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Theoretical platform for designing virtual excursions and their scenarios

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Abstract

Virtual schooling can be seen as a phenomenon that is going to contribute significantly to the development of all areas of human society. The professional interest of the authors of the paper is focused on the use of virtual reality in education in general, and specifically on the issue of replacing field excursions with their virtual alternatives within the framework of secondary vocational education and training. In the paper, they present a literary study whose aim is to offer a general theoretical platform for the development of these kinds of didactic means or teaching aids. The study deals with defining and distinguishing the content of the basic terms associated with the creation of a virtual environment, namely the terms of virtual reality and virtual world, along with the pedagogical aspects of both field trips and virtual excursions, as well as the factors influencing the creation of virtual excursions. To illustrate the elaborated study, the authors present a scenario of a virtual excursion created by them (Virtual excursion of a robotic line to process metal products) which is available at the link https://www.youtube.com/watch?v=yG-0d8gZXFw&t=187s and shows how engineering education and the preparation of the future workforce can be supported by these kinds of teaching means.

Keywords: Creation of digital didactic means, teaching materials, virtual excursions, virtual reality, vocational education, training.

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1. Introduction

After the outbreak of the coronavirus pandemic in 2020, all educational institutions found themselves in a difficult, unexpected, and unprecedented situation. Under the conditions of total forced isolation, they had to transfer all teaching processes to home schooling forms carried out on the platform of the newest digital technologies and related software applications. The transition from traditional to online teaching and learning entailed a significant transformation in education, requiring changes in teaching practices and new learning approaches. The transition to the online form of education at that time was made without any consideration of whether the necessary appropriate study materials and teaching methods were available. This ad hoc shift was a must. Although schools and educational institutions tried to ensure the same quality of education, comparable to the results of traditional forms of teaching, the situation was not the same for all of them. Some faced easier challenges, while others faced more difficult ones. According to Aristovnik and his colleagues Aristovnik et al. [1], as well as others such as Dedeilia et al. [2], Tang [3] and Waller et al. [4], the groups worst affected by the pandemic situation were cohorts of higher education students, participants in employee training, and partially participants in some kinds of lifelong education.

From our point of view, the problem of transitioning the education process from face-to-face mode to online mode was, thanks to a certain level of availability of the appropriate technological means, quite easy to solve in the majority of the study branches. A worse situation was observed in ensuring the appropriate quality of continuing professional training and vocational practice. This was a serious problem mainly for (upper) secondary vocational schools, which were expected to ensure some substitution of practical vocational training and student excursions during the pandemic quarantine and isolation [5-7]. Based on the previous cooperation of the Faculty of Education with the Faculty of Natural Sciences and Informatics at Constantine the Philosopher University in Nitra, a group of people came up with an idea to help secondary vocational schools replace personal forms of excursions with their virtual forms [8-10]. As a result of those intentions, virtual excursions focused on the production and processing of metal products were created. More details related to the created virtual excursions and the process of verifying their applicability in technical subjects teaching have been published in Applied Sciences 2024, 14 Kuna et al. [11], which is available at the link https://www.youtube.com/watch?v=yG-0d8gZXFw&t=187s.

The current paper can be understood as a complementary contribution to the above-mentioned research study. It presents a literary study, the aim of which is to offer a general theoretical platform for developing these kinds of didactic means or teaching aids. The study deals with defining and distinguishing the content of the basic terms associated with the creation of virtual environments, namely the terms of virtual reality and virtual world, along with the pedagogical aspects of both field trips and virtual excursions, as well as the factors influencing the creation of virtual excursions. To illustrate the elaborated study, the authors present a scenario of one of the above-mentioned virtual excursions (Virtual excursion of a robotic line to process metal products), which is available at the link https://www.youtube.com/watch?v=yG-0d8gZXFw&t=187s.

2. Background of the Presented Topic

With respect to the use of virtual reality in teaching and learning processes, we come across two terms: virtual reality and virtual world. The term virtual reality marks technological concepts which are created by means of hardware and software tools, an interactive, computer-generated environment that gives users a feeling of being in another place or world, enables them to create virtual models of objective reality, and then allows their use for generating one's personal perceptual feelings. Such an environment is created by means of computer graphics, sound, and other sensors that allow the users to move and interact with the virtual environment almost as if in the real world. On the one hand, virtual reality technologies can be used to create 3D spatial models, followed by 3D modeling and exploring properties of real objects based on the concerned 3D models. On the other hand, it is possible to use the means of virtual reality to create a "realistic" model spatial environment in which a person can virtually "realize" required activities [12]. The phenomenon of virtual reality is used in different fields, such as the game industry, medicine, education, military training, architecture, and many others. Its goal is to create an engaging and realistic experience that can have a variety of applications, from entertainment to serious professional use.
The main components of virtual reality are Armstrong [13]:

- Visual elements: These create the illusion of a virtual environment using computer graphics. Users can see virtual objects, scenes, and environments in real time through a display or special virtual reality headsets.
- Sound elements: These provide sounds and sound effects that contribute to the sense of presence and immerse users in the virtual environment. This can include 3D sound effects that move in space to simulate hearing sounds from different directions.
- Interactive elements: These allow users to interact with the virtual environment. This can include controls such as joysticks, controllers, gestures, voice commands, or even body tracking.
- Sensory elements: These record movements and reactions of the users and transmit them back to the virtual environment. This allows users to move and interact with the virtual world according to their own actions.

The virtual world is a computer-generated environment that exists independently of the physical world and allows users to interact with digital objects and entities. This world can be presented in the form of 2D or 3D graphics and can include different elements, such as scenes, objects, characters, buildings, and other elements that are perceptible in a sensory way through digital devices. If several people can influence the same environment simultaneously, we call such worlds "shared" or multi-user. Unless no users are connected to the environment, the environment continues to exist and continues to develop internally (at least to a certain degree). Despite the fact that virtual worlds can be used in different ways, their primary and, so far, the most widespread use is in the realm of computer games. Therefore, many expressions used to describe the virtual world come from the game environment. For example, users who engage with the virtual environment are often called players. However, different specialists can apply their vocabulary to this environment; for example, for a sociologist, users of a virtual environment (players) can be referred to as "individuals." The content of the term virtual reality, compared to the content of the term virtual world, is much more specific, so it cannot be equated with the content of the term virtual reality. Virtual reality is primarily associated with the mechanism by which a person manages a computer simulation [14].

Virtual worlds are characterized by several features which are a precondition for their reliable and effective operation. According to Peachey and his colleagues, Peachey et al. 15 virtual worlds must fulfil the following requirements:

- Virtual worlds are permanent and independent. That means they exist regardless of whether a particular individual is connected. Usually, several processes take place in these worlds, which develop even without human intervention [16].
- Virtual worlds should exist exclusively on wide area networks (WANs). This is so that the virtual world can truly be a “world” and not just an “environment” or a “place.” The virtual world must be widely accessible and not "hidden" behind a firewall or similar restrictions.
- Virtual worlds are exclusively multi-user, that means they are capable of including users on a global scale. This is a significant difference compared with virtual environments that are built only for a few users [17].
- Virtual worlds should use avatars to represent users. Avatars are semi-autonomous "agents" representing the users in the virtual world and are able to perform certain activities when controlled by the users. It is therefore important to distinguish avatars from icons or user profiles that cannot perform any activities.

While these insights help to separate virtual worlds from other online communities, such as social networks or blogs, we must remember that even between virtual worlds, there are differences that result in the creation of intermediate categories. The two most general categories are game virtual worlds and social virtual worlds. According to Peachey and his colleagues (Peachey et al. [15]), game worlds, i.e., games with multiple players (users), have become, within the last 10 years, a multi-billion dollar industry. MMORPG (Massive Multiplayer Online Role-Playing Games) is the most represented genre. In addition to the initial purchase price, a monthly subscription is often required for playing MMORPG games. Such games allow players to perform a huge number of activities; in addition, we can create our own avatars with different skills. However, a much more important category of virtual worlds, from the point of view of us as educators, is social virtual worlds. Social virtual worlds are the mainstay of virtual worlds that are used in educational processes. As Peachey and his colleagues state (Peachey et al. [15]), the beginning of virtual social worlds is connected to the massive expansion of individuals' access to data. However, we must not forget the possibility of individuals joining each other. Examples of development (discussion forums, chat services, social networks) show that the Internet, in contrast to various proclamations and forecasts, has proven to be a significant social "connector" rather than a social "isolator."

Key characteristics of a virtual world include:

- Interactivity: Users can interact with objects and entities within the virtual world in various ways, such as movement, manipulation, communication, and other activities.
- Diversity: Virtual worlds can contain a wide variety of environments, from realistic copies of existing places and objects to fantastic and imaginative worlds that are created out of nothing.
- Community: Virtual worlds can serve as places where users from all over the world come together to meet, communicate, cooperate, and create new things.
- Content creation: Many virtual worlds allow users to create their own content and help to expand and improve the environment. This can include the creation of new objects, scenes, missions, stories, and other content [18].
- Immersion: The goal of virtual worlds is to provide users with an engaging and immersive experience that draws them into the digital environment and allows them to feel as if they are part of this world.

As Biznár [19] notes, a significant intensification of the development of virtual reality technologies and an increase in the use of virtual reality have been taking place since 2015. In 2016, more than 230 companies around the world were already dedicated to virtual reality. These tools can help us not only in fields such as medicine or the military sector, but most recently, their usefulness in the real estate business and even in repair and engineering works is being demonstrated. It is also important not to forget about the endless possibilities of their use, as mentioned above, in the entertainment industry.

3. Pedagogical Aspects of Virtual Excursion Creation

One of the problems that schools have faced in recent years is the question of how to effectively convey a large amount of knowledge and information that their graduates will need in order to successfully apply themselves in the dynamically changing labor market. The requirements placed on job seekers are constantly increasing, especially in the field of information and production technologies. Schools are therefore forced to look for solutions to provide their students with an appropriate education and to ensure sustainable quality of the education and training provided, while maintaining the affordability of financial costs. Effective use of virtual reality for educational purposes can contribute to solving the stated problem. In the engineering industry, the use of virtual reality applies not only to individual production items and production steps but also to entire production processes. Covering the entire production segment through virtual reality is an increasingly frequent phenomenon in modern companies of the 21st century. Those interested in employment, including graduates and students of secondary schools focused on various branches of engineering, have access to virtual excursions, which allow them to look into the production premises of the respective companies. As an example of the use of virtual reality in the vocational education and training of secondary vocational school students, specifically in the training of future car mechanics, virtual reality computer games in which the contestants are in the position of a car mechanic can be mentioned (e.g., Warr [20]). Visualization, which multimedia brings into teaching, enhances the quality and durability of knowledge, and it also supports the establishment and creation of correct ideas in students.

The reasons for the active use of multimedia resources in educational processes can be summarized according to Stoffová [21] in the following points:

- They increase visualization of teaching and evoke students' motivation.
- They contain a broad range of information about the concerned object in a concentrated form.
- They support the activities of students.
- They enable us to carry out our experiments.

- They support the acquisition of knowledge based on observation and their own experiences.
- They increase the effectiveness of teaching.

Research results point to the fact that to increase the effectiveness of teaching, it is important not only to visualize learning materials but also to ensure their connection with reality and practice (so-called making connections [22]). From the point of view of the implementation of the means of virtual reality in vocational education and training, we consider the use of virtual excursions to be one of the most significant possibilities in this context. Excursions to various enterprises and companies are normally included in the curricula of professional education and training for students. In the traditional form, they are conducted through teaching based on a walk, e.g., across the production premises of the relevant company. Virtual excursions utilize the possibility of 'digitalized traveling,' which digital technologies enable as an alternative to real traveling [23, 24]. Virtual excursions have already been mentioned as a means through which companies allow job seekers to 'have a look' at their real spaces. As for the technical support for the implementation of virtual excursions in the classroom, the most commonly used tools for viewing virtual excursions are Adobe Flash Player and HTML5 technology, which are widely available in Internet browsers. It is also possible to use gyroscopic control (device movement control) on tablets or mobile devices with iOS or Android operating systems. However, it is necessary to have a sufficiently fast Internet connection so that the image does not take too long to load. 3D stereoscopic technologies are already starting to be used in schools, allowing excursion participants to 'immerse themselves more deeply' in the relevant virtual space of the excursion or of the investigated object [25, 26].

Virtual excursion (field trip) development is a process involving several steps and phases. A general overview of them may be summarized through the following items:

3.1. Planning and Needs Analysis

- Identifying the objectives of the virtual excursion: It is important to determine what we want to achieve by creating a virtual excursion. It can be to support learning achievements, increase student engagement, or create an attractive presentation for the public [27].
- Target group analysis: It is important to know the target group of users and take into consideration their needs, abilities and preferences [28].
- Planning content and interactions: Deciding what content we want to present in the virtual excursion and what interactions we want to allow users. This can include videos, photos, text, audio, animations, 3D models, interactive elements, etc [29].

3.2. Content and Environment Development

- Content Creation: Creating content of the virtual excursions includes selection of texts, media interactive elements. The content should be informative, relevant and attractive for the target group of users [30].
- Environment design: Design of the virtual environment in which the excursion will take place. This can be the environment of a real place, such as a museum, factory, or space station, or a fictional place, created specifically for the purpose of the excursion [31].

3.3. Implementation and Testing

- Software development: Implementing content and interactions into a virtual environment using specialized development tools and software.
- Testing and debugging: Testing the virtual excursion with real potential users and getting feedback that can be used for improving the content and user experience [32].

3.4. Publishing and distribution

- Excursion distribution: After completion and testing, one can publish and distribute the virtual excursion to the target groups of users. This can be done by means of a website, mobile app, virtual reality headsets or other platforms [33].

3.5. Rating and Update

- Evaluation of Success: Evaluation of the success of the virtual excursion based on the set goals and user feedback. This makes it possible to identify the strengths of the created product and areas for its improvement.
- Update and improve: Based on the knowledge gained, one can update and improve the created product (virtual excursion) to ensure that it is the most effective and engaging for the potential users [34].

3.6. Implementation of User Interaction

- User interface creation: Design and implementation of the user interface allows users to navigate and interact with the virtual environment. This may include controls, gestures, voice commands, or control using a computer mouse and keyboard [35].
- Implementation of interactive elements: Inserting interactive elements into the virtual environment allows the users to manipulate objects, open doors, move between the particular spaces, or run interactive simulations [36].

3.7. Optimization and Performance Improvement

- Graphics optimization: We optimize the graphics elements of the virtual excursion to improve performance and speed on different devices. This can include optimizing textures, geometry, lighting, and animations [37].
- Performance improvement: Potential performance issues, such as loading delays, stutters, or frame rate drops to ensure a smooth and comfortable experience for users, should be identified and eliminated [38].

3.8. Testing and Feedback

- Extensive testing: Testing the virtual excursions on different devices and with different kinds of users to identify potential problems and shortcomings.
- Gathering feedback: Gathering feedback from test users and analysing it to identify areas that need improvement or modification.

3.9. Completion and Release:

- Finalization: Making final adjustments and improvements based on the feedback and test results.
- Release of the virtual excursion: Publishing and distributing the final version of the virtual excursion to the target group of users [39].

3.10. Support and Maintenance

- Support provision: Making support available to users who have questions or problems with the use of the created virtual excursion.
- Updates and maintenance: Regular updating and maintenance of the virtual tour to ensure its proper and long-term operability.

The presented process may vary in dependence on the specific needs and requirements of the virtual excursion project [40].

4. Factors Influencing Scenarios of Virtual Excursions

Virtual excursions work on the basis of creating a virtual world and displaying it on the user's device. The creation of a virtual world is most often done with the use of 3D graphics and special programs for creating virtual content. After creating such content, it is necessary to display it on the teacher's or student's device to help students better understand concepts that would otherwise be abstract, difficult to imagine, and therefore difficult to understand. The development of a virtual excursion involves several technical aspects that must be carefully planned and executed. Hereinafter, some examples related to different kinds of virtually visited facilities are presented.

- A car manufacturing plant visit: Students could explore car production lines and watch every step of the manufacturing process, from body molding to engine and interior assembly. They could view the different types of machines and robots used in the automotive industry and gain a deeper understanding of the modern manufacturing process [41].
- A research lab visit: Students could visit a research lab to see advanced technology experiments and projects in robotics, artificial intelligence, or nanotechnology. They could „meet“ researchers and engineers, and get an idea of how new technologies are being developed and tested [42].
- Space station visit: Such an excursion should allow students to explore the space station and watch how astronauts work and live in space. They could tour the station's various modules, such as the laboratory, living quarters, and control center, and learn about the technologies used to live in space.
- Visit at the world's technological innovations: Students could visit a virtual museum of technological innovations and discover important inventions and advances in the field of engineering and technology. They could view exhibits and information about the inventors and scientific discoveries that shaped the world today [43].
- Visit at a virtual model of the universe: Students could explore a virtual model of the universe and discover different planets, stars, and galaxies. They could learn about astronomy and space missions and watch space flight and exploration simulations [44].
- Visit to a digital development studio: Students could visit a digital development studio and gain insight into the process of creating computer games, animations, or software. They could observe the workflows of programmers, designers, and artists and see how digital products are created.
- Exploring virtual reality and augmented reality: Students could learn the basics of virtual reality and augmented reality and gain insight into the technologies behind creating interactive virtual environments. They could participate in simulated interactions and experiments with VR and AR devices [45].

Movement within the virtual excursion is carried out using the cursor and mouse movements. For devices with a touchscreen, this movement is controlled by the movement of the finger across the display. Virtual excursions are also designed for virtual reality headsets, with the help of a gyroscope and by turning the head to the sides; it moves similarly to a cursor or the aforementioned movement of a finger on a touchscreen. Each video sequence lasts 20-30 seconds. During this time, one can watch all the subtitles, which are spatially displayed, and then one moves on to the next sequence. The implementation of a virtual excursion into the teaching process can bring many benefits for both students and teachers. Here are some key steps and practices for their better achievement:

- Choice of a suitable topic and relevant goals: Consideration of topics or areas that might be suitable for this form of education. Selection of a virtual excursions fitting into the educational program and the goals to be achieved through this excursion [46].
- Choice of the right tools and platforms: Exploring different tools and platforms for creating and playing virtual excursions and selecting the ones that best suit the concerned needs and capabilities.
- Creation and search of the appropriate content: Creation of own content of the virtual excursion or searching for existing resources that can be used. Consideration working with professional content creators or using the existing online resources [47].
- Integration of virtual excursions into the school curricula: Determining where and how virtual excursions will be integrated into the school curricula. Their use as a part of teaching new concepts, as a tool for exploratory learning, or as a supplement to traditional teaching methods.
- Provision opportunities for students to actively participate at the event (activity): Creating opportunities for students to actively interact with given virtual excursion environment. This may include assignments, discussions, group work or projects based on the excursion experiences [48].
- Achievements and results evaluation: Provision of feedback to students and consideration of how well the virtual excursions are integrated into the teaching process and whether the planned learning outcomes were achieved by them.
- Adaptation and improvement: Based on the feedback received, adaptation and improvement of the use of the virtual excursions within the teaching process should be done. Openness to new approaches and reflection of the needs and interests of students [49].
- Provision of access to technology: Providing access to the necessary technological means (computers, smartphones, tablets, or virtual reality headsets) to view the virtual field trips. An important factor is whether the school has sufficient technological equipment and access to the Internet [50].
- Teacher and student technology familiarization: Providing teachers and students with the necessary training and support in the use of the technologies required to complete a virtual excursion. Making sure everyone is familiar with using the concerned apps, software, and hardware needed to play and interact with virtual excursions [51].
- Integration of virtual excursions into the existing teaching materials: Incorporation of virtual excursions into the existing curricula, teaching plans, and teaching materials. Possibility to put links to virtual excursions into learning materials or prepare special lessons and activities based on virtual excursions [52].
- Support to individualization and differentiation: Use of virtual excursions as a tool supporting individualized and differentiated teaching and learning [53].
- Assessment and efficiency evaluation: Evaluation of the efficiency of the implementation of the virtual excursion by means of different evaluation methods such as survey questionnaires, classroom observations, and performance tests. Analysis of the results and considering possibilities of how the practice could be further improved [54].

Implementation of virtual excursions into the teaching process can significantly enrich the educational experience and support active and interesting learning. The presented steps are very important for a successful implementation of virtual excursions into the teaching process and ensuring its efficiency, and sustainability of the achieved results in a long-term point of view [55].

5. Example of a Created Virtual Excursion Scenario

To illustrate the theoretical principles involved in the literature study presented above, a scenario of one of the virtual excursions created by us is presented hereinafter.

As it is already above-mentioned, our primordial intention, which arose even during the coronavirus pandemic, was to help vocational schools replace face-to-face excursions with their virtual substitutions. We maintained this idea even after the decline of the pandemic, and subsequently, after the pandemic, following the State Educational Programs of secondary vocational schools, we created a virtual excursion focused on the production and processing of metal products: a virtual excursion of a robotic line to process metal products. The venue of the excursion is the facilities of a company that produces aluminum profiles, predominantly for the automotive industry, and which cooperates, within the system of dual vocational education and training, with some secondary vocational schools as a training workplace for their students (apprentices). The excursion is available at the link https://www.youtube.com/watch?v=yG-0d8gZXFw&t=187s, and hereinafter we present its scenario.

The online tour through the visited facilities (without making any stops) is approximately 7 minutes, and it consists of 14 sequences. For illustration Figure 1 presents a possible stop during the sequence 8, enabling to observe a press and its surrounding.

5.1. Sequence 1: 00:00 – 00:20s

The first sequence represents the storage and export of finished aluminum profiles with a length of 8 meters. The method of storing and loading profiles using industrial cranes can be seen in detail. The sizes of the manufactured profiles range from 40 centimeters to a maximum length of 8 meters. A maximum of two trucks can be loaded at the expedition position at the same time. Profile shapes are produced depending on customer requirements.

5.2. Sequence 2: 00:21 – 01:11

In the second sequence of the excursion, which consists of two views, the run-out fields of the press with finished products of aluminum profiles are shown. As this is the longest equipment in the process, the sequence is split into two previews. Running fields are 40-60 meters long for the handling of profiles. Pressed finished products intended for inspection or packaging are moved along the run-out fields of the press. Several products can be moved simultaneously through this field. However, the products must be of the same type.

5.3. Sequence 3: 01:12 – 01:38

The third sequence presents a stack of long pins ready for the production process, and a conveyor that moves the long pins into the production process. The length of the long pins is 8 meters. The magazine must always contain a larger number of long pins for the smooth running of the entire process and to maintain uninterrupted operation. The magazine capacity is divided into 14 columns, where each column contains 12 pins stacked on top of each other. The reservoir is replenished several times during the day.

5.4. Sequence 4: 01:39 – 02:11

In the fourth sequence, the process of shortening and cutting the studs into shorter pieces with a saw is recorded. The length of the stud cutting is determined by the type of order. In this step, the pins are also heated to a temperature of 600°C, which is necessary for the next steps. Heating takes place in two ways, through a gas oven or an induction oven. Cutting long pins into short ones is necessary for better handling and better workability for the press.

5.5. Sequence 5: 02:12 – 02:58

The fifth sequence presents the supply of short pins and their sorting. During this process, failures are separated, and based on the assessment of the length of the studs, the next course of action is determined. Short pins, the length of which is more than 100 cm, are put aside for possible further use; shorter pins are recycled as waste. Compliant pins are moved to the charger for the press. In this sequence, the presented space is reserved for the collection and storage of metal sawdust from cutting long pins into short ones. From scraps and metal sawdust, so-called "pellets" with dimensions of 10 x 10 centimetres for better handling and consistency.

5.6. Sequence 6: 02:58 – 03:18

The sixth sequence presents devices for measuring pin length and induction heating. As part of this step, the last control measurement takes place before the pressing process itself. Heating is ensured through an induction furnace, in which the short pin is heated to 600°C. The short pin heated in this way is moved directly into the press via the feeder. Heating to the indicated temperature is necessary for easier processing for the press. As a result of the high temperature, the short pin softens, and the press processes this pin without disturbing the structure of the material.

5.7. Sequence 7: 03:18 – 04:01

The seventh sequence presents the hydraulic reservoir of the press, which is filled with the hydraulic oil necessary to create the proper pressure of the press on the short pin. The pressure on a given short pin and the speed at which the pin is pressed are determined by the technical tables. In the background of the short stud conveyor, there is also a feeder that puts the short studs directly into the press.

5.8. Sequence 8: 04:02 – 04:36

The eighth sequence is focused on the charging mechanism of the press, in which the short pin delivered by the conveyor is subsequently pressed. The short pin is pressed into the desired shape by means of pressing tools that serve as moulds. In this sequence, the pressing tools and the storage basket for the pressing tools can be seen. The basket is used for storing or quickly using pressing tools for the press. Before the pressing process, it is important to heat the pressing tools for better working with a short pin and let them cool down after the process. There are several pieces of pressing tools, differing among themselves in the size of the hole through which the pin pushed through the press passes. Between the final point of the press and the pressing tool, there is waste material in the form of undercuts, which are then transported (under the marked green floor) to the undercut container. Undercuts have a pie shape, and their size is individual. The width of the landing is at least 10 centimetres.

Figure 1.
Illustration of Sequence 8: Press and its surroundings.

5.9. Sequence 9: 04:36 – 04:54

The ninth sequence represents the main centre of the production process. The control and control panel of the press is located here. This panel contains all information from the input product to the final product. Under the order number, there are all the necessary parameters for the processing of short pins, from their sizes to sorting and transfer to the packaging tools. According to the parameters of the order, the pressure and speed of the press acting on the short pin are corrected. Other possibilities of the control panel include a fire protection safety system, which must be ready to intervene at the right time under all circumstances. BICS cooling of the mouldings takes place immediately after pressing. Cooling is carried out through an air and water system, set with precise parameters, after which steam is produced. With the help of water cooling, the hardening process also takes place. Quenching is the process of heat treatment of metals by heating and subsequent cooling, in order to change the internal structure and thereby change the properties of the metal. Hardening affects properties such as hardness, strength, toughness, etc. The cooling system space takes place behind a glass wall. The preview also shows the area of the heating furnaces, which serve to preheat the pressing tools.

5.10. Sequence 10: 04:55 – 05:15

The tenth sequence is focused on profile sawing. Shows the input field for the short saw and the sample testing stand. The mechanical test samples from the short saw also serve as templates for the rest of the moulded products. The samples are tested for tensile and compressive strength. The pressing tools are attached to the press by sleeves, which must be changed together with the pressing tools, in order to avoid damage to them. The input field for the short saw is the transport area of pressed products to the saw, which cuts the required dimensions of the products. The required dimensions are the customer's parameters for the given product. Several pieces of profiles can pass through the input field at the same time, depending on their width.

5.11. Sequence 11: 05:16 – 05:40

As part of sequence eleven, the participants of the excursion are on the opposite side of the paddock from the press, which is located in the second sequence containing two previews. Again, there are the press tools and the press run-out field, which is 40-60 meters long. This sequence shows the press tools ready for use in the press. The input field for a short saw has a length of approximately 30 meters.

5.12. Sequence 12: 05:41 – 06:00

The twelfth sequence represents the run-out field of the press in combination with feeders and sorters for entering the short saw. Sorters and feeders correct the amount and direction of the blanks intended for the short saw. There is also a saw for trimming the edges of mouldings, which is important for the final shape of the product - the profile. The edges need to be trimmed due to possible deformation that may occur due to handling of the mouldings or temperature.

5.13. Sequence 13: 06:00 - 06:30, and *Sequence 14:* 06:31 - 06:58

Sequences thirteen and fourteen are identical in terms of the production process, although they are realized from different perspectives. In these sequences, there are finished products in the form of aluminum profiles ready for shipment. From the production side, the finished aluminum profiles are moved by means of a destacker to the next step, which is packaging and later export. Profiles are securely packed and secured for handling. The industrial cranes located in the upper part of the production hall allow for moving or possible loading within the expedition.

6. Conclusions

Verification of the applicability of the virtual excursion of a robotic line to process metal products, a scenario of which is presented in the previous chapter, in technical subjects teaching at secondary vocational schools, was based on an analysis of experts' opinions collected from semi-structured interviews focused on the following eight key questions:

1. What was difficult and caused the expert (who used the virtual excursion within a relevant teaching lesson) any problems during the lesson planning or teaching of the lesson?
2. What are the advantages of the used virtual excursion?
3. What are the disadvantages of the used virtual excursion?
4. Did the preparation for the lesson go well, or were there any changes the expert (who used the virtual excursion within a relevant teaching lesson) had to introduce regarding the content of the trip (necessity to modify the scenario of the taught lesson)?
5. How did the students perceive the virtual excursion, and how did they complete the set tasks (students' evaluation of the excursion and provided instructions)?
6. Has the students' attitude to teaching changed after the introduction of the virtual field trip into the teaching process (was there a positive impact of the intervention of the virtual excursion on students' knowledge? Would the students like to have more presentations of virtual excursions)?
7. How does the expert (who used the virtual excursion within a relevant teaching lesson) evaluate the concept of the virtual excursion (including the Methodology and Technical Guide, i.e., the teacher supporting materials developed with respect to the virtual excursion)?
8. How does the expert (who used the virtual excursion within a relevant teaching lesson) evaluate, as an expert, the usability of the assessed materials in practice?

The findings of the qualitative analysis of the interviews with the experts proved several positive impacts of the implementation of virtual excursions into teaching practice. They included increased student motivation to learn, increased student interest in lesson content, increased student activity, and intensified learning activities in general, including various forms of self-study. Moreover, the materials positively impacted the attractiveness of the teaching profession, making it look more modern and up to date (for more details, see [11]).

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