[2023-1-TR01-KA220-VET-000152218]

“Development of VR/AR Assisted Digital Training Materials for Hybrid and Electric Vehicles”

Need Analysis (Survey) Report

Prepared by:

Prof. Dr. Rıdvan Arslan

Prof. Dr. Abdil Kuş

2024

CONTENT

1. INTRODUCTION

The aim of the project “Development of Virtual and Augmented Reality (VR/AR) assisted digital training materials for Hybrid and Electric vehicles” is to develop training content and Virtual Reality supported digital training materials (DTM) using multidisciplinary design based research methodology to improve the teaching/learning performance of Hybrid and Electric Vehicles maintenance and service related topics in Vocational Education and Training.

In the frame of the project studies, basic and advanced standards and principles used in HEVs and EVs education and training are aimed to transfer to virtual/augmented reality (V/AR) environment so that students and employees at all levels can use V/AR applications to understand these topics more easily in three-dimensional environment. For this purpose, in the context of the HEVs manufacturing and servicing sector; the project consisted of certain stages including, the needs analysis carried out in order to identify the most critical subjects and knowledge; the determination of content based on the results of the need analysis; the transfer of the determined contents to the virtual reality environment; and pilot study of the training modules. Determining the priority training topics that are needed in the field with the stakeholders by employing survey methodology and statistical analysis.

2. LITERATURE REVIEW

In parallel with the widespread use of hybrid and electric vehicle production in the world and reaching a significant market share, the training needs of all relevant stakeholders, especially maintenance and service operations, are increasing rapidly, in addition to the routine vocational training of these vehicles. However, it is impossible to say that the vocational education infrastructure that can meet this increasing need is sufficient due to both costs and new technology. This situation has significantly increased the need to maintain and repair these vehicles. Professionals in the motor vehicle and repair industry must be up-to-date on the technological developments that occur with these increases and the critical safety measures implemented in these vehicles. Again, the design of electric vehicles is quite different from conventional vehicles and involves more risks than other vehicles. These risks may be related to the employee's knowledge, experience, and psychosocial situation. In order to minimize employee-related problems, schools and businesses need to develop serious training programs to eliminate this three-way problem [1].

Fechtner H. et al. [2] in their study investigating new methods in electric vehicle education, it is emphasized that the increasing diffusion of electric vehicles causes a new challenge and program development needs for the education sector. For example, applying a high-voltage system to automobiles creates a new potential for danger to working people, necessitating a new and specialized training program. To meet this need, this study presents a student-centered model with a modular approach in which different technologies and occupational safety concepts are integrated. In another study, Fechtner H. et al. [3] investigated the training needs of employees in areas such as technicians and firefighters on electric vehicles, including occupational safety risks. An approach to the development of a unique training program for working on electric vehicles is also presented in this paper. This training program focuses on improving the learning process with a learning concept blended with a modular approach.

In another study; Arslan et al. [4], a comprehensive training needs analysis was conducted to determine the vocational education and training needs of those working in the field of hybrid and electric vehicle technologies, and the findings were evaluated. In the study, 30 questions on a 5-point Likert scale were applied to the participants, which was structured under the headings of perception, knowledge, skills, and expectations about hybrid and electric vehicle

education. 54 sector representatives, 650 students, and 652 vocational high school teachers and administrators participated in the surveys. Interestingly, in the needs analysis results, all three groups provided a similar response in all questions; that is, they stated the exact needs. Therefore, the training programs to be developed based on these results will meet all three priority stakeholder groups' hybrid and electric vehicle training needs. Karahan et al. [5] studied the infrastructure needs analysis findings were made to determine the Vocational Education and Training needs of employees in the hybrid field. Electric vehicle technologies were evaluated and aimed to provide infrastructure for training programs in line with these needs, thereby strengthening the existing education infrastructure.

3. STAKEHOLDER ANALYSIS

To determine methods of development process and to find true answer for these curriculum development questions the stake holder anlaysis should be done. Stakeholder Analysis will be conducted in order 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 get 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.

- The first method is national and international literature review,
- The second method 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 stakeholders are given in Table 1. Stakeholders are sorted according to their roles as clients/ getting service, main partners, and service providers and according to the status of stakeholders as internal stakeholders, external stakeholders, and customers.

The stakeholders identified in this preliminary stakeholder analysis are also the ones to be collaborated to evaluate any improvements in the participants' competencies (i.e. performance analysis) as a result of the material to be developed in the project. The most important group among the stakeholders is undoubtedly clients that mean students. Subsequently, the second largest stakeholder group is service providers consisted of a group of educators which is expected and consistent with the literature [6, 7 and 8].

Table 1. Draft Stakeholders and Distribution by Priority

Stakeholders	How	Why	Priority
Students	Internal	Base Beneficiary	1
Sector Employees	Internal	Beneficery	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	Beneficery and Strategic stakeholder	9

4. NEEDS ANALYSIS

Methodology of Needs Analysis

The need is the gap between the current situation and the desired situation. In a way, it is the difference between "What" and "What should be?" It is a process that would be followed in order to reveal the difference between the current situation and the desired situation in order to develop a curriculum and teaching materials to be achieved consisted of four stages. This process provides a rationale to set priorities and use resources productively.

1. Preparation: Completing the necessary preparations for the Needs Analysis. 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.

2. Data Collection: Gathering information from stakeholders through the Needs Analysis questionnaire.

3. Data Analysis: 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. It will be carried out and the first 5 perception questions will be evaluated in accord with difference approach, then other 20 questions will be evaluated directly to show current situations and expectations as % within the scope of the project. The difference approach accounts for the difference between observed current situation and expected success levels. On the other hand next 20 questions shows the skills, knowledge and technology expectations directly.

4. Reporting the Results: Writing a report with descriptions for each of the identified need. A detailed description of the scope and reasons of the determined needs will be provided, and some solutions are proposed in the report.

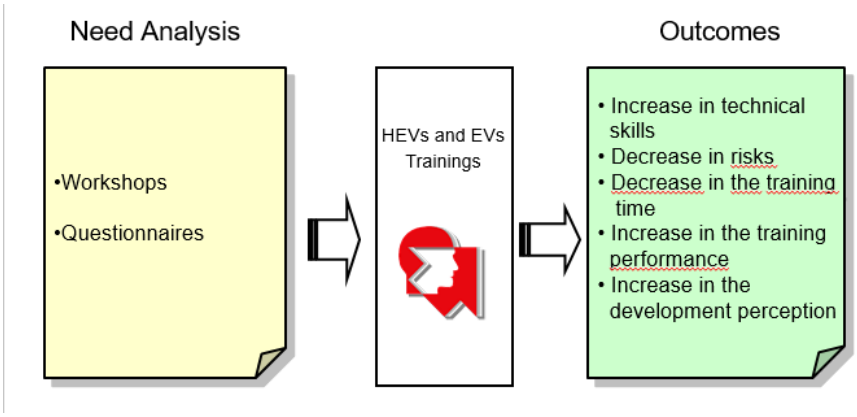

Figure 1. Goals of the Needs Analysis

The needs analysis and basic outputs can be seen in Figure 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. 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.

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 [9].

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. The survey is given in Table 2. 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).

Table 2: The questionnaire items

PERCEPTION	
As a Hybrid and Electric vehicle industry stakeholder, for you…	
1	Currently, the Hybrid and Electric vehicle sector is prepared for market conditions in terms of education infrastructure.
2	The Hybrid and Electric vehicles training currently provided is sufficient to meet the expectations of the sector.
3	Adequate resources and hardware infrastructure are used in the Hybrid and Electric vehicles training currently provided.
4	Virtual and Augmented Reality applications that will facilitate troubleshooting in Hybrid and Electric vehicles support employees in taking correct action.
5	Hybrid and Electric training contents should include a section on maintenance and occupational safety in electric vehicles.
CONTENT (KNOWLEDGE, SKILLS, AND ABILITIES)	
The contents of VR/AR supported digital training materials to be developed for Hybrid and Electric Vehicles training include…	
6	Design and structural features of Hybrid and Electric vehicles should be included.
7	Power transmission and motion control systems of Hybrid and Electric vehicles should be included.
8	High voltage lines and operating principles used in Hybrid and Electric vehicles should be included.
9	The use and storage of hydrogen in electric vehicles should be included.
10	Battery and charging systems of Hybrid and Electric vehicles should be included.
11	Dismantling the batteries from the vehicle, fault detection and repair should be included.
12	Topics related to the structure and operation of automotive electronic control systems should be included.
13	Reading block diagrams and interpreting software algorithms should be included.
14	Engine management and vehicle communication technologies should be included.
15	Vehicle comfort and advanced driving support systems should be included.
16	In Hybrid and Electric vehicles, issues regarding making the vehicle electrically safe before and after maintenance should be included.
17	General maintenance and service issues should be included in Hybrid and Electric vehicles.
18	The ability to use electrical measurement and diagnostic devices with all their functions should be included.
19	Reading diagnostic fault codes and troubleshooting methods according to these codes should be included.
20	Hybrid and Electric training contents should include a section on maintenance and service occupational safety in electric vehicles.
TECHNOLOGY	
H/E vehicles as digital education tools…..	
21	Virtual Reality applications are more useful.
22	Augmented Reality applications are more useful.
23	Video and animation supported applications are more useful.
24	Applications compatible with mobile devices and tablets are more useful.
25	Virtual and Augmented Reality supported.

5. RESULTS

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. 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 Figure 2, and the stakeholder status or occupational distribution of the survey participants from Bulgaria and Romania is shown in Figure 3. As seen in Figures, 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.

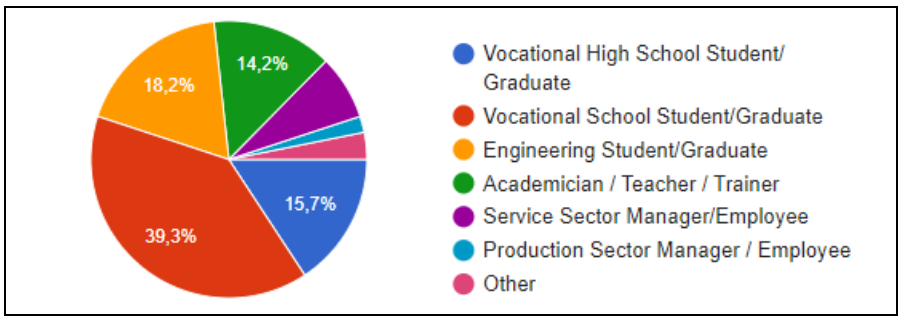

Figure 2. . The distribution of the respondents from Turkey

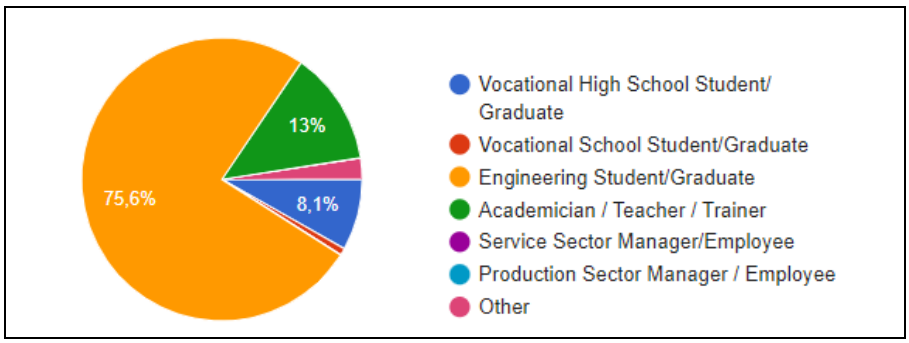

Figure 3. The distribution of the respondents from Bulgaria and Romania

Evaluation

Statistical Analysis

The results obtained were analysed 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 3).

Table 3. 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 analysed based the question groups focused on three different factors. Figure 4 show the mean scores for each item in the questionnaire of Turkey and other participating countries.

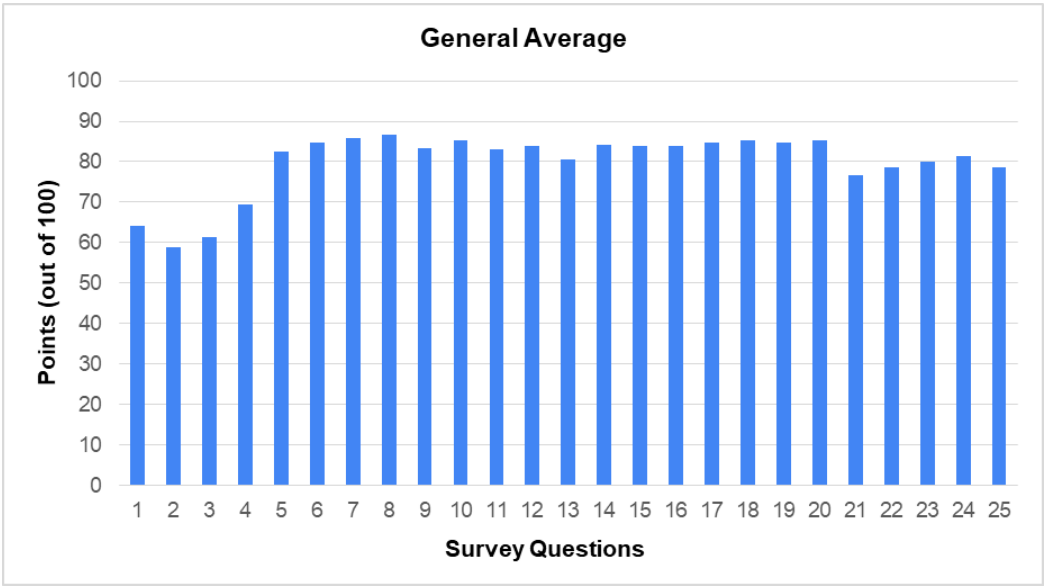

Figure 4. General Average of responses in Turkey and the other participating countries

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

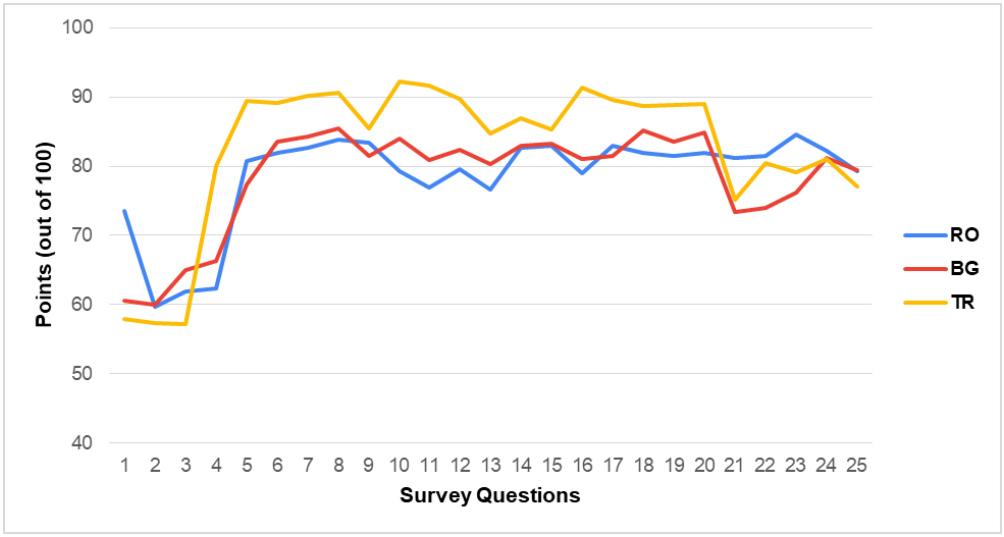

Figure 5. Comparisons of responses in Turkey and the other participating countries

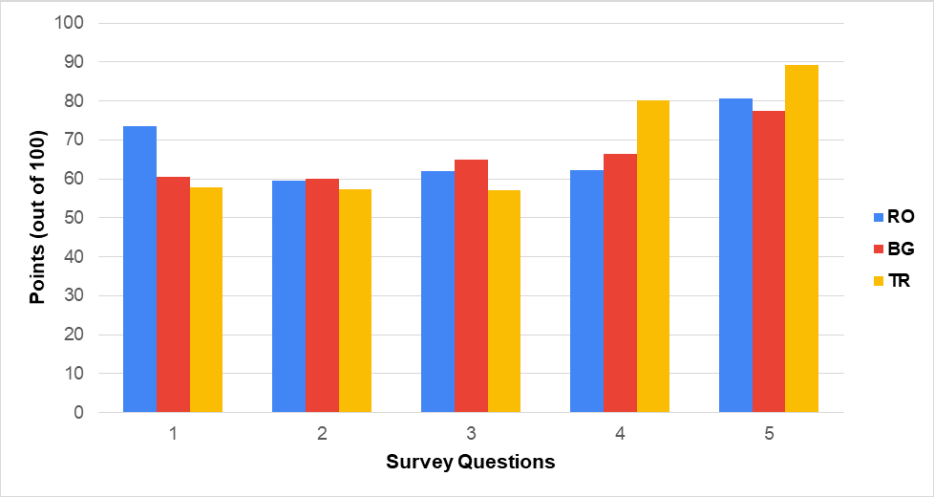

Figure 6. Responses to the “perception of education” questions

In the graph in Figure 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 4.

Table 4. 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 is seen that the lowest average value in the table is in the questions " The Hybrid and Electric vehicles training currently provided is sufficient to meet the expectations of the sector" and "Adequate resources and hardware infrastructure are used in the Hybrid and Electric vehicles training currently provided," with 59% and 61%. It needs to be worked on. Another important topic, “Currently, the Hybrid and Electric vehicle sector is prepared for market conditions in terms of education infrastructure" received a response of 64%. Here, too, it is seen that there is a 36% gap/need that needs to be closed.

At the end of the ranking, 70%-83% answered the questions " Virtual and Augmented Reality applications that will facilitate troubleshooting in Hybrid and Electric vehicles support employees in taking correct action." and " Hybrid and Electric training contents should include a section on maintenance and occupational safety in electric vehicles" such returns. Therefore, this gap can be closed with little perception support work in these topics where high perception is formed.

Figure 7 show answers to the “knowledge and skills” questions.

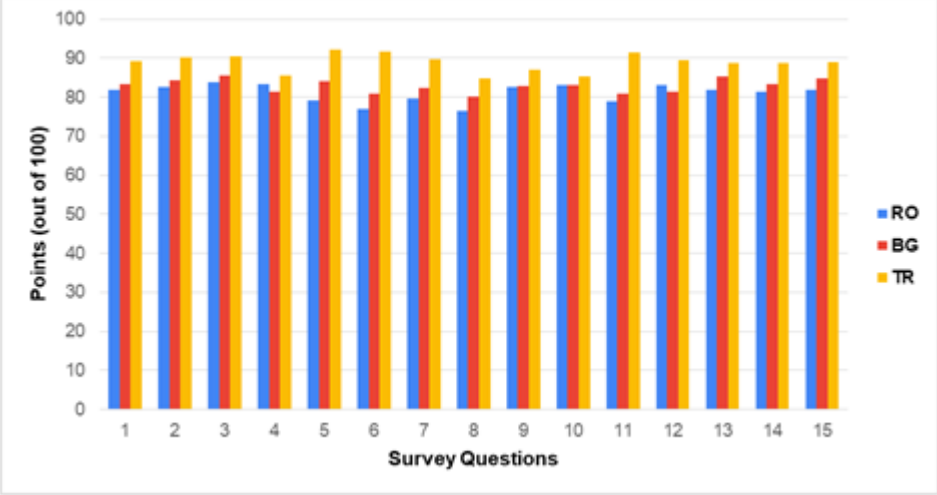

Figure 7. Answers to the "Knowledge and Skill" questions

While evaluating these questions, which were prepared to determine the current knowledge and skill situation and to see the need, instead of analysing one by one, sorting them according to the priority and percentage of needs as given in Table 5, and the priority method in writing the content was based on these results.

Table 5. 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) Vehicles 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
13.	Reading block diagrams and interpreting software algorithms should be included.	81

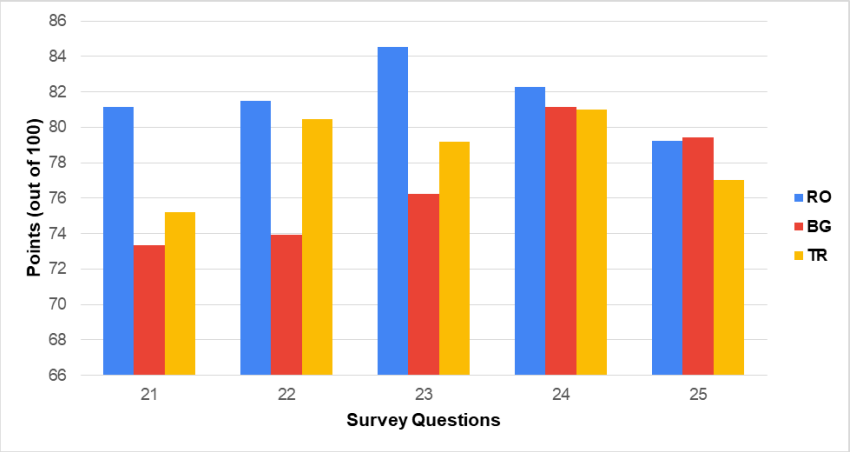

Figure 8. Responses to the “perception of digital training technologies” questions

Figure 8. Show 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 Romania. Similarly, for the question "Augmented Reality applications are more useful", Romania 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.

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 6. Listed according to the percentage of needs/priorities of the answers given to the questions of “expectation of H/E education”

Table 6. 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

Conclusion

This study where a lot of different analyses can be performed constitutes an important database in terms the number of participants, the diversity of the participants and the diversity of the countries. It was also possible to carry out many sub-analyses that were not given in the above findings. Change of differentiation on schools and occupational groups, comparison

between countries, and other results were archived and evaluated in order to use in the content and material development stages of the project. All these evaluations and comments are evaluations made on the general averages of the answers constructed under the headings of perception/knowledge-skill and expectation. These three groups were compared, and it was seen that there was no such breakup or separation, and the results were overlapping. This ultimately confirms the accuracy of the scientific study.

REFERENCES

[1] Arslan, R., & Uzaslan, N. T. (2017*). Impact of competency-based and target-oriented training on employee performance*: A case study, Industry and Higher Education, 31 (5), 289-292.

[2] Fechtner H., Fechtner E., Schmuelling B., Saes K.-H. (2015): *A new challenge for the training sector: Further education for working on electric vehicles.* 2015 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE), Zhuhai, China, 2015, pp. 88-95, doi: 10.1109/TALE.2015.7386022, https://ieeexplore.ieee.org/document/7386022

[3] Fechtner H., Saes K.-H., Fechtner E., Braun T., Schmülling B. (2016): *Clarification of the Training Requirements for Working on Electric Vehicles*. International Journal of Advanced Corporate Learning(iJAC), eISSN 1867-5565, Vol. 9, no. 1, pp. 35–43, https://doi.org/10.3991/ijac.v9i1.5635

[4] Arslan R, Karahan M., Kuş A., Şen M., Kaplan C. (2023) *Sectoral Needs Analysis to Develop Training Programs for Hybrid and Electric Vehicle*s, Recent Journal, Universitatea Transilvania Brasov (24), 84-94

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

[6] Ashford, N. A. (2004). *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), 239-250.

[7] Crawley, E., Malmqvist, J., Ostlund, S., & Brodeur, D. (2007). *Rethinking engineering education*. The CDIO Approach, 302, 60-62.

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

[9] Turan, İ., Şimşek, Ü., & Aslan, H. (2015). *Eğitim araştırmalarında likert ölçeği ve likert-tipi soruların kullanımı ve analizi.* Sakarya Üniversitesi Eğitim Fakültesi Dergisi, (30), 186-203.