2025 6th International Conference on Communications, Information, Electronic and Energy Systems (CIEES) | 979-8-3315-0119-8/25/$31.00 ©2025 IEEE | DOI: 10.1109/CIEES66347.2025.11300254

An Evaluation of Hybrid and Electric Vehicles Training Needs for Developing VR/AR Supported Digital Training Materials

Ridvan Arslan
Vocational School of Technical Sciences
Bursa Uludağ University
Bursa, Turkey
ridvan@uludag.edu.tr

Abdil Kus
Vocational School of Technical Sciences
Bursa Uludağ University
Bursa, Turkey
abdilkus@uludag.edu.tr

Dorian Gorgan
Dept. of Computer Science
Technical University of Cluj-Napoca
Cluj-Napoca, Romania
dorian.gorgan@cs.utcluj.ro

Vladislav Ivanov
Dept. of Machine Elements and Non-metallic Constructions
Technical University of Sofia
Sofia, Bulgaria
vvi@tu-sofia.bg

Lubomir Dimitrov
Dept. of Machine Elements and Non-metallic Constructions
Technical University of Sofia
Sofia, Bulgaria
lubomir_dimitrov @tu-sofia.bg

***Abstract*—Electric and hybrid vehicles are widely spread in the world nowadays. This requires training at all levels: design, production and maintenance. This paper is devoted to the assessment of the training needs in vocational education in the field of electric and hybrid vehicle design. It justifies the application of modern VR/AR technology in education and the development of digital training materials. In order to evaluate the training needs in vocational education, an original questionnaire has been developed. It consists of 25 questions and a 5-point Likert scale has been used. The questionnaire is structured in the following sections: perception, knowledge, skills and expectations. Totally 440 stakeholder representatives of manufacture and service sector, students, teachers in vocational schools, academics and administrators (employees) participated in the surveys made in three countries: Turkey, Bulgaria, and Romania. It is noteworthy that all three countries provided similar answers to all questions in the questionnaires and thus indicated the exact needs. It can be said that the training programs that will be developed in accordance with these results will meet the priorities and needs of all stakeholders regarding the training needs for electric and hybrid vehicles.**

Keywords—electric vehicles; hybrid vehicles; VR/AR; vocational training; training materials

I. INTRODUCTION

Electric and hybrid vehicles are increasingly entering our lives. As a result, the need for training in their design, manufacture, maintenance and service is also rapidly increasing. This particularly affects higher technical and vocational education. The current infrastructure in vocational education cannot meet modern requirements. It is necessary to introduce new digital technologies in training for the maintenance and repair of electric and hybrid vehicles. Specialists in the automotive and repair industry must keep up with new technological advances and especially with the critical safety measures implemented in these vehicles. The design and production of electric and hybrid vehicles is significantly different from that of conventional cars. There are many more problems here. The problems are different for the three groups involved in the development of the documentation: in schools, in administration and in manufacturing enterprises. These problems are presented in more detail in publications [1, 2, 3].

Other authors (Arslan et al. [4], Karahan et al. [5]) have made a comprehensive analysis to determine the vocational education and training requirements of workers in the field of electric and hybrid vehicles. The results of the analysis are presented in (4, 5). The questionnaires offered 30 questions and used a 5-point Likert scale. The questions were structured in the following sections: “perception, knowledge, skills and expectations”. A total of 54 representatives of the sector were surveyed. Among them were 650 students; 652 teachers and administrators from vocational high schools. The authors indicate that when analyzing the results, all three groups gave similar answers to all questions. The authors conclude that the training programs to be developed based on these results will meet the training needs for hybrid and electric vehicles of all three priority stakeholder groups.

Arslan et al. [6] and Kuş et al. [7] studied, in-service training given to 257 vocational high school teachers at the New Generation Vehicles vocational qualification center of excellence, established with EU funds in Turkey, was evaluated. Experimental research method with control group was used in the trainings to determine the contribution of the training programs developed and the infrastructure created to the learning performance. Data of the study; it was evaluated with a pre-test-post-test exam and Likert-scale survey measuring changes in knowledge-skills-perception. As a result of academic measurements: it has been observed that trainings using new content and center of excellence infrastructure increased teachers' academic success by 91%, and the increase in performance, which consists of meeting the needs in their perception-skills-and expectations, was 20.41% on average.

Authorized licensed use limited to: Bursa Uludag Universitesi. Downloaded on December 26,2025 at 12:21:02 UTC from IEEE Xplore. Restrictions apply.

II. VR/AR Assisted Digital Training Materials Development Project

The aim of the EU Erasmus+ strategic project "Development of Virtual and Augmented Reality (VR/AR) assisted digital training materials for Hybrid and Electric vehicles" is to develop new learning content for the course "Hybrid and electric vehicles". This includes development of digital training materials (DTM) based on virtual reality applications. For this purpose, a multidisciplinary research methodology was used, which led to an improvement in the effectiveness of teaching on topics related to the maintenance and service of hybrid and electric vehicles in vocational education.

The authors' aspiration is for teachers and students to be able to use VR/AR applications to facilitate the perception of the taught material. This is most easily achieved by using a three-dimensional environment.

To solve these tasks, separate stages were developed: needs analysis (carried out to identify the most important topics and knowledge needed); content definition based on the results of the analysis; transfer of the determined content into a virtual reality environment; development of training modules; pilot training on the developed training materials.

Following the pilot training, an analysis was conducted using the survey methodology and statistical approach. The results of the pilot training are presented in the article.

III. Material and Method

A. Stakeholder Analysis

To determine methods of development process and to find true answer for these curriculum development questions the stake holder analysis should be done. Stakeholder Analysis will be conducted to take into account the opinions of all parties associated with the "Hybrid and Electric vehicle training" in order to determine the expectations correctly in the selection of the content and products to be developed within the scope of the project and to ensure participation, which is one of the basic elements of the planning. In the first stage of stakeholder analysis, the answers to the following questions were sought in order to determine who the stakeholders are:

- Who are the Hybrid and Electric vehicle trainers and practitioners in the field?
- Who are directors of these trainings, activities and services?
- Who gets trainings (Hybrid and Electric vehicle) offered by the institutions?
- Who are those affected by the training activities and services provided by the institutions and who affect these activities and services?

During the determination of the stakeholders, three different methods will be followed and the groups forming the common denominator will be identified as stakeholders.

- At the beginning, a literature review was conducted on the issue.
- The second step is interviews with the representatives of the sector and non-governmental organizations (NGOs).
- The third method is a mini workshop conducted by the program development commission with university faculty members, teachers and trainers in the sector.

As a result of these studies stakeholders will be determined for needs analysis about Hybrid and Electric vehicle training. The result of prior studies and draft version of stake-holders are given in Table I. Stakeholders are sorted according to their roles and the status of stakeholders as internal or external stakeholders. The stakeholders identified in this preliminary stakeholder analysis are also the ones to be collaborated to evaluate any improvements in the participants' competencies because of the material to be developed in the project. The most important group among the stakeholders is undoubtedly students. Subsequently, the second largest stakeholder group is service providers consisted of a group of educators which is expected and consistent with the literature [8, 9, 10].

TABLE I. Stakeholders and Distribution by Priority

Stakeholders	How	Why	Priority
Students	Internal	Base Beneficiary	1
Sector Employees	Internal	Beneficiary	2
Lecturers	Internal	Teaching and developing	3
Teachers	Internal	Teaching	4
Universities	External	Teaching and developing	5
Vocational High Schools	External	Teaching	6
Sector Managers	External	Strategic stakeholder	7
Governmental Staff	External	Base stakeholder	8
NGOs	External	Beneficiary and strategic stakeholder	9

B. Needs Analysis

1) Methodology of needs analysis

"Need" is the difference between the current situation and the desired situation. In a way, it is the difference between "What" and "What should be?" This is a process that will be followed to uncover the gap between the current situation and the desired situation. As a result, new curricula and new teaching materials will be developed. This process includes four stages and as a result of the work, a justification will be presented and the main priorities for the productive use of resources will be determined. Developing a questionnaire for the Needs Analysis and creating an online questionnaire form via Google Forms for the groups that the data would be gathered. Sorting the data provided from the sources mentioned above and other needed areas by the characteristics of the data and determining needs. The needs analysis can be evaluated using different scientific methods.

The needs analysis and basic outputs can be seen in Fig. 1. The data in Needs Analysis will be collected from a sample of stakeholders and as a result of the data analysis main subjects and topics that a need for content and material development is required will be identified.

Authorized licensed use limited to: Bursa Uludag Universitesi. Downloaded on December 26,2025 at 12:21:02 UTC from IEEE Xplore. Restrictions apply.

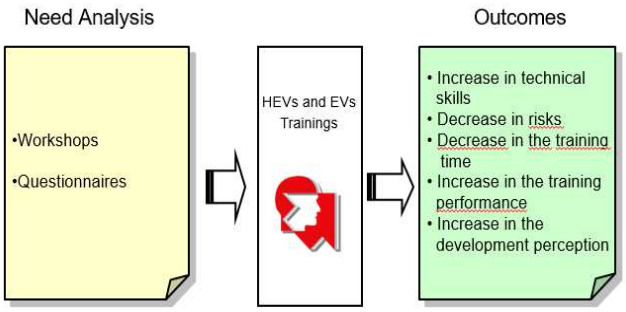

Fig. 1. Goals of the needs analysis.

The needs analysis questionnaire is also administrated to evaluate training methods and educational technology in these trainings. Thus, a roadmap of teaching material development will be established based on the survey results. The questionnaire and how it is administered, and the data analysed is explained under the heading of evaluation.

2) Scale of the needs analysis

The questionnaire that will be used in the needs analysis consists of 25 questions five-point Likert types. While the Likert scale refers to a study that covers all questions, Likert type questions are handled one by one, independently of each other. Although multiple questions are used in studies using Likert-type questions, the researcher does not aim to make a general inference by using the average values of these questions as in the holistic Likert scale [11, 12].

The first five items seek HEVs perceptions and second 15 items test knowledge, skills and abilities, and last five items scrutinize expectations about digital education technology. Having three different factors allow having different evaluations in the analysis including correlations between level of education and knowledge and skills competencies, differences between institutions or countries etc.

The questionnaire form that developed as five-point Likert scale without any judgmental items will be uploaded to Google Forms and submitted all stakeholders. The five-point Likert scale items range from '1' (Strongly disagree) to '5' (Strongly agree).

IV. Findings and Evaluation

A. Needs Analysis Participants

Within the scope of the study, total 440 people (318 from Turkey, 53 from Romania and 69 from Bulgaria) in different position related to Hybrid and Electric Vehicles were surveyed and 389 of the participants are men, 51 are women, and the average age is 26. The stakeholder status or occupational distribution of the participants in Turkey is shown in Fig. 2, and the stakeholder status or professional distribution of the survey participants from Bulgaria and Romania is shown in Fig. 3. As seen in Fig.s, vocational school students comprised a large portion of the respondents from Turkey and engineering students were the first group in the survey from Bulgaria and Romania [11].

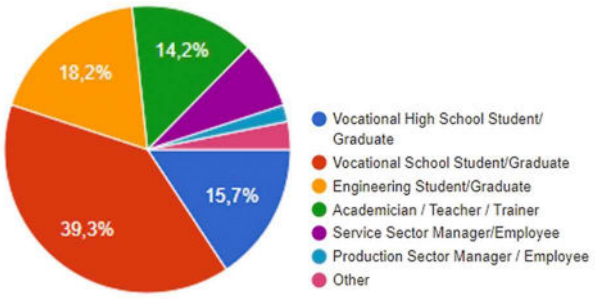

Fig. 2. The distribution of the respondents from Turkey.

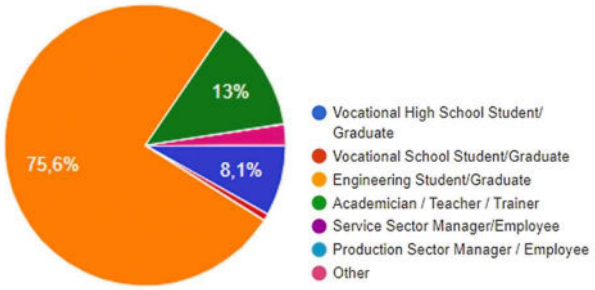

Fig. 3. The distribution of the respondents from Bulgaria and Romania.

B. Statistical Analysis

The results obtained were analyzed using the Excel statistical program (95% confidence interval). In the analysis, a single sample "z" test was applied to determine whether the differences between the data were statistically significant and whether the differences between the data were statistically significant. When the results are examined, the fact that the reliability value is statistically much lower than 0.05 shows that the distribution of the data is meaningful, in other words, the reliability rate is high (Table II).

TABLE II. Statistical Results of the Evaluated Data

Participant	N	Mean ($\bar{x}$)	Std. Deviation	Reliability
440	11000	4.07	0.955	0.0178

The survey data were analyzed based on the question groups focused on three different factors. Fig. 4 shows the mean scores for each item in the questionnaire of Turkey and other participating countries. It is a summary of the results of the study in the three countries participating in the project.

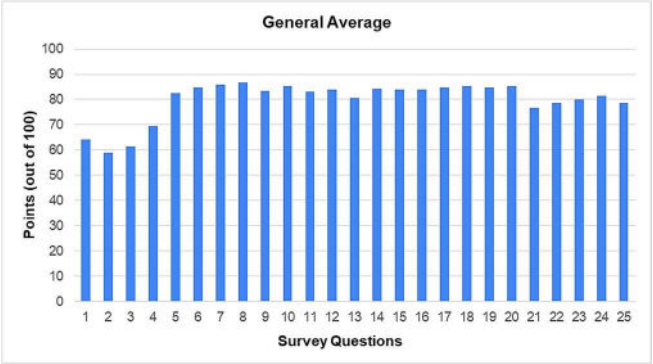

Fig. 4. General Average of responses in Turkey and the other participating countries.

As seen in the Fig. 4 and also the Fig. 5 which shows the same data as line chart, consistent and similar results have

Authorized licensed use limited to: Bursa Uludag Universitesi. Downloaded on December 26,2025 at 12:21:02 UTC from IEEE Xplore. Restrictions apply.

emerged both in terms of each item and general results. This shows us that the topics perceived as need are the same in Romania and Bulgaria in addition to Turkey that is an important finding in scientific terms.

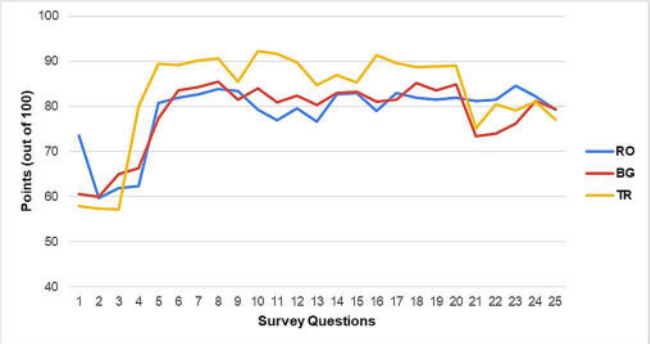

Fig. 5. Comparison of responses in Turkey and the other participating countries.

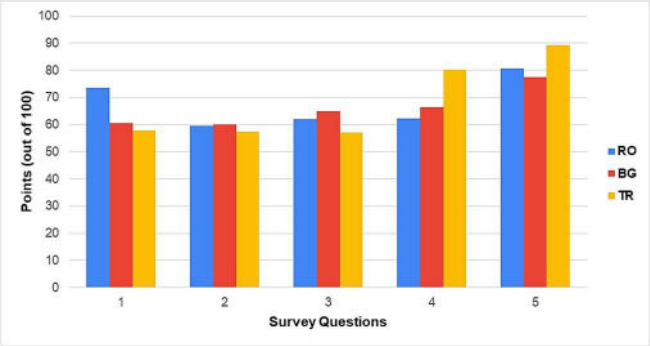

Fig. 6. Responses to the "perception of education" questions.

In the graph in Fig. 6, the answers given to the 5 "perception" questions directed to participants and the order of these answers according to the percentage of need/priorities are shown in Table III.

TABLE III. THE ANSWERS GIVEN TO THE "PERCEPTION" QUESTIONS SORTED BY NEED PERCENTAGE/PRIORITIES.

Qu.	As a Hybrid and Electric vehicle (HEVs) industry stakeholder, for you	%
2	The HEVs training currently provided is sufficient to meet the expectations of the sector	59
3	Adequate resources and hardware infrastructure are used in the HEVs training currently provided	61
1	Currently, the H/E vehicle sector is prepared for market conditions in terms of education infrastructure	64
4	Virtual and Augmented Reality applications that will facilitate troubleshooting in H/E vehicles support employees in taking correct action	70
5	HEVs training contents should include a section on maintenance and occupational safety in electric vehicles	83

It should be noted that the lowest average value in the table is for the questions "The training for hybrid and electric vehicles currently provided is sufficient to meet the expectations of the sector" and "the training for hybrid and electric vehicles currently provided uses adequate resources and hardware infrastructure" with 59% and 61%. Here we need to make more efforts [12]. Another important topic concerns "the preparation of the sector (electric and hybrid vehicles) for market conditions in terms of educational infrastructure". Here the answer is around 64%. Here too it can be seen that there is a 36% gap that needs to be filled.

Finally, we can say that 70%-83% answered the questions "Virtual and augmented reality applications that will facilitate troubleshooting of hybrid and electric vehicles help employees take the right actions" and "The content of hybrid and electric vehicle training should include a section on maintenance and safety when working with electric vehicles". Therefore, this gap can be filled with some work on supporting perceptions on these topics, where high perceptions are formed. Fig. 7 shows the answers to the questions on "knowledge and skills".

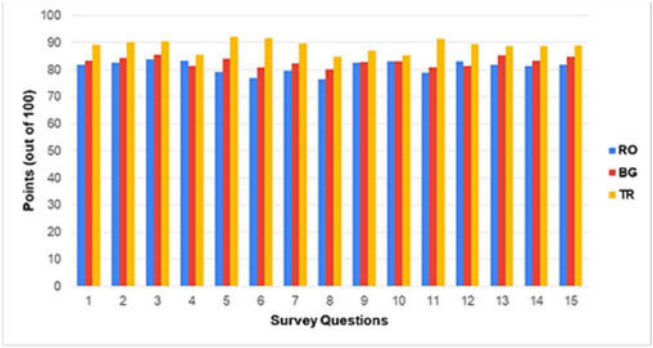

Fig. 7. Answers to the "Knowledge and Skill" questions.

The content of VR/AR digital training materials is shown in Table IV. In it, the materials are sorted according to priority and percentage of needs. Based on these studies, digital training materials for vocational training were later developed.

TABLE IV. THE ANSWERS GIVEN TO THE "KNOWLEDGE AND SKILLS" QUESTIONS SORTED ACCORDING TO THE PERCENTAGE OF NEED/PRIORITIES.

Qu.	The contents of VR/AR supported digital training materials to be developed for Hybrid and Electric (H/E) Vehicle's training include:	%
8	High voltage lines and operating principles used in H/E vehicles should be included	87
7	Power transmission and motion control systems of H/E vehicles should be included	86
18	The ability to use electrical measurement and diagnostic devices with all their functions should be included	85
20	H/E training contents should include a section on maintenance and service occupational safety in electric vehicles	85
10	Battery and charging systems of H/E vehicles should be included	85
6	Design and structural features of H/E vehicles should be included	85
17	General maintenance and service issues should be included in H/E vehicles	85
19	Reading diagnostic fault codes and troubleshooting methods according to these codes should be included	85
14	Engine management and vehicle communication technologies should be included	84
12	Topics related to the structure and operation of automotive electronic control systems should be included	84
15	Vehicle comfort and advanced driving support systems should be included	84
16	In H/E vehicles, issues regarding making the vehicle electrically safe before and after maintenance should be included	84
9	The use and storage of hydrogen in electric vehicles should be included	83
11	Dismantling the batteries from the vehicle, fault detection and repair should be included	83
3	Reading block diagrams and interpreting software algorithms should be included	81

Authorized licensed use limited to: Bursa Uludag Universitesi. Downloaded on December 26,2025 at 12:21:02 UTC from IEEE Xplore. Restrictions apply.

Fig. 8 shows the responses to the “perception of digital training technologies” questions. Here too, the answers obtained from the three countries were found to be close to each other. While Turkey and Bulgaria gave very similar answers to the question "Virtual Reality applications are more useful", the expectation rate was slightly higher in Ro-mania. Similarly, for the question "Augmented Reality applications are more useful", Ro-mania and Turkey gave close expectation answers, while Bulgaria gave a slightly lower expectation answer. In the question "Mixed Reality Applications are more useful", it is seen that technology expectation ranks second on average, with the rate being the highest in Romania.

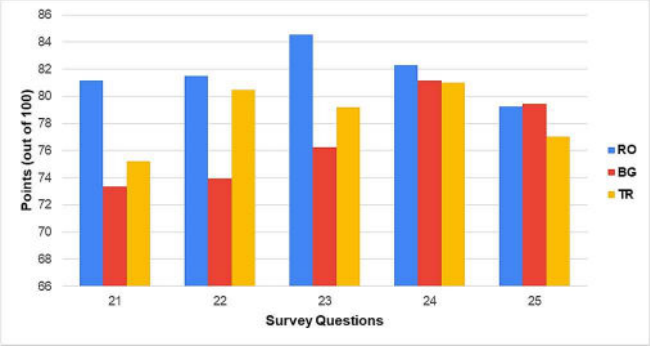

Fig. 8. Responses to the “perception of digital training technologies” questions.

However, the similar and highest expectations in this group were obtained in the question "Applications compatible with mobile devices and tablets are more useful". Similar answers were given to the question "Virtual and Augmented Reality supported QR code e-books are more useful", showing that such an expectation is quite high in terms of developing digital educational materials. Table V illustrates the needs/priorities listed in percentage order of the answers given to the questions “expectations for higher education”.

TABLE V. LISTED ACCORDING TO THE PERCENTAGE OF NEEDS/PRIORITIES OF THE ANSWERS GIVEN TO THE QUESTIONS OF “EXPECTATION OF H/E EDUCATION”.

Qu.	H/E vehicles as digital education tools	%
24	Applications compatible with mobile devices and tablets are more useful	81
23	Mixed Reality Applications are more useful	80
22	Augmented Reality applications are more useful	79
25	Virtual and Augmented Reality supported QR code e-books are more useful	79
21	Virtual Reality applications are more useful	77

V. CONCLUSION

The article describes the analysis of the results of a study conducted to determine the educational infrastructure in vocational training in the field of hybrid and electric vehicles. The aim is to recommend such an educational infrastructure in order to improve the acquisition of knowledge by learners, mainly by using the advantages of virtual and augmented reality technology.

The assessment of the achieved results was made on the basis of the total average values of the answers, constructed in three categories: perception, knowledge-skills and expectations.

The study confirmed the need to develop a modern training infrastructure (by the use of virtual and augmented reality technologies) in the field of vocational education in training on hybrid and electric vehicles. This concerns both the design of such vehicles and their maintenance and repair.

ACKNOWLEDGMENT

The authors would like to thank the Research and Development Sector at the Technical University of Sofia for the financial support.

REFERENCES

[1] R. Arslan, N.T. Uzaslan, “Impact of competency-based and target-oriented training on employee performance: A case study”, Industry and Higher Education, 31(5), pp. 289-29, 2017.

[2] H. Fechtner, E. Fechtner, B. Schmuelling, K.-H. Saes, “A new challenge for the training sector: Further education for working on electric vehicles”, In Proceedings of the IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE), Zhuhai, China, pp. 88-95, 2015, doi: 10.1109/TALE.2015.7386022.

[3] H. Fechtner, K.-H. Saes, E. Fechtner, T. Braun, B. Schmülling, “Clarification of the Training Requirements for Working on Electric Vehicles”, International Journal of Advanced Corporate Learning (iJAC), *9* (1), pp. 35–43, 2016.

[4] R. Arslan, M. Karahan, A. Kuş, M. Şen, C. Kaplan, “Sectoral Needs Analysis to Develop Training Programs for Hybrid and Electric Vehicles”, Recent Journal, *24*, pp. 84-94, 2023.

[5] M. Karahan, R. Arslan, A. Kuş, M. Şen, C. Kaplan, “A Study to Determine Infrastructure Needs for Hybrid and Electric Vehicle Training in Vocational Education”, Recent Journal, *24*, pp. 4-8, 2023.

[6] R. Arslan, M. Karahan, A. Kuş, “A Case Study of Sectoral Vocational Competence and Training Centre; Evaluation of In-Service Teacher Trainings for Hybrid and Electric Vehicles”, Recent Journal, 73, pp. 114-121, 2024.

[7] A. Kuş, R. Arslan, E. Unver, O. Huerta, L. Dimitrov, P. Tomov, Y. Tekin, “An evaluation of technical drawings training needs for developing new training methods”, In Proceedings of the XXVII International Scientific and Technical Conference Automation of Discrete Production – ADP2018", Sozopol, Bulgaria, 26 June, 2018.

[8] N. A. Ashford, “Major challenges to engineering education for sustainable development: what has to change to make it creative, effective, and acceptable to the established disciplines?”, Int. Journal of Sustainability in Higher Education, *5*(3), pp. 239-250, 2004.

[9] E. Crawley, J. Malmqvist, S. Ostlund, D. Brodeur, “Rethinking engineering education. The CDIO Approach”, 2nd ed., Springer, 302, pp. 60-62, 2007.

[10] M. Besterfield-Sacre, M. F. Cox, M. Borrego, K. Beddoes, J. Zhu, “Changing engineering education: Views of US faculty, chairs, and deans”, Journal of Engineering Education, 103(2), pp. 193-219, 2014.

[11] İ. Turan, Ü. Şimşek, H. Aslan, “The use and analysis of Likert Scales and Likert-Type items in Educational Research”, Journal of Sakarya University Educational Faculty, 30, pp. 186-203, 2025.

[12] P. Tomov, “The innovative development base of automation in the industrial sphere”, In Proceedings of the International Conference on Creative Business for Smart and Sustainable Growth, CreBUS 2019, Sandanski, Bulgaria, 2019, doi:10.1109/CREBUS.2019.8840088.

Authorized licensed use limited to: Bursa Uludag Universitesi. Downloaded on December 26,2025 at 12:21:02 UTC from IEEE Xplore. Restrictions apply.