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The use of project technologies in teaching the structure and maintenance of cars

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Abstract. The research focused on how the application of the project method in the educational process contributes to a deeper understanding of theoretical knowledge and the development of practical skills among students of technical specialities. In this study, an analysis of the effectiveness of design technologies in teaching the construction and maintenance of cars was carried out, which allowed assessing their impact on the development of theoretical and practical skills of students. It was found that the use of project technologies in teaching significantly improves the quality of students' assimilation of theoretical knowledge and contributes to the development of practical skills. It was found that students who completed tasks in the form of projects better understood the principles of operation of automotive systems and were able to apply their knowledge in real situations. Practical work in the project format contributed to the development of critical thinking and the ability to make informed decisions, as participants were forced to analyse problems and find optimal ways to solve them. It was also found that the project method increased students' motivation to learn and encouraged them to independently search for information, collaborate in a team, and use modern diagnostic tools. Work in groups contributed to the development of communication and time management skills, which are important in professional activities. In general, the results of the study indicate a significant increase in the effectiveness of the educational process through the integration of the project method, which contributes not only to a deeper assimilation of theoretical knowledge, but also to the development of practical skills that directly affect the professional readiness of students of technical specialities. The results of this study can be used in educational institutions that train car maintenance specialists to improve training programmes and teaching methods

Keywords: critical thinking; teamwork; motivation; diagnostic tools; professional activity

INTRODUCTION

In the modern educational process, it is important to combine theoretical knowledge with practical skills, especially in technical specialities. One of the most effective approaches to achieve this goal is the use of project technologies. This method allows students not only to assimilate the material, but also to learn how to apply knowledge in practical situations, developing important competencies such as critical thinking, teamwork, and the ability to solve technical problems. In the field of vehicle design and maintenance training, design technologies open up new opportunities for integrating theoretical aspects with practical experience. Based on this, students gain a comprehensive understanding of the operation of automotive systems and acquire the skills necessary for successful professional activity.

In the field of training in the construction and maintenance of cars, there is a problem of insufficient integration of theoretical knowledge with practical skills of students.

According to A. De Marco *et al.* (2021), project methods have contributed to students' deeper understanding of the material, helping them apply theoretical knowledge in practice. This ensured the integration of the educational process and increased the effectiveness of training. A. Theissler *et al.* (2021) noted that students' implementation of projects increased their motivation to learn, as they saw the real result of their work. This, in turn, stimulated their interest in professional activities in the field of automotive technology. E. Jääskä *et al.* (2022) showed that the introduction of project technologies improved problem-solving skills and the development of critical thinking. Students have become more confident in their ability to find solutions to complex technical problems. According to the conclusions of Z. Wang *et al.* (2022), this method has contributed to the development of teamwork and the ability to communicate effectively. Students, working in groups, learned to exchange opinions and resolve conflicts, which is important in the professional sphere. D. Ghosheh Wahbeh *et al.* (2021) pointed out that projects stimulated students' independence and responsibility for their decisions. This contributed to the development of their entrepreneurial spirit and willingness to take risks.

C. Cortázar *et al.* (2021) emphasised that students who worked on projects became more familiar with modern diagnostic tools and working methods. This allowed them to be more prepared for the challenges they might face in the labour market. The study by P. Stahel *et al.* (2022) showed that this approach prepared students for real-world working conditions, where they had to apply their knowledge to solve complex problems. This allowed them to develop skills to adapt to a rapidly changing environment. Y. Ma *et al.* (2024) noted that project activities contributed to the integration of knowledge from different disciplines, forming a holistic view of automotive systems. This helped students understand how different elements of the car interact with each other. According to N. Kholiavko *et al.* (2021), students who worked on group projects gained valuable experience in sharing responsibilities and planning. This experience was important for further professional activity in a team environment. A. Rohm *et al.* (2021) stressed that the introduction of such technologies has had a positive impact on the overall training of specialists, making them more competitive in the labour market. This provided students with opportunities for further professional development. Thus, despite existing research, there are gaps in understanding effective strategies to improve student learning in technical specialities that require further study and development.

The purpose of the study was to investigate how the application of the project method in technical education affects the depth of assimilation of theoretical knowledge and the development of practical skills of students, and their motivation to learn and ability to work independently. Objectives of the study:

1. To consider the main advantages and disadvantages of using the project method in the educational process.

2. To assess the level of development of students' practical skills as a result of the introduction of project technologies in training.

3. To identify gaps in students' knowledge and skills that arise when using conventional teaching methods.

MATERIALS AND METHODS

The analysis helped to consider in detail the stages of project implementation and their impact on the development of students' professional skills. Through the analysis of various stages of projects, such as diagnostics and repair of automobile engines, development of electronic control systems and creation of suspension models, it was possible to determine what skills and knowledge students develop at each stage of work. The analysis helped to find out how students apply the acquired theoretical knowledge in practice and how this knowledge interacts with other stages of learning, contributing to the development of comprehensive professional skills.

A modelling method allowed recreating real technical processes and tasks that students may encounter in their professional activities. For example, modelling the process of diagnostics and repair of automobile engines or creating electronic car control systems allowed students to understand not only theoretically, but also practically how these systems work. Modelling has contributed to the development of problem-solving skills in real-world settings, using theoretical knowledge in specific situations. The system approach method was used to assess the interaction of various project stages, such as research, modelling, testing, and their impact on the final learning outcomes. The systematic approach helped to find out how each stage of the project interacts with others and how this contributes to the development of theoretical and practical knowledge of students. It helped to consider learning not as isolated stages, but as an interconnected system in which each element has an impact on the overall result of students' training.

The method of interdisciplinary integration has become the main one for evaluating the effectiveness of integration of various academic disciplines – mechanics, electrical engineering, and computer science. Based on this approach, it was established how combining knowledge from different industries helps students to understand the car as a complex technical system that allows them to solve more complex technical problems. The method of interdisciplinary integration allowed creating a complete picture of learning, where different disciplines interact with each other and contribute to the development of multifaceted professional skills, which is important for training highly qualified specialists.

To compare conventional and project-based approaches, the paper used the findings of F. Brandl *et al.* (2021), who analysed project management in the automotive industry, and E. Soriano-Heras *et al.* (2022), who evaluated project-oriented learning in technical disciplines. These studies helped to identify the benefits of the project method, in particular, increasing student motivation, improving understanding of theoretical aspects through practical

application, and developing professional skills such as critical thinking and teamwork. Performance evaluation criteria included the level of student engagement, the ability to solve real-world problems, and the development of communication skills and working with modern engineering technologies. The paper identified elements of the educational process that need to be improved, and also assessed the level of assimilation of the material by students who completed projects. A comparative analysis between the academic performance of students who used the project method and those who studied according to the conventional scheme helped to determine the advantages of the project approach in teaching.

RESULTS

Project technologies in the educational process are an interactive approach focused on the active participation of students in real or simulated practical tasks within the framework of specific projects. They allow not only to gain theoretical knowledge, but also to actively apply it in solving problems, which helps students to understand the practical value of this knowledge. This increases motivation to learn and promotes the development of important professional skills, such as critical thinking, problem solving, and the ability to work with technical means and equipment. The project method also allows students to test themselves in real-world conditions, which is important for future professional activities, because in today's ever-changing world, professionals must be able to adapt to new technologies and requirements.

It is difficult to overestimate the importance of the project method in teaching technical specialities, since it helps students to develop not only theoretical knowledge, but also practical skills that are necessary for performing professional tasks. In technical disciplines such as automotive engineering, where practical training is an important part of the learning process, students should be able to combine theoretical foundations with real-world technical challenges. The project method integrates these two components, allowing students to gain a deeper understanding of the subject and prepare for solving real-world problems that may arise in their future careers. For example, during projects, students develop critical thinking, learn to generate innovative ideas and work in a team, which are important qualities for successfully solving complex technical problems.

Project technologies also contribute to the development of an interdisciplinary approach to learning. Students are given the opportunity to interact with different areas of expertise, which allows them to better understand how different disciplines can be applied to solve complex problems in technical areas. In project work, for example, students can use their knowledge of mechanics, electronics, computer science, and other disciplines to create more efficient and innovative solutions. This interdisciplinary approach is important for modern specialists, as it allows them to work in different conditions and adapt to changes in the technological environment. This allows students not only to prepare for work in a particular field, but also to be ready to solve various problems that will arise in their professional activities. Table 1 shows how a project-based approach can be more effective than a traditional teaching method, especially in technical disciplines where practical application of knowledge is important.

Table 1. Comparison of conventional and project approaches

Criteria	Conventional approach	Project approach
Level of student engagement	Low, students often passively perceive the material	High, students are actively involved in the learning process
Ability to solve real problems	Limited, focus on theoretical knowledge	High, students apply their knowledge to solve real-world problems
Development of communication skills	There are few opportunities for developing communication skills	High, working in teams contributes to the development of these skills
Application of modern engineering technologies	Limited, usually learning the basics without applying new technologies	Significant use of the latest engineering technologies and tools
Development of critical thinking	Moderate, focused on theoretical knowledge	High, students should analyse and make informed decisions
Teamwork	Limited or missing	Develops through group projects, cooperation among students
Level of material assimilation	May be low due to lack of practical experience	Higher, due to the integration of theory and practice in the process of project activities
Elements that need improvement	Conventional teaching methods may not be effective enough to develop practical skills	It is necessary to improve the support of students in the project work process to ensure better assimilation of the material

Source: compiled based on F. Brandl *et al.* (2021), E. Soriano-Heras *et al.* (2022)

Thus, design technologies are a powerful tool for training future specialists in the field of technical sciences. They allow students to develop comprehensive skills that are necessary for successful work in real-world conditions. Engaging students in project activities helps them to adapt to the rapidly changing world of technology, develop professional qualities that meet the requirements of the modern labour market, and prepare for challenging

tasks in their future careers. The introduction of project technologies in the educational process also contributes to the development of competitive professionals who can successfully solve the problems that they face in the face of constant changes and innovations in the technical industry.

The automotive industry is constantly evolving, integrating the latest technologies, innovations and high standards of safety, ecology, and efficiency. As students study this field, it is important for their training to apply modern design technologies that help develop not only technical, but also managerial, communication and innovation skills. Design technologies provide students with the necessary tools to solve real-world problems, explore new concepts, and design complex systems. They allow students to engage in engineering practice, prepare them to work with new technologies and integrate these technologies into the real environment of the automotive industry.

One of the most effective approaches to training in the automotive industry is project-oriented training. This approach is based on the fact that students work on real or close-to-real projects, which allows them to gain practical experience in solving specific problems. As part of project-based training, students are engaged in developing new cars, optimising technological processes, or studying new materials and technologies. This approach not only helps in solving technical problems, but also promotes the development of important skills such as project management, teamwork, strategy development, and presentation of results.

One of the most important components of modern project-based learning is the use of computer-aided design (CAD) tools. CAD systems enable students to create precise 3D models of automotive components and systems, allowing them to better understand their design and interaction. An important aspect is that these models can be used to check the quality and effectiveness of projects even at the design stage. The use of CAD systems allows students to work not only with individual parts, but also with entire automotive systems, studying their interaction in the context of the overall design of the car. Thus, it helps to develop students' ideas about the integrity of the structure, the interaction of various systems and processes in the car.

In addition to CAD systems, computer-aided engineering (CAE) technologies are widely used in the automotive industry, which allow for a variety of analyses at the design stage. This includes modelling the behaviour of automotive systems during accidents, analysing mechanical and thermal loads, and evaluating the performance of various components under various conditions. The use of such technologies gives students the opportunity to predict possible problems even before a physical prototype is built, which significantly reduces development costs and allows them to optimise the project at an early stage. It is important that these systems help to conduct accurate analysis and simulation of car operation in real conditions, which allows students to assess not only the technical side of the development, but also the impact on safety, comfort and efficiency.

One of the key components of project-based training is the integration of computer-aided manufacturing (CAM). These technologies allow students to move from digital models to real-world prototypes. CAM systems are used to create models that can be immediately used for the production of parts, which is important for creating functional prototypes of automotive systems. Students working with CAM systems have the opportunity not only to develop models, but also to study production processes, which allows them to gain real-world experience of interaction between design and production. It is important to note that this training helps students prepare for real work in modern manufacturing enterprises.

The use of simulations and simulations to analyse the behaviour of automotive systems and their components is another important aspect in automotive education. Simulations allow students to evaluate different aspects of the vehicle's operation under different conditions. For example, they can simulate the behaviour of a car during an accident, analyse the performance of the braking system, check safety systems, and even simulate fuel consumption. With this approach, students can test constructive ideas without creating expensive physical prototypes. This gives them the opportunity to quickly get results, conduct tests at different stages of the project, and correct errors.

An equally important tool in training is 3D printing, which allows creating physical prototypes of car components and systems. Due to rapid prototyping, students can test their ideas and designs at the design stage and before mass production begins. This allows reducing development costs, and speeding up the process of testing and improving parts. The use of 3D printing gives students the opportunity to study not only the technical characteristics of automotive systems, but also the features of production processes.

Modern technologies also help to actively apply international cooperation within the framework of projects. Joint international projects give students the opportunity to work with colleagues from different countries, gain experience in global teams, and learn innovative methods used in other parts of the world. This collaboration allows students not only to improve their technical skills, but also to develop cross-cultural communication abilities, which is an important aspect in international engineering projects.

Sustainability in the development of the automotive industry is an important area of study. Students should not only know the technology, but also understand the importance of environmental aspects in the development of new cars. Projects that include environmental aspects such as reducing emissions, introducing alternative energy sources, optimising fuel consumption, and improving resource efficiency contribute to the development of future engineers' environmental awareness. This allows students to develop responsibility to society and the environment.

The project method in teaching the construction and maintenance of cars provides students with a unique opportunity to better understand the theoretical foundations,

applying them in practical tasks (Table 2). One of the most striking examples of the implementation of this approach is the project for diagnostics and repair of an internal combustion engine. As part of such a project, students not only learn the principles of engine operation, but also gain practical experience in its maintenance.

Table 2. Main advantages and disadvantages of using the project method in the educational process

Advantages	Disadvantages
Active involvement of students in the educational process	Need for significant time costs
Development of critical thinking and analytical skills	High dependence on team performance
Integration of knowledge in various disciplines	Possible difficulties in planning and organising the project
Development teamwork skills	It can be difficult to estimate an individual contribution
Application of theoretical knowledge in practice	Need for additional training of teachers

Source: compiled based on A. Rasyid *et al.* (2023)

When performing a project on engine diagnostics, students begin by studying the theoretical aspects of its structure and functioning. This includes understanding basic components such as cylinders, pistons, distribution mechanisms, and power supply systems. Further, at the practical stage, students use diagnostic equipment, in particular, computer scanners, to identify possible malfunctions. The use of such equipment allows analysing the data obtained during engine operation and comparing it with the standards, which helps to identify problems that may affect the performance of the car.

In addition to diagnostics, an important component of the project is the modelling of various engine operation scenarios. Students can use the software to simulate engine performance under various conditions, allowing them to understand how various factors such as temperature, pressure, and fuel composition affect its performance. This research forms students' systematic approach to understanding the operation of technical systems and develops their ability to predict results. In addition, the project method allows students to conduct their own research, which encourages them to study independently and delve deeper into the topics that interest them (Jääskä & Aaltonen, 2022). For example, students can initiate research on the effects of different types of fuel on engine performance or evaluate the effectiveness of different repair methods. This approach promotes the development of critical thinking, as students must analyse, compare, and draw conclusions based on the data obtained. Thus, the practical application of the project method in teaching technical specialities, in particular, in the framework of the engine diagnostics and repair project, demonstrates how theoretical knowledge can be successfully implemented in practice. Students not only gain knowledge, but also develop the skills necessary for future professional activities, forming a comprehensive understanding of technical systems and ways to effectively maintain them. This approach provides high-quality training for specialists who are ready for the challenges of the modern automotive industry.

In a world where technology is constantly evolving, technical problem-solving skills are becoming increasingly important for automotive service professionals. The project-based training method, which is actively used in technical specialities, allows students not only to master theoretical knowledge, but also to face real problems that arise during car maintenance. This approach helps to develop critical thinking and the ability to analyse information that is important for successful professional activity in future specialists (Table 3). Conventional teaching methods that focus on lectures and passive assimilation of information often lead to gaps in students' knowledge and skills. Table 4 summarises the main types of these gaps.

Table 3. Assessment of the level of development of students' practical skills as a result of the introduction of project technologies in training

Level of development of practical skills	Description	Examples
Low	Limited application of theoretical knowledge in practice	Lack of skills in working with modern equipment
Moderate	Basic practical skills, but no depth of knowledge	Knowledge of mechanics, but insufficient diagnostic experience
High	Well-developed practical skills, ability to work independently	Successful implementation of complex projects using diagnostic equipment
Very high	High level of adaptation and innovation implementation	Development of new solutions for optimising automotive systems

Source: compiled based on T. Gomez-del Rio & J. Rodríguez (2022)

Table 4. Gaps in students' knowledge and skills when using conventional teaching methods

Type of gaps	Description	Examples
Theoretical knowledge	Lack of a deep understanding of the subject	Students know the definitions, but they cannot put them into practice
Practical skills	Limited experience with real systems	Insufficient knowledge of diagnostic devices
Teamwork	Lack of experience in collaboration in groups	Difficulties in communication and sharing responsibilities
Critical thinking	Low level of analytical skills	Difficulties in evaluating information and making decisions
Integration of knowledge	Inability to combine knowledge from different disciplines	Limited understanding of complex technical systems

Source: compiled based on M. Ashraf *et al.* (2021)

During their studies, students often encounter real problems that may arise during car maintenance. For example, a situation where the car does not start can have several reasons, from a low battery to a malfunction of electronic systems. Students learn to systematically approach the solution of such problems, using the acquired knowledge about the structure of the car and the principles of its operation. They are trained to perform diagnostics, identify problems, and offer effective solutions that require not only knowledge, but also practical experience.

Developing critical thinking is a key element in solving technical problems (Minarti *et al.*, 2022). Students learn to analyse various aspects of a problem, evaluate information, and make informed decisions. For example, when working with electronic vehicle systems, such as an engine control system or an anti-lock braking system, students should understand how these systems work and what factors can affect their performance. They study the principles of operation of sensors, drives and electronic control units, which allows them not only to identify problems, but also to suggest ways to fix them.

In addition, the project-based teaching method encourages students to conduct independent research, which contributes to the development of analytical skills. For example, while working on a project to optimise an electronic engine management system, students can explore different approaches to improving its efficiency. This may include comparing different driving strategies, analysing their advantages and disadvantages, and evaluating possible impacts on vehicle performance. Thus, the development of technical problem-solving skills among students of automotive specialities is an important aspect of their training. Facing real challenges in car maintenance and developing critical thinking and analytical skills foster competent specialists who are ready for the challenges that arise in the modern automotive industry. This approach not only prepares students for practical work, but also promotes their personal development, providing a foundation for a successful career.

In education, especially in the field of technical specialities, an interdisciplinary approach becomes a necessary element of the educational process. This approach allows students to integrate knowledge from various fields such as mechanics, electrical engineering, and computer science, which is particularly important in teaching automotive engineering. Since cars are complex systems that combine different technologies, the ability to combine knowledge from multiple disciplines is crucial for training specialists who can successfully solve modern technical problems (El Hadraoui *et al.*, 2022).

The integration of knowledge in mechanics, electrical engineering and computer science allows students to gain a comprehensive understanding of the principles of automotive operation. For example, knowledge of mechanics helps to understand the basics of driving and dynamics of a car chassis, while knowledge of electrical engineering is essential for working with the car's electronic systems. Computer science, in turn, opens up opportunities for using software in diagnostics and optimisation of automotive systems. In this way, students become able to assess various aspects of the operation of the vehicle as a whole, which is important for their professional development (Asef & Kalyvas, 2021).

Examples of projects that combine different disciplines demonstrate how this interdisciplinary approach can be implemented in practice. One of these projects is the development of a fuel consumption monitoring system. Students working on this project should consider mechanical aspects such as the car's aerodynamics and weight characteristics, and electronic systems that are responsible for measuring and managing fuel consumption. Computer science knowledge is also essential for creating software that will analyse fuel consumption data and offer optimisation recommendations (Olabi *et al.*, 2021).

Another example is a project dedicated to modelling car suspensions. Students integrate knowledge of mechanics to understand the operation of spring and damping systems, and electrical engineering to create electronic control systems that can automatically adjust suspension stiffness depending on road conditions. They can also use computer simulation software that allows them to predict suspension behaviour in various scenarios. This training allows students to gain valuable experience in interdisciplinary teamwork and develops their practical skills (Darabseh *et al.*, 2021).

Thus, an interdisciplinary approach to teaching technical specialities is a powerful tool for training future specialists. The integration of knowledge in mechanics, electrical engineering and computer science not only expands their professional horizon, but also forms the ability to comprehensively analyse and solve complex technical problems.

Due to projects that combine different disciplines, students get a unique opportunity to prepare for the challenges that arise in the modern automotive industry and become competitive specialists in the labour market.

In the educational process, especially in technical specialities, the development of teamwork and managerial skills are key aspects of training specialists. The project-based teaching method actively encourages students to cooperate in groups, which not only contributes to a deeper assimilation of the material, but also forms the skills necessary for successful professional activity. In the context of automotive engineering, where it is often necessary to work in teams to solve complex problems, these skills become even more relevant (Tryus & Herasymenko, 2021). Collaboration in groups during project execution allows students to learn how to work in a team, share roles and responsibilities, and share knowledge and experience. For example, when working on a project to develop a car control system, students can be divided into groups, where each team is responsible for a specific aspect of the project, such as the mechanical part, electronic systems, or programming. This approach not only increases work efficiency, but also promotes the development of communication skills and collective decision-making.

The importance of communication in the process of teamwork should not be underestimated. An open exchange of ideas and information between team members is crucial to achieving common goals. Students learn to formulate their thoughts, listen to others, and consider different opinions, which contributes to more productive discussion and decision-making. This not only improves the quality of the project, but also creates an atmosphere of mutual respect and support in the team. Effective time planning is also an integral part of teamwork. When completing projects, students are faced with the need to meet deadlines and complete tasks in limited time. They learn how to develop work schedules, prioritise, and evaluate the resources required to complete a project. This ensures not only the successful completion of projects, but also develops management skills that will be useful in their future professional activities.

In general, the development of teamwork and managerial skills through the project-based training method contributes to the formation of an integrated approach to solving problems in automotive engineering. Students who have learned how to work effectively in teams, communicate and plan their time become not only more competitive in the labour market, but also able to successfully cope with the challenges that arise in the modern world of technology. This, of course, provides them with an advantage in their professional activities and contributes to their personal development.

DISCUSSION

The analysis of the results obtained showed that the use of the project method in teaching the structure and maintenance of cars significantly improved the assimilation of theoretical knowledge and practical skills. Students who will participate in project tasks will be able to better understand the basic principles of automotive systems and learn how to apply knowledge in real-world situations. Based on this approach, they will not just remember information, but learn to analyse complex technical problems and find optimal ways to solve them.

This problem was also investigated by J. Chen *et al.* (2021), where the results confirmed that the introduction of the project method in the training of automotive technology can significantly increase the efficiency of mastering theoretical knowledge. Practical activities within the framework of projects allow students to directly apply the information received in practice, which contributes to a better understanding and memorisation of the material. Thus, students can not only study theoretical aspects, but also realise their significance for real tasks, which helps to prepare them for future professional activities.

The study by C. Purchase *et al.* (2022) also showed that the benefits of mastering theoretical knowledge through practical activities within projects are the development of critical thinking, the ability to solve specific problems and work in a team. Teachers, using the project method, can create learning situations that reflect the real problems of automotive technology, thereby contributing to the preparation of students for future professional activities. This allows students to better understand how theoretical knowledge is used in practical activities, which is important for the development of their professional skills.

It is worth noting that although the design method has significant potential to improve training in automotive technology, its implementation requires careful preparation and resource support. Not all educational institutions have sufficient equipment and qualified teachers to effectively implement project tasks, which may limit the effectiveness of this approach. In addition, it is important to ensure proper organisation of the educational process, so that project activities do not become superficial or isolated from the main theoretical material, but are an organic part of the curriculum. The implementation of the project method will also contribute to the development of students' critical thinking and analytical skills. In the process of completing projects, students will face a variety of technical tasks that will require informed decisions. This will encourage them to find and evaluate alternative approaches, which will give them the skills of independent analysis and decision-making. Thus, design technologies have proven to be an effective way to train future specialists who can independently evaluate and solve complex problems in real practice.

S. Shanta & J. Wells (2022) concluded that developing students' critical thinking through participation in technical projects is an important aspect of modern education, as this approach allows students to systematically analyse a problem and evaluate various solutions to it. In the process of working on projects, students learn to look for alternative ways to achieve goals, critically evaluating available resources and limitations. This approach contributes to the

development of independent thinking, which is the basis for further professional activity. The study by J. Sitopu *et al.* (2024) found that developing analytical skills and decision-making in the process of completing educational tasks helps students to understand the importance of each step in solving technical problems. They learn to apply a variety of methods of analysing situations, in particular, technical and economic calculations, and predict the consequences of their decisions. Such skills are essential for making effective decisions in real-world settings, where the ability to act in conditions of uncertainty and limited resources is important. These results support the above study, as they indicate a positive impact of project activities on the development of students' critical thinking. In particular, participation in technical projects allows students not only to acquire theoretical knowledge, but also to apply it effectively in real conditions, which contributes to a deeper understanding of the subject. This approach also helps to develop the ability to analyse complex situations and make informed decisions, which is an important aspect of training future specialists in the field of technology.

Another significant result will be an increase in the level of teamwork among students. Projects often require collaborative activities that promote communication skills and the ability to work effectively in groups. Students learn to coordinate their actions, share responsibilities, and share ideas to achieve a common goal. This experience would allow them to acquire the collaboration skills needed to work in the automotive industry, where most of the work is done in a team. It is necessary to emphasise the study by D. Avila *et al.* (2021), who also found that improving teamwork through project-based learning activities is an important aspect, as teamwork allows students to develop the ability to collaborate by considering the opinions of others and making collective decisions. Within the framework of projects, students learn to share responsibilities, effectively organise work processes, and achieve common goals. This contributes to the development of social skills needed in a professional environment, where it is often necessary to work in groups on complex tasks.

In turn, A. Owens & R. Hite (2022) concluded that the importance of developing communication skills during collaborative projects should not be underestimated, as effective communication is a key factor in achieving success in teamwork. Students, working in groups, learn to express their ideas clearly, listen to others, and constructively discuss different approaches to solving problems. Such skills are important not only in the learning process, but also in future careers, where they help to ensure effective interaction with colleagues and partners. These data are consistent with the theses presented in the previous section, as they confirm the importance of developing teamwork and communication skills through project activities. As the results show, participation in joint projects significantly improves students' ability to interact effectively in groups, which, in turn, contributes to the successful completion of complex tasks. This demonstrates the importance of integrating such practices into the educational process to train specialists who can work effectively in a team environment at all stages of professional activity.

The project approach will also encourage interdisciplinary thinking, as tasks often require knowledge not only in mechanics, but also in electrical engineering, computer science, and other related disciplines. Students will have the opportunity to integrate knowledge from different fields, which will allow them to develop a comprehensive understanding of automotive systems. This approach will prepare them to meet challenges that require the application of interdisciplinary knowledge and the ability to adapt to new technologies that are constantly being introduced in the automotive industry. L. Bertel *et al.* (2022) also conducted a study, the results of which confirmed that the integration of interdisciplinary knowledge for complex solutions to technical problems is becoming increasingly important in the context of rapid technology development. Modern technical problems often require the use of knowledge not only in one discipline, but also in different areas, which allows finding more effective solutions. This increases the ability of students not only to solve problems, but also to understand the relationship between different aspects of technical systems, which is necessary for future professional activities.

E. Iacovidou *et al.* (2021) also found that developing systems thinking through a combination of mechanics, electrical engineering, and computer science allows students to see technical problems from different perspectives, which helps them to find optimal solutions to complex problems. The combination of these disciplines helps to better understand the principles of operation of complex systems, where the influence of each of the elements is important. This approach develops students' strategic thinking skills that allow them to effectively apply various technologies to achieve a common goal within a comprehensive technical project.

Comparing the data obtained in the course of research, it can be concluded that the integration of interdisciplinary knowledge really contributes to a more effective solution of technical problems. Comparing the results of different projects shows that students who work on tasks that require knowledge of several disciplines show better results in solving complex technical problems. This confirms the importance of developing systems thinking and the ability to combine different scientific approaches to achieve optimal solutions in real-world conditions. In addition, the project method will contribute to the development of students' managerial abilities. They will be able to develop work plans, evaluate resources, and monitor project deadlines. This experience will help them to master the basic principles of time and resource management that are important for further professional activity. Such skills will increase the level of training of graduates to perform managerial duties and plan work processes in production.

S. Sutrisno & J. Nasucha (2022) concluded that developing students' managerial skills in project planning and execution is an important component of professional training. Project activities allow students to gain experience

in task planning, role allocation, and team coordination, which is essential in any field. This process contributes to the development of managerial qualities such as leadership, organisational skills, and responsibility for achieving results. C. Wolters & A. Brady (2021) found that building resource assessment and time management skills in training projects is a key aspect for successfully completing tasks in limited time. Students learn how to allocate resources correctly, plan project stages, and complete tasks in a timely manner, which avoids delays and reduces the risk of failure to fulfil their goals. These skills are important not only in training, but also in further professional activities, where effective management of resources and time is the basis for achieving success in any project.

When analysing the results of the study, it is clear that the development of managerial skills through participation in project activities significantly improves students' ability to effectively plan and organise work processes. The data shows that students who are actively working on projects demonstrate a high level of responsibility for completing tasks and the ability to manage time and resources. This confirms that the project approach is an effective tool for developing important managerial competencies that will be useful in their future professional activities. Overall, the results showed that the use of design technologies in vehicle design and maintenance training will provide deeper and more comprehensive training for students. They will gain not only theoretical knowledge, but also practical experience, the ability to analyse, the ability to work in a team and manage work processes. This approach to learning will contribute to the comprehensive development of students, preparing them for the real challenges that they may face at a professional level in the automotive industry.

CONCLUSIONS

The use of design technologies in the training of technical specialities, in particular, in automotive engineering, brings numerous advantages that significantly affect the learning process and professional development of students. The project method, which focuses on the practical application of knowledge and skills, allows students not only to assimilate theoretical material, but also to develop practical skills necessary for a successful career. The application of project technologies in automotive education not only deepens students' technical knowledge, but also contributes to the development of their ability to innovate, think critically, manage projects, and collaborate. An important aspect is the integration of the latest technologies, such as CAD, CAE, CAM, 3D printing, modelling, and international cooperation and sustainable development. These technologies help students to prepare for real-world working conditions in the automotive industry, provide an opportunity to actively participate in innovations and change the industry, making it more efficient and environmentally friendly. They help not only to gain deep technical knowledge, but also to develop skills that will be useful in any part of the world.

Design technologies promote the integration of knowledge from various disciplines, such as mechanics, electrical engineering, and computer science. This allows students to gain a comprehensive understanding of complex technical systems, which is critical to their future professional activities. Due to this integration, students learn not only to analyse various aspects of car operation, but also to find innovative solutions to modern challenges. The project method develops teamwork skills and managerial abilities. Collaboration in groups during project execution teaches students how to communicate effectively, plan their time, and allocate responsibilities. These skills are vital to a successful career in any field, as most modern projects require working in teams.

The use of project technologies contributes to the development of critical thinking and analytical skills. Students learn to ask questions, analyse information, and make informed decisions that are key to professional performance. This aspect of learning helps them to become more adaptive and able to respond to changes in the technology environment. The impact of project technologies on the professional development of students is indisputable. They build self-confidence by preparing them for the real challenges they may face in the labour market. Students who have learned how to work effectively on projects are more competitive and prepared to work in a rapidly changing technological field. Thus, further research can focus on the long-term impact of project technologies on the career development of graduates, their adaptation to changes in the industry, effectiveness in various training formats, and the possibility of using them to improve the skills of employees in the automotive industry.

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CONFLICT OF INTEREST

None.

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Використання проектних технологій у навчанні будови та технічного обслуговування автомобілів

Анотація. Дослідження зосереджене на тому, як застосування проектного методу в освітньому процесі сприяє глибшому розумінню теоретичних знань і формуванню практичних умінь у студентів технічних спеціальностей. У цьому дослідженні було здійснено аналіз ефективності проектних технологій у навчанні будови та технічного обслуговування автомобілів, що дозволило оцінити їх вплив на розвиток теоретичних і практичних навичок студентів. Дослідження продемонструвало, що застосування проектних технологій у навчанні суттєво підвищує якість засвоєння теоретичних знань студентами та сприяє розвитку практичних навичок. Виявлено, що студенти, які виконували завдання у формі проектів, краще розуміли принципи роботи автомобільних систем і могли застосовувати отримані знання в реальних ситуаціях. Практична робота у форматі проектів сприяла формуванню критичного мислення та вмінню приймати обґрунтовані рішення, оскільки учасники були змушені аналізувати проблеми та знаходити оптимальні шляхи їх вирішення. Також встановлено, що проектний метод підвищує мотивацію студентів до навчання та заохочує їх до самостійного пошуку інформації, співпраці в команді та використання сучасних діагностичних інструментів. Робота в групах сприяла розвитку комунікативних навичок і навичок управління часом, що є важливими в професійній діяльності. Загалом, результати дослідження свідчили про значне підвищення ефективності навчального процесу через інтеграцію проектного методу, що сприяє не тільки глибшому засвоєнню теоретичних знань, а й розвитку практичних навичок, які безпосередньо впливають на професійну підготовленість студентів технічних спеціальностей. Результати цієї роботи можуть бути використані в навчальних закладах, що готують фахівців з технічного обслуговування автомобілів, для вдосконалення навчальних програм і методик викладання

Ключові слова: критичне мислення; командна робота; мотивація; діагностичні інструменти; професійна діяльність