

IMPLEMENTING VIRTUAL REALITY INTO EMPLOYEE EDUCATION IN PRODUCTION SECTOR OF AUTOMOTIVE INDUSTRY: CREATING WORKER TRAINING FOR ASSEMBLING CAR DASHBOARD IN VIRTUAL REALITY

^aMONIKA DÁVIDEKOVÁ, ^bMICHAL MJARTAN, ^cMICHAL GREGUŠ

Department of Information Systems, Faculty of Management, Comenius University, Odbojárov 10, 820 05 Bratislava, Slovakia
email: ^amonika.davidekova@fm.uniba.sk,
^bmichal.mjartan@st.fm.uniba.sk, ^cmichal.gregus@fm.uniba.sk

The support of the Faculty of Management, Comenius University in Bratislava, Slovakia is gratefully acknowledged.

Abstract: Education represents an ongoing and never ending process aiming to prepare learners for processing and execution of future tasks. Employee training in business organizations equips workers with know-how that is essential for their work. Diverse educational methods are utilized in various fields of industry with different efficiency. Traditional educational methods consisting of static texts and pictures are perceived as protracted, boring and time consuming. These aspects of established learning processes hamper further self-development and lack demonstrativeness. This paper analyses actual situation of currently utilized educational methods in selected industry sectors with focus on application of innovative methods using ICT and describes implementation of virtual reality into employee training in automotive industry.

Keywords: education employee training, learning, innovative technologies, information and communication technology (ICT), virtual reality, gamification, learning by doing.

1 Introduction

The primary goal of each business entity is to achieve and maximize gains from trade. This can be attained by applying diverse measurements. One of those is the continuous efficiency improvement of conducted tasks by introducing new processes and educating employees and their specialization. Therefore, each company should devote considerable attention to their internal organizational employee education system to ensure its timeliness, user-friendliness, attractiveness and motivational influence. Qualified employees who underwent attractive, interactive and innovative trainings compose invaluable base of the organization's future success and sustainable positive performance. The availability of skills has become the key to achieving innovation¹, sustainable existence and precondition for achieving success of business entities.

Information and communication technology (ICT) enable applying various innovative methods for employee training. Applying ICT in education may improve the quality of education and the active participation of trainees on educational process². One of it represents the virtual reality technology that represents interactive virtual environment with the most possible resemblance to physical reality. Virtual reality denotes an environment modeled by a computer to simulate the physical reality³. Its emergence can be tracked back to 60th 20th century when visualizing and computational technology were at very low level and such appliances are called "amateur attempts" if compared with today's technology⁴. During the last decades, various innovative cutting edge technologies for virtual reality entered the market that can be used for education, graphical design, architecture etc. Among those appliances belong virtual technologies by Oculus and by Valve companies⁵.

The most suitable sectors for implementing virtual reality trainings are e.g. flying trainings of pilots, simulating surgical interventions in chirurgery, remote control of robots or production and assembling⁶. Therefore, this paper proposes and describes implementing of virtual reality for employee training in production sector for assembling a car instrument board of a personal car. It describes the development process stage by stage including brief description of processing at individual stages for better demonstration. This contribution also provides a calculation of such a solution based on actual tax rates for described specification.

This paper is organized as follows: next section 2 provides in-depth description of the development process for an employee training implementing virtual reality technology. Section 3 demonstrates cost calculation of proposed solution. The conclusion briefly summarizes the content of this paper.

2 Process steps for creating training in virtual reality

This section depicts the process of creating virtual reality training for employee education in automotive industry. The a description deals with one selected assembling activity that the worker has to learn during this training and that he will execute in his job later on. The chosen task represents only one example of possible applications of virtual reality in employee training in production sector.

The process of creating training content in the environment of virtual reality consists of several steps. Creating simulation trainings in virtual reality is analogue to creating simulations for computer games and console game applications⁷. The whole process will be demonstrated on a concrete example: dashboard installation in personal car 3.5t.

The process compounds following steps (fig. 1):

1. Selection of an object which shall be virtualized, supplying documents and scenarios by customer.
2. Photo shooting of objects not included in documents provided by the customer, creating Detailed Functional Technical Specification (DFTS) documents.
3. Editing and processing of photos for textures, materials and panorama photos.
4. Modeling of objects.
5. Creating textures and materials.
6. Control and summary of objects.
7. Animation.
8. Creating virtual scenery and programming of logic.
9. Testing of simulation.
10. Customer delivery.

¹Volná, J., Kohnová, L., Bohdalová, M., Holienka, M., Innovative Mindset and Management Styles: An Intellectual Capital Approach. In: *Proceedings of the 12th International Conference on Intellectual Capital, Knowledge Management and Organisational Learning*, pp. 316-323. Bangkok: Academic Conferences and Publishing International Limited, 2015.

²Vesely, P., Karovic, V., Karovic ml., V. Investments in Education as a Benefit for e-Government. In: Drobyazko, S. I. (eds.) *Economics, Management, Law: Innovation Strategy*, pp. 280-284. Zhengzhou: Henan Science and Technology Press, 2016.

³Burdea, G. C., and Coiffet, P. *Virtual reality technology*. Hoboken: John Wiley & Sons, 2003.

⁴GIGANTE, M. A. Virtual reality: definitions, history and applications. In: Earnshaw, R. A., Gigante, M. A. And Jones, H. (eds.) *Virtual Reality Systems*. London: Academic Press Ltd., 1993, pp. 3-14.

⁵Lamkin, P. *The Best VR Headsets: TheVirtual Reality Raceis On*. Created May 24, 2017. Retrieved June 02, 2017.

⁶Novak-Marcincin J. Technologiami virtualnej reality podporovane vzdelavanie. In: Pavelka J, Franko F (eds.), *II. InEduTech 2006*, pp. 71-75. Presovska univerzita, Presov, 2006.

⁷Satheesh, P. V. *Unreal Engine 4 Game Development Essentials: Master the basics of Unreal Engine 4 to build stunning video games*. Birmingham: Packt Publishing Ltd, 2016.

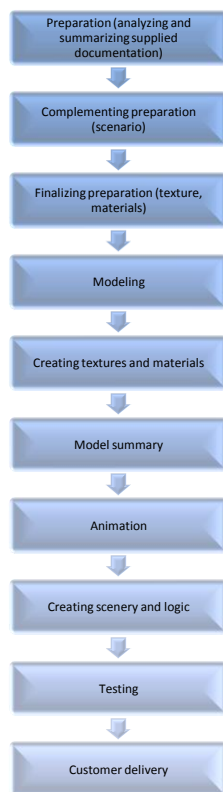


Fig. 1 Process for creating training using virtual reality

2.1 Preparation

First step contains the selection of the object to virtualize. In other words, the object is photographed for digitalizing, a digital 3D model is created and parsed in the virtual reality environment. For this step the cooperation of the required customer/organization is necessary. Thus, the production company provides available technical documentation for all objects to be virtualized, preferably in electronic format or in printed form.

This step is also called creating scenarios for designing simulation in virtual reality. Besides these aforementioned documents containing technical information about machinery, equipment and rooms, the customer company has to collaborate in designing scenarios mirroring the individual working processes along the assembly line to be reality close emulated by the virtual reality simulation.

The outcomes of this first step is the summary of all documents for all objects and scenarios for all work processes necessary for creating the required training in virtual reality environment.

To demonstrate activities of this step on selected concrete example of dashboard installation in a personal car, it means the selection of the dashboard to be installed with all its assembly parts and the place of installation at the assembly line. The producing company provides all materials denoting all 3D components and objects that are available in electronic form including all technical drawing documents containing the technical drawing of the assembly hall, tools and equipment utilized for the installation. Alongside with all these aforementioned documents the producing company delivers also process descriptions including workflows and textual description denoting manuals for the assembling that provide the scenarios of the dashboard assembly and installation. The realizing team is then able to compose and build the dashboard in digital form in virtual reality and create the training for workers.

2.2 Complementing

Completing first preparation step the second step follows. Its main purpose is to complement all missing data for virtualization of all objects required for the virtual reality training. In other words, during this step it is necessary to physically visit the producing company in person and to analyze if all necessary documents for all needed objects and components are available for digitalization.

At this step, the personnel of the realizing team identifies and documents all objects that shall be included in the virtual reality training and for which the necessary documents and descriptions are missing from the preparation step. This means to shoot photos of all missing objects, to measure them to document their dimensions and to create their digitalized reproductions.

During this second complementing step the individual processes building the training scenarios are digitalized as well. This is done with camera recording of the processes, if possible. If recording is not possible, the process is emulated following the process descriptions delivered in first step in collaboration with representatives of the customer company to identify any gaps, unclear or forgotten activities or components and to clarify ambiguous parts.

Last, but not least task of this step to be done is the final summary of all data necessary for simulating the training in virtual reality environment. This summary is compiled into so called functionality and technical solution specification that is sent to the customer company for review and confirmation and builds the mandatory fulfillment of the contract.

To demonstrate this step for the selected activity of assembling dashboard and its installation into a personal car, it means the realizing team visits the producing company including their assembly line and observes the reproduction of the assembling activity and records it with a camera. The realizing team examines whether all components and objects utilized during the observed activities were already in possession of the realizing team for virtualization and identifies objects that are missing or deviating from delivered documents. It shoots photos of all components needed for the assembling of the dashboard and records all its attributes including dimensions, descriptions of surfaces and other features. The outcomes of all these analyses and specification tasks are summarized and compiled into functional and technical specification of proposed solution. It concludes in-depth description of all objects and detailed depiction of the assembly process step by step. The underlying document also narrowed determination of the functionality included in the final simulation in virtual reality environment along with the detailed description of the creating process.

2.3 Finalizing preparation

After all complementing tasks were finalized, the third step compounds photo shooting of all component parts and other parts as well as documenting the working space for assembling to be virtualized and reproduced in virtual reality. The photos that are recorded can be divided into three types: reference photos, texturing photos and panorama photos.

Reference photos of all individual objects document those in various view points and angles. These photos serve for better demonstrativeness and base for the 3D designer to accomplish his/her task. These photos are then used also to confront the 3D model depicting the imagination of the 3D designers with the real, physical and actual state of the virtualized object.

Second type of taken photographs denotes photos for texturing and material covering. The very important requirement for these photos is the conditions of shooting them in right angle to the surface of given object parts that are texturized. These photos are taken without perspective by utilizing special tilt-shift objectives. These photos are captured in high resolution at the lowest possible sensitivity of the recording camera device. At

this photo shooting, camera stand is necessary for better picture stability also by inconvenient light conditions.

Third and last photo types represent panorama records that are used for virtualization of surroundings. In other words, these photos build the background of the whole scenery and virtual workplace. These photos serve for reality close perception of the whole virtual training.

To demonstrate the aforementioned activities on the assembling and installation of a instrument panel for a personal car, this step compounds next personal visit of the realizing team representatives to the producing company. During this visit, the team members take photos of all components and objects using perspective mode to create reference photos. After all reference photos were created, the realizing team shoots photos without perspective for texturing and modelling the surface of the material.

After all components including screws, bolts, gripping, anchoring, front case cover of the dashboard, doors, tachometer, r. p. m. counter and other objects were documented and photographed, the working tools utilized for the assembly is being photo shoot including industry screw driver and air screw drivers. The photos are taken of the working table and assembly line too, including all utilized stands, technical drawings and support tables, eventually cranes or other leveraging tools. This all serves for the documentation of the surroundings.

Last, but not least, panorama photos of the whole working place and assembly hall are shoot. These are made from the middle of the working place of the future assembling team. These photos are later combined in the virtual reality environment to build 360° panorama to emulate the reality close perception of the trained worker.

2.4 Modeling

Finalizing all the documenting part, the real physical objects and components are reproduced in virtual reality. Each single component, object and tool is reproduced individually using the lowpoly (low polygon technology) technology. This processing mode denotes modelling in simple forms where all complex surface characteristics are emulated through texturing⁸, e.g. the threads of a screw etc. The selection of this technological procedure for modelling allows faster processing of the objects and also higher processing speed of the final software application due to lower visualizing complexity. At the same time, it allows placing broader number of objects into the virtual scenery and working place by lower demands on computational performance.

Electronic and 3D models provided by the customer company are transformed into lowpoly format. Components documented only in paper form by technical documentation and drawings or reference photographs are being created from the scratch by 3D modelers. All in lowpoly format. Combining all these components, the scenery of the working place is being created. Several experience and high expertise in creating 3D models is necessary for all members of the 3D modeling team, as the 3D object models build the base and the essential part of the scenery with highest importance.

Finalizing the 3D modeling part, the created objects are equipped with events and logic in subsequent process steps.

To demonstrate the processing activities on chosen procedure for assembling of car dashboard, it means that all materials and documents received from the producing company in first process step and created by the realizing team in second process step are delivered to designer team responsible for 3D modeling. They process component by component and transform it into lowpoly format.

Most important objects like the working tools and utensils used for the installation are being modeled from scratch or reused from other projects if available. This is mostly true for screw drivers, air wrench, allen key, hex key tools etc.

The modeling of the scenery for the working place is usually created from scratch, based on reference photos, technical drawings and documentation describing the workplace. Step by step the 3D model of the workplace gets equipped with floor, walls, and ceiling. All small details including lamps, cabling, crane anchors etc. are modelled too to provide reality close virtual reproduction of the workplace.

2.5 Texturing

Next step, the texturing, is usually done simultaneously in parallel with 3D modeling step. During this step, the textures and surface emulating models for the materials are being created based on photographs without perspective.

Textures are prepared utilizing special technological procedure to eliminate the visibility of connecting lines and to ensure smooth flow.

During this step, part of the team is dedicated to model unwrapping. It stands for creating 2D visualizations of 3D models. Graphic designers combine textures with unwrapped 2D visualizations and manually remodel necessary parts and create details like oil flecks etc. to emulate real physical working environment to the greatest possible extend⁹.

To demonstrate this processing on selected training activity, at this step a major part of the 3D designers creates 3D models of all objects and the remaining team members are dedicated to model unwrapping of composed 3D models of all objects including screws, pads, matrixes and bolt nuts as well as individual parts of the car dashboard like tachometer, r. p. m. counter etc. The unwrapping is done also for working tools and utensils like screw driver, air wrench etc. and the working table, stand for technical drawings, crane anchors etc. Each unwrapped object is then provided to 2D graphical team to get "dressed" which cover all models with appropriate corresponding textures and manually remodel all imperfections including oil flecks, scratches, corroded parts of the working tools and utensils to provide traces of usage to these objects. These imperfections contribute to extended reality close perception of the vectored digital virtual reality environment.

The reality close textures are then delivered back to 3D graphical designers who wrap the 3D models with these coverings. At this state, the modeling part and the graphical processing of 3D models for these objects is finished.

2.6 Model summary

Finalizing the texturing step, the next sixth step compounds the check and summarizing of all objects according to planned scenarios and reference photographs. Thus, the comparison of created wrapped 3D models with reference photos is carefully assessed.

Finishing verifying produced models with reference photos, the planned and described scenarios are reviewed to double control whether all wrapped 3D models of needed objects are created in the virtual reality environment. All missing objects are processed to ensure the availability of all necessary objects for programming of business logic.

To demonstrate the processing of this step on selected activity for assembling car dashboard, it concludes the verification of all created models through their comparing with technical drawings and documentation provided by the producing company. Each single model is checked to assure its creating, its compliance

⁸Webster, N. L. High poly to low poly workflows for real-time rendering. *Journal of Visual Communication in Medicine*, 2017, vol. 40, no.1, pp.40-47.

⁹Hassan, M. *Proposed workflow for UV mapping and texture painting*. Dissertation. 2016. 41 p.

with provided documentation and reference photographs, its similarity to real components with reality close visual appearance after remodeling. All assembling components and working tools must be available.

Similar reviewing is conducted for the workplace scenery, working equipment and surroundings. After all objects were reviews and their compliance with physical reality was confirmed, the programming step providing each object with business logic can start.

2.7 Animation

At this seventh step dedicated to animation, the modeled objects are enriched with events and business logic. Animating team consisting of animators and riggers are provided with all 3D wrapped object models for processing.

A rigger creates digital skeletons, bones, bone joints and muscles of all 3D object models¹⁰. At first task, the rig of given object is being created. It represents the base for object animation. In other words, the rig serves for flexibility where nodes are matching the moving of other nodes during animation. For example during smile animation, the corners of the mouth are moved to the top is accompanied by the matched movement of other face muscles to this movement.

After rigs of all objects are accomplished, the animators create animations for all necessary events and available models in produced scenery according to provided scenarios. These animations include also events triggered by the end user through his/her interaction.

This step denotes the processing of created models by riggers and animators for the chosen activity of assembling a car dashboard. A rigger reads and analyses all training scenarios accomplished in previous steps in collaboration with the customer and identifies all animation necessary parts. He/she prepares the crane pulley blocks and analyzes how the chain is moving after a gear wheel has been manipulated. The rigger identifies the skeletons necessary for animation of given objects and equips the 3D models with these rigs. The same is done for all working tools like drill, air screw driver, angular grinder, etc. All these utensils are analyzed how they behave when on at various intensity levels.

When all objects are furnished with rigs, animators start to animate objects through creating visualizations of moving behavior, e.g. rotating gear wheels, rotating sharpener of the angular grinder, rotating drill, etc. All the rotations are reproduced in virtual environment emulating various intensity levels of moving objects.

When all moves are animated, the business logic and events triggering those animations are programmer in next step.

2.8 Programming business logic

At this eight step, the prepared modeled and animated objects are inserted into the software for creating simulations and trainings in virtual reality. Finishing the input of all objects into the environment, the scenery of the working place is created based on underlying scenarios. Objects are placed to their positions according to the description of workplace in given scenario. The created workplace with all its components compounds the base for programming of business logic of given training scenario. Each object is equipped with physical or non/physical attributes interaction logic and events triggered by user interaction and timers. Collisions among objects are also event triggers enriched by business logic. In other words, all buttons and other interactive fields are assigned programmed events how to react. Everything interactive to be manipulated by the end user is created at this step. During this processing, the application logic

and various persistent services connecting this particular application with other 3rd party software applications are created if necessary¹¹.

To demonstrate the processing of this step on selected training activity for assembling car dashboard in automotive industry, all animated and wrapped 3D model objects are inserted into the software for creating virtual reality simulations to create new scenery. All objects are placed to their positions described in the scenarios, technical drawing specification and reference photographs. For the surrounding of the scenery 360° panorama photo is used. After finishing the graphical visualizations, the programming for creating interactive dynamic content starts.

Each single manipulable objects is provided interaction events according to specification of the business logic. Working tools are equipped with logic how they have to be gripped, how they may be moved and with which object they may be used and on the other hand, with which object they might not be used. The programmed logic contains also handling for such event like object falling on the floor and what happens to the object, e.g. destroyed, scratched, damaged or the object might be bounced back etc.

At this step, all components are processed and assigned interaction logic object by object until the whole dashboard is not completed. Afterwards, the working place and the surrounding scenery is provided interactive business logic, too. This means that a table, a stand or technical drawings are equipped with interaction logic, in particular for collision handling. In other words, what can be laid down on the table, where are the borders and edges of the table, etc.

2.9 Testing

When all objects are modeled, animated and enriched with interaction logic, the testing can start. The testing compounds several testing aspects: testing the graphical interface containing all model objects of the simulation, testing all required and programmed functionality of all objects and the simulated workplace surroundings, etc. Finishing the internal testing made in-house by the developing company successfully without any bugs and/or noteworthy deviations from the specified scenarios, further testing involve the customer representatives for further tuning of all imperfections reported by the customer that are not in compliance with the functional and technical specification of the solution agreed on at the beginning.

The testing consists of several testing scenarios applied in software development industry in following order¹²:

- Integration tests – testing all individual features separately and common interaction of all software objects working together;
- System testing – the application is tested as whole with focus on compliance with functional requirements and technical specification;
- Regression testing – analyzing whether adding new objects, functionality and/or bug fixes has no influence on previously achieved and tested functions and/or no new bugs were produced;
- Installation testing – the overall computational performance and load capability of the whole system is sufficient with regards to end hardware, operating system and installed software;
- Acceptance testing – end to end testing following various cases described in the specified scenarios and test cases. This testing is performed in collaboration with the customer and subsequently by the customer representatives individually.

¹⁰Zeman, N. B. *Essential Skills in Character Rigging*. Boca Raton: CRC Press, 2016. 224 p.

¹¹Tavakkoli, A. *Game Development and Simulation with Unreal Technology*. Boca Raton: CRC Press, 2016. 701 p.

¹²Lewis, W. E. *Software testing and continuous quality improvement*. Boca Raton: CRC press, 2016. 688 p.

To demonstrate the processing of this step on selected training activity for assembling a car dashboard, during integration testing each component is tested in a virtual reality environment, whether it can be properly grasped, what is going on when it is dropped on the floor and if it handles the collisions correctly.

In system testing, the entire dashboard is scrapped according to scenarios agreed on and the process flows are verified to assure the compliance with all defined scenario steps.

During regression testing, a new object is inserted into the simulation and monitored whether the behavior of the application as a whole changes and/or the behavior of all objects that are directly in contact with the newly inserted object as well is still not influenced and correct.

For installation testing, the programmed and created software simulation is installed on the client hardware and test the computational performance with the application software. The software development company specialized in creating virtual reality trainings can recommend the appropriate hardware to assure achieving the best performance on customer demand.

Acceptance testing is performed at first internally where in-house personnel perform the end to end tests according to the scenarios. Subsequently, the acceptance tests are conducted by a person from the customer side according to the scenarios. It means the assembling and installation of the whole car dashboard; testing the functionality of all the components and tools by focusing on their reality close perception and reliability.

All detected bugs and undesired behaviors are processed for identifying the root cause based on logged events¹³ and finding appropriate software solution in form of bug fixes and patches. This whole process represents an iterative process until no further bugs are detected and customer satisfaction is achieved.

2.10 Customer delivery

The last, but not least, step of the whole process is the delivery of the created product solution to the customer. A handover protocol is created containing all important information including the documentation of the whole software as well as manual for simulation utilization. The software is then commissioned into the educational environment of the customer organization, in other words it is installed on customer hardware at customer side under supplier's supervision and tested. First employee trainings are conducted by the supplier to school the employees and future trainers how to use the virtual reality training.

The final form of the proposed solution composes the virtual environment of the assembly line for assembling a car dashboard that resembles the reality to the greatest possible extent in graphical design as well as in functional features. Employees, trained in virtual reality via appropriate hardware suitable for virtual reality application, can execute all tasks of the car dashboard assembly that emulates real works on physical system.

The created simulation works also in testing regime where the employee conducts all his/her tasks in compliance with the scenario and in case his/her handling deviates from pre-described process flow and requirements, the event is logged in a report that is sent to the learning management system of the company or/and to the responsible lecturer afterwards.

The training solution in virtual reality integrated gamification factors that support trainee interaction and motivation and prevent monotony and tedious static learning based on text and pictures as is valid for traditional educational methods. At the

same time, the trainee is forced to involve more senses and can control the learning process through his/her own interactions that provide better demonstrativeness and contribute to greater internalization of taught content¹⁴.

Among the advantages of virtual reality training, besides the aforementioned benefits, belong the reality close perception of the training and the immense similarity of conducted tasks with physically executed activities and the graphical visualization of all components, tools and objects alike physical reality¹⁵.

3 Cost calculation

For the development of described training solution in virtual reality a large group of experts is necessary including:

- Team of programmers with experience in programming virtual reality;
- 3D designers;
- 2D designers;
- Animators;
- Riggers;
- Photographer;
- Project manager;
- etc.

The cost of described solution can be estimated to approximately 20.000 euros where 3.000 euros represents the hardware costs. This estimated cost calculation does not include travel costs for individual visits at customer side as well as no profit margin of the seller or risk costs. Project management practices traditionally recommend increasing the estimated calculation by approximately 20-30% to include the profit margin and costs induced by the project risk. However, such orders are usually not only for simulating one activity, but multiple activities of similar processes e.g. assembling various car dashboards with diverse appearance, but with similar assembly scenario. In such a case, each additional dashboard with similar assembling process flow at similar/the same work place could be estimated to represents additional 5.000 euro costs. These estimated costs include the use of existing logic and scene for new components. For above mentioned calculation the rates of specialized companies in given field in Slovak Republic were used as reference¹⁶ as it is a very narrow segment with very few specialists available with necessary experience for the intended purpose.

The development of described final solution takes approximately 3 months from the customer's delivery of all necessary documents on.

The hardware needed for implementing the described virtual reality training is estimated at the price of 3.000 euros where 2.200 euros corresponds to desktop computer with the appropriate parameters for such type of virtual reality simulation¹⁷ and 800 euros corresponds to the displaying device for virtual reality¹⁸ such as glasses etc.

¹³Dávideková, M. and Greguš, M. ml. Software Application Logging: Aspects to Consider by Implementing Knowledge Management. In: Awan, I. and Younas, M. (eds.) *Proceedings of IEEE 2nd International Conference on Open and Big Data (OBD 2016)*. Vienna, Austria, pp. 102- 107, 2016.

¹⁴Dávideková, M. and Hvorecký, J. Collaboration Tools for Virtual Teams in Terms of the SECI Model. In: Auer, M. E., Guralnick, D., Uhomobhi, J. (eds.) *International Conference on Interactive Collaborative Learning (ICL 2016)*, *Advances in Intelligent Systems and Computing*, vol. 544, pp. 97-111. Springer, Cham, 2016.

¹⁵Gavish, N, Gutiérrez, T., Webel, S., Rodríguez, J., Peveri, M., Bockholt, U., Tecchia, F. Evaluating virtual reality and augmented reality training for industrial maintenance and assembly tasks. *Interactive Learning Environments*, vol. 23, no. 6, pp. 778-798, 2015.

¹⁶Soltec. Price list. Retrieved from <http://www.soltec.sk/cennik/>

¹⁷Soltec. Price list. Retrieved from <http://www.soltec.sk/cennik/>

¹⁸Soltec. Price list. Retrieved from <http://www.soltec.sk/cennik/>

Table 1: Estimated calculation of presented training solution in virtual reality

Process step	Role	Experts in persons	Hourly tax	Number of hours	Sum
1	Architect	1	40€	40	1600€
2	Photograph	1	30€	8	240€
	Architect	1	40€	16	640€
3	Photograph	1	30€	24	720€
4	3D Graphic	1	30€	80	2400€
5	2D Graphic	1	30€	80	2400€
6	Architect	1	40€	8	320€
7	Rigger	1	30€	40	1200€
	Animator	1	30€	40	1200€
8	Programmer	2	30€	80	4800€
	Architect	1	40€	40	1680€
9	Tester	1	20€	16	320€
In total					17 520 €

4 Conclusion

Emergence of information and communication technology allowed new ways of processing and enabled innovation of established methods and techniques. In the field of education, ICT provide interactive and attractive education in virtual reality environment with high resemblance to physical reality. The learners are acquiring new knowledge through attempts and failures in dynamic and interactive environment that provide the empirical "learning by doing" experience.

This paper proposed implementation of virtual reality into employee education in production sector of car dashboard assembly in automotive industry. It outlined and described the development process of such a training with estimated cost calculation to provide more insights for applying virtual technology in education to broad public.

Literature:

- Volná, J., Kohnová, L., Bohdalová, M., Holienka, M., Innovative Mindset and Management Styles: An Intellectual Capital Approach. In: *Proceedings of the 12th International Conference on Intellectual Capital, Knowledge Management and Organisational Learning*, pp. 316-323. Bangkok: Academic Conferences and Publishing International Limited, 2015.
- Veselý, P., Karovič, V., Karovič ml., V. Investments in Education as a Benefit for e-Government. In: Drobyazko, S. I. (eds.) *Economics, Management, Law: Innovation Strategy*, pp. 280-284. Zhengzhou: Henan Science and Technology Press, 2016.
- Burdea, G. C., and Coiffet, P. *Virtual reality technology*. Hoboken: John Wiley & Sons, 2003. ISBN 0-47-36089-9.
- Gigante, M. A. Virtual reality: definitions, history and applications. In: Earnshaw, R. A., Gigante, M. A. and Jones, H. (eds.) *Virtual Reality Systems*. London: Academic Press Ltd., 1993, pp. 3-14. ISBN 0-12-227748-1.
- Lamkin, P. The Best VR Headsets: The Virtual Reality Race is On. Created May 24, 2017. Retrieved June 02, 2017. Retrieved from <https://www.wareable.com/vr/best-vr-headsets-2017>
- Novak-Marcincin J. Technologiami virtualnej reality podporovane vzdelavanie. In: Pavelka J, Franko F (eds.), *II. InEduTech 2006*, pp. 71-75. Presovska univerzita, Presov, 2006.
- Satheesh, P. V. *Unreal Engine 4 Game Development Essentials: Master the basics of Unreal Engine 4 to build stunning video games*. Birmingham: Packt Publishing Ltd, 2016. 244 p. ISBN 978-1-78439-196-6.
- Webster, N. L. High poly to low poly workflows for real-time rendering. *Journal of Visual Communication in Medicine*, 2017, vol. 40, no.1, pp.40-47.

- Hassan, M. *Proposed workflow for UV mapping and texture painting*. Dissertation. 2016. 41 p. Retrieved from <http://urn.kb.se/resolve?urn=urn:nbn:se:bth-12799>
- Zeman, N. B. *Essential Skills in Character Rigging*. 2nd edition. London: CRC Press, 2016. 224 p. ISBN 978-1-4822-3524-1.
- Tavakkoli, A. *Game Development and Simulation with Unreal Technology*. 2nd edition. Boca Raton: CRC Press, 2016. 701 p. ISBN 978-1-4987-0625-4.
- Lewis, W. E. *Software testing and continuous quality improvement*. 3rd edition. Boca Raton: CRC press, 2016. 688 p.
- Dávideková, M. and Greguš, M. ml. Software Application Logging: Aspects to Consider by Implementing Knowledge Management. In: Awan, I. and Younas, M. (eds.) *Proceedings of IEEE 2nd International Conference on Open and Big Data (OBD 2016)*. Vienna, Austria, pp. 102- 107, 2016.
- Dávideková, M. and Hvorecký, J. Collaboration Tools for Virtual Teams in Terms of the SECI Model. In: Auer, M. E., Guralnick, D., Uhomiohi, J. (eds.) *International Conference on Interactive Collaborative Learning (ICL 2016), Advances in Intelligent Systems and Computing*, vol. 544, pp. 97-111. Springer, Cham, 2016.
- Gavish, N, Gutiérrez, T., Webel, S., Rodríguez, J., Peveri, M., Bockholt, U., Tecchia, F. Evaluating virtual reality and augmented reality training for industrial maintenance and assembly tasks. *Interactive Learning Environments*, vol. 23, no. 6, pp. 778-798, 2015.
- Soltec. *Price list*. Retrieved from <http://www.soltec.sk/cennik/>

Primary Paper Section: I

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