистісно зростати. Отже, відповідно до завдання 1. STEM-освіта дозволяє розвинути наступні технічні/загальні компетентності: уміння комунікувати, працювати в команді, разом з тим, при потребі, працювати самотужки, тобто дозволяє виховати асертивну особистість, розвинути вміння навчатися, досліджувати світ протягом усього життя та адаптуватися до змін у суспільстві, успішно жити в ньому. Розвивати здатність до управлінської діяльності як в особистому житті так і при керуванні командою. Стосовно завдання №2, то розвинути всі ці навички для спеціалістів, що працюють із електротранспортом допоможе навчальна проєктна діяльність та розв'язання проблемних завдань.

Ключові слова: *практична освіта, інженерні компетенції, електромобільність, розвиток технічних навичок, навчання на досвіді, STEM-освіта.*

Statement of the problem: in the modern world, scientific progress is extremely rapid, it covers all areas of professional life and requires training throughout the entire time a person is in the profession. They must study regularly, constantly updating and improving their skills, abilities and knowledge. This also applies to the electric transport industry. Over time, the requirements for professionals working with cars have also become higher.

Today, we can observe that a relatively new requirement for specialists in this industry is, on the one hand, the development of engineering competencies, and, on the

other hand, a practical approach is increasingly valued in the course of learning the profession, so that graduates in the field of electric transport have a high level of practical skills already at the time of graduation and at the time of starting work in their first position. In other words, all skills, including engineering skills, should be acquired by performing practical tasks, thus consolidating the theoretical basis.

Therefore, this paper aims to study and analyse methodological approaches to the development of engineering skills in the field of electric transport through practical training. The study is relevant because electric vehicles are becoming increasingly popular. They are coming into mass use, so specialists involved in their production, repair and improvement need to know not only what the car consists of and how it works, but also have the latest knowledge in electrical engineering.

Analysis of recent research and publications. The issue of using methodological approaches to the development of engineering skills in the field of electric transport through practical training is not sufficiently discussed in scientific discussions, which is why we are raising this important topic. At the same time, scientific research discusses such topics as the training of engineering specialists, including the development of basic engineering skills, in particular in the work of I. V. Batsurovska, O. O. Lymar [1].

A swot analysis of the possible development of electric transport in Ukraine is described in the study by G.P. Kostenko [2]. A study by A. Gnatov, S. Arkhun, H. Gnatova, P. Sokhin [3] is devoted to the conversion of a car from an internal combustion engine into an electric vehicle. In the article, the authors proposed a sequence of actions for determining the engine power for an electric vehicle, calculated the power of the electric motor for the effective conversion of an internal combustion engine into an electric vehicle. They determined the cost of such a conversion and graphically showed the correlation between the speed of an electric vehicle and the power of the electric motor.

G. Prokudin, O. Chupailenko, I. Lebid, A. Kozlov [4] studied the methods of effective management of a motor transport enterprise. Knowledge about this part of the professional sphere in particular will be useful for future specialists, and management skills should be developed during their studies, in particular, it is important for students to learn how to manage a road transport enterprise from the practical side. Thus, the authors point out that it is important for managers to perform not only a managerial function, but also an executive one. In particular, this means that a manager should be not only a leader, but also a practitioner in his or her field.

And O. Derevianchuk [5] in his article described the development of technical skills in students of engineering and pedagogical specialties in the context of digitalisation. The author also demonstrated the process of building a logical and conceptual working model of a vehicle image segmentation system.

Antonio Nelson Rodrigues da Silva studied learning through problem cases and practice in his scientific work [6]. The concept of "STEM education" is highlighted in the scientific work of V. V. Oliynyk, O. M. Samoilenko, I. V. Batsurovska and N. A. Dotsenko [7]. The authors noted the following aspects that are valuable for our study: this technology contributes to the formation of engineering and creative thinking, as well as the acquisition of competencies that are the basis for further professional activity.

All the same active teaching methods, i.e. those that allow to develop practical skills, were highlighted in their joint study by V. Zhyhir and S. Onyshchenko [8]. In particular, they considered the problems of applying this type of education in the training of specialists in the speciality 015.33 "Vocational Education (Energy, Electrical Engineering and Electromechanics)". Further, S. Dotsenko studied the concept of STEM education, in particular as an educational practice and in the key of scientific discussion [9]. For our study, it is the author's analysis of approaches to

defining this type of education, her research on the development and teaching of STEM subjects that is valuable.

The use of elements of STEM education in teaching students of transport technologies and logistics, in the study of probability theory and mathematical statistics was studied by I.P. Kudzinovska, V.I. Trokhymenko, O.P. Oliynyk [10]. In particular, the authors noted that this type of education is effective for the development of critical thinking skills and analytical skills, and they presented their own methodology for conducting practical classes with elements of this educational technology in the discipline "Probability Theory and Mathematical Statistics".

Y. Matviychuk [11] also conducted a similar study and concluded that STEM education is an effective method and, accordingly, a learning technology that bridges the gap between theoretical and practical learning, as it allows the learner to immediately use the information received, creating something new and acquiring or consolidating skills.

In general, the problems and prospects of this area of education in Ukraine were highlighted by A. P. Ovchatova [12]. In particular, the author noted that, despite certain obstacles, the introduction of STEM education in Ukraine is inevitable, and she also pointed out that this educational technology is a good way to improve the quality of education in secondary schools and universities.

We analysed the study by K. Habel, A. Fedorchenko, and O. Mekhed [13] on the impact of STEM education on the development of leadership skills of university students. The researchers point out that project work and solving problem cases will allow students to develop leadership, communication skills and the ability to work in a team and with the latest digital technologies.

The development of integrated curricula for STEM education was discussed in the study by V.V. Ulishchenko, V.E. Cheshuk and A.B. Ulishchenko [14], in particular, the authors emphasised that STEM education allows developing creative skills, critical

thinking and helps to link theoretical knowledge with the practical side of professional activity.

In their work, L. M. Hrynevych, N. V. Morse, V. P. Vember, and M. A. Boyko proved the need to form a STEM educational ecosystem, analysed its components, and described such a method as “learning projects”, which is one of the main ones in this type of learning [15].

Identification of previously unresolved parts of the overall problem. After analysing all the above articles, we found that several aspects are unresolved and need to be clarified and completed, among other things:

- the list of engineering skills that an electric transport specialist should possess should be streamlined;
- to explore how these skills can be developed by applying them in practice and to do so using methodological approaches.

Formulation of the objectives of the article. Therefore, in accordance with our analysis and the parts of the general problem that have not been resolved before, and given that this issue requires scientific development, we have identified the following objectives of our research:

1. streamlining the list of engineering skills that a graduate specialist in the field of electric transport should possess;

2. explore possible ways to develop these skills in practice using methodological approaches.

A summary of the main research material. An electric vehicle is a type of transport that can replace the current conventional transport running on petrol or natural gas in the future, because according to the SWOT analysis conducted by G. P. Kostenko, the vehicle's strengths include reduced air pollution, electric motor efficiency of 85-90% compared to 30-35% of the inherent efficiency of an internal combustion engine, more efficient in urban areas, the difference in prices for

conventional fuel and electricity, the availability of appropriate infrastructure, the appropriate level of digital technology in our country, the availability of the necessary bases for research and development of this type of transport, and the growing demand for electric vehicles among the population.

Among the opportunities offered by the development of electric vehicles for our country, the author mentioned a reduction in the use of natural gas, as a result of reduced dependence on exports, a decrease in carbon dioxide in the air, and an increase in the number of electric vehicle models and demand for them.

The researcher pointed out the following weaknesses:

- Consumers prefer familiar modes of transport despite the growing demand for electric vehicles;
- high price;
- lack of appropriate advertising and events to promote this particular mode of transport;
- 85% of cars are used and need to be charged daily, and there are few places to do so today;
- High loan interest rates and lack of adequate parking space, an insufficiently developed regulatory framework for the use of electric vehicles, insufficient infrastructure development and lack of domestic production;

As for the threats, the author pointed to a likely rise in the price of electricity due to increased use, the secondary market for old car models will be more accessible, and there may be negative impacts on the country's energy system, as the number of charging stations will increase, as well as the exploitation of the energy system, which will lead to a decrease in the period of its use [2].

According to the above data, it is obvious, in our opinion, that although the popularity of old-style cars is undeniable at the moment, the demand for electric transport is growing, which in turn requires an appropriate response from educational

institutions that train specialists whose work will be related to transport in one way or another. HEIs should initiate the training of graduates who will be able to work in modern conditions with modern modes of transport.

In addition, employee competencies are important, so educational institutions should pay attention to the development of engineering and technical skills. The most effective way to develop the above skills is through a methodological approach. Methodological approaches are a set of principles and methods of scientific understanding that are aimed at solving a particular problem in a practical way.

In general, STEM education is an effective pedagogical technology in teaching. This concept was first proposed by the American bacteriologist R. Colwell, but it was actively used only in 2011 on the initiative of biologist J. Ramali. In particular, J. Ramaley noted that STEM education is teaching in the field of technology, engineering, mathematics and natural sciences. This educational technology is used in China, the USA, Germany and many other countries, as it helps to bridge the gap between theoretical and practical training.

Changethe Equation in the United States organised a study and found that 1.7 open positions are accounted for by one potential employee, while in other industries there is a tendency for 4.1 candidates to apply for one position. This indicates a shortage of workers in the following areas: natural sciences, mathematics, engineering, and many others. According to the study, 9 out of 10 professions require STEM knowledge [9].

As for the introduction of STEM education in Ukraine, it is an inevitable process, as Ukraine strives to be a modern, developed European state, and this technology is now gaining more and more development in the advanced countries of the world. Therefore, the introduction of this teaching technology is a priority for the educational system of Ukraine, in particular in higher education institutions and secondary schools [12].

According to scientific publications, the latest educational approaches to the development of integrated STEM education curricula are required in postgraduate studies [14]. In particular, this indicates the need for specialists with STEM knowledge in the labour market. STEM education, as already mentioned, involves a more practical approach, in particular:

- development and implementation of STEM projects. That is, it is a process of creative search for a rational solution to a task [11];
- problem-based learning. It means that students have to solve a certain problematic issue or case.

In particular, in the process of training specialists in 015.33 “Professional Education (Energy, Electrical Engineering and Electromechanics)”, both reproductive and active teaching methods are used during the electric power cycle of disciplines. During reproductive methods, higher education students receive material in a ready-made form, for example, listen to a lecture, perform certain actions in accordance with instructions without the slightest deviation from them.

At the same time, the person who teaches in a higher education institution is a lecturer. And he or she must, using reproductive methods, be able to keep the audience's attention, in particular, be a skilled speaker, because in this case, students only receive theoretical information without consolidating it on a practical level. In this case, the motivation to listen is significantly reduced, as well as the level of concentration and memorisation.

Practical tasks allow students, in particular, when studying the disciplines of the electric power cycle, to observe phenomena, study the equipment they will have to deal with in their professional life, as well as to investigate certain phenomena, make empirical calculations and draw conclusions on their own, thus consolidating their knowledge. The students themselves look for the causes of certain malfunctions. In addition, they use diagrams and images of certain parts to study their structure,

operation, etc. In addition, students are engaged in modelling certain processes, phenomena or devices to better understand their structure and principles of operation [8].

One of the main objectives of this teaching technology is to arouse interest in technical, mathematical and natural sciences, motivate them to study them theoretically and practically. However, one of the weaknesses of this method is the lack of clear guidelines and instructions, which can be a problem when teaching students with low levels of knowledge, skills and abilities. At the same time, working in creative, small groups, students learn better, in particular, the disciplines of the mathematical cycle and demonstrate much better results than when working independently.

The applied tasks on economics and technology developed by NAU teachers of probability theory for students majoring in 275 “Transport Technologies (Air Transport)” facilitate independent calculations by students, stimulate learning and practical study of probability theory, and help to better understand the role of mathematics in practical activities. However, STEM education is best developed during conferences, competitions, and contests, i.e. in extracurricular activities. In addition, students are also encouraged to work on projects in a group, collecting certain statistics in the media and analysing them according to certain parameters, depending on the topic of the task [10].

It is also important to note that experiential learning and the technology we have studied above allow students to develop leadership skills. These competences are necessary for them, as in any other profession, because electric vehicle management is possible in various fields, including the agricultural sector, industrial electric vehicles, public transport of this type, or even the management of an electric freight vehicle, or a whole range of them. In the above examples, a person is capable of holding both the position of a subordinate and a manager, so students should develop this competence from the time of their studies.

To develop leadership qualities, it is necessary to use the mechanisms listed in Table 1.

Table 1

Mechanisms that help in the formation of a leader

Use a problem-based approach and develop critical thinking;
Organise joint training, thus building teamwork skills and developing leadership skills, both situational and permanent team leader skills;
Motivation for innovative thinking and creative activity;
Stimulation of independent activity and acquisition of practical skills through experience.

And all these mechanisms are what STEM education aims to develop in pupils and students, as it includes the following key components:

- the availability of elective courses to help students form an individual development trajectory;
- performing practical interdisciplinary tasks that go beyond academic knowledge to develop adaptability and the ability to seek out solutions and additional knowledge on their own;
- use of various types of project activities, themed days, events, competitions, problem tasks, engineering project festivals, and team tasks;
- development of special research and presentation areas, museums, etc.;
- use of modern digital technologies for educational purposes [13].

Thus, the above-mentioned components and mechanisms can help in the development of leaders, but in the transport sector, both managerial talent, i.e. the ability to understand what personnel are available, the strengths and weaknesses of employees and the available material and technical base and how to use it, and the practical experience of the manager himself are important. That is, the ability to perform the tasks that he or she sets for employees [4].

In addition, the advantages of education through experience are:

- learning by topics rather than by subjects;
- application of research skills and knowledge in real life and everyday situations, i.e. the link between learning and life;
- Developing the ability to critically analyse a situation and solve certain problems, first within the school and then outside it;
- Increasing the level of belief in oneself and one's own skills;
- as we have already mentioned, the development of communication skills and teamwork;
- creative and innovative approaches to project activities;
- Preparing students for life in an innovative, digital society;
- the connection between professional activity and education.

To sum up, STEM education can help develop such general skills as the ability to communicate, work in a team, and, if necessary, work independently, i.e. it allows you to develop an assertive personality, develop the ability to learn, explore the world throughout life, and adapt to changes in society and live successfully in it. To develop the ability to manage both personal (to become a leader in one's own life and take responsibility for it) and team management.

In addition to general skills, this methodological approach can develop a number of specialised engineering competencies. These include:

1. the ability to observe certain phenomena and events;

2. ability to think logically and consistently;

3. as a consequence of the previous point, the ability to draw conclusions and build theories and assumptions about a particular topic or phenomenon;

4. the ability to predict the consequences of certain actions of one's own or other people's actions, the consequences of phenomena and events in the external world;

5. the ability to classify certain events, phenomena, etc.;

6. The ability to communicate in a professional manner and to measure something;

7. to formulate or create a model of something;

8. the ability to design and conduct an experiment, interpret its results in accordance with the objectives;

9. ability to solve complex problems.

Above, we have repeatedly mentioned such a method as project-based learning. So, project activities can develop both general and engineering competencies. This is because the following features are inherent in this method:

- the presence of a problem that is meaningful to the learner and, as a result, motivation to solve the task. At the same time, the problem is real, which is no less important. It can be a task that is meaningful both for the learner and his/her needs and for the needs of the social environment;
- the independent work of the student ends with a certain result and the development of a certain product;
- To cope with this task, the applicant needs to use multidisciplinary knowledge, i.e. from different subjects and areas of knowledge;
- the project should involve all participants in the educational process and should be dominated by teamwork, joint activities and communication. Last but not least, this communication should be effective even in the event of conflicts, and the norms and rules of modern society should be followed and respected. That is, the rules of ecological communication should be followed and equality between participants in the educational process and the right to an opinion should be recognised;
- A number of problematic research methods should be used;
- mandatory presentation of the results of activities, which in turn will allow students to summarise the results of their own project, and on the other hand, will teach

them how to present themselves and their work in the following similar situations. For example, during employment or at the beginning of it;

- The lecturer or teacher has the role of facilitator, expert, developer and consultant in this work. He or she can motivate and encourage activity, but not perform tasks for students.

In addition to developing competencies, this type of activity contributes to the following behavioural changes:

1. the applicant's ability to work in a team and then independently;

2. not just memorisation, but discovery, creative combination and demonstration of their own results;

3. from simply listening and understanding the material to responding, discussing and integrating it into your own experience;

4. from simple theoretical assimilation of the studied material to its use in your practical activity, professional or everyday life;

5. dependence on the subjective opinion of the teacher, his/her conclusions to his/her own conclusions and the presence of his/her own perception of this or that information, his/her own opinion [7; 15].

In general, to summarise the above, we would like to note that transport-related specialities, like any other specialities, are developing incredibly fast with the help of modern technologies such as electricity and digital technologies, so graduates of vocational schools at all levels are required to have a high level of understanding of these technologies and the ability to use them in practice.

For example, in terms of digital technologies, professionals need to know how to work with image editors (Canva) and tools for creating presentations (Prezi), videos (Mozilla Popcorn Maker), organise meetings and webinars (Zoom) to develop models, diagrams, share experiences and work in a safer environment, given the situation in

Ukraine. In addition, modern technologies make it possible to organise research and educational work online, in particular through the Go-Lab ecosystem [15].

Conclusions. In accordance with the objectives of the article, namely:

1. streamlining the list of engineering and technical skills that a graduate specialist in the field of electric transport should possess;

2. explore possible ways to develop these skills in practice using methodological approaches.

Thus, according to Objective 1. STEM education allows you to develop the following technical/general competences: the ability to communicate, work in a team, and, if necessary, work independently, i.e. it allows you to bring up an assertive personality, develop the ability to learn, explore the world throughout life and adapt to changes in society, and live successfully in it. To develop the ability to manage both in personal life and when leading a team.

As for engineering competences, the research has resulted in the following list, shown in Table 2. List of engineering competences required for research and invention activities.

Table 2

List of engineering competences

1. logical thinking;
2. observation;
3. the ability to draw conclusions and build theories and assumptions;
4. the ability to predict consequences;
5. ability to classify;
6. the ability to communicate in a professional manner and make measurements
7. to create a model of something;
8. the ability to design and conduct an experiment, interpret its results in accordance with the tasks set

With regard to task 2, educational project activities and problem-solving will help to develop all these skills for specialists working with electric vehicles.

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