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Virtual Field Practice Education for Total Station

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Abstract

Virtual education emerges as an important alternative in situations where distance education is required, such as during the pandemic period, when fieldwork is required, but weather conditions do not allow it, the number of devices is low, or the technology is insufficient. The main aim of this study is to teach the usage areas, usage purposes, basic measurement principles, and measurement strategies of the total station instrument in a virtual environment. For this purpose, the total station device and related equipment, such as tripod, prism, and telescopic pole, were designed in 3D in a virtual environment by reality. Web programming was chosen to program the virtual environment and simulation process due to its advantages of accessibility, interactivity, performance, and ease of development. Three basic web programming languages and a library were utilized collaboratively during the developed web program process. Javascript programming language is used for mathematical operations and programming methods. HyperText Markup Language (HTML) was used to structure and present the content of the web page. Cascading Style Sheets (CSS) is utilized to describe the presentation of a document written in HTML. Three.js library was used to create and display 3D computer graphics. Fundamental quantities such as angle and distance concepts that can be observed with the total station are included in the model, aiming to improve users' real-time usage practices and to enable them to understand these variables.

1. Introduction

With rapidly developing technology, crucial changes in our daily lives can be observed in many areas, such as social needs, tools, and ways of accessing information. The field of education has to keep up with these changes in both traditional and e-learning processes (Abdul Halim & Abdul Rasam, 2021). E-learning is still in development and needs to be extensively improved compared to conventional learning (Jia et al., 2022). While pursuing this change sometimes requires updating the information taught and educational materials, greater technology integration is required in applied sciences.

These rapid developments in technology also change the collection and processing processes of geographical data. Geographical data is mainly collected with automatic systems; sometimes, it may still need to be collected through field studies (Levin, Shults, Habibi, An, & Roland, 2020). Engineering disciplines that use geographic data, such as Geomatics, depend heavily on hands-on training, practical courses, and theory (Gartner et al., 2022). In these disciplines, while theoretical education is conducted in classes, the practical part of the education is undertaken outside as well as in laboratories. Unfortunately, bad weather conditions significantly hinder training that should be carried out outdoors. Moreover, in cases where education must be carried out partially or entirely with distance education, such as those experienced during the COVID-19 process, it becomes challenging to understand practical issues. In order not to disrupt education during the COVID-19 pandemic, most universities have implemented a wholly digital or more e-learning education model (Dubois et al., 2022; Retscher, Gabela, & Gikas, 2022).

Geomatics is a field of study concerned with investigating, monitoring, and analyzing natural and built environments from metric and thematic perspectives (Botto, Federici, Ferrando, Gagliolo, & Sguerso, 2023). Intensive indoor and outdoor laboratory components are essential requirements for teaching the Geomatics discipline (Abd-Elrahman et al., 2023). These lab directives are conducted in pre-lab preparation, actual data collection, and post-lab computations stages (Abd-Elrahman et al., 2023). During this process, both the devices used and education-training techniques should be updated by technological developments. Geomatics education should apply flexible curricula to deal with the necessity of technological changes (Çoruhlu et al., 2023). To provide the education required by the age, curriculum design, and course delivery must be innovative and adaptable (Çoruhlu et al., 2023). To adapt the newest technologies emerging in this field to the profession, it is necessary to examine the products and prepare the required documents in real or virtual environments (Chizhova et al., 2020).

The knowledge of geomatics and topography is a part of the learning process for many fields of study, such as geomatics, civil, environmental, and geology engineering, as well as architecture and urban planning. This information is taught through field studies using specialized surveying instruments such as total station, global navigation satellite system receivers, leveling instruments, and laser scanners, as well as theoretical knowledge (Yeomans-Galli, Vela-Coiffier, Gutierrez-Hernandez, & Ballinas-Gonzalez, 2023). Many studies have been carried out in which these state-of-the-art devices are used for educational and academic purposes using traditional methods (Akgül, Görmüş, Kutoğlu, & Jin, 2024; Karadeniz, Pehlivan, Altıntaş, & Usta, 2024; Maraş & Karafazlı, 2024; Ozdemir, Akbulut, Karsli, & Acar, 2021; Promneewat & Taksavasu, 2024; Yakar & Doğan, 2017).

Virtual education emerges as an important alternative in situations where distance education is required, such as during the pandemic period, when fieldwork is required, but weather conditions do not allow it, the number of devices is low, or the technology is insufficient. In recent years, a limited number of studies have been carried out using virtual reality technology in the fields of geomatics and topography. For this purpose, the historical underwater Calarcheo Park archaeological site was modeled (Barrile, Fotia, Bernardo, & Candela, 2020) and used for educational purposes. (Yeomans-Galli et al., 2023), the study evaluated the learning outcomes of the traditional teaching method and virtual field practice of photogrammetry and terrestrial laser scanning. The authors concluded that the virtual education model is an efficient complementary teaching process. In (Levin et al., 2020), the authors focused on installing the total station instrument in a virtual reality project. In (Abd-Elrahman et al., 2023), the centering and leveling lab activities are presented with an educational virtual reality application.

2. Purpose and Significance of the Study

Online learning environments have the potential to overcome the learning deficiencies caused by the problems of access to face-to-face and hands-on education in engineering education. According to (Seryakova et al., 2022), online applications in engineering education can support the development of the competencies of future engineers by providing practical applications. On the other hand, although the use of virtual or remote laboratory applications has increased rapidly in recent years, it is considered an obstacle in online engineering education(Al-Nsour, Alkhasawneh, & Alqudah, 2022). One of the main reasons for this is the lack of interaction with real hardware, and studies suggest that virtual labs should cover all real-life cases (Budai & Kuczmann, 2018). It is thought that the prototype application presented in this study has the potential to overcome this deficiency in the literature.

The main aim of this study is to teach the usage areas, usage purposes, basic measurement principles, and measurement strategies of the total station instrument in a virtual environment. For this purpose, the total station device and related equipment, such as tripod, prism, and telescopic pole, were designed in 3D in a virtual environment by reality. Also, benchmark points are added to understand the reference point concepts. In addition, fundamental quantities such as angle and distance concepts that can be observed with the total station are included in the model, aiming to improve users' real-time usage practices and to enable them to understand these variables. Thanks to this virtual environment, students can learn measurement variables of total station and improve theoretical and practical knowledge about total station without going out into the field. In addition, nine different virtual environments, such as rural and urban areas, are prepared to enable users to develop their practical knowledge about measurement strategies in various environments. Within this virtual environment, the user can freely navigate, change the position of the instruments, conduct the measurements, and see the related observation values and coordinates.

3. Material and Method

Land surveying in geomatics engineering is one of the operational workflows that must be implemented for map production and modeling. Understanding land topology is a skill that researchers or students interested in collecting topographic data must develop. For surveyors, these skills are learned in the field using devices such as electronic theodolites, GNSS, and laser scanners (Levin et al., 2020). Since this training is carried out in the field, they are sensitive to the seasons of the year and weather conditions. Therefore, Virtual Reality and Augmented Reality (VR/AR) technologies have begun to be used to provide this training at any time or condition.

This study aims to give the necessary knowledge and practice about the total station to the students and surveyors by using virtual programming. Web programming was chosen to program the virtual environment and simulation process due to its advantages of accessibility, interactivity, performance, and ease of development. Three basic web programming languages and a library were used collaboratively during the developed web program process. Javascript programming language is used for mathematical operations and programming methods. HyperText Markup Language (HTML) was used to structure and present the content of the web page. Cascading Style Sheets (CSS) is used to describe the presentation of a document written in HTML. Three.js library was used to create and display 3D computer graphics.

The produced virtual tool is mainly focused the understanding the principles of angle and distance measurement of a total station. To achieve this aim, the total station and related equipment, such as tripod, prism, pillar, and telescopic pole, were modeled in the 3D virtual environment. To reflect the real scenario, all these devices are designed as movable. The main structure of the education tool is given in Figure 1.

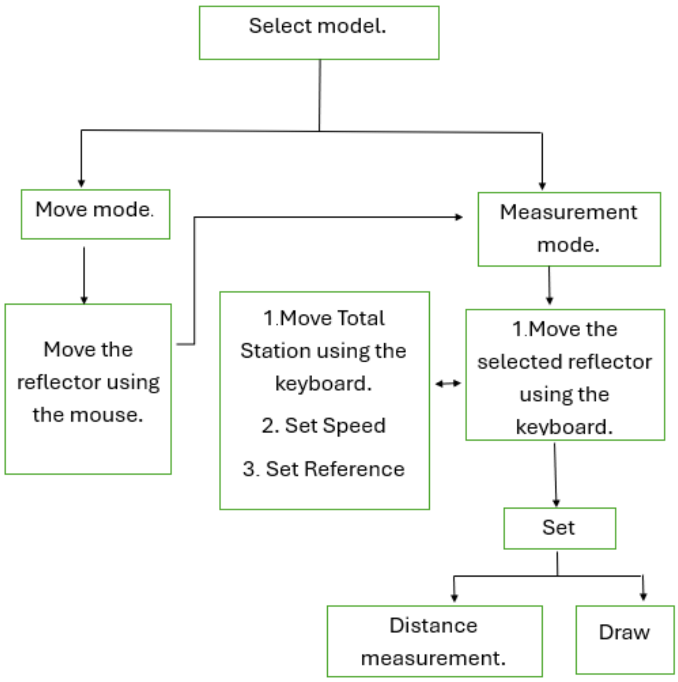
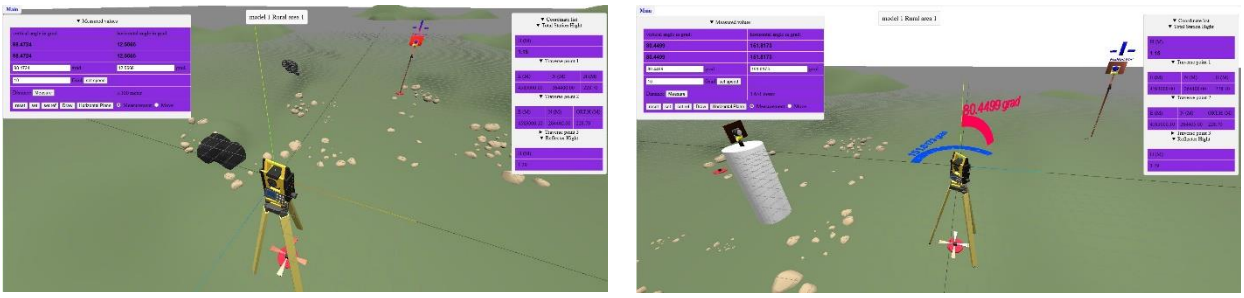


Figure 1. The main structure of the tool

In the move mode user can settle the total station and the reflectors at the desired positions. When the settlement of the devices is completed, the user can switch to the measurement mode. In the measurement mode, the user can set the horizontal angle to the desired reflector. In this case, it will be seen that the total station device rotates on the horizontal and vertical axes. Simultaneously, vertical and horizontal axis values are seen on the screen. Moreover, the measured horizontal and vertical axis values in grad and the slope distance in meters are given in the above-left drop-down menu. In the above-right drop-down menu, the height of the total station, the height of the reflectors, and the coordinates (in easting, northing, and orthometric height) of the traverse points are given (Figure 2).



(a) (b)

Figure 2. Measured values in the drop-down menus (a: axis and b: horizontal and vertical angles)

Different application areas in field studies may require different measurement strategies. To carry this situation to the virtual education environment, 9 different 3D models were used: 2 rural areas, a suburban area, an urban area, a desert area, an archaeological area, a road, a highway, and a building. These models were downloaded from the Sketchfab website which gives opportunity to the users many kinds of 3D environments (Sketchfab, 2024). On the main page of the virtual tool, the user can choose the desired environment in the drop-down menu (Figure 3).

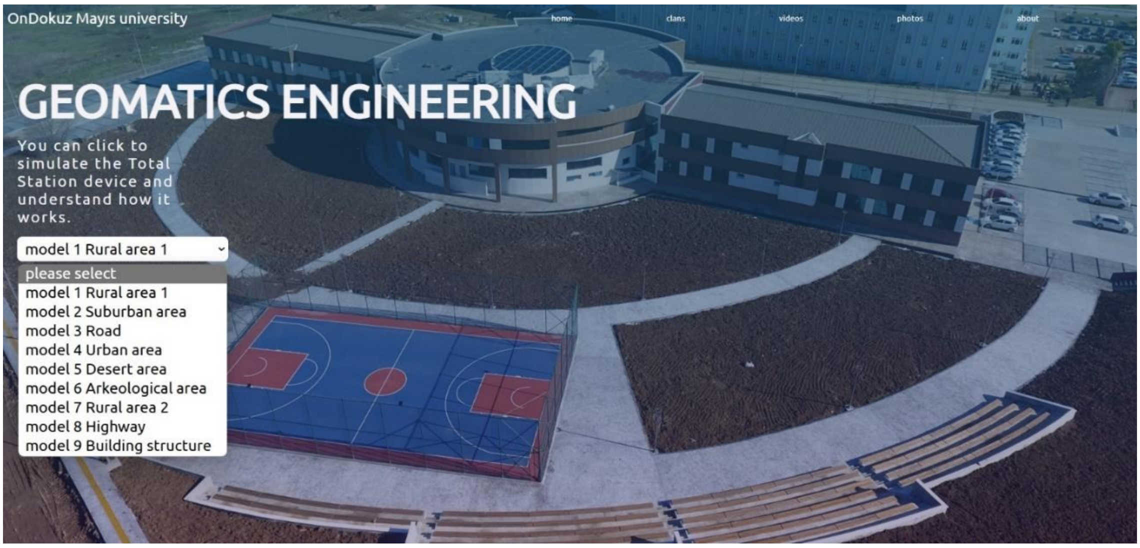
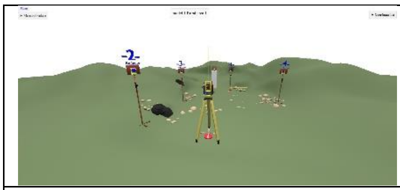
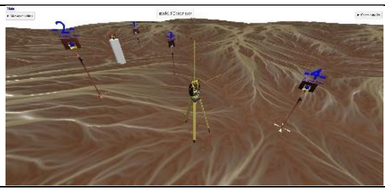
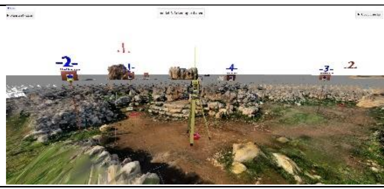


Figure 3. Home screen of the tool

After the choice of the desired environment, the user can design the device settlements and start the measurement as explained above. The sample representations of the nine environments are seen in Figure 4.

		
Rural area 1	Suburban area	Road
		
Urban area	Desert area	Arkeological area

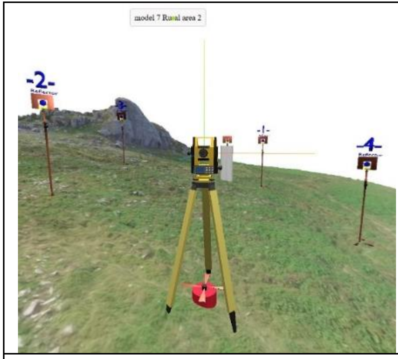
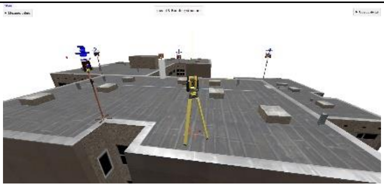
		
Rural area 2	Highway	Building structure

Figure 4. The nine different measurement scenarios

4. Conclusion

Thanks to today's technological opportunities, virtual education has become applicable today. Virtual education can offer an important alternative, especially in educational fields where field studies are frequently used, such as geomatics engineering. In addition, when weather conditions are not suitable or face-to-face education is prevented due to the pandemic, virtual tools will be able to provide alternative education opportunities and ensure that education is not interrupted. In this study, a study was developed for total station training, which is one of the basic devices in survey engineering. In this study, which includes the total station device and related equipment developed in a virtual environment;

- Axes of the device,
- Coordinate concept,
- Ellipsoidal and orthometric height,
- Horizontal and vertical angle concepts,
- Slope and horizontal distance concepts,
- Location and measurement strategies in different environments,

It is intended to be taught. Thus, an alternative training opportunity was provided in cases where field studies were disrupted. In the future study, the contribution of this tool to different student groups in learning the total station device will be investigated and the results will be shared.

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Author contributions:

Bashar Helal: Methodology, Software. **Veli İlçi:** Conceptualization, Methodology, Validation, Writing-Original draft preparation. **Kaan Batı:** Conceptualization, Writing-Reviewing and Editing.

Conflicts of interest

The authors declare no conflicts of interest.

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