RECENT J. (2024), 73:114-121
https://doi.org/10.31926/RECENT.2024.73.114

A Case Study of Sectoral Vocational Competence and Training Centre; Evaluation of In-Service Teacher Trainings for Hybrid and Electric Vehicles

Ridvan ARSLAN
Bursa Uludağ University, Türkiye, ridvan@uludag.edu.tr
Mehmet KARAHAN
Bursa Uludag University, Türkiye, mkarahan@uludag.edu.tr
Abdil KUŞ
Bursa Uludağ University, Türkiye, abdilkus@uludag.edu.tr

Abstract
New Generation Hybrid and Electric vehicle production is rapidly increasing worldwide as a cleaner and sustainable alternative. This rapid change has significantly increased the needs for maintenance and repair of these vehicles. In order to meet this need, infrastructure and material development studies for new generation vehicle technologies trainings are intensively carried out all over the world. In this study, 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 Türkiye, 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. The results obtained show that the content, training material and infrastructure developed within the scope of the project make significant contributions to people's learning and teaching performances.

Keywords
electric vehicles, hybrid vehicles, vocational training, performance measurement

1. Introduction

In parallel with the car manufacturers in the world, it has made a rapid entry into the electric automobile industry with the TOGG brand in Türkiye. This rapid sales potential of both domestic production and imported vehicles has also significantly increased the needs for maintenance and repair of these vehicles. Therefore, professionals working in the motor vehicle and repair industry need to have up-to-date information on the technological developments that occur with these increases and the critical safety measures implemented in these vehicles. Due to their structural and hardware features, electric vehicles pose a higher risk of electrical accidents or fire than internal combustion engine vehicles. These risks may vary depending on the knowledge, experience and current psychosocial state of those working on electric vehicles. In order to minimize employee-related problems, schools and businesses need to develop serious training programs [1]. In addition, in-service teacher training that provides vocational education has a large and positive impact on teacher performance. Effective training brings improvement in the productivity and performance of employees due to the acquisition of new knowledge and skill [2]. Arslan et al. [3] evaluated the findings obtained by conducting a comprehensive training needs analysis to determine the vocational education and training needs of employees in the field of hybrid and electric (H/E) vehicle technologies. In this study, a 5- point questionnaire was given to the participants under the headings of perception, knowledge, skills and expectations regarding H/E tools training. A survey of 30 questions on a Likert scale was applied. 54 sector representatives, 650 students and 652 vocational high school teachers participated in the surveys. In the needs analysis results, all three groups provided similar responses to the questions, that is, they stated their needs in the same percentages. Based on these results, it is predicted that the training programs to be developed

will meet the H/E vehicles training needs of all three priority stakeholder groups. Similarly, Karahan et al. [4] evaluated the findings of the infrastructure needs analysis conducted to determine the vocational education and training needs of employees in the field of H/E and electric vehicle technologies. Within the scope of the study, a survey was conducted with 458 vocational high school teachers and administrators across the country. According to the results obtained, the infrastructure, hardware and other equipment that should be present in the schools or centers where H/E training will be provided were determined. A study was conducted by Saleet et al. [5] regarding the needs of professionals who will work in the field of maintenance and service, which emerged with the promotion of the H/E vehicle market in Jordan. The surveys used in the study targeted key stakeholders from different geographical regions in Jordan and were administered to academic staff and students from eight universities. According to the data obtained from the study, training needs were determined and suggestions developed and the results discussed.

Pandjatian et al. [6] investigated the impact of teachers' approach methods to students on the adoption of electric vehicles and technological innovations in vocational high school education. One of the results of the study is that the type and quantity of student-centered teaching approaches implemented by teachers have a significant impact on teaching electric vehicle technology topics among vocational high school students. In the research results, student-centered education was ranked at 37.7%, classical education method at 30.6%, and both individual teaching approach and group work teaching methods were ranked at around 31.5%. According to Adam et al. [7], it is necessary to simplify and strengthen the training of vocational high school teachers to improve their competencies by providing them with knowledge and skills regarding electric vehicle maintenance and repair using a multi-training approach. For this purpose, the multi-approach methods used in their studies include discussion, explanation, question-answer, demonstration and applications on electric vehicles and their components. In the evaluation, pre-test post-test performance tests and teachers' success level based on knowledge and skills showed an 80% increase in competence with this method. Fechtner et al. [8] in studies investigating new methods in electric vehicle education, it is emphasized that the increasing spread of electric vehicles causes a new challenge and program development needs for the education sector. For example, the application of a high voltage system to automobiles creates a new danger potential for working people, which creates a need for a new and special training program. In the study, a modular approach and student-centered model in which both different technologies and occupational safety concepts are integrated and presented to meet this needs. In another study, Fechtner et al. [9] investigated the training needs of employees in fields such as technicians and firefighters on electric vehicles, including occupational safety risks. An approach to developing a special training program for working on electric vehicles is also presented in this paper. The focus of this training program is on improving the learning process with a blended learning concept with a modular approach.

In this study, the contribution of the training given to vocational high school teachers at the New Generation Vehicle Technologies Sectoral Vocational Education and Training Competence and Development Centre established in Bursa to the competencies of teachers and the effects of the training on people's learning performance were evaluated.

2. New Generation Vehicle Technologies Sectoral Vocational Competence Training Centre

In this study, the training activities carried out within the scope of the EU “New generation Vehicle Technologies Sectoral Vocational Competence Training Centre" project carried out jointly by Bursa Chamber of Commerce and Industry (BTSO) and BTSO Education Foundation (BUTGEM) were evaluated. The project aims to establish a Sectoral Center of Excellence in the field of H/E Autonomous Vehicles, strengthen the existing education infrastructure, prepare in-service training programs and training materials for New Generation Vehicle technologies, and strengthen the capacity of vocational teachers with a mixed education model.

Within the scope of the project, a fully equipped professional competence center of excellence was established in the first phase, where in-service training will be provided to field teachers affiliated with the Ministry of National Education (MEB). The workshop-laboratory and hardware infrastructure of the center was created by working with both needs analysis outputs and examples from around the world.

In addition, in order to meet the Vocational Education and Training needs of those working in the field of H/E vehicle technologies, training contents were developed by taking the feedback of academicians, vocational training managers and teachers, sector representatives and students, and then training materials and documents were prepared. Figure 1 shows the book and presentation file covers produced within the scope of the project.

Fig. 1. Publications produced within the scope of the project are published by Arslan et al. [10]

It is necessary to measure the performance and competency increase contribution of the training in order to test the infrastructure facilities of the project and to observe to what extent it responds to the training needs of teachers. In this context, 12 different in-service trainings given in Table 1 were successfully completed with the participation of 257 teachers. Some pictures of the trainings are given in Figure 2.

Table 1. In-service training modules

	Training Name	Hours
1	Electric Motor Vehicles Technology	80
2	Fuel Cell Battery Charging Systems	40
3	Electric Vehicle Conversion and Renovation Technologies	40
4	Hybrid Motor Vehicles Technology	80
5	Power Transmission and Motion Control Systems in H/E Vehicles	40
6	Autonomous and Advanced Driving Support Systems	80
7	Vehicle Communication Technologies	40
8	Vehicle Electronics; Vehicle Comfort Systems	40
9	Automotive Electronics	40
10	Maintenance Troubleshooting in Automotive Electronics	40
11	Embedded Systems in Automotive Electronics	40
12	Vehicle Diagnostics and Troubleshooting	40

Within the scope of the project, original Virtual Reality (VR) applications have been developed to ensure that these technology products can be accessed easily and free of charge in our country as a cheaper and more accessible solution to the high cost of physical workshop/laboratory installation and equipment supply for H/E vehicle training in the world, and the use of these applications in in-service trainings shared with the participants.

Fig. 2. Pictures of the training given within the scope of the project

3. Material and Method

In this study, educational measurement and evaluation studies were carried out to determine the effects of the infrastructure and materials developed within the scope of the project on people's learning performance. For this purpose, the trainings held at the BUTGEM training center between June and September 2023 and the participants of these trainings constituted the population of the study. Two different methods have been applied to measure and evaluate the scientific contribution to the education and learning performance of the established infrastructure, developed contents and different teaching materials or programs. These are:

1) Academic success measurement: The data obtained by comparative success measurement with the pre-test-post-test exams applied for each education were used in academic success evaluation;
2) Training Performance measurement: The measurement of training performance was determined as a quasi-experimental method with a pre-test-post-test control group with a performance measurement survey applied to those who received training and those who did not;
3) In order to evaluate the educational success and its contribution to people's competencies with a simple experimental measurement method, a comparative competency analysis was conducted between teacher groups who received and did not receive training. For this purpose, firstly, a scale to be used for performance measurement was developed and the results were analyzed and evaluated with statistical programs;
4) A random experimental design with a post-test control group was used to evaluate the content and education model developed within the scope of the study and the classical education given with similar content. In this method, a 5-item questionnaire consisting of 30 questions is used. A survey prepared on a Likert scale and equivalent to the questions used in the needs analysis was applied to the experimental and control groups via Google survey.

4. Findings and Evaluation

4.1. Academic success measurement

The academic achievements of those who participated in in-service training were measured by pre- and post-tests in each course. Exams are prepared by instructors according to the nature of the education, whether test or classical. A total of 257 teachers participated in this measurement study in 20 separate in-service trainings. However, in the statistical analysis, the "autonomous driving techniques" training, which included four participants, was not included in the pre-post-test analysis for the sake of accuracy, so the statistics were made on 253 participants. Excel independent samples *t*-test (95% confidence interval) was used to compare the participants' pre-test and post-test results. As seen in Table 2, the *t*-test results were 2.07 and the p value was found at 2.71E-07.

In the Table 2, it is seen that the standard deviation values are much higher than the average, especially in the pre-tests, which indicates that the group has a heterogeneous (different) structure in terms of the measured feature. Indeed, there are serious fluctuations between the pre-tests of the participants who received the same module training. This shows that some of the teachers already have the infrastructure to provide these trainings and that some of them do not have any knowledge and skills in this regard.

Table 2. Independent *t*-test results pre-test – post-test

	N	*Cover.* $\bar{x}$	*St. Deflection*	*t*	*P (2-lead)*
Pretest	253	44.57	148.06	2.08	2.71E-07
Post-test	253	85.16	103.19		

Figure 3, the overall average academic level of the participants increased by 91.07% at the end of the training compared to the moment they started the training. This evaluation was obtained from the academic results of 257 participants in 12 separate trainings and 20 trainings in total, including the repeated trainings given in Table 1. These results, as average academic success, represent very serious values in terms of the contribution of the trainings to the personal knowledge of the participants.

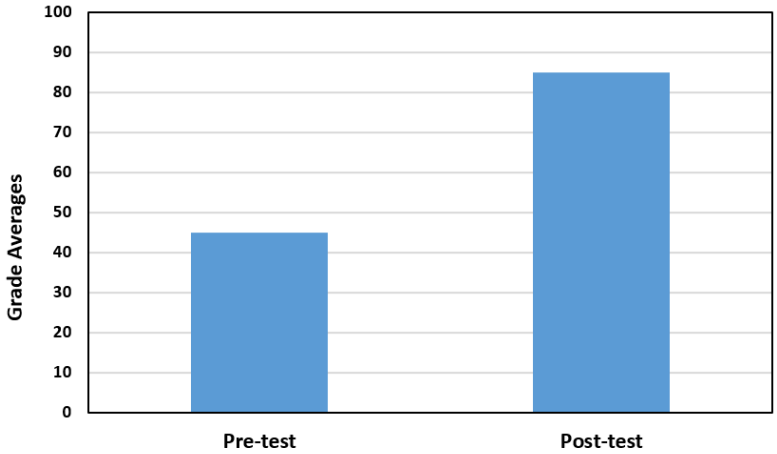

Fig. 3. Pre-test and post-test academic achievement comparisons of all trainings

On the other hand, it is a fact that this average will not be the same for every education. For this reason, pre-test – post-test comparisons based on training topics are given in Figure 4.

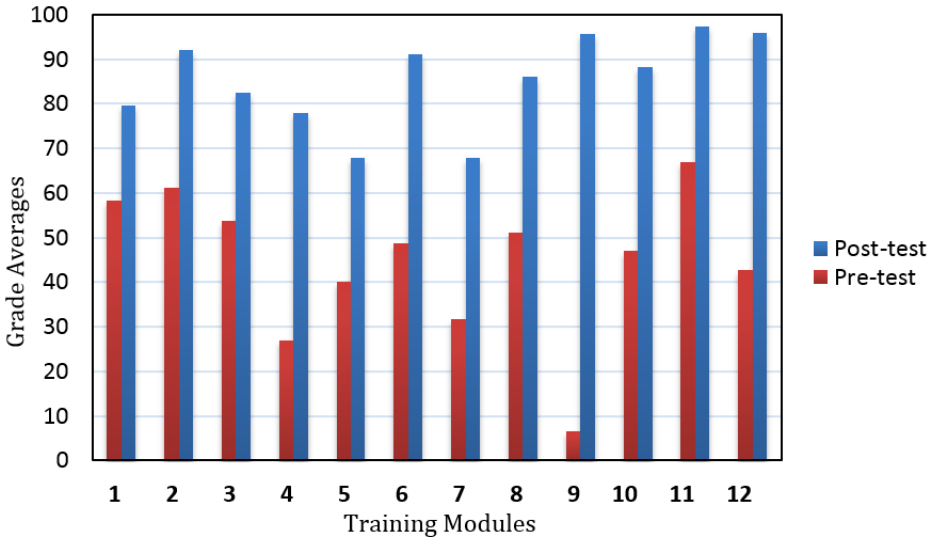

Fig. 4. Pre-test and post-test academic achievement comparisons for each training

The results obtained are quite interesting and noteworthy. For example, while the difference between pre-tests and post-tests in Vehicle Communication Technologies training is as high as 189%, this difference decreases to around 70 % in Automotive Electronics training. The obvious meaning of this is: participants have been teaching Automotive Electronics and Maintenance malfunction courses for years and have already been doing practical applications, and there is no significant difference in these matters with H/E vehicles. The contribution here is the contribution of updated knowledge and skills that directly supports the infrastructure.

The difference seen in Autonomous Driving Techniques, which was not evaluated because it was anticipated that it would be statistically misleading, was due to the fact that there were 4 participants in this training and they gave almost no answers in the pre-tests. It is clear that more participants are needed for scientifically meaningful results, however, there are topics such as Communication Systems where the knowledge and skills of the participants are much less and their gains are high.

There are trainings that will bring a different perspective to the evaluation, for example, while the preliminary tests of Embedded Systems in Automotive Electronics were expected to be low, a result of 48% was obtained and the training was completed with an average of 91%. Here it is revealed in both practical dialogues and academic measurements that the instructors who prefer education are those who have a special interest in software.

4.2. Performance measurement

In order to measure the increase in the educational performance (competence) of vocational high school teachers who participated in in-service training, 30 survey questions prepared on a 5-point Likert scale were used in the needs analysis conducted during the program development phase within the scope of the project [4]. Thus, it was evaluated to what extent the needs that teachers felt were met, in other words, to what extent their competencies increased. Naturally, it is difficult to measure the impact of such training on working life. For this reason, a random experimental design with a post-test control group was used to evaluate the content and educational model developed within the scope of the study. In this method, subjects are randomly assigned to groups and no pre-test is applied for comparison before the application. Again, in this method, those who participated in the training constitute the experimental group and those who did not participate in the training constitute the control group. Excel to compare the performance of those who attended and did not attend the training independent samples t-test (95% confidence interval) was used.

Excel independent sample t-test (95% confidence interval) was used to compare the test results of the participants. As seen in Table 3, the "*p*" value was obtained as .000124. These results show that the data is healthy and therefore the evaluation will be meaningful.

Table 3. Independent t-test results for those who did not trained and those who trained

	N	*Cover* $\bar{x}$	*St. Deflection*	*t*	*p (2-lead)*
Untrained	652	2.89	0.33	2.00	0.000124
Trained	113	3.48	0.28		

The study was conducted with 652 people who did not receive training and 113 people who attended training. The performance measurement results of the study, consisting of 3 subheadings and 30 questions prepared on a 5-point Likert scale, are given in Figure 5. The survey results of the groups were found to be 3.48 out of 5 for the experimental group and 2.89 for the control group. This indicates a 20.41% higher learning performance in the experimental group compared to the control group. However, it is useful to examine this evaluation in detail in terms of perception-knowledge/skills and expectation performances separated in the survey.

The performance increase of those who received training under the title of perception is 18% compared to those who did not receive training. In other words, an 18 % increase was achieved in the perceptions of the participants. The most noticeable question in this heading and where the highest performance increase was achieved was "You have the technical knowledge and skill competencies to provide H/E Vehicles training" with a perception increase of 49.04%. This result alone is an indication that a significant success has been achieved with the project.

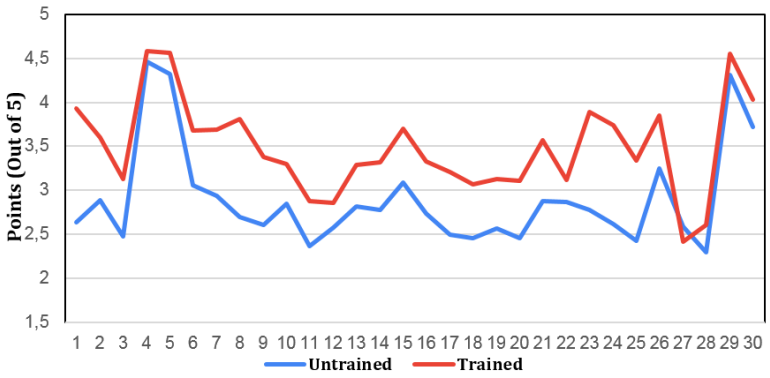

Fig. 5. Performance analysis results compared with Needs Analysis

The performance increase value obtained from 20 questions asked under the title of knowledge and skills is 24.44%. It should be taken into account here that the participants of the training attended different modules and all questions were answered without discrimination. In other words, the person who did not participate in the autonomous driving training also answered the question about that training. This method was preferred because the same questions were asked to those who did not receive training, regardless of their competence, and therefore it would be more meaningful to make a scientific comparison with the same questions. In detailed analysis, we see that those who attended the relevant training showed much higher performance on questions related to their training.

Again, when we look at the two questions where the highest gain was achieved between those who received training and those who did not receive training under this heading, we see the following. Participants showed an increase in knowledge and skills of 40.74% in response to the question "Do you know and distinguish the high voltage lines and battery systems of H/E Vehicles in terms of their types and functions?" Again, “H/E You know the risks posed by dangerous electrical high voltage in vehicles and the precautions to be taken” in the question, this rate is 40.88 %. Just these two questions show a performance increase of up to 40 % in the basic knowledge and skills that are intended to be given to the participants within the scope of the project.

Finally, we see that the increase rate in the answers given by the participants to the expectation questions was determined as 12%. The result here is interesting because we see that the expectations of those who received education were met compared to the expectations of those who did not receive any education, and we can say that their expectations decreased by 12%. At this point, one of the most interesting results is the expectation that decreased by -6.20%. "You think that H/E Vehicles basic training can also be given via distance education method" we see it in the question. Participants declare that as a result of the training, their expectations that these trainings cannot be given remotely have decreased. This result is something that should be taken into consideration and studied.

As a result, these results are very important in terms of showing the change in the participants' knowledge, skills and behaviors regarding H/E vehicles and the significant increase in performance of the infrastructure, training programs and in-service trainings created.

5. Conclusion

The measurement and evaluation results of the trainings carried out within the scope of the project in order to increase the knowledge and skills of vocational education teachers about current issues in the field of H/E vehicles show that the trainings provide high added value to the teachers. It is envisaged that the infrastructure established within the BTSO Education Foundation BUTGEM will serve for many years to increase the competencies of individuals in need of training in the public and private sectors all over the country, and especially those who carry out maintenance service operations of H/E vehicles, following the in-service training of vocational high school teachers.

Acknowledgements

This work, within the scope of the "New Generation Vehicle Technologies Sectoral Vocational

Competence Training Centre" project numbered TREESP2.1.IQVETIII/P-03/38 of the European Union, was carried out carried out jointly by BTSO and BTSO Education Foundation.

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, eISSN 2043-6858, Vol. 31, is. 5, pp. 289-292, https://doi.org/10.1177/0950422217715199
2. Asghar M.Z., Afzaal M.N., Iqbal J., Waqar Y., Seitamaa-Hakkarainen P. (2022): *Evaluation of In-Service Vocational Teacher Training Program: A Blend of Face-to-Face, Online and Offline Learning Approaches*. Sustainability, ISSN 2071-1050, Vol. 14, is. 21, art. 13906, https://doi.org/10.3390/su142113906
3. Karahan M., Arslan R., Kuş A., Şen M., Kaplan C. (2023) *A Study to determined infrastructure needs for Hybrid oath electricity Vehicle Training in Vocational Education*. RECENT, eISSN 2065-4529, Vol. 24, is. 1(69), pp. 4-8, https://doi.org/10.31926/RECENT.2023.69.004
4. Arslan R., Karahan M., Kuş A., Şen M., Kaplan C. (2023): *Sectoral Needs Analysis to Develop Training Programs for Hybrid and Electric Vehicles*. RECENT, eISSN 2065-4529, Vol. 24, is. 2(70), pp. 84-94, https://doi.org/10.31926/RECENT.2023.70.084
5. Saleet H., Aldamsah A., et al. (2023): *Importance and Barriers of Establishing Educational/Training Programs in Electric Vehicles/Hybrid-Electric Vehicles in Jordan*. World Electric Vehicle Journal, ISSN 2032-6653, Vol. 14, is. 9, 232, https://doi.org/10.3390/wevj14090232
6. Pandjaitan R.H., Dewi I.R. (2021): *The Influence of Teachers' Approaching Obstacle on the Adoption Technological Innovation within the Electric Vehicle among the Vocational High School Educations*. Psychology and Education, ISSN 0033-3077, Vol. 58, is. 2, pp. 6058-6071, https://doi.org/10.17762/pae.v58i2.3082
7. Adam R., Permana T., Sukrawan Y. (2022): *Online and Offline Training of Electric vehicle Technology for Automotive Productive Teachers at Smkn Al Mufti, Subang Regency*. ABDIMAS: Jurnal Pengabdian Maslamakat, eISSN 2614-8544, Vol. 5, is. 1, pp. 1601-1604, https://doi.org/10.35568/abdimas.v5i1.1659
8. Fechtner H., Fechtner E., Schmuelling B., Saes K.H. (2015): *A new challenge for the training sector: further education for working on electric vehicles*. In 2015 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE), e-ISBN 978-1-4673-9226-6, pp. 88-95, DOI:10.1109/TALE.2015.7386022
9. Fechtner H., Saes K.H., Fechtner E., Braun T., Schmülling B. (2016): *Clarification of the Training Requirements for Working on Electricity Vehicles*. International Journal of Advanced Corporate Learning, eISSN 1867-5565, Vol. 9, is. 1, pp. 35-43, https://doi.org/10.3991/ijac.v9i1.5635
10. Arslan R, Kuş A., Karahan M. (Eds.) (2023): *Hibrit ve Elektrikli Taşıt Teknolojileri* (*Hybrid and Electric Vehicle Technologies*). Ekin Publishing House, ISBN 978-625-6460-15-7 (in Turkish)