Methodology of using mobile apps with augmented reality in students' vocational preparation process for transport industry

Olena O. Lavrentieva[1,2][0000-0002-0609-5894], Ihor O. Arkhypov[1][0000 0003 3002 6431], Oleksandr P. Krupskyi[3][0000-0002-1086-9274], Denys O. Velykodnyi[1][0000-0001-6375-5775] and Sergiy V. Filatov[1][0000-0002-1771-4734]

[1] Kryvyi Rih State Pedagogical University, 54 Gagarin Ave., Kryvyi Rih, 50086, Ukraine
[2] Alfred Nobel University, 18 Sicheslavska Naberezhna Str., Dnipro, 49000, Ukraine
[3] Oles Honchar Dnipro National University,
35 Vladimir Mossakovsky Str., Dnipro, 49000, Ukraine
helav68@gmail.com

Abstract. In the paper the current state and trends of use AR technologies in transport industry and in a future specialists' vocational training process have been reviewed and analyzed. The essence and content of the AR technologies relevant to transport industry have been clarified. The main directions of the AR introduction for the various spheres of transport industry including design and tuning, mechanical and automotive engineering, marketing and advertising, maintenance and operation, diagnostics and repair of cars have been determined. The AR mobile apps market and the features of the mobile apps with AR have been outlined. The pedagogical terms of effective organizing the students' cognitive activity for transport industry via AR technologies have been determined and researched, namely: to provide each student with the position of an active actor of study and cognitive activity, to switch the study information in a mode of the project activity, the educational content professionalization and to teach students to use the modern ICT purposefully, to manage students' cognitive process by means of ICT. The methodology of using mobile apps with AR in students' vocational preparation process for transport industry has been presented. It covers the system of educational tasks, updated content of lectures, practical and laboratory classes for specialized disciplines.

Keywords: vocational training, ICT in transport industry, students of transport area of expertise, mobile learning, AR technologies.

1 Introduction

Today is the era of computer-rich life. Thanks to developments in IT industry, materials in science and cybernetics, the fields of modern manufacturing, business, medicine, advertising, design, engineering and science are widely deploying augmented (AR) technologies and virtual reality (VR). With the development of smart technology, there are many mobile apps with AR and VR that are unfortunately mostly used for entertainment. The flagships of the transport industry and world-renowned manufacturers implement the benefits AR technology as tools and advertising to improve and enhance the design and tuning, engineering and automotive, marketing and advertising, vehicles maintenance, automotive repair and operation. The scientific and technical laboratories of BMW Group, Bosch, Caterpillar, Genesis, Hyundai, Porsche, Volkswagen, Volvo Group and others focus considerable attention to the training of staff and clients to use modern ICT in the operation and repair of vehicles, as well as the arrangement of transportations. This fact, in turn, highlights the problem of updating the content of future specialists' vocational training for transport industry.

Meanwhile, in the practice of vocational training there are some contradictions. One is between rapid development of computer focused pedagogical and industrial technologies and low efficiency of their use in the practice of students' vocational training for transport industry. Yet another is between personal orientation of the vocational training process and insufficient working up of methodological supply for the shaping of the future specialists’ professional competencies via VR and AR technologies.

The purpose of the paper is to review and analyze the current state and prospects of using AR technologies in the transport branch, as well as presentation of the methodology of usage the mobile apps with AR during the students' vocational training process for transport industry.

2 Materials and methods

Today, the training of specialists for transport industry is considered as one of the priorities of national education. However, as Valentyna V. Kochyna points out, one of the most significant problems in the professional education in the transport area of expertise is the predominance of theoretical learning. Courses and disciplines that are offered to students are not always based on up-to-date information and do not realize the necessary types and methods of professional activity [20]. As a result, the students do not have a clear idea of the future profession and the requirements that are made in the transport field in practice. The lack of hands-on training eventually leads to the fact that a sufficiently successful student is unable to carry out professional functions and withstand high competition in the labor market.

Ihor O. Arkhypov [23], Victor V. Aulin [4], Nataliia O. Briukhanova [7], Roman M. Horbatiuk [15], Igor E. Kankovskii [18], Olena E. Kovalenko [21], Yuri M. Kozlovskii [22], Olexander P. Krupskyi [14], Olexander I. Kuchma [23], Olena O. Lavrentieva [29], Olexiy V. Pavlenko [27], Aleksandr D. Uchitel [11], Denys O. Velykodnyi [5] and others emphasize in their works the need to create terms for mastering by students all types of professional activity (that means automotive design, operational, repair, logistics, organizational and management etc.) including the implementation of modern VR and AR technologies. Researchers point out the requirement to use special software, to create on its basis complete environments to shape importance for students' professional competences in transport area of expertise [18; 22].

To create a fundamentally new vocational training methodology with AR technologies we have explained the significant experience and real achievements of the world's automotive brands – BMW Group [6], Bosch [8], Caterpillar [34], Genesis [16], Hyundai [17], and Volvo Group [37]. It has been also taken into account the considerable technical and information supply in this context, provided by the scientific and technical centers of Apple [1], Google [13], Microsoft and others [25]. Some aspects and technologies which are widely covered in the publications by scientists of Sumy State University [39], Kryvyi Rih State Pedagogical University [32], Kryvyi Rih National University [19], company HQed [3], as well as Chris Bruce [9], Masahiro Hara [12], John Lyon [24], Yevgen Paschenko [26], Serhiy O. Semerikov [31] and others have been considered. However, all learning innovations will confront with opposition from the teaching staff until the external stimulating influences and the lecturers' own needs for educational services will be in consensus [14].

The study of existing experience and the review of online sources have shown increasing introduction e-learning and mobile technologies into the educational process of future specialists' vocational training for transport industry. It should be noting the pedagogical effectiveness of mobile apps with AR is currently underestimated [25]. However, nowadays, with the growing development of the smartphone technical base, free or shareware educational, information and advertising software products for transport branch are widely distributed by means of Google services [13].

Further, the essence and content of AR technologies that are actual to the transport industry, will be revealed; the directions of their implementation for different areas of transport branch will be outline; the market of mobile apps with AR, as well as the experience and methodology of using such software in the practice of students' vocational training process for transport industry will be determined.

3 Theoretical background

Modern advanced AR technology has many varieties. However, all existing diversity used in the transport industry can be divided into four main types. These are marker-based technology, markerless, projection-based, and overlay or superimposition-based ones [32].

Marker-based AR or image recognition technology can use as a marker anything from QR-code to special characters (like those worked out by the Volvo Group). In some cases, the AR device also calculates the marker's position and orientation for the content or content placement. Accordingly, the marker initiates digital animations for viewing by the user, resulting in images being transformed in 3D models [26].

Despite some evident benefits of marker-based AR, their visual appearance like black marker turned out unattractive for users. This fact had reduced the popularity of marker-based AR solutions in the market and so the *markerless AR* was specifically developed for commercial usage [32]. Sometimes such modern technologies are also called coordinated or GPS oriented ones. To provide data, they may exploit a GPS, a digital compass, a speed sensor, or an accelerometer equipped by a computer device. Thanks to the smartphones and tablet PC widespread, such technologies are extensively used to identify destinations, to find the right places like office or point of a cargo delivery, as well as in the location-based apps to monitor the vehicle.

Projection-based AR exploits a video projector to display information on a screen or on various physical surfaces. At the heart of this technology is the exploitation of real-world objects as a base for the projection of virtual images. It is usually used in industrial warehouses, factory shops, as well as for objects of logistic chain to visualize products, goods, cargos, cars etc. It should be noted the portable projection-based AR has certain disadvantages in terms of the quality of projection on heterogeneous surfaces of unusual shape due to differences in reflectance, color, and geometry [32].

Overlay or superimposition-based AR performs full or partial replacement of the original real object image via graphical additions. It allows to get an augmented view of the real object. A visual example of such technology usage is vehicle technical inspection. In this way user can, for instance, superimpose the images of units and aggregates of a vehicle on the real vehicle image [3].

To put it simply the AR uses animations, videos, 3D models as images, then transforming and providing them to the user in a natural or artificial way. By using AR technologies, users do not feel immersion into the virtual environment, they fully recognize their presence in the real world. To this end, AR exploits a variety of devices to display information: screens, displays, special glasses, smartphones, tablets, and a lot of other interesting things. AR technologies, in particular for transport industry, cover following:

- ICT, in particular processor, GPU, memory, communication devises (Bluetooth / Wi-Fi, GPS), which must process input date, provide space orientation, measure speed, angle, direction of motion of the investigated objects (it can be vehicles, automotive units and aggregates, transport systems etc.).
- SLAM technology, which literally translates as "simultaneous localization and map construction". It involves constructing a map in an unknown space or restoring it in a known space with simultaneous control of the current location and the traveled track of an object [38]. The technology is quite relevant for a logistic analysis of transport systems.
- Cameras and sensors (mechanical, acoustic, optical, biological, etc.) that scan environment, find physical objects, collect data about them, generate 3D models, and provide user interaction.
- Depth monitoring technologies with the use of sensors.
- Software that allows to exploit, in addition to existing I/O tools, voice commands to control the operation of the vehicle or to communicate with other experts of transport branch.
- Data projection technology is a miniature projector on AR headsets that outputs processed data for user's viewing. It should be born in mind the aspect is not yet sufficiently developed and is mostly used for promotional purposes including automatic shows. However, this AR feature makes it possible to magnify real-world objects for study by any medium, allowing users to enjoy projection as if on-the-go by displaying AR elements in the environment [3].

- Information display technology ensures the user aligns the virtual image correctly to generate photorealistic images. Some AR devices exploit a system of mirrors or double-sided mirrors which reflect light from the camera and the user's eyes.

AR-assisted devices integrate the above technologies into a single complex that usually includes sensors, cameras, accelerometer, gyroscope, digital compass, GPS, processor, displays [3].

As reviewed by Internet sources, devices for realizing AR can be classified as following types, namely [25; 33]:

- Mobile devices (smartphones and PC-tablets) that are operated on the basis of special mobile apps.
- Special AR devices which designed exclusively to create an augmented reality, among these are HUD (head-up display) that sends data to a transparent display, AR laboratories for vehicle design, a screen is built into helmet and others.
- AR Glasses (or smart glasses, or 3D glasses), as an instant Google Glass, Meta 2, Laster See-Thru, Laforge AR, and others.
- AR contact lenses (or smart lenses) which already allow even photography and data storage [25].
- Virtual Retina Displays (VRD) that create and project images directly into a person's eye via a laser.

Indeed, AR technologies had been initially used to create a fundamentally new type of computer games; however, quite quickly their advantages were noticed in the business field. Further many powerful tools for manufacture and marketing were developed, and then they were included to production and vocation training in transport industry. Today it is seen the emergence and spread of a new scope in their use due to the development of the mobile software apps market, the technical improvement of smartphones and other gadgets. This trend is based on the use of QR technologies, which has greatly simplified the access process to the relevant apps and allowed organization of extracted vocational training [40].

QR Code (abbreviated from Quick Response Code) is a trademark for the type of matrix barcodes (or two-dimensional barcodes) originally developed by Denso Wave (then a division of Denso Corporation) in 1994 for the Japanese automotive industry. Although the “QR Code” designation is a registered as “Denso Corporation” trademark, the use of the QR Code is not subject to any license fees. It is being described and published as ISO standards [12].

In general, as early as the last century, Denso Corporation responded to a request from the Japanese industry to develop a new type of barcode that would contain more than 20 alphanumeric characters and might be quickly readable [12].

The developers have solved this problem by adding positional information to the code. Eventually, a square QR Code model has appeared. The modeling had proceeded by a careful analysis and search for patterns in the ratio of black and white areas on the printed matter, in order to prevent mistaken scan of similar images in the future. Thus, a device was created to identify the object regardless the scanning angle. The created QR Code model is capable of encoding about 7.000 numerals with the additional possibility to encode Kanji characters. This code can also be read as likely 10 times faster as other codes [12].

Through the efforts of Masahiro Hara-led labs, the automotive business has adopted a QR Code for use in their electronic Kanban (it is a communication tool used in production management systems). This made it possible to increase the efficiency of car production, improve transport systems beginning from cargo delivery and finishing a receipt obtains. The main advantage of QR Code is the easy recognition by scanning equipment, which enables it to be exploited in trade, production, logistics, services, tourism etc. The QR Code is used for transparency of production processes, for product monitoring and quality control, for navigating and tracking the movement of vehicles and individuals [12].

So far new types of QR Codes have been created to meet the more complex needs of manufacturing, the service industry and ordinary people. Micro QR Code allows place compressed information in a small space. The IQR Code occupies a small area, but even so it has large encoding capacity. The SQR Code enforces restrictions on reading sensitive information. FrameQR Code permits freely combine illustrations and photos. The new High Capacity Colored 2-Dimensional (HCC2D) Code and a color 2D matrix symbology JAB Code have also been proposed.

The QR Code specification does not describe the data format. The most popular QR Code viewers support the following data formats: URL, bookmark in browser, Email (with letter subject), SMS to number (with subject), MeCard, vCard, and geographical coordinates. Some apps can detect GI, JPG, PNG, or MI files of less than 4K and encrypted text. Without exaggeration, any smartphone equipped with a workable camera is able to read the QR Code generated by the manufacturer. And every person, even the most ignorant person in ICT, can use it to solve a variety of problems including vehicle operation. Today, QR Code technology not only allows read new information exiting fairly simple apps, but also to create someone own codes for specific needs. The QR Code can be save relevant information or links to it.

The aforementioned features of AR technologies and the technical and software solutions for their implementation make it possible to qualitatively update the transport branch and the vocational training system for respective area of expertise. It makes sense if the above-mentioned means will be adapted to the university study conditions.

4 Results and discussion

4.1 Use AR technology in transport industry

A survey of online sources shows that widely recognized world's automotive brands invest heavily in AR technology and create dedicated laboratories for these purposes. Next, we are going to look at the most general ways of AR used in transport industry (see fig. 1).

It's a vehicle design and tuning. Engineers exploit AR technologies to complete design faster by working on a virtual vehicle, developing new components and units of it in real time and in natural sizes, changing as needed and color solutions, as instant at

Volkswagen's virtual engineering laboratory in Wolfsburg. Modern ICTs allow different project teams to do synchronously one draft at a distance [26].

It's mechanical and automotive engineering. AR technologies allow rapid development and introduction of unique production assembly instructions for a vehicle, which, unlike papery ones and their analogues, are interactive and richly illustrated. They provide quick text navigation and even connection with third-party consultants [8].

It's vehicles marketing and advertising by means of virtual automotive shows, virtual manufacturing tours or dealer networks. AR-based apps activating via components and units of vehicle or manufacturer markers, permit users to visualize their full size, even open and close the trunk and doors, look inside and, to some extent, tuning the car [30]. For example, today BMW Group is using *iVisualizer* to sell *I3* and *I8* make of vehicles. The app places branded models in front of a potential buyer, who can evaluate and validate the model functionality by virtual tools including viewing available colors and kinds of body processing [6].

It's vehicle maintenance and operation. The field of AR exploitation in this sphere is expanding every day. In general, it can be represented in two main directions. One is usage of additional visualization tools to increase the comfort of vehicle operation. Yet another is usage a virtual Guide that works on the above-described AR tools. The first direction is well illustrated by the development of Apple and Hyundai [1; 17]. The two companies have independently offered some ways to use the windshield of a vehicle like a powerful navigation display [9]. It should be emphasized the virtual Guides are being developed by all well-known car brands. For example, the Volkswagen Mobile App *MARTA* allows the user to see the details of the car and how to solve certain issues [26].

It's vehicle diagnostics and repair. It is believed that the first experience of using AR-technology for this purpose belongs to BMW Group. In 2009 the company offered AR glasses for car diagnostic and the BMW Augmented Reality Car Repair App (CRP). Attention should be paid to smart glasses which make technician's hands free and simplifies establishing and current repair of a vehicle. The idea is that wearing these glasses gives opportunity to look at the BMW Group engine, with its separate units highlighted in different colors, which allows to notice general mechanical problems [6].

Obviously, regardless of the hardware used, AR technologies have many significant advantages then traditional instructions and manuals and simplify vehicle maintenance even for beginners [9]. It is likely that in the near future, with mobile apps or smart glasses, it will be possible to keep up the engine and detect problems in a timely manner, illustrating step-by-step solutions with support and graphics AR [25].

The Bosch research has found that the use of AR technologies accelerates technical maintenance processes by 15% [8]. This idea is being developed by Porsche Service, which had developed smart glasses helping mechanics address complex peripheral maintenance issues with the support of Atlanta-based US headquarters. It is quite possible to transmit videos and describe the problem in real time and to receive advice from more qualified specialists [30].

We found a lot of other projects to create integrated AR laboratories for specialist training. AR-based laboratories like virtual ones significantly reduce the time spent on training and the cost of materials. For example, Bosch uses AR and tools and a dedicated platform with educational content for technicians' training so called CAP (Common Augmented Reality Platform). Developed apps by Bosch experts allow to see the necessary elements, units and aggregates of the car, refer to watching videos, text instructions and moving 3D objects, do self-control of knowledge level. The CAP can publish new contents and apps for engineering and training sectors in a straightforward manner. The platform compiles the required data for each specific AR app and implements different training scenarios both in "Trainer Mode" and in "Trainee Mode" [8].

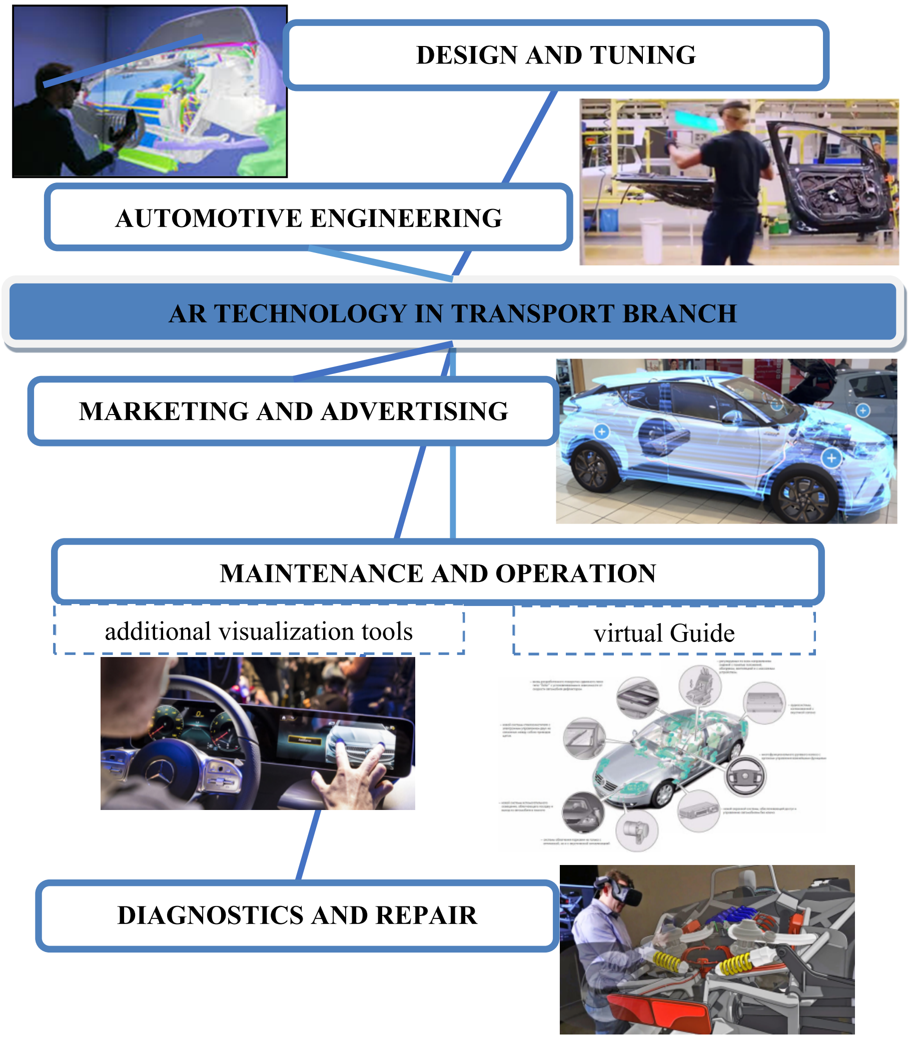

Fig. 1. The most general ways of AR exploiting in transport industry (prepared by the authors with use of freely distributed advertising images).

Volvo Group's contribution to the development of AR ideas for training is powerful enough. We mean AR markers for the study of separate components and units of vehicles, guidance for current repair and operation. The developed *Meet the Virtual Engine* app allows to study the smallest features of the *D11* engine [36].

It should be considered the most significant projects with the use of AR for educational and advertising from leading automotive brands.

4.2 Review the market of mobile apps with AR for vehicle operation and maintenance needs

In the matter of fact nowadays mobile apps are widely used in the transport industry for improvement carriage and development in the transport systems functioning. Clearly, the AR technologies based on them, arouse the particular interest for study purposes. Below we are presenting mobile apps that are freely available in Google Play Market [13] and Apple App Store Support [1].

Cat® VR Learning [10] is an interactive multilingual app that allows to explore key features of Caterpillar. After selecting the scope and model, the app permits 360° view and with the help of "hot" points to find out the peculiarities of certain components and units of Caterpillar. Each access point is equipped with text, graphic, audio and video information (shown on fig. 2).

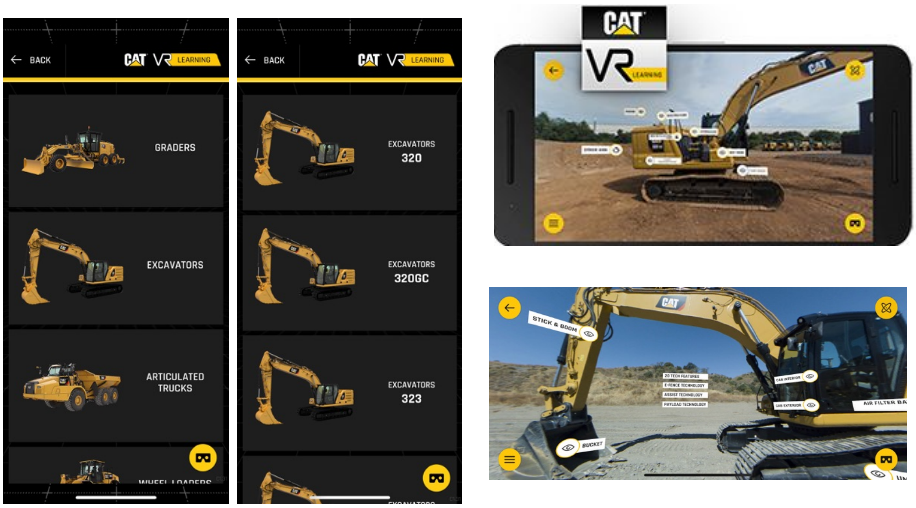

Fig. 2. Studying the construction of Caterpillar vehicles with the exploit of *Cat® VR Learning* app (prepared with use of [10]).

In conjunction with the smart glasses *Cat® VR Learning* app can create full virtual environment. The app "puts" the user into the vehicle, creating a sense of physical presence. The virtual Guide, navigated by the user's look, provides up-to-date information, gradually organizes the study of a particular vehicle unit, even with the training of driving skills.

The *Hyundai Virtual Guide* [17] is an AR smartphone app that Hyundai owners can download and exploit as an illustrated instruction manual. Instead of browsing through the guidance, it will be enough to point smartphone camera at the car containing the company markers and view the overlay digital information. The *Hyundai Virtual Guide* can virtually identify and provide instructions for the following features: air filter, Smart Cruise Control, Bluetooth phone pairing, warning indicators, clock, engine oil, brake fluid, fuse box, SMART trunk (fig. 3).

Fig. 3. Separate functionality of the *Hyundai Virtual Guide* app (prepared with use of [6]).

I-Mechanic – AR Car Repair App is car repair software offering the same instruction manual like Hyundai, but for any other vehicle make. With the help a mobile device, it makes it possible to view a convenient AR graphic "imposed" on an actual engine in real-time that allows pinpoint important maintenance aspects [2]. The app can help to check the level of oil or coolant, as well as skillfully top up the coolant and charge the battery even to a beginner (fig. 4).

Genesis AR Manual [16] helps owners understand the features of a vehicle explaining how to connect their phone via Bluetooth, how to use cruise control, and what the warning indicators mean. At the same time, AR capabilities allow the user to orient their smartphone or tablet to engine operation and maintenance, and to receive step-by-step instructions to help check the oil level or top up the wiper (fig. 5).

Genesis Virtual Guide app [9; 16] is a modern look at traditional manuals that allow customers to exploit their smartphone to get information on car repair, maintenance and features. Typically, the 2D and 3D AR technologies are used for these purposes, providing an in-depth level of information according to the user needs (see fig. 6).

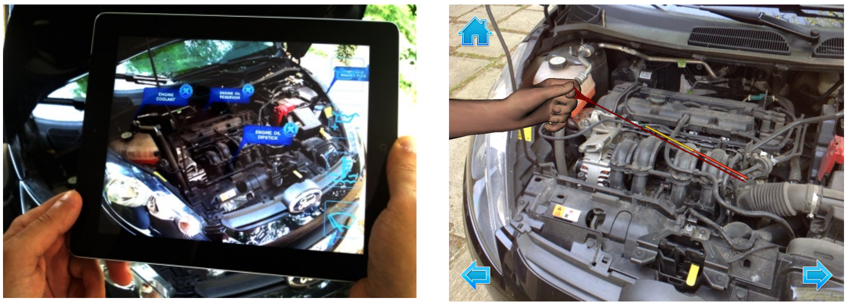

Fig. 4. Working with help of *I-Mechanic* (prepared by the authors with use of [2]).

Fig. 5. Oil level control with the use of *Genesis AR Manual* app (prepared with use of [16]).

Fig. 6. Separate functional properties of *Genesis Virtual Guide* app (prepared with use of [16]).

The guidance contains up about 135 videos with practical recommendations and 25 three-dimensional layering for units and aggregates of Genesis such as engine compartment and dashboard, cabin functions and signal indicators, ways to use an adaptive cruise control, Bluetooth phone pairing, a clock, and a lot of other interesting thigs. The app helps owners do simple maintenance tasks such as checking oil, replacing filter elements, adding process fluid to various vehicle units according to operating requirements [9].

Volvo Trucks Corporation offers many mobile apps with AR that can be used to operate and repair a vehicle, familiarize with its components and aggregates. One is the *AR Stories* [36]. The fig. 7 shows the algorithm for working with the app [37]. It involves the app installation, searches in the logs of the corresponding images or QR Codes in Volvo Group magazine [35] and works with them via the *AR Stories* app. Obviously, the most of the presented menu items (fig. 7c) are primarily advertising kind and to a greater extent work without AR. Meanwhile, for vocational training purposes, the issues such as *Meet the Virtual Engine* and *Engine room fuse box* are interestingly enough. About their usage we are going to report in next part of the paper.

Fig. 7. The algorithm for working with the *AR Stories* app.

It is significant the Volvo Group magazines always contain new AR markers that illustrate the manuals for vehicle maintenance and repair, as well as cognitive materials about transport systems, environmental and road safety, manufactory organizing with the use of Volvo vehicles [35] (Fig. 7a).

The apps described above are mostly English-language that quite the contrary is their advantage. We mean that as for transport industry specialists English language skills are the key to their successful professional career. It should be emphasized the mobile apps with AR don't have clear educational purposes. The effectiveness of their use in the vocational training process is conditioned by the development and implementation of a special methodology.

4.3 Experience of organizing students' cognitive activity via AR technologies

In the professional activity of lecturers of the General Sciences and Vocational Training department of Kryvyi Rih State Pedagogical University a students' mobile learning is widely practiced [23]. Continuous monitoring of the mobile apps market allows to update the content of lectures gradually, practical and laboratory classes in special disciplines in transport area of expertise such as “Vehicles operation and repair”, “Vehicles maintenance”, “The transport vehicles engines” “Transport logistics”, “The freight and passenger transportation technologies” and others.

As a result of the analysis of practice experience, it was found that during organizing students' cognitive activities with the use of AR technologies certain pedagogical terms should be created, namely:

- it needs to provide each student with the position of an active actor of studies and cognitive activity. It means the freedom to choose forms, methods and directions of engineering and pedagogical creativity, implementation relevant ICT into studies and professional activity in line with the students' level of vocational knowledge and their mastery degree in mobile learning tools area (e.g. student can use ready-made apps, improve them, create their own methodological techniques based on them);
- it must facilitate the switch the study information in a mode of the project activity, to introduce and distribute design tasks in the form of cases, game projecting, web-quests, creative competitions with the use of the AR technologies;
- to do professionalization of educational content and purposefully teach students to use the modern ICT in the study process in line with requirements of up-to-date vocational school. It assumes mastering by student the professionally important knowledge and computer focused pedagogical technologies;
- to manage students' cognitive processes by means of ICT, to variably select VR and AR technologies and to combine them with traditional study. It signifies justified introduction of ICT for the realization of educational, professional and developmental goals during vocational training process.

It should be remembered that the professional properties that are shaped as a result of these terms do not guarantee mastering the profession by a student. To do this, a student must be an informed carrier of “norms” and “freedoms” within the relevant professional culture. A “norm” concept we correlate with the students' conscious requirement to acquire professionally meaningful knowledge, and “freedom”– with the conscious need to choose from among the various public, intellectual, social, and other stimuli precisely those that make it possible to become a professional, but not a “high-stepper” [28].

As a result of testing, set of study and cognitive tasks based on the matter of some mobile apps with AR including *Cat® VR Learning, Cat Technology Experience, Hyundai Virtual Guide, I-Mechanic – AR Car Repair App, Genesis AR Manual, Genesis Virtual Guide* ones, as well as Volvo Group publications, has been introduced into the special subject content. New approaches to teach and to organize lectures, laboratory and practice classes have been developed.

As an example, next we will consider the series of laboratory work in the course “Vehicles operation and repair” with the use of the *Genesis Virtual Guide* mobile app.

Students can scan the engine (fig. 8) by means of a smartphone camera then they will be able to work with the engine menu via pictorial cues at certain units or aggregates of a vehicle. Next, following the virtual Guide instructions, students will do the car maintenance on the example of checking the oil level in the crankcase (Engine oil check), adding detergent (Adding the washer fluid), cleaning the air filter (Air cleaner filter), checking the brake fluid (Brake fluid check), doing coolant checkup (Coolant check).

Fig. 8. Studying vehicle engine with the help of *Genesis Virtual Guide* app (prepared with use of [16]).

Evidently, it is the Volvo Group's mobile app *AR Stories* that has a great potential in experts' vocational training for transport industry. The company distributes AR tokens in the media by means of QR Codes. After reading them an image is downloaded and processed via AR Stories app. The app contains full AR instructions and a built-in photo marker reader [36]. The main features of this app have been described above, and further we are going to cover only some of them.

By way of illustration it will have a look at the laboratory work on topic “The structure, operating properties and methods of current repair of a Common Rail fuel feed system”. To study the Common Rail replacement methods *Meet the Virtual Engine* and *Engine room fuse* box tabs in *AR Stories* can be used as likely as an additional dynamic means of clarity. Access to them is shown in fig. 9.

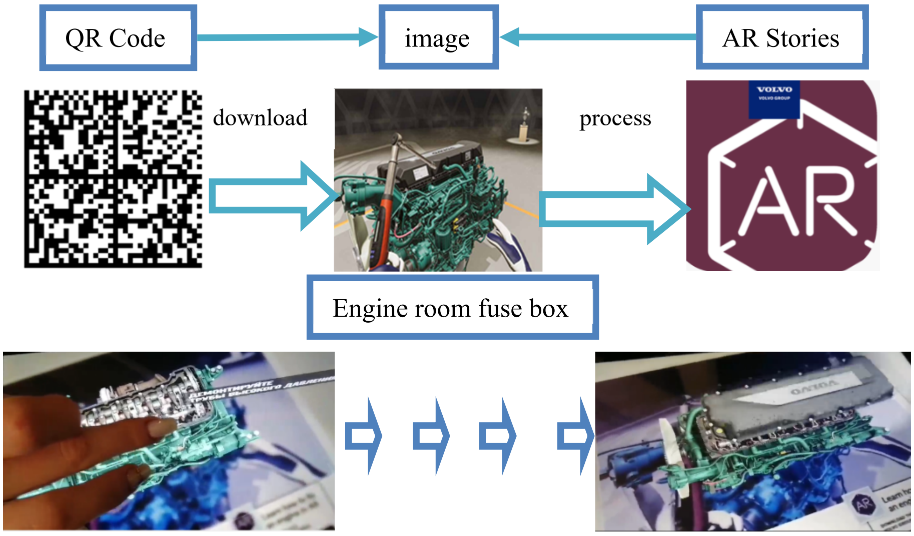

Fig. 9. The algorithm for working with the *Engine room fuse box* (prepared with use of [35; 37]).

In addition to technical products, the Volvo Group also offers advertising with AR. Their exploitation can greatly enhance any study material. For example, with the help of a photo marker on a career in Gothenburg (Sweden), VOLVO offered to consider the operation of electric dumpers with remote control (Fig. 10).

Fig. 10. The photo marker on a career for *AR Stories* app [37].

The company also proposes companion videos that are accessible by means of a QR Code. They can help look at a career and prototypes of unmanned dump truck. As part of an advertisement for the Electric Site project aimed at creating a fully autonomous quarrying process, Volvo has started testing unmanned electrical machinery in the Vican Cross career in Gothenburg, Sweden. Each stage of the mining cycle including extraction, primary crushing and transportation will occur automatically. For that, Volvo and the Skanska Company will use prototypes of autonomous dump trucks, a cable-driven hybrid excavator and a diesel electric forklift. All of these aspects are accessible via VR and AR and tools, and can be used for theoretical training of future professionals for transport area of expertise [35].

Volvo Group's Future Transport Solution concept is interesting for working out the main traffic and logistic ideas. With the help of the AR Stories mobile app, students can get acquainted with the latest development; this is Volvo Vera that is autonomous freelance freight electric vehicle – robo-truck [36].

The *Cat Technology Experience* app has significant advantages in organizing theoretical and practical students' vocational training for transport industry [34]. The app offers virtual guidance on Caterpillar engineering into a simulated career with smart glasses. It should be noticed that it is perhaps the only AR tool to study methods of operation, repair maintenance of career transport (fig. 11).

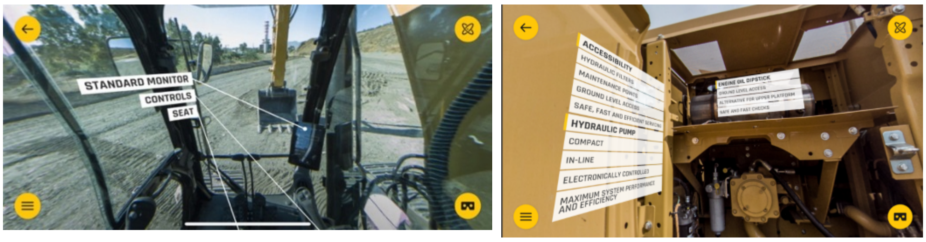

Fig. 11. Familiarization with components and units of a Caterpillar vehicle in the *Cat Technology Experience* app (prepared with use of [34]).

Sitting on the operator’s seat will make it possible to learn about the features and benefits of Cat Payload on wheel loaders, Cat Grade on excavators and bulldozers, Cat Grade with Assist on excavators and Cat Grade with Slope Assist on bulldozers. User has a good chance to look around to get the full 360° ride [34].

Thus, based on the founded on experience and theoretical elaboration of the issue, a step-by-step methodology of application the mobile apps with AR in the students' vocational training process for transport industry has been developed. It has been concluded that at *the preparatory stage of the methodology* it is necessary to ensure the following activities:

1. It should examine the topic features and the possibilities of using AR technologies during the learning study material.
2. Introduce to students and provide them with general knowledge of the AR technologies features and methods of working up with AR-based hardware and software (smartphones, tablets, mobile apps, AR markers, 3D glasses etc.).
3. Mastering by students the main mobile apps with AR that will be used during the study of the topic.
4. Forming to students’ skills and competences of independent study and cognitive activity on the basis of work with the AR-focused mobile apps market. This process assumes search and analysis of existing apps with AR, their scopes in future specialists’ vocational training.

5. Work on the development of students' educational and vocational motivation for the use of AR-technologies, as well as forming the goals of students' project activity.

At the *substantive stage* of the methodology it is necessary to ensure following:

1. To master the content and specifics of the selected for educational purposes apps with AR in classroom work.
2. To organize students' independent study activities with the AR-focused mobile apps.
3. To prepare and elaborate the individual study projects based on the AR technologies.
4. To organize and provide the pedagogical management of students' extra-curricular independent cognitive activity with the use of AR-technologies. It means students involve in the execution of service and material projects, in web-quests, do topic blogging, and the analytical activities on the fields of transport industry.

Finally, it is advisable to introduce it in the students' classroom and independent work and their research activities in the elaborated projects which concern the solving professional problems with the use of AR and it's tools.

5 Conclusions

A review of the primary sources and analysis of experience show that the AR technologies are being stood out among modern computer focused means of vocational training due to the creating with their usage exceptional conditions for organizing mobile, high-quality and intensive students' professional preparation for transport industry. Such training, realized via mobile devices and up-to-date software, provides students with the acquisition of professionally important knowledge in the fields of design and tuning, mechanical and automotive engineering, marketing and advertising, maintenance and operation, diagnostics and repair of cars.

Based on the experience of organizing students' cognitive activity for transport area of expertise the step-by-step methodology has been elaborated and presented in the paper. The methodology covers a system of training tasks based on mobile apps with AR (e.g. *Cat® VR Learning, Cat Technology Experience, Hyundai Virtual Guide, I-Mechanic – AR Car Repair App, Genesis AR Manual, Genesis Virtual Guides*, as well as apps and publications from the Volvo Group), and it was implemented during the preparatory, substantive and final stages. Over and above, the possibilities of mobile apps with AR to qualitative update of lectures, practical and laboratory classes for specialized disciplines for students of transport area of expertise.

The methodology has been tested within the students' vocational preparation for transport industry based on General Technical Sciences and Vocational Training department of Kryvyi Rih State Pedagogical University and its effectiveness has been confirmed by experiment results. Future experts have pointed out the expediency of the usage of VR and AR elements and organization on this background independent study activities and research, game forms of work (web-quests, competitions, quizzes etc.), as well as creation of a new type of laboratory and practical classes. As a result, the students' knowledge quality in specialty subjects has increased by 15%.

We emphasize that the information in this paper reflects only certain aspects of the use of modern ICT in the vocational training of future professionals in transport area of expertise. The daily hard work of scientists around the world introduce new ideas to this process. However, a specialist with a high level of professional competence and information culture is able to pick up these ideas and adapt them to the professional activities conditions.

References

1. App Store – Official Apple Support. https://support.apple.com/apps (2020). Accessed 21 Mar 2020
2. AR-media™: I-Mechanic, the AR App that turns yourself into a Mechanic. http://www.armedia.it/i-mechanic (2020). Accessed 21 Mar 2020
3. Augmented Reality App Development Company LITSLINK, USA. https://litslink.com/services/augmented-reality-app-development (2020). Accessed 21 Mar 2020
4. Aulin, V., Lyashuk, O., Pavlenko, O., Velykodnyi, D., Hrynkiv, A., Lysenko, S., Holub, D., Vovk, Y., Dzyura, V., Sokol, M.: Realization of the Logistic Approach in the International Cargo Delivery System. Communications – Scientific Letters of the University of Zilina **21**(2), 3–12 (2019). doi:10.26552/com.C.2019.2.3-12
5. Aulin, V., Lysenko, S., Lyashuk, O., Hrinkiv, A., Velykodnyi, D., Vovk, Y., Holub, D., Chernai, A.: Wear resistance increase of samples tribomating in oil composite with geo modifier KgMf-1. Tribology in Industry **41**(2), 156–165 (2019)
6. BMW Group: Brand & Services. https://www.bmwgroup.com/en/brands-and-services.html (2020). Accessed 21 Mar 2020
7. Bondarenko, T., Kovalenko, D., Briukhanova, N., Iagupov, V.: Method of thematic immersion in the information educational environment as a tool for the formation and assessment of professional competence of future engineering teachers. Advances in Intelligent Systems and Computing **1134** AISC, 301–308 (2020)
8. Bosch Auto Parts: Common Augmented Reality Platform (CAP) From Bosch. https://www.boschautoparts.com/en/news/quarterly-news/first-qtr-2017/augmented-reality (2017). Accessed 21 Mar 2020
9. Bruce, C.: Why flip through an owner's manual when your phone can explain things to you? https://www.motor1.com/news/176067/genesis-augmented-reality-app/ (2017). Accessed 17 Aug 2017
10. Cat® VR Learning App. https://www.cat.com/en_US/campaigns/event/Cat-VR-Learning-App.html (2020). Accessed 21 Mar 2020
11. Chorna, O.V., Hamaniuk, V.A., Uchitel, A.D.: Use of YouTube on lessons of practical course of German language as the first and second language at the pedagogical university. CEUR Workshop Proceedings **2433**, 294–307 (2019)
12. DENSO WAVE, the Inventor of QR Code: Answers your questions about the QR Code. https://www.qrcode.com/en/index.html (2020). Accessed 21 Mar 2020
13. Google: Android Apps on Google Play. https://play.google.com/store/apps (2020). Accessed 21 Mar 2020
14. Grynko, T., Krupskyi, O., Koshevyi, M., Maximchuk, O.: Tangible and Intangible Rewards in Service Industries: Problems and Prospects. Journal of Applied Economic Sciences **12**(8), 2481–2491 (2017)
15. Horbatiuk, R., Voitovych, O., Voitovych, I.: Formation of project competence of future

environmentalists. In: Semerikov, S., Chukharev, S., Sakhno, S., Striuk, A., Osadchyi, V., Solovieva, V., Vakaliuk, T., Nechypurenko, P., Bondarenko, O., Danylchuk, H. (eds.) The International Conference on Sustainable Futures: Environmental, Technological, Social and Economic Matters (ICSF 2020). Kryvyi Rih, Ukraine, May 20-22, 2020. E3S Web of Conferences **166**, 10026 (2020). doi:10.1051/e3sconf/202016610026

16. Hyundai Motor America: Genesis Virtual Guide. https://play.google.com/store/apps/details?id=com.hyundaiusa.genesisar (2020). Accessed 21 Mar 2020
17. Hyundai Motor Company: Hyundai Virtual Guide Introduces Augmented Reality to the Owner's Manual. https://www.hyundai.com/worldwide/en/company/newsroom/hyundai-virtual-guide-introduces-augmented-reality-to-the-owner%2527s-manual-0000005199 (2015). Accessed 21 Mar 2020
18. Kankovskyi, I.Ye.: Systema profesiinoi pidhotovky inzheneriv-pedahohiv avtotransportnoho profiliu (The system of professional training of teaching engineers of automative profile). FOP Tjupak AA, Khmelnitsky (2014)
19. Kiv, A.E., Shyshkina, M.P., Semerikov, S.O., Striuk, A.M., Yechkalo, Yu.V.: AREdu 2019 – How augmented reality transforms to augmented learning. In: Kiv, A.E., Shyshkina, M.P. (eds.) Proceedings of the 2nd International Workshop on Augmented Reality in Education (AREdu 2019), Kryvyi Rih, Ukraine, March 22, 2019. CEUR Workshop Proceedings **2547**, 1–12. http://ceur-ws.org/Vol-2546/paper00.pdf (2020). Accessed 10 Feb 2020
20. Kochyna, V.: The content and structure of phenomenon “Culture of professional communication” in the context of teacher-engineer's professional activity. Problemy inzhenerno-pedahohichnoi osvity 52-53, 93–101 (2016)
21. Kovalenko, O., Bondarenko, T., Kupriyanov, O., Khotchenko, I.: Allocation of Latent Variables from Big Data in Institutional Researches of Engineering Teachers. Advances in Intelligent Systems and Computing **1135** AISC, 288–296 (2020)
22. Kozlovskii Yu.M.: Intehratsiini protsesy v profesiinii osviti: metodolohiia, teoriia, metodyky (Integration processes in vocational education: methodology, theory, techniques). Lviv Polytechnic Publishing House, Lviv (2018)
23. Lavrentieva, O.O., Arkhypov, I.O., Kuchma, O.I., Uchitel, A.D.: Use of simulators together with virtual and augmented reality in the system of welders' vocational training: past, present, and future. CEUR Workshop Proceedings **2547**, 201–216 (2020)
24. Lyon, J.: Genesis Augmented Reality App Makes Car Owner Manuals Obsolete: This app lets users point their smartphone at various components to learn more about them. Robb Report. https://robbreport.com/gear/apps/genesis-augmented-reality-car-owner-manuals-hyundai-smartphone-2728899 (2020). Accessed 21 Mar 2020
25. Makarov, A.: 9 augmented reality trends to watch in 2020. https://mobidev.biz/blog/augmented-reality-future-trends-2018-2020 (2020). Accessed 21 Mar 2020
26. Paschenko, Ye.: AR – stvorennia novoi avtoservisnoi realnosti (AR – the creation of a new car service reality). Suchasna avtomaisternia 1-2 (129). http://www.automaster.net.ua/artykuly/ar-stvorennya-novoyi-avtoservisnoyi-realnosti,51977 (2020). Accessed 21 Mar 2020
27. Pavlenko, O., Shramenko, N., Muzylyov, D.: Logistics Optimization of Agricultural Products Supply to the European Union Based on Modeling by Petri Nets. Lecture Notes in Networks and Systems **128** LNNS, 596–604 (2020)
28. Pavlova, T., Zarutska, E., Pavlov, R., Kolomoichenko, O.: Ethics and Law in Kant's Views: The Principle of Complementarity. International Journal of Ethics and Systems **35**(4), 651–664 (2019). doi:10.1108/ijoes-04-2019-0080

29. Pererva, V.V., Lavrentieva, O.O., Lakomova, O.I., Zavalniuk, O.S., Tolmachev, S.T.: The technique of the use of Virtual Learning Environment in the process of organizing the future teachers' terminological work by specialty. CEUR Workshop Proceedings **2643**, 321–346 (2020)
30. Porsche Consulting: The Networkers. https://newsroom.porsche.com/en/2020/company/porsche-consulting-deutsche-bahn-modernization-projects-19717.html (2020). Accessed 21 Mar 2020
31. Rashevska, N.V., Semerikov, S.O., Zinonos, N.O., Tkachuk, V.V., Shyshkina, M.P.: Using augmented reality tools in the teaching of two-dimensional plane geometry. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
32. Shepiliev, D.S., Semerikov, S.O., Yechkalo, Yu.V., Tkachuk, V.V., Markova, O.M., Modlo, Ye.O., Mintii, I.S., Mintii, M.M., Selivanova, T.V., Maksyshko, N.K., Vakaliuk, T.A., Osadchyi, V.V., Tarasenko, R.O., Amelina, S.M., Kiv, A.E.: Development of career guidance quests using WebAR. Journal of Physics: Conference Series (2020, in press)
33. Syrovatskyi, O.V., Semerikov, S.O., Modlo, Ye.O., Yechkalo, Yu.V., Zelinska, S.O.: Augmented reality software design for educational purposes. CEUR Workshop Proceedings **2292**, 193–225 (2018)
34. The WFA: Cat® Technology Experience. https://thefwa.com/cases/catr-technology-experience (2020). Accessed 21 Mar 2020
35. Verzameld Werk: Volvo Group Truck Center. https://apps.apple.com/ua/app/volvo-group-truck-center/id1021601775 (2015). Accessed 21 Mar 2017
36. Volvo Group: AR Stories. https://apkpure.com/ar-stories/com.volvogroup.arstories (2020). Accessed 21 Mar 2020
37. Volvo Group: Home. https://www.volvogroup.com/ (2020). Accessed 21 Mar 2020
38. Zelinska, S.O., Azaryan, A.A., Azaryan, V.A.: Investigation of Opportunities of the Practical Application of the Augmented Reality Technologies in the Information and Educative Environment for Mining Engineers Training in the Higher Education Establishment. CEUR Workshop Proceedings **2257**, 204–214 (2018)
39. Zhylenko, T.I., Koziy, I.S., Bozhenko, V.S., Shuda, I.A.: Using a web application to realize the effect of AR in assessing the environmental impact of emissions source. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)
40. Zhylenko, T.I., Martynova, N.S., Shuda, I.A., Chykalov, Ye.A., Kuzmuk, D.A.: Auto Checker of Higher Mathematics – an element of mobile cloud education. CEUR Workshop Proceedings **2643**, 662–673 (2020)