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Development of a virtual experience of evaluation of the concept of a low and SAE formula vehicle

Desarrollo de una experiencia virtual de evaluación del concepto de un vehículo tipo baja y formula SAE

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Abstract

Technological growth focused on virtual reality has allowed us to develop new processes and tools that allow us to incorporate simulation methodologies in a virtual environment for the launch of any prototype, in such a way that the first physical models for testing are built after complex analysis. in 3D. The research shown below focuses on analyzing the different possibilities of virtual reality concerning the visualization and dimensional validation of a Baja and Formula SAE-type vehicle, to improve vehicle development processes through the application of this tool, optimize the experience of those in charge of design, saving time and increasing operational efficiency. With the help of a VR team and special software for 3D visualization (VRED), the quality offered by the virtual environment was evaluated, as well as the different tools offered by the software to make the virtual experience as close to reality as possible. The results obtained in this research will allow the reader to know the tools that were used during the process to create a virtual environment and have the ability to interact with the model and the created environment.

Baja SAE, Formula SAE, Validation, VRED, Visualization, Virtual Reality

Resumen

El crecimiento tecnológico enfocado a la realidad virtual ha permitido desarrollar procesos y herramientas nuevas que nos permiten incorporar metodologías de simulación en un ambiente virtual para el lanzamiento de cualquier prototipo, de tal manera que los primeros modelos físicos para las pruebas se construyen luego de complejos análisis en 3D. La investigación que se mostrará a continuación se enfoca en analizar las diferentes posibilidades de la realidad virtual con respecto a la visualización y validación dimensional de un vehículo tipo Baja y Formula SAE, esto con el propósito de mejorar los procesos de desarrollo de vehículos mediante la aplicación de esta herramienta, optimizando la experiencia de los encargados del diseño, ahorrando tiempos y aumentando la eficiencia operativa. Con la ayuda de un equipo de VR y un software especial para la visualización en 3D (VRED) se evaluó la calidad que ofrece el entorno virtual, así como las distintas herramientas que ofrece el software para volver la experiencia virtual lo más cercana a la realidad. Los resultados obtenidos en esta investigación permitirán al lector conocer las herramientas que se utilizaron durante el proceso para crear un entorno virtual y tener la capacidad de interactuar con el modelo y el entorno creado.

Baja SAE, Fórmula SAE, Validación, VRED, Visualización, Realidad virtual

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Introduction

The beginning of the evolutionary history of virtual reality is marked in the nineties; however, it has an origin with experiences in cinematographic sectors in 1950, when the "sensorama" appeared as a pioneer experience in the development of virtual reality [1]. The development of virtual reality programs is more frequent and more popular, in recent years, Virtual Reality (VR) applications have become widely available [2], since there is a wide variety of software that facilitate tasks ranging from manufacturing 3D models, control of a graphics engine that is mainly responsible for 2D and 3D digital content. Through extensions of the same software, Virtual Reality is a medium that is composed of interactive simulations by means of a computer, which sensitize the position and actions of a user, generating the sensation that the user is immersed or present in the simulation (virtual world) [3]. Software such as Solid Works, Unity 3D and Catia V5, to mention a few in their free versions, have the necessary tools to visualize the models adequately even with their limitations.

The Baja and Formula SAE vehicles that will be shown are designed to participate in competitions of their branches, these events are held around the world, within these are achieved to expose the designs of different off-road or track vehicles, built by their teams based on the Baja SAE regulations of the competition [4], our contribution to this project will be to model in a virtual environment for both vehicles in order to show the prototype designed by the team in each of the branches, to a scale size and can make the necessary changes to pass the various tests that encompass these competitions.

Taking into account the development of these new technologies, it was decided to venture into the development of a virtual reality prototype with respect to the Baja and Formula SAE created by the students of the Universidad Popular Autónoma del Estado de Puebla, with the aim of assessing the quality of the environment of the virtual prototype and evaluate the dimensional validation offered by the VRED software.

Virtual reality is currently understood as a digital experience enhanced through a vision gadget (special viewers) by means of which, before the reproduction of an environment (artificial or obtained from real events), physical and emotional sensations and reactions are achieved, just as they are experienced in real life [5].

Problem

Before being able to add a CAD model to a virtual reality software, it was necessary to investigate the features offered by such software. As part of the obstacles of this project, it was found that the number of programs that will be able to perform this type of projects is minimal at the moment, in addition to the fact that not all programs have student licenses. During the search process, good software was identified but with limitations, such as access to the program and its features, and the only way to use it was to purchase it.

The program used for the visualization of the 3D models in a virtual environment was VRED. During the process it was identified the problem that the tools of this program change depending on the version, since in current versions of the software there are more complex tools with less information released, it should be clarified that not all versions handle the same interface which forced to make different tests in order to achieve the desired result even with the lack of information.

For the selection of the CAD models to be imported to the virtual reality software (VRed) it was necessary to homologate them with respect to other prototypes of vehicle design. In the case of this project, the CAD models to be used are the competition models of the UPAEP university, both the Baja and the Formula SAE.

The tools and the different elements that will be added will be to make the virtual experience more pleasant and comfortable for those who are viewing the model with the virtual reality glasses, as part of these amenities is the interaction with the change of environment, as well as with the change of model to be displayed, the power to make a point to point measurement, among others.

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When these functions are active and working, a displacement of the model will be performed so that the user can observe in detail the path of a Formula or Low SAE type vehicle and also be able to see specifically how the components of each area work together to generate the movement of the vehicle.

Justification

Throughout history, the automotive industry has been updated to be able to have a relationship with its consumers, allowing access to new technologies such as virtual reality, which already has more than 50 years of trajectory, which previously focused on other areas such as video games, culture, art and entertainment. This generated an opportunity for growth in the automotive sector, which is gradually developing.

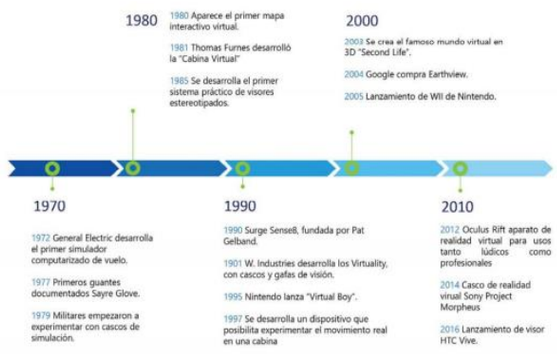

Figure 1 Development of virtual reality
Source: [6]

The popularity of these new technologies has increased considerably due to the multiple benefits they offer in the area of design and marketing, sources such as INSIDER Intelligence, which are dedicated to research and statistical forecasts on various topics, took on the task of forecasting the increase in the use of VR and AR. In the image number 2 is presented in a bar chart, the percentages of people using these technologies, either with headset or non headset, only for the years 2019 to 2023. Although the forecast was made exclusively for the U.S. population, this helped to have a clearer idea of the progress being made in the field of virtual reality.

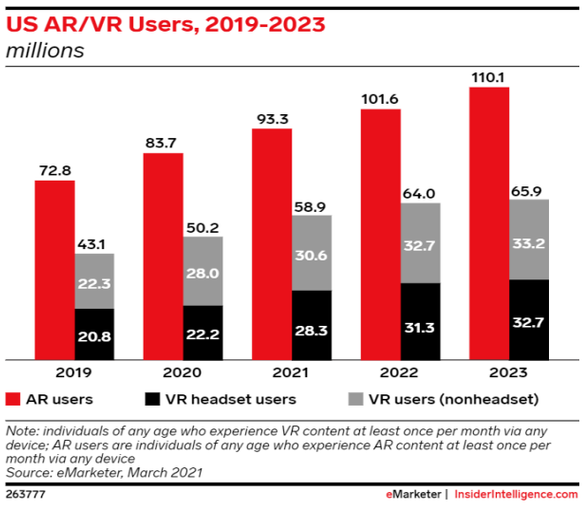

Figure 2 Chart of forecasts of increased use of VR and AR
Source: [7]

Conceptualization

As part of the theoretical and practical development for this work, it was essential to go deeper into the topic of the virtual environment focused on the existing standards for this type of technologies and thus be able to justify the work more clearly. Among the existing standards, ISO/IEC TR 18040:2019 Information technology- Computer graphics, image processing and environmental data representation-Live actor and entity representation in Mixed and Augmented Reality (MAR) was located; which manages to present the correct compatibility between data to share them in the correct way, since it provides a reference model for applications in MAR, in addition, it manages and controls learning, education and entertainment (LAE) in a MAR environment [8]. Another standard found during the research is ISO/IEC TR 23842- 1:2020 Information technology for learning, education and training-Human factor guidelines for virtual reality content-Part 1: Considerations when using VR content [9].

This standard specifies the different considerations that designers should have for the proper and effective use of the virtual environment in different areas, such as education, learning and training as the first part, this standard has an extension of the content, subdividing the standard into two, to achieve a more dynamic content for the reader with the following nomenclature ISO/IEC TR 23842-2:2020 Information technology for learning, education, and training-Human factor guidelines for virtual reality content-Part 2: Considerations when making VR content [10].

Objective

The joint goal of the virtual reality team and the representative team of Baja and Formula SAE is to present the vehicle in a virtual environment taking into account the needs of each team, with the purpose of showing the new innovation methodologies for the construction, validation and visualization acquired by the VRED software.

Methodology

As part of the correct construction of this project it was necessary to follow a series of initial steps in order to visualize the vehicle properly and present a final product suitable to the requirements of each competition regulation. Within the design and simulation process it was inevitable to have errors in order to reach the correct manipulation and understanding of the software and thus achieve a quality virtual experience.

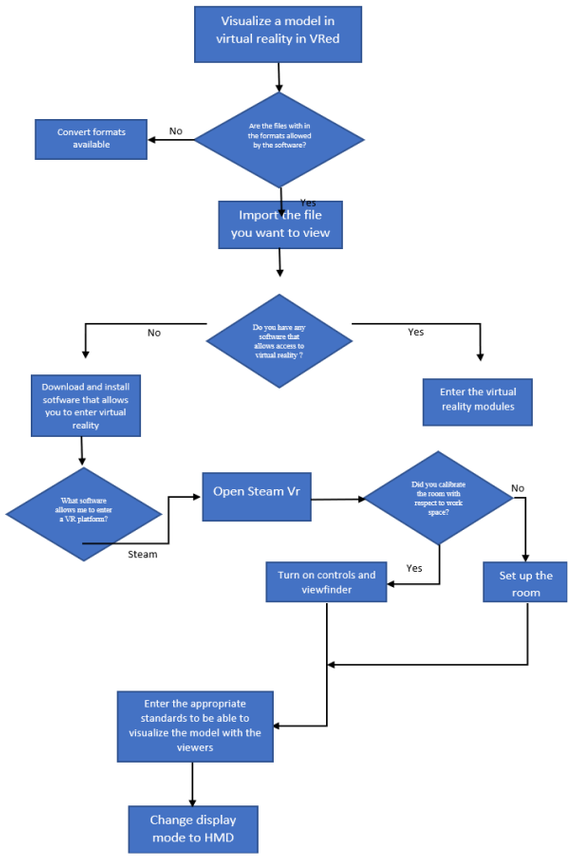

Figure 3 Flowchart to model a vehicle in a virtual environment

In order to start the project process, it was necessary to download the VRed program through the Autodesk platform, to enter this platform it is necessary to enter student data and thus have downloaded the student license, taking into account the year of the version to use.

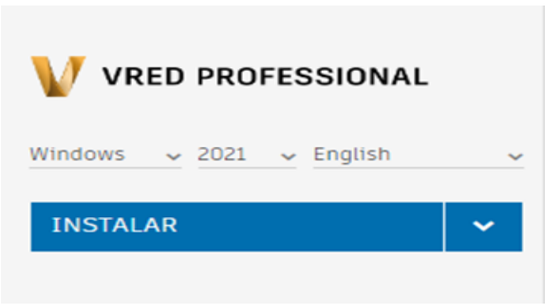

Figure 4 Software download screen

Once the software was installed, the next step was the creation of the document (Graph). We started by importing and placing the CAD models of each branch in which the UPAEP University participates with the stp format, as well as the use of images with extension type (hdr, mtd, tif or dif) to mention a few, to be able to add in this way environments in 360 formats and to be able to visualize the desired image.

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Figure 5 Image in 360 format for Vred

Once the workspace was created and the CAD models (Formula and Baja SAE) were inserted, we continued to arrange their colors and add textures to achieve a more realistic and cleaner finish.

Figure 6 Color and texture arrangement in Cad formula SAE

First of all, it is necessary to activate the menu that enables access to different configurations (Scrips - VR menu - Show VR menu) because the version used this in order to use two specific functions which are teleport (to be able to move anywhere in the environment) and mesure (to verify the model in the virtual reality environment).

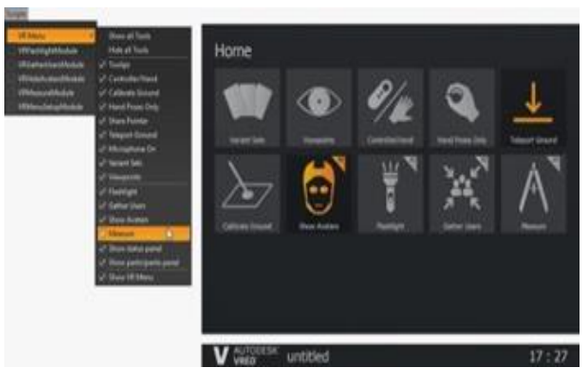

Figure 7 Function menu of Vred version 2021

Once this was done, we looked for a worktable with the .stp extension, which will serve as the basis for us to simulate, through Python programming, a set of buttons that serve as commands to activate the various tools that help us to interact with both the prototype and the environment.

Figure 8 Work table

We proceeded to the creation of the commands in the work area to perform the interaction activities subdivided into 4 sub menus (Environment, Variants, Tools, Antialiasing), which were grouped and developing the panels of each of these tools in order to interact with the environment and CAD models, in this case the Formula SAE and Baja SAE.

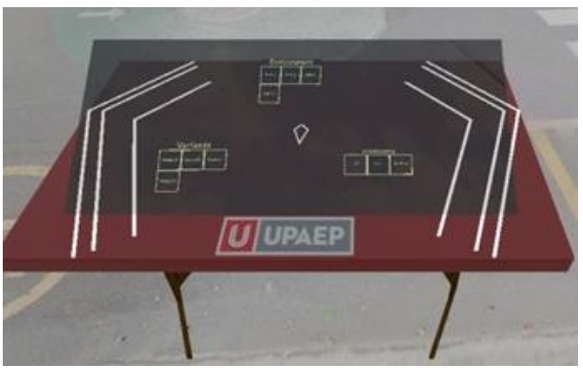

Figure 9 Work table with added sub menus

Since all the programming was done, we continued with the development of the animation of the models (Baja and Formula SAE) and with this, the vehicle within the virtual environment has a cyclic path in the environment of the selection.

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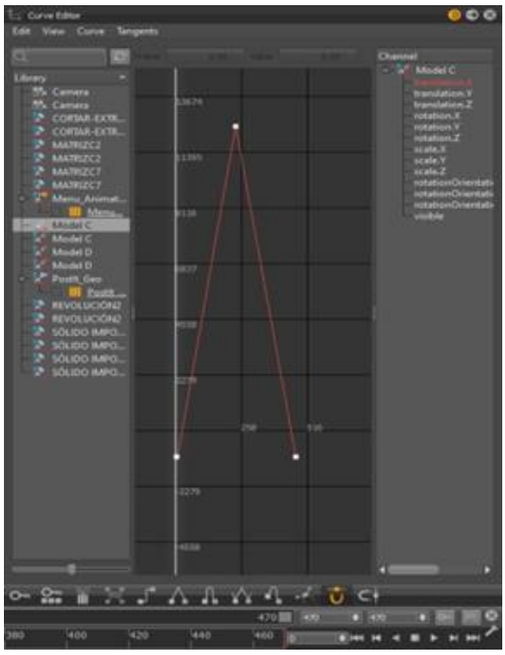

Figure 10 Cyclic animation graph

Subsequently, the environment was modified. To create a virtual environment it is necessary to take into account the extensions to have an image that meets the format requirements of the software, in order to have an environment as close as possible to the real thing.

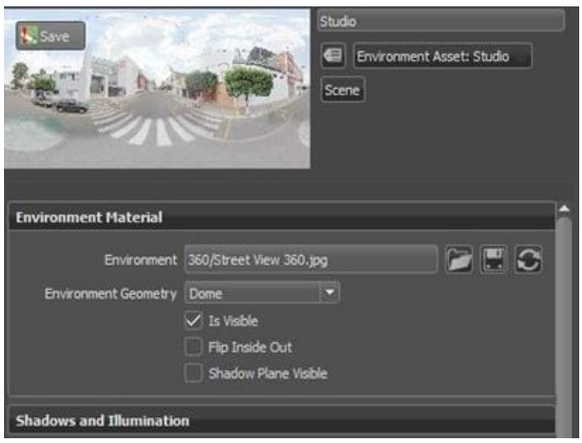

Figure 11 Environment change panel

To conclude this work, the next step was the visualization of the vehicles, applying the previous procedures for each one of them, in order to have a quality and presentable product.

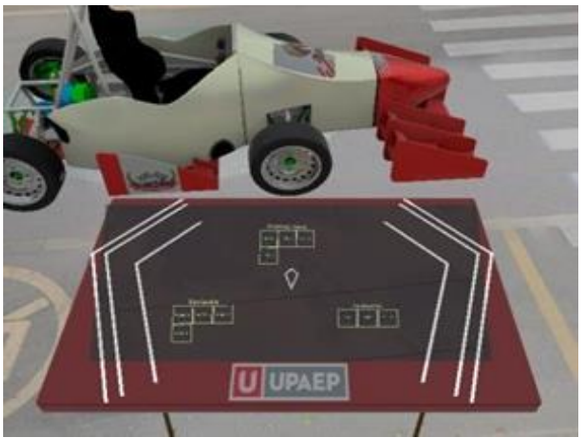

Figure 12 Final model of the project

Rendering

In this work were developed renderings of the models with which they are working, generating a better perspective of how the models can be displayed in a real way, in the same way you can adjust certain parameters of the models so that they are in the best way and can meet the general and specific objectives of the project, the final renderings were as follows, in the image 13 and 14 we can visualize the cars of the UPAEP university of both branches, in which we can see that it is in a track type environment, and in the second rendering which is the image 14 we can observe a Baja SAE type car, which is in an unpaved environment, since it is the environment where the competitions for this type of vehicles take place.

Figure 13 Rendering Formula SAE

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Figure 14 Rendering Low SAE

Results

To evaluate the final experience of the virtual environment, the evaluation was subdivided into 3 categories: the environment, the visual detail of the model and the ability to interact with the environment and the model, in order to take into account all the fundamental aspects of the virtual environment.

In terms of ambience, we were able to add a series of different scenarios in which the prototype of the Baja and Formula SAE vehicles could be presented in different ways, within these scenarios we were able to modify the dimensions and scale. To make the experience more real, a scenario known by the team members was added, so it was decided to capture one of the streets of the city of Puebla (Av. 11 poniente, between C. 23 and 25 sur).

Figure 15 Scenario selected by the team. Av. 11 poniente, between C. 23 and 25 sur

Regarding the visual detail of the models in the virtual environment, we concluded that all parts, accessories and components that make up the Baja and Formula SAE vehicles have a fairly high visualization quality. In this way we were able to see both vehicles in detail and thus present to each team the proposals of the design models in real size.

Figure 16 Presentation of the Baja SAE model in simulator

As a result of the last criterion about being able to interact with the model and the virtual environment, they were mostly enriching for the creation of a more real and interactive environment with the user and is that within the virtual environment was added a panel of tools that allows the change of scenario and model.

Figure 17 Presentation of the Formula SAE model in simulator

To finalize this work, a questionnaire was developed with the purpose of generating a more accurate opinion of the quality of the work done for the creation of the virtual reality models presented.

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For the data analysis a non-probabilistic sampling by convenience was carried out, resulting in a population of 17 males and 1 female, this instrument was based in the facilities of the Universidad Popular Autónoma del Estado de Puebla, in the summer academic period, it can be highlighted that the student population in this period is of low demand as it is a private institution. The instrument was validated by calculating Cronbach's alpha with a value of 0.7091. The questions related to the equipment (viewers) affected your experience reported the lowest values, so that future studies will consider improving the experience and raising awareness of the use of the equipment in advance. Table 1 shows the averages and variances obtained from the sample studied.

Question	Average	Variance
The quality of the models is adequate to distinguish the subsystems that make up the vehicle.	4.6	0.38
The quality of the scenery is adequate.	4.6	0.25
The animation of the vehicles is adequate.	4.7	0.35
Understanding how to use the tools turns out to be easy.	4.6	.35
The equipment (scopes) affected your experience.	3.2	2.15
The components of each vehicle resemble the real thing.	4.5	0.38
Hand controls are easy to use	4.7	0.21
The use of the tool panel was adequate.	4.7	0.49

Table 1 Statistics obtained from the simple

It is also noted that the animations of the vehicles are adequate, the hand controls are easy to use, and the quality of the models is adequate to distinguish the subsystems that make up the vehicle. Something that is of interest was that some users reported the absence of an environment accompanied by sound to achieve a more impacting effect in the experience, on the other hand, the presence of dizziness when turning the viewers was detected precisely because it was the first time using the equipment and the lack of awareness in the correct handling of the equipment.

The details in the scenarios were very well qualified, generating a reality that makes you have an immersion in your environment. The open questions identified areas of opportunity to evaluate other scenarios, such as the validation of prototypes at real scales and thus save response times in modifications of a design before building it, achieving an impact in different areas of study.

Conclusions

The work previously presented on the development of a virtual experience for the evaluation of the concept of a low and SAE formula vehicle was born from the need to have a prototype of the cars designed by the members of both teams, with the aim of having the possibility of redesigning the model if it has a design error or if it is required to create another proposal to change the order of the subsystems within the vehicle. Within the development of this virtual experience, the process that was carried out during all the work that goes from the conceptualization to the modeling of the virtual environment is exposed, it is necessary to emphasize the limited information that is available with respect to these new technologies, since it was one of the biggest limitations that were found during the conceptualization process, Other limitations worth mentioning were the selection of the 3D visualization software to be used for the creation of the virtual environment, since most of the companies that create these programs ask for money to use the software, without having a few days to test and evaluate whether the software has the necessary tools to achieve the objectives. On the other hand, the experience that was had as a team is something unique, having the possibility to study, use and test these new technologies opens the mind to new possibilities and new ways in which these tools can be used by the new generations. It is a fact that virtual reality is one of the technologies with the highest growth projection, according to the latest IDC Research forecasts (2020), investment in VR and AR will multiply by 21 in the next four years, reaching 72.8 billion euros in 2022 [11]. It is worth noting that both technologies will take an important part for the digital transformation plans of companies, therefore it is expected that by 2024 more than 50% of large European companies have a VR and AR strategy.

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Finally, it is essential to mention how important were both the results and the comments made by the participants of the sampling, within this feedback highlights the great experience they had within the virtual environment and the great detail of the models, in the same way they commented on the proposals to use these tools and software within their projects, but in different areas. The authors are in favor of the idea that this technology is being known by many more people, this will help that in the future every day there will be more innovations in the field and thus to know all the possibilities that exist for these technologies.

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References

[1] Sousa Ferreira, R., Campanari Xavier, R. A., & Rodrigues Ancioto, A. S. (2021). La realidad virtual como herramienta para la educación básica y profesional. Revista Científica General José María Córdova, 19(33), 223–241. https://doi.org/10.21830/19006586.728

[2] Men, L., Bryan-Kinns, N., Hassard, A. S., & Ma, Z. (2017). The impact of transitions on user experience in virtual reality. In 2017 IEEE virtual reality (VR) (pp. 285-286). IEEE. DOI: 10.1109/VR.2017.7892288

[3] Ramírez, D. F. (2013). "Aplicaciones de la Realidad Virtual en la Ingeniería Mecánica y Automotriz". Revista Digital Universitaria, 14(5), 1-17. http://www.revista.unam.mx/vol.14/num5/art06/index.html

[4] Collegiate Design Series Baja SAE® Rules.(s.f.). https://www.saemx.org/bajasaemexico.https://www.saemx.org/_files/ugd/804925_7f73ff7362444f0ca0409d86cd6d106c.pdf

[5] Herranz de la Casa, J. M. (2019). La realidad virtual y el vídeo 360º en la comunicación empresarial e institucional : Virtual reality and 360º video in business and institutional communication. Revista de Comunicación, . 18, 177–199. https://doi.org/10.26441/RC18.2-2019-A9

[6] Aplicación de la RV (Realidad Virtual) como un recurso educativo en el aula de clases. [s. l.], 2020. Disponible en: https://ezproxy.upaep.mx:2103/login.aspx?direct= true & db= edsoai & AN= edson.on1241104879 & lang= es & site=eds-live. Acceso el: 13 jun. 2022

[7] Victoria Petrock . (February 22, 2021). US Virtual and Augmented Reality Users 2021. INSIDER Inteligence, 8, 19. June 12, 2022, De Google scholar Base de datos.

[8] ISO. (2019). ISO/IEC 18040:2019(en) Information technology — Computer graphics, image processing and environmental data representation — Live actor and entity representation in mixed and augmented reality (MAR). 16/10/2021, de ISO Sitio web: https://www.iso.org/obp/ui/#iso:std:iso-iec:18040:ed1:v1:en ISO - International Organization for Standardization. (2020).

[9] ISO/IEC TR 23842-1:2020 Information technology for learning, education and training — Human factor guidelines for virtual reality content — Part 1: Considerations when using VR content. 18/10/2021, de ISO - International Organization for Standardization Sitio web: https://www.iso.org/obp/ui/#iso:std:iso-iec:tr:23842:- 1:ed-1:v1:en ISO - International Organization for Standardization. (2020).

[10] ISO/IEC TR 23842-2:2020 Information technology for learning, education, and training — Human factor guidelines for virtual reality content — Part 2: Considerations when making VR content. 18/10/2021, de ISO - International Organization for Standardization Sitio web: https://www.iso.org/obp/ui/#iso:std:iso-iec:tr:23842:- 2:ed-1:v1:en

[11] IDC. (2020). Worldwide Spending on Augmented and Virtual Reality Forecast to Deliver Strong Growth Through 2024, According to a New IDC Spending Guide. 13 de Junio de 2022, de International Data Corporation Sitio web: https://www.idc.com/getdoc.jsp?containerId=prUS47012020

[12] Moltó, G., & Caballer, M. (2022). AVADRA: Análisis Visual Automatizado Dual de Retroalimentación del Alumnado. Actas de las Jenui, 7, 97-104.

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