Universidade do Minho
Escola de Letras, Artes e Ciências Humanas

Ana Sofia Marques Nogueira

Developing a gamified and interactive virtual tour to a research centre as an educational resource – the International Iberian Nanotechnology Laboratory

março de 2022

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UMinho | 2022

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Relatório de Estágio
Mestrado em Humanidades Digitais

Trabalho efetuado sob a orientação de
Professor Doutor António Vieira de Castro
Professora Doutora Sílvia Araújo

março de 2022

Acknowledgements

Firstly, I would like to thank my parents and my brother for all the support and strength they gave me during my academic path.

Thank you to Joana for all the help during the master's degree, and for being the best partner I could have asked for in this project. It wasn't always easy, and I really couldn't have done it without you.

I would also like to thank Patrícia Barroso and the communication department at the International Iberian Nanotechnology Laboratory for making this project possible, and for all the help and resources provided during it.

To my Professors, António Vieira de Castro from ISEP (Instituto Superior de Engenharia do Porto) and Sílvia Araújo from UMinho (University of Minho), thank you for all the support and guidance during this project and for the collaboration in writing the article "Planning a Virtual Tour to a Research Center as an Educational Resource".

To SIIS (Social Innovation and Interactive Systems) from ISEP and the Polytechnic of Porto, thank you for inviting me to be a part of the team as a researcher.

Lastly, thank you to the PortLinguE project, an initiative of the Digital Humanities Group and the School of Engineering, for making the participation in the conference "ARTIIS 2021: International Conference on Advanced Research in Technologies, Information, Innovation and Sustainability" possible.

Statement of integrity

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

I further declare that I have fully acknowledged the Code of Ethical Conduct of the University of Minho.

O desenvolvimento de uma visita virtual gamificada e interativa a um centro de investigação como um recurso educativo – o Laboratório Ibérico Internacional de Nanotecnologia

Resumo

Num mundo digital em constante crescimento, a tecnologia pode ser uma ferramenta importante para ajudar os professores a atender às necessidades de cada aluno, à medida que novas estratégias pedagógicas e recursos de ensino on-line estão a ser introduzidos nas salas de aula. As visitas virtuais podem tornar-se um destes recursos tecnológicos valiosos ao aproximar os alunos da ciência, permitindo-lhes visitar centros de investigação e laboratórios – não só do seu país, mas também internacionais – sem a necessidade da sua presença física. Estes tipos de tecnologias permitem que os alunos visitem lugares que de outras formas não poderiam visitar, seja por causa da distância ou outros impedimentos, mas também laboratórios que mesmo numa visita presencial não conseguiriam entrar, como "salas limpas", que são ambientes controlados altamente monitorizados que só podem ser vistos de fora numa visita escolar normal. Uma visita virtual permite que os alunos vejam de perto o que acontece dentro desses laboratórios e os equipamentos neles utilizados, para além de terem acesso a mais informações e conteúdos do que numa visita física, que podem revisitar a qualquer hora e em qualquer lugar. Esta forma de visita escolar remota aliada ao potencial da gamificação como estratégia pedagógica podem tornar-se uma forma inovadora de cativar e despertar o interesse dos alunos no ensino de ciência e tecnologia.

Este relatório de estágio explora o desenvolvimento de um protótipo de uma visita virtual 360° gamificada ao Laboratório Ibérico Internacional de Nanotecnologia (INL), como uma ferramenta educativa para comunicar ciência de forma divertida e interativa, e também para dar a conhecer a investigação desenvolvida no INL. Para esse propósito, o presente relatório aborda os conceitos de visitas virtuais e gamificação, bem como a importância das visitas de estudo e a noção das visitas virtuais se poderem vir a tornar uma alternativa para as visitas escolares. Com isso exposto, as tarefas para o desenvolvimento da visita virtual e a sua gamificação são descritas detalhadamente ao longo do relatório, e uma avaliação dos resultados é feita por meio de um questionário feito a uma amostra do público-alvo da visita: alunos do 8° ao 11° anos.

Palavras-chave: Comunicação de ciência, ferramenta educacional, gamificação, visita virtual

Developing a gamified and interactive virtual tour to a research centre as an educational resource – the International Iberian Nanotechnology Laboratory

Abstract

In an ever-growing digital world, technology can be a powerful tool to help teachers meet the needs of each individual student as new pedagogical strategies and online teaching resources are being brought into the classroom. Virtual tours can become one of these valuable technological resources by bringing students closer to science, allowing them to visit research centres and laboratories – not only from their country but also internationally – without requiring their physical presence. This technology enables students to see places they wouldn't be able to visit because of either distance or other impediments, but also laboratories that even in a physical field trip they wouldn't be able to enter, such as "cleanrooms", which are highly monitored and controlled environments that can only be seen from the outside on a normal school visit. A virtual tour allows students to see up close what goes on inside these laboratories as well as the equipment used there, while also having access to more information than they would on a physical visit, at any time and place. This form of remote visit combined with the potential of gamification as a pedagogical strategy can be an innovative way to teach science and engage students.

This internship report explores the development of a gamified 360° virtual tour prototype of the International Iberian Nanotechnology Laboratory (INL), as an educational tool to communicate science enjoyably and interactively and to bring awareness to the research developed at INL. For this purpose, the present report addresses the concepts of virtual tours and gamification and the importance of field trips focusing on the idea of virtual visits becoming an alternative for field trips. With this exposed, the tasks for the development of the virtual tour and its gamification are described in detail throughout the report, and an assessment of the results is done through a questionnaire made to a sample of the tour's target audience: students from the 8th to 11th grades.

Keywords: Educational tool, gamification, science communication, virtual tour.

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1. Introduction

The first chapter of this report comprehends the contextualization of this project. It explores why virtual tours can be an important resource to be incorporated into the classroom and identifies the problems that led to the development of this prototype and the motivation to propose this internship to the International Iberian Nanotechnology Laboratory. Finally, this chapter ends with the organization of the present report, detailing every subject that will be analysed throughout this work.

1.1. Contextualization

Over time, the approach to teaching and learning has undergone many changes. Today's students are digital natives who grew up with and around digital technologies. We are surrounded by a social context where children get familiar with technology from an early age and these technologies are increasingly being brought into the classroom to enhance the experience of both the students and teachers. More than ever, teachers need to adapt the learning process towards each student and explore unconventional teaching and learning styles. Many people in the educational technology field see new technologies as powerful tools that can help schools meet the needs of ever more distinct student populations. According to Herold (2016), the concept is that digital services, software and learning platforms offer an unimaginable array of options for tailoring education to each individual student's academic strengths and weaknesses, personal preferences, interests and motivations, and optimal pace of learning.

Especially since the global shift to remote teaching and learning caused by the COVID-19 pandemic, teachers were forced to find new innovative and engaging ways to deliver content to their students. The pandemic caused a worldwide need to adapt and find new pedagogical strategies of teaching that had to incorporate online technology.

Virtual tours are simply one of the many ways that technology can be incorporated into the classroom. These types of resources allow digital exploration of the real world through 360° images, videos, audio, and other multimedia tools. They are not limited by distance – they can be accessed in both a traditional classroom setting or at home – and are usually more cost-effective and safer than traditional physical field trips. Additionally, virtual tours can create a more interactive and enriched experience for students that exposes them to different learning perspectives.

When we consider the expeditious technological advance in education and learning, this project identifies and explores the potential virtual tours have as pedagogical tools by developing a prototype of a virtual tour of the International Iberian Nanotechnology Laboratory, that aims to serve as a science learning resource for students from 8th to 11th grades. The development of this virtual tour was carried out in conjunction with my master's colleague Joana Fernandes, and the strategic science communication aspect of the visit is further explained in theory in her internship report "Science Communication: a strategic approach to the International Iberian Nanotechnology".

1.2. The International Iberian Nanotechnology Laboratory

Leading international organization in Europe in the fields of nanotechnology and nanoscience, the International Iberian Nanotechnology Laboratory (INL) was founded in 2008 by the governments of Portugal and Spain and is located in Braga, Portugal.

Figure 1 – International Iberian Nanotechnology Laboratory's logo

The institute develops a variety of projects based on pioneering research focused on six main areas that complement each other: environment, health, energy, food, information and communication technology, and future emerging technologies (INL, n.d.). At INL, researchers from over 40 countries work together to respond to the main challenges of our day. Physicists, chemists, biologists, engineers, pharmacists, among other specialists, join forces in interdisciplinary research to develop and articulate nanotechnology for the benefit of society. The INL aims to be a world hub for the development of nanotechnology, addressing the biggest societal challenges.

1.2.1. INL's school visits

The INL hosts regular but restricted visits to its premises which aim to increase and foster public engagement, communicate science, and promote their work and research. These visits are destined for students at private or public high schools and universities where the field of study is science and technology. The requests for these visits must be made at least one month in advance and the students need to be at least 15 years old to attend them. They take place on pre-selected dates, throughout the school year, – from October to June – and have a total duration of 2 hours. By visiting the INL, students become more acquainted with their history, research activities, scientific facilities, and achievements (Scale Experiences, n.d.).

During the tour, a guide introduces students to the history of the INL and explains each laboratory and the research developed there. These tours usually have a duration of 60 minutes, starting at the reception hall and obeying the following script:

1. Side corridor of the Cleanroom;
2. Staircase to level -2;
3. High accuracy laboratories;
4. Staircase to level 0;
5. Walkthrough P0 main open space corridor and stop at the middle lobby;
6. Staircase to level 1;
7. Walkthrough P1 open space along with P1 labs;
8. Bio Labs facility;
9. Staircase to level 0.

1.2.2. Limitations of in-person visits to the INL

Since research centres are working areas and aren't specifically destined for school visits, it's understandable that these visits must be restricted both in time and number of visitors and present some limitations. Firstly, the visits to the INL are destined to a maximum of 30 students that must be older than fifteen years old and attending courses in scientific areas (Scale Experiences, n.d.). This means that students below 10th grade or from other fields of study will not be considered for visiting. Secondly, there are generally some laboratories that are not accessible to the public, – like cleanrooms, due to their high-level control of air circulation – but in school visits, due to the large number of participants, most laboratories can only be seen from the outside. Distance is also a constraint in a physical visit since it is not always possible for a student, a school, or even a researcher interested in working at INL, to visit their premises. Lastly, one of the main impulses for this project is the current pandemic situation that has prevented many visits from being made due to rules of confinement and social distance. All these problems can be solved with a virtual tour of the building that is accessible 24 hours, 7 days a week, and can be accessed by everyone, everywhere, at any time.

1.3. Identifying the problem

For students to be able to attend school trips, a certain number of factors must be achieved, since these trips usually need funding and imply the need for students to travel to one or more locations. Even though nothing compares to seeing and experiencing things in person, in-person visits do have several disadvantages that can't be bypassed, such as high costs and financial unavailability that may prevent some students from attending them, logistical and preparation problems, lack of time, difficulties faced by disabled students, safety concerns, among others. These disadvantages are higher when the destination of the school visit is a research centre since most laboratories and rooms can't be visited by such a high number of people. These problems often prevent schools from organizing school visits, and students from attending them, despite their desire and curiosity.

In an attempt to fight these problems, the use of virtual tours can be an important resource to allow students to see and know more about places they otherwise wouldn't have the means to. Though virtual visits may have other application and usage issues, they do present an alternative that overcomes all these impossibilities listed above.

1.4. Goals and expected contribute

This project identifies and analyses the potential of virtual visits in educational contexts, as well as the potential of these types of technologies in encouraging students to visit the physical spaces in person. It also explores ways to motivate students to learn through the incorporation of different types of multimedia resources into the virtual tour's prototype.

The main goal of this project was to successfully map out relevant rooms of the INL, and, from there, to create a virtual tour of the spaces. Moreover, we intended to create gamification hotspots – quizzes, audio, videos, text, images, and presentations – to enable the users to further explore their surroundings while also making the tour more immersive and interactive.

As a consequential goal or outcome, we expected our target audience – mainly teenagers from 8th to 11th grade – to expand their interest in science and to make a research centre and its scientists more easily accessible to them. Being in an age where students begin to think about their future and their vocations, it is hoped that this project was able to shed some light and possible interest in following scientific careers.

Despite the established target audience being teenage students, the outcome of this virtual tour will be made to be experienced and enjoyed by everyone regardless of their demographics.

1.5. Motivation of the project

The interest and motivation in developing this project as an internship at INL began with a collaboration made in the first year of the master's degree in Digital Humanities, where I and my group developed a game app based on one of the themes researched at the centre: water quality. The scientists provided us with information about their projects' research in this field of study, which we gamified into a game in a simple and captivating way so that it could be accessible and engaging for young children. This form of communicating science to young audiences by creating appealing content fascinated me and made me acknowledge the importance of interconnecting the scientific and educational areas, in order to bring a little bit of real science to schools and create scientific awareness among young people.

1.6. Organization of the report

This report consists of six chapters: introduction, theoretical framework, development of the virtual tour, creation of the gamification, assessment of the results and conclusion/future work. The introduction presents an overview and contextualization of the project – the internship at INL, the problems and limitations faced, and the expected goals. The theoretical framework explores the importance of field trips and virtual tours, their differences, advantages, and disadvantages, as well as analyses the concept of gamification in teaching and learning. The third and fourth chapters correspond to the creation of the virtual tour and gamification and explain the processes, tools and software used in each step of the development. The assessment of the results is an analysis of a questionnaire conducted to a sample of the target audience as a way to consolidate the study. Lastly, the sixth chapter represents the conclusion of the project and the report.

2. Theoretical Framework

The second chapter of this report explores the theoretical framework of the project, more specifically, the importance of field trips as educational resources, the concept of virtual tours and gamification and their possible use as alternatives for physical visits, and the advantages and disadvantages of both virtual tours and field trips. In this section are also examined similar projects of virtual tours to three laboratories and research centres available online: the Abertay University Science Department, the Lawrence Berkeley National Laboratory, and the Pacific Northwest National Laboratory.

2.1. The importance of field trips as educational resources

Field trips, excursions, or school trips can be defined as trips arranged and undertaken for educational purposes, in which the students go to places where they can observe and study the materials of instruction directly in their functional setting (Duvall & Krepel, 1981). They are educational journeys made by a group of people to a place away from their normal environment, which the purpose is usually observation for education, non-experimental research, or to provide students with experience outside their everyday school activities (Shakil et al., 2011). These trips provide new learning environments that allow students to interact physically and intellectually with the subject they are learning outside of their classroom. Field trips are designed to connect classroom topics to real-world contexts and provide direct learning experiences, adding realism and relevancy to studies (Klemm & Tuthill, 2002).

Many researchers have investigated the knowledge gain and learning that occurred during field trips and the consensus seems to be that they represent helpful learning experiences. Jordan and Nadelson (2012) refer that students who directly participate in field experiences generate a more positive attitude towards the core subject of the trip; Gillani (2000) states that these learning experiences produce more meaningful learning and are more likely to change behaviour and improve the retention of students. According to Clark (1996), these excursions provide different insights and learning experiences from those provided by a lecture or practical, as well as being a unique social experience, including the building of group identity, team spirit, and good staff-student relationships.

The effects these positive field trip experiences have on students can have an impact not only on their academic paths but can also be decisive in the choosing of their future careers. Research by Cwikla et al. (2009) suggested that eighth grade students with an interest in science were significantly more likely to acquire science-related careers than students with no interest in science. Having said that, schools can't always organize field trips and students can't always attend them, so alternatives for these situations that would still allow students to interact with the materials of study in their natural settings would be an important addition to students' learning experiences.

2.2. Virtual visits as alternatives for field trips

Naturally, virtual visits do not replace physical visits; that is not their goal. They are an innovative solution that can be an alternative for whenever the field trip destinations can't be visited, an alternative for those who are unable to visit the places in person (whether for economic reasons, the distance to the site or even lack of time), and a way to acquire information without the need of someone allocated to perform a tour.

Field trips are known to enhance the learning experience for students, yet few secondary teachers include field trips in their curriculum because of numerous logistical problems (Klemm & Tuthill, 2002). With the use of virtual tours, teachers can still bring real-world situations to the classroom without the need to leave them. As reported by Stainfield et al., (2000), virtual tours basically emulate the actual field trips and have a valuable role in supporting and enhancing real fieldwork and empowering students who are disadvantaged financially or physically. Research has long demonstrated that using a variety of instructional strategies optimizes the effectiveness of teaching and learning (Hofstein & Rosenfeld, 1996). Virtual tours are one way of adding variety to education, thus optimizing teaching effectiveness while also motivating students.

2.2.1. The concept of virtual visits

The notion of virtual tours has been slowly increasing in popularity over the years. Museums, universities, tourism, and real estate businesses are some of the main fields and institutions that have been benefiting and improving in numerous ways due to the virtual tour system. According to Roussou (2004), in the past few years, there has been a proliferation of virtual reality installations (in the form of exhibits) and VR applications (in the form of "experiences") available and accessible to the public, and museums and informal educational institutions – generally hesitant in adopting cutting-edge digital technologies – are now considering various forms of VR to attract and motivate visitors, but also to ultimately deliver their educational agenda more effectively.

To better understand what virtual visits are, it is important to understand the concepts of virtual reality and virtual tours. Roussou (2004) defines virtual reality as a three-dimensional multisensory, immersive, and interactive digital environment. Similarly, a virtual tour is an immersive technology that places the viewers inside the image, enabling them to significantly enhance situational awareness and providing the highest level of functionality for viewing, capturing, and analysing virtual data (Mohamhamad et al., 2009). These technologies create a simulation of an existing location, which allows the users to see the world from the comfort of their own homes and have a real immersive experience close to the actual physical one.

Virtual Reality is a very powerful and compelling technology that aims to mimic the real world by creating a computer-generated environment and engaging all the senses of the users. Compared with traditional graphic research, virtual reality technology emphasises the interaction between user and system; i.e., the user could enter and experience the digital environment in real-time, feeling like being there. As such, virtual tours are always an active and challenging topic in the VR field (Wu et al., 2008).

Virtual tours and virtual reality are two technologies that go hand in hand, as a virtual tour is most of the time developed from virtual reality software. However, it can also be created through a sequence of video images or panoramic pictures that have an unbroken view. For this project, it was used the latter, since virtual reality systems that use 3D computer graphics to model and render virtual environments in real-time often require laborious modelling and expensive special-purpose rendering hardware (Chen, 1995). The tour developed in this project consists of still images captured with a 360° camera combined through stitching and patching techniques to produce panoramic images.

Virtual Reality may become a valid form of alternative travel as it can allow users to do normal daily tasks and visit places without having to physically be there. Over the next five years, the virtual tour software market will register an 18.9% compound annual growth rate (CAGR) in terms of revenue and the global market size will reach $406.1 million by 2025, from $203.1 million in 2019 (LP Information, 2020). The growth and demand for these types of technologies have been specially strengthened due to the worldwide current pandemic situation. In a time when school visits to museums and historical places are no longer viable, virtual tours are a solution to this problem – which makes this project's goal an even more current and essential one.

2.2.2. Advantages and disadvantages of virtual visits and field trips

Naturally, both virtual tours and field trips exhibit each their advantages and disadvantages. Their failure or success can't be measured by weighing their pros and cons, since they are two forms of exploring a location that serve each their own purpose. By exposing these aspects, the intention is merely to point them out, never to access which one is more or less beneficial. The table below presents some of the most prominent positive and negative aspects of both virtual tours and field trips:

Virtual Visits		Field Trips	
Positive	**Negative**	**Positive**	**Negative**
Allows interactivity	Limited social interaction	Social activity	Restricted to number of students
Low cost of production	Lacking sensory experience	Real-life application of subjects	Costly
No size limit	Impersonal	Learning outside the classroom	Transportation issues
Visit inaccessible areas	Technical difficulties	Increase motivation	Liability
Accessible everywhere	Requires internet or computer access	Beneficial for economy	Pending parental approval

Table 1 – Advantages and disadvantages of virtual and physical visits

Regarding virtual visits, their positive aspects consist mostly of their accessibility - since they can be accessed with no time, weather, or distance constraints - and interactivity. They can be visited by people anywhere and everywhere and allow users to visit areas that may be inaccessible physically; for example, cleanrooms and other labs only available to scientists (Çaliskan, 2011). Virtual visits also support all types of information with no size limit, allowing the incorporation of videos, links, articles, and many other forms of multimedia that can be viewed and reviewed as many times as the user wants. The costs of production can vary, they can be high if the virtual tour is made by a professional company, but they are mostly low since anyone with a smartphone can create their virtual tour. The negative aspects of virtual tours concern their limited social interaction and lack of sensory experiences, making the tours quite impersonal and monotonous. As with any other technological resource, they can present technical difficulties and require internet and/or computer/smartphone access.

For field trips, their positive aspects involve the motivation they bring to students as a social activity outside the classroom. They help students understand concepts in real life and are always a fun and exciting new way to learn. They are beneficial for the students and can also economically benefit the place where the field trip is situated. The negative aspects of field trips are more serious than those of virtual tours. Field trips may present a liability since students can get lost or hurt in an unknown environment. They also present logistical issues like preparation, transportation, restrictions on the number of students, costs, and parental approval.

2.3. Analysis of virtual tours to research centres and laboratories

Nowadays, when people want to visit a certain place, they usually search for it online first. It's increasingly more common for students to visit websites of universities before applying for a college, or researchers to look up laboratories and research centres before applying for a job. For these institutions, having a virtual tour of the grounds is an opportunity to elevate their online presence and promote their work, making them more accessible to the worldwide community and allowing individuals to get familiar with the premises without having to go there.

The goal of these visits is not always the same, – some aim to share only the institutions' space, so they are monotonous visits limited to moving from corridor to corridor; others have hotspots with information, videos and images that viewers can enjoy and gain more knowledge while taking the tour – that's why it was important to look into similar examples before starting to develop the virtual tour, to see what was expected and note interesting features.

2.3.1. Abertay University Science Department

Abertay University in Scotland has a virtual tour available online of their science department that is composed of two facilities: the Science Lab and the Darkroom. Both tours are very simple, consisting only of one 360° image, and only allowing the user to move around said image and use zoom in and zoom out.

Figure 2 – Abertay University Science Lab's virtual tour[1]

[1] Albertay University Science Department's virtual tour. Accessible at https://www.abertay.ac.uk/visit/virtual-campus-tours/

The information hotspots are red with a book icon which allows users to distinguish them well from the rest of the environment and open a pop-up window at the centre of the screen with text and images explaining the laboratory's equipment.

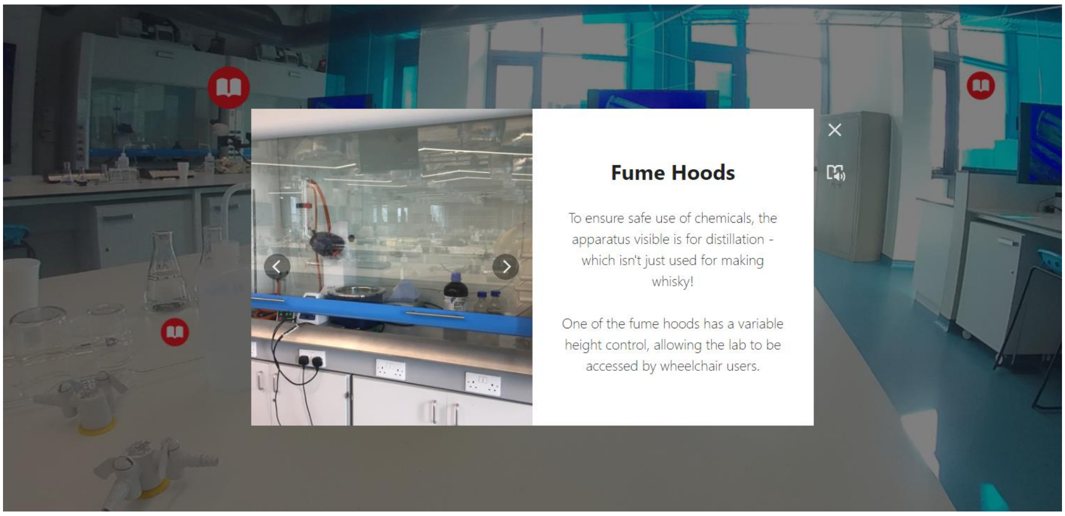


Figure 3 – Demonstration of Abertay University's information and image hotspots

On the right side of the information hotspots is an icon that opens an immersive reader – as seen in figure 4 – that allows readers to not only read the text but also hear the information presented on the hotspot. This feature is very inclusive for people with visual disabilities and should be more implemented on virtual tours.

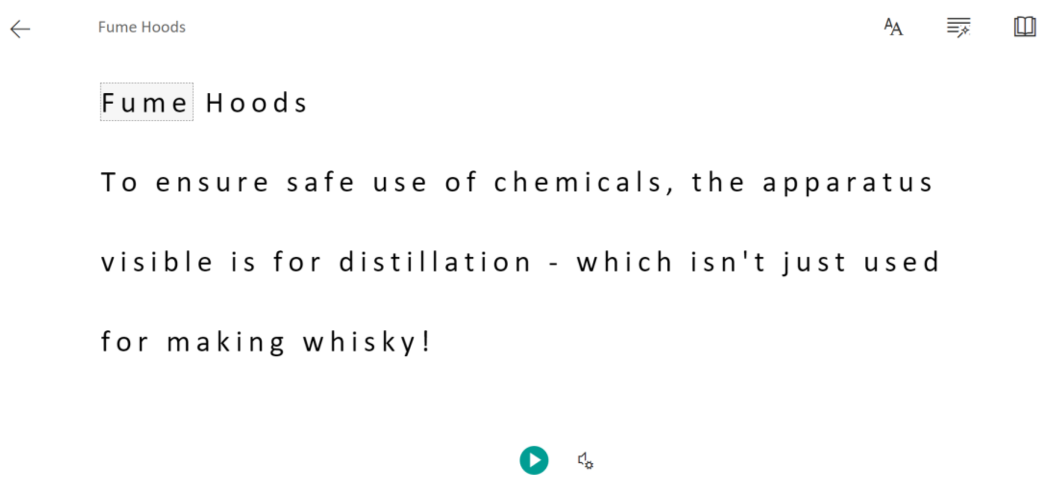


Figure 4 – Example of Abertay University's immersive reader

Even though this virtual tour may be simple in terms of the number of images and movement allowed, it fulfils the purpose of helping students to get to know the laboratories and understand more about their equipment.

2.3.2. Lawrence Berkeley National Laboratory

The Berkeley Lab is a Department of Energy (DOE) facility managed by the University of Carolina. Its virtual tour allows visitors to explore the Foundry's facilities from their computer or VR headset (like Google Cardboard) using their 3D walkthroughs. Instead of being a complete visit of the building, it is divided into seven separated facilities, each with its own tour: the Molecular Foundry Lobby and Theory Facility, the Imaging Facility, the Nanofabrication Facility, the Inorganic Facility, the Biological Facility, the Organic Facility, and the National Centre for Electron Microscopy (NCEM).

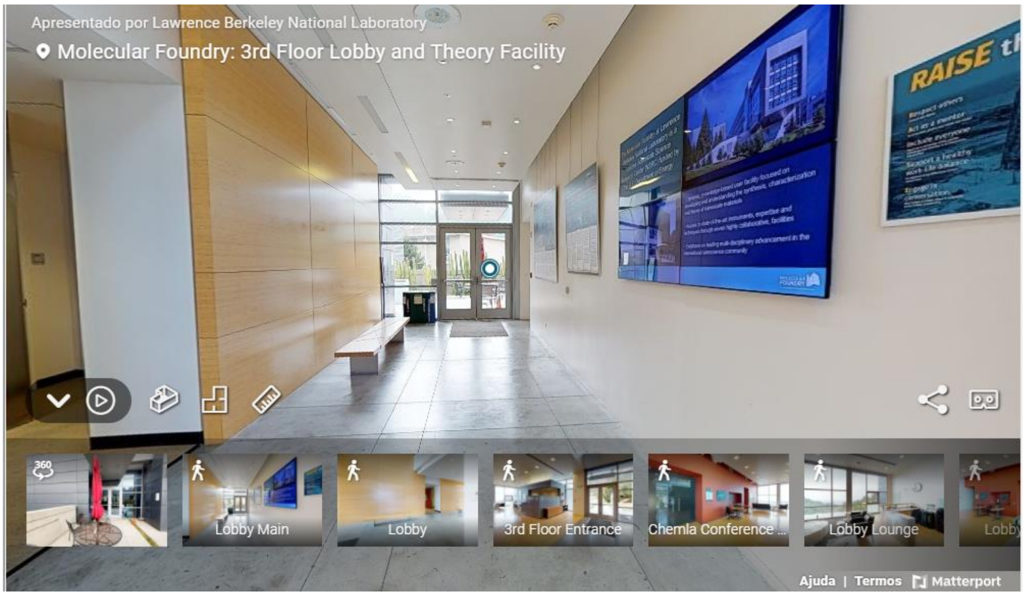


Figure 5 – Lawrence Berkeley National Laboratory's virtual tour[2]

According to their website, the scans of the visit were created using Matterport equipment and software. The tour presents very high-quality images that don't lose quality when zooming in and out and allows users to see 360° and move in any direction. Users can also choose to see the tour in virtual reality using Oculus Go. To facilitate navigation, the tour provides the option to select the rooms through a drop-down menu located at the bottom, as seen in figure 5 above. This menu can be opened or closed and also has the option to be reproduced, which makes each scene of the virtual tour reproduce itself automatically.

There is also a floorplan and dollhouse view features that enable users to better understand the plan of the building:

[2] Lawrence Berkeley National Laboratory's virtual tour. Accessible at https://foundry.lbl.gov/about/virtual-tour/

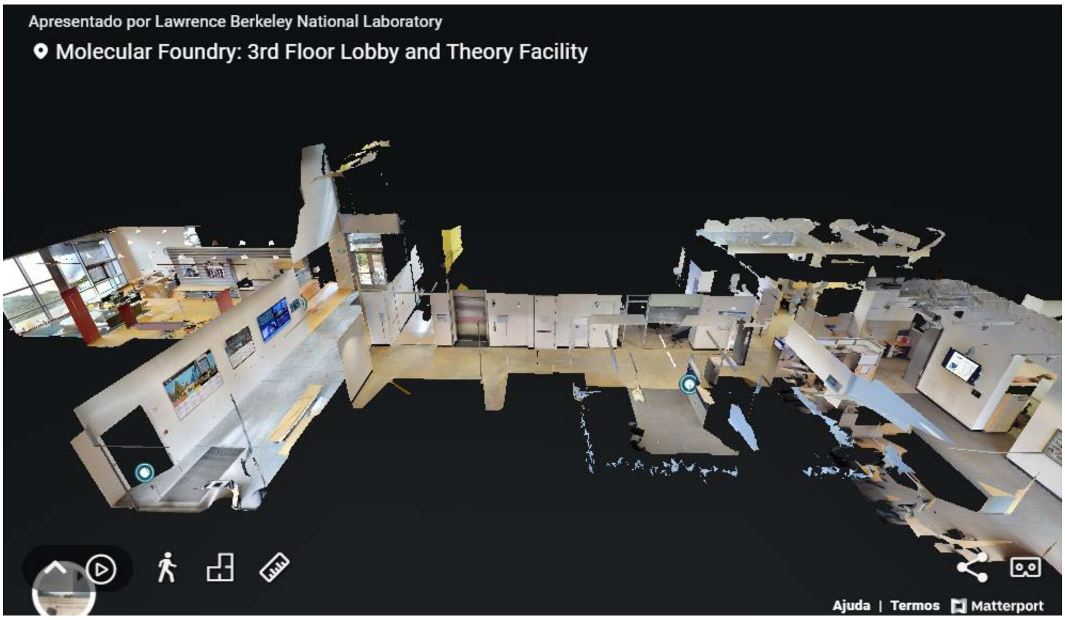


Figure 6 – Example of the dollhouse view feature of the Molecular Foundry lab

This Matterport virtual tour has a feature that I have never seen before in other virtual tours, which is a measurement mode where users can measure spaces with high-level precision. This feature isn't extremely useful for these virtual tours but could be an important addition to real estate and housing virtual tours.

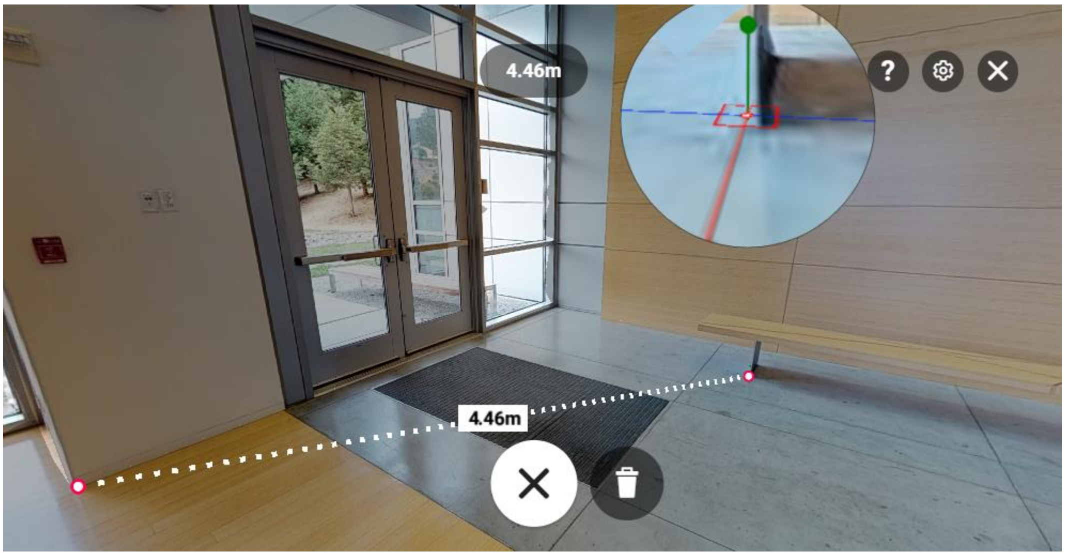


Figure 7 – Demonstration of the use of the measurement feature

In terms of hotspots, this virtual tour has circular white hotspots with a blue outline that flashes constantly. Having a hotspot that moves or flashes is a good alternative for them to be noticeable without the need to use vibrant colours.

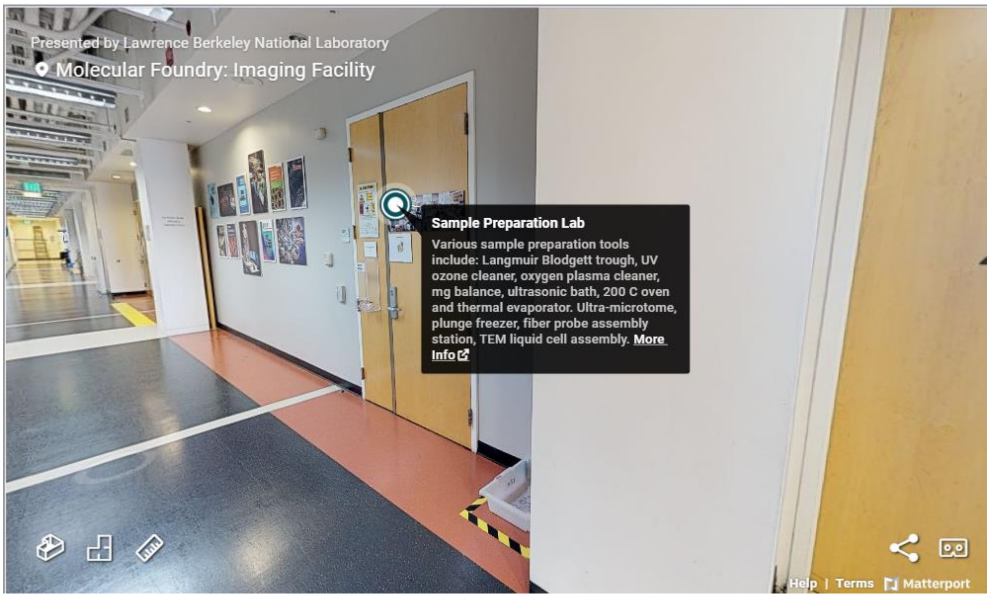


Figure 8 – Example of Berkeley Lab's information hotspots

The content of the hotspots of the Berkeley Lab's virtual tour is composed of extensive informational text with scientific jargon, which makes it clear that this tour is destined for professionals and technicians in the field and not lay people in scientific areas.

2.3.3. Pacific Northwest National Laboratory

The Pacific Northwest National Laboratory (PNNL) is one of the United States Department of Energy's national laboratories located in Washington. The laboratory provides a virtual tour[3] of three of their laboratories: the Environmental Molecular Sciences Laboratory (ESML), the Shallow Underground Laboratory (SUL), and the Interdiction Technology and Integration Laboratory (ITIL).

Before the tour starts, a "how to navigate" window appears with instructions on how to navigate through the tour:

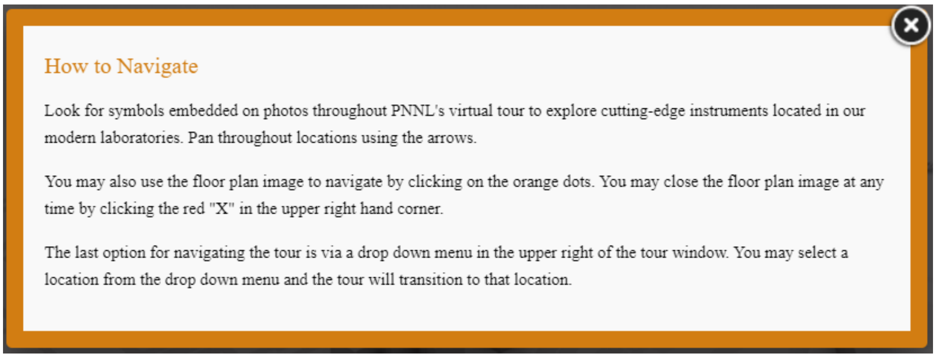


Figure 9 – "How to navigate" window of the Pacific Northwest National Laboratory's virtual tour

[3] Pacific Northwest National Laboratory's virtual tour. Accessible at https://tour.pnnl.gov/

The first page of the tour presents an interactive map of the laboratory grounds, where users can choose what building they want to visit (within the three existing possibilities). This tour is the only one I have observed that offered these features.

Figure 10 – Interactive map of the PNNL's virtual tour

After choosing one of the laboratories to visit, users are directed to a page with a floorplan of the building and additional information where they can learn more about the lab, its sustainability features, see a welcome overview video, or start the tour itself.

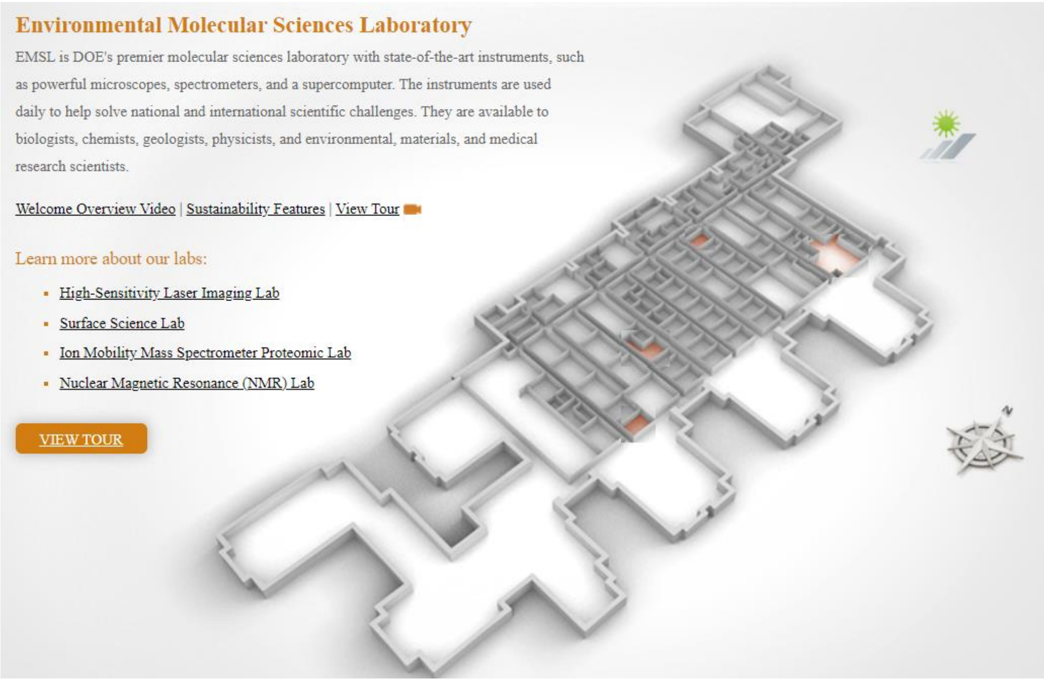


Figure 11 – Informative page about the PNNL laboratories

The tour is made by VPiX and has information hotspots containing text, images, and video. The hotspots are circular and orange or yellow with a white outline. The icon of the hotspots depends on the type of hotspot: movement hotspots have an arrow icon, text hotspots a text icon, and video hotspots a camera icon.

Figure 12 – Pacific Northwest National Laboratory's virtual tour

It has also a map on the left side of the screen where users can see where they are in the building's blueprint, and a drop-down menu on the right side of the screen with the available rooms.

2.4. Gamification and its importance in education and learning

The term gamification had its origins in 2008 in the digital media industry but did not gain widespread recognition until approximately 2010. Despite the term's relatively recent coinage, there seems to be a general agreement about its meaning. According to Fardo (2013),

> (...) "gamification presupposes the use of elements traditionally found in games, such as narrative, feedback system, reward system, conflict, cooperation, competition, clear objectives and rules, levels, trial and error, fun, interaction, interactivity, among others, in other activities that are not directly associated with games, to try to obtain the same degree of involvement and motivation that we normally find in players when interacting with good games." (p.2)

Gamification has overall been defined as the use of game design elements (mechanics, techniques, aesthetics, etc.) in non-game contexts such as finance, health, and education (Deterding et al., 2011).

Although gamification techniques were initially applied to marketing programs and web applications in order to engage and retain customers and users (Cunningham & Zichermann, 2012) they have become a popular educational approach to solve the lack of engagement and motivation in the classroom experienced by students. As seen by Stott et al. (2013), these underlying dynamics that make games engaging had been largely already recognized and utilized in modern pedagogical practices, although not under the designation of gamification.

The goal of incorporating these game design elements into teaching is to motivate students to act, focus on problem-solving, promote learning, and obtain the motivation that games attain. The author also explains that these elements aim at a greater commitment in the students' learning, due to issues specific to human psychology, such as the taste for challenges and desire for recognition and reward (Kapp, 2012). By integrating gamification into the virtual tour, it’s hoped to obtain the same degree of involvement and motivation in students that would normally be caused by a game. Hence, combining 360° photography with gamification and adaptive learning designs can trigger the students’ interest, resulting in heightened stimulation and a richer and more unique experience, while gaining a deeper understanding of science.

3. Development of the virtual tour

This chapter explores all the steps taken in the creation and development of the visit, from the gathering of the necessary information, images, and videos, to the selection of the software and tools used. This chapter also demonstrates how to develop a virtual tour in Lapentor and shows the prototype created in this project.

3.1. Bureaucratic issues and initial planning

Given the particular nature of this project and the fact that it involves an international organization, it was first necessary to carry out a series of preliminary meetings with the INL's communications department to explain our objectives and the purposes of our project and obtain the necessary authorizations to proceed.

The first matters and authorizations for the internship were resolved via email, and after that, there were conducted 3 online meetings with some members of the communications department to present them the project and its objectives and to schedule the dates and arrange all the details relating to the visits to capture the images interview the researchers. During these meetings the team provided the plant of the facilities so it would be easier to locate the areas that would be photographed.

Before every visit to the facility, an access submission request form had to be filled in with personal information and signed by each of the visitors.

3.2. Gathering of the necessary information

The main purpose of this virtual tour was not only to be a way to get to know the INL but also to communicate nanotechnology enjoyably and easily for students to comprehend. As such, it was also important to think about what type of gamification and multimedia content would be integrated into the tour. The first content we planned to create were video interviews with the scientists of the INL, to better understand what they do and which projects they develop there. After that, we also thought it was important to explain to students what nanotechnology is in a way that wouldn't be too tedious or difficult, so we thought about quizzes, hotspots, and interactive presentations. To be able to produce these contents, we had to make two physical visits to INL to take the images and record the videos, and there was also a need to seek educational resources and information about the laboratory to be included in the gamification.

3.2.1. Videos and interviews

To ensure the quality of the virtual tour, it was necessary to gather the most suitable equipment possible beforehand. The interviews conducted with the scientists and other videos used throughout the visit were recorded using a Canon EOS 2000D. It is a 24.0 megapixels digital single-lens reflex camera (DSLR)[4].

Figure 13 – Canon EOS 2000D camera

The camera was positioned at a constant position and the videos were recorded without interruptions and later edited to include only the important parts.

Figure 14 – Canon 18-55mm IS STM lens

The lens used with the camera was the 18-55mm IS STM, which is a basic zoom for Canon's 1.6x cameras. It has both image stabilization to eliminate the need for a tripod and has the new STM silent autofocus motor to help with quiet, smooth autofocus while rolling DSLR video. Even though the lens had image stabilization, a tripod was used to allow the steadiness of the camera when recording the videos and to make sure the images were not blurred, especially in situations with less light. In this case, it is advisable to use a tripod with a panoramic head and with degrees marking (from 0° to 360°).

3.2.2. 360° images and pictures

The Samsung Gear 360 camera was used to collect all the images used to create the virtual tour. This was the first 360-degree camera created by Samsung Electronics and was released as a part of the

[4] DSLR is an abbreviation for "digital single-lens reflex", which is a type of digital camera

Samsung Gear family of devices. It is compact, lightweight, and uses two cameras (one on the front and one on the rear) to take 360° photos and videos. A tripod was also used to ensure the stabilization of the camera.

Figure 15 – Samsung Gear 360 camera

The usability of the camera is quite simple. It is necessary to first install and launch the Samsung Gear 360 app on a phone to use the camera. After successfully connecting the camera to the phone using bluetooth, users can take photos remotely using their phone as a viewfinder. It was important that no person was seen on the images for this virtual tour, so making sure we could take pictures remotely with the camera was a crucial factor.

3.2.3. Documents provided by the INL

Throughout the preliminary meetings held with the INL, the communications department also provided us with fundamental elements for the planning and development of the visit, such as:

- Detailed maps of the three floors of the building containing the names of all laboratories and spaces;
- Usual routes followed and information provided in the INL's physical visits with schools;
- Educational booklet for dissemination and teaching of nanotechnology;
- Booklet about the INL, each laboratory, and research group.

After analysing the information acquired at the meetings, we began to plan the visit and define the educational content that was going to be produced to integrate it. With this information and the help of the communications department it was possible to decide which laboratories would be included in the visit:

- Cleanroom (level 0);
- Dry Labs (level 0);
- Wet Labs (level 1);

- Central Bio (level 1);
- High Accuracy Labs (level -2).

As previously referred, a cleanroom is a laboratory that is not accessible to most people, let alone on physical school visits to the building, so being allowed to integrate it in our visit was extremely important and an advantage from physical tours, since it will allow users to visit this space.

3.3. Analysis of solutions to implement the virtual visit

Before choosing a tool to implement the virtual visit, research had to be conducted to analyse the most fitting software for the project. Through online research, four tools were found that seemed to be free and fit in with what was looked for in this project: Lapentor, Kuula[5], Klapty[6] and DiveIn[7]. I was mainly looking for tools that enabled the incorporation of hotspots, audio, videos, embedded links, plugins, and the most customization possible.

To decide which of the tools would be best for this implementation, an in-depth study the tools found was made, and the results can be seen in the figure below.

	LAPENTOR	KUULA	KLAPTY	DIVEIN
HOTSPOTS	✓	✓	✓	✓
AUDIO	✓	✗	✗	✗
VIDEO	✓	✗	✗	✓
EMBEDDED LINK	✓	✗	✓	✓
PLUGINS	✓	✗	✗	✗

Figure 16 – Study of online virtual tour software

The free versions of Kuula, Klapty and DiveIn didn't allow much customization and didn't provide audio hotspots and plugins, which were important parts to be integrated into the virtual tour. Lapentor was the only one of these four tools to create virtual tours that offered unlimited free use, freedom for sharing or publishing the tour, hotspot features, plugins, and customization. This software and its features

[5] Kuula available at https://kuula.co/
[6] Klapty available at https://www.klapty.com/
[7] DiveIn available at https://www.divein.studio/

will be explored more thoroughly in the next section, but it is important to mention that it was the ideal choice for this project and to be used by someone who had never made a virtual tour before.

3.4. Tools and software

The multiplicity of the tasks carried out to develop this tour demanded the use of a range of tools, each with a different function and purpose. All the tools utilized are completely free to use and accessible to the common user. Firstly, it is going to be describing the tools used to develop the virtual tour, and further on it will be explained the remaining tools which were used to create the visit's gamification and multimedia.

By analysing similar projects and conducting online research, it was narrowed down some software that seemed most fitting for the development of this project. I was mainly looking for software that was free to use and allowed the most customization and gamification possible through its features.

Software	Company	Description
Lapentor	Lapentor	Cloud-based software to develop virtual tours
NadirPatch	NadirPatch.com	VR photography tools website
GIMP	GIMP	Open-source program to create and edit images

Table 2 – Tools and software used to develop the virtual tour

As depicted in table 2 presented above, the three tools used were Lapentor, NadirPatch and GIMP. GIMP and NadirPatch were used in the image processing and Lapentor was the software chosen to build the virtual tour.

3.4.1. GIMP

GIMP[8] is a free and open-source image manipulation program used for tasks like photo retouching, image composition and image authoring. It has many capabilities and has a standard interface common to other editing programs and is the best free alternative for professional-grade and paid programs. According to their website, GIMP can be used as a simple paint program, an expert quality photo retouching program, an online batch processing system, a mass production image renderer, an image

[8] GIMP available at https://www.gimp.org/

format converter, among other things. Other basic features of GIMP include colour adjustment, gradients, noise reduction, cropping, customizable brushes, and automatic tools for image enhancements.

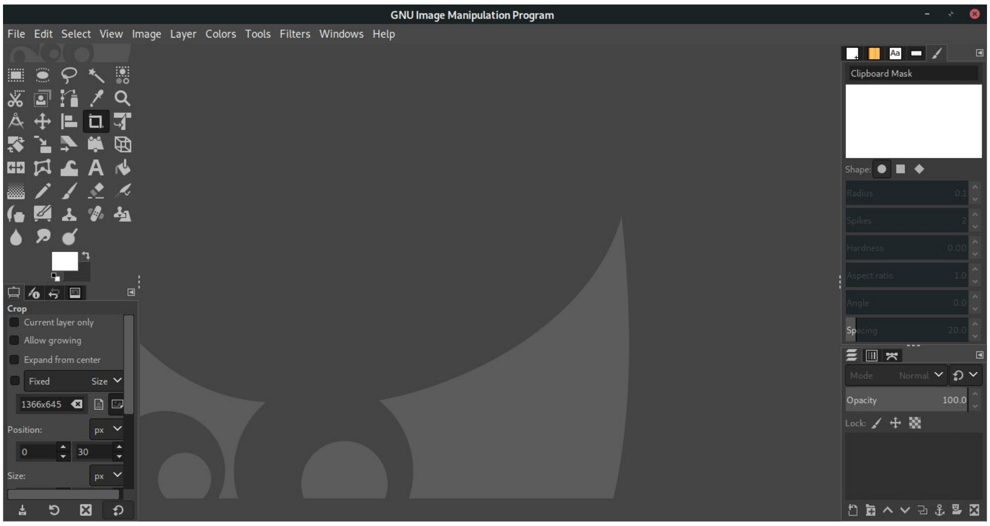


Figure 17 – GIMP's interface

3.4.2. NadirPatch

Since Samsung Gear 360 doesn't stitch the photos on the device, it was needed to find a suitable stitching and patching software. NadirPatch[9] offers free cloud-based tools for patching and stitching 360 photos. Although the tool does allow users to create an account, there is no need for an account to use the features.

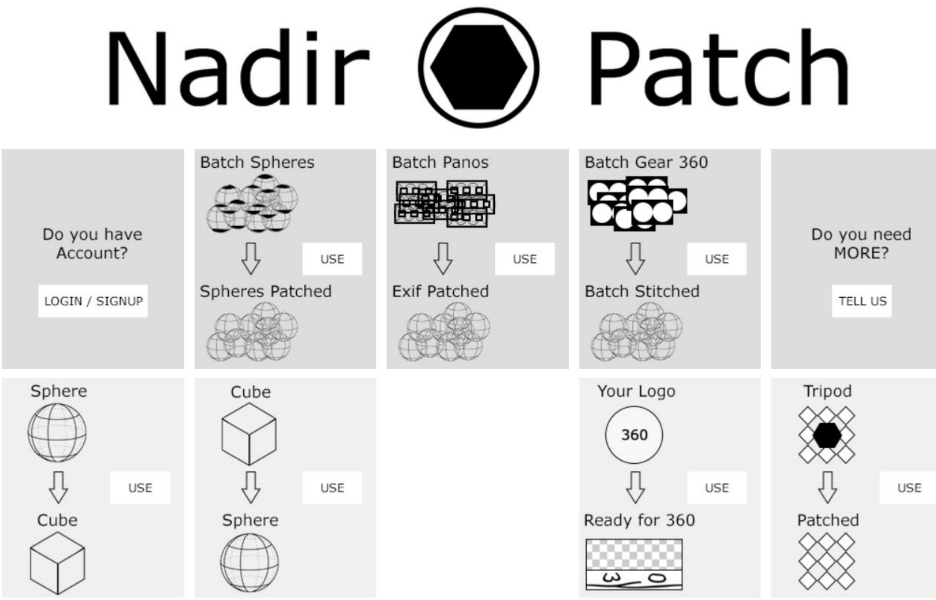


Figure 18 – NadirPatch's interface

[9] NadirPatch available at https://nadirpatch.com/

NadirPatch currently provides users with seven useful tools: panorama EXIF patcher, sphere to cube, cube to sphere, sphere patching tool, cube patching tool, gear 360 stitching, and logo for 360 panorama tool. There are also three more options to patch images in batches for the Gear 360 images, spheres, and Exif patchers. These options can be extremely useful when needing to stitch a high number of images, but they do have a price – prices range from 5$ for 10 files to 10$ for 100 files.

3.4.3. Lapentor

The process to begin using Lapentor is quite simple; all that is needed to start is a Lapentor account which can be created in a couple of minutes. The interface is extremely intuitive, and I never found myself needing help understanding or learning how to use a certain feature of the software. The most valuable feature I found on Lapentor was the capacity to customize and design all the virtual tour interfaces from the hotspot icons to the scene list in minutes without any line of code. It was also difficult to find software that had no limit on the number of panos or projects, but in Lapentor that access is also free and unlimited. Other customization features in Lapentor include:

- Modern themes;
- Customizable hotspots;
- Customizable scene list;
- Background sound;
- Auto transition;
- 7 different interactive hotspots;
- 21 functional plugins;
- Intentional view.

To share the virtual tour, the user can choose to publish it, share it through a link or with password limited-access. It can also be hosted in a self-hosting domain or under cloud hosting via Lapentor's service. The tours created run smoothly on PC, mobile and VR, and are multiresolution with a KRPano-based engine.

3.5. Image treatment and development of the tour

Stitching, patching, and organizing the images in the virtual tour software was the most laborious phase of the process of creating this tour. The image treatment methods assured that the untreated photos that were taken with the Samsung Gear 360 camera could be transformed into 360-degree panoramic images that could be used to build the tour. After conducting these processes in all the 100+ images used, they were uploaded into Lapentor, organized, and connected through hotspots to create an authentic view of the International Iberian Nanotechnology Laboratory.

3.5.1. Workflow

Before starting to build the virtual tour, it was important to have a clear workflow of steps that were needed to be completed in order to finish the prototype on time. This workflow consisted of four main steps, as presented below:

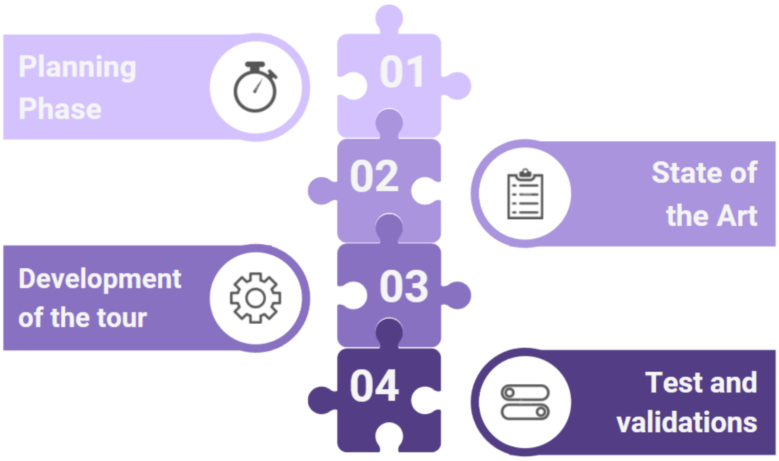


Figure 19 – Workflow followed to complete the project

The first step was the planning phase, which was already discussed in this report and consisted of the identification of the problem and the preliminary meetings with the INL, as well as resolving bureaucratic matters. The second phase was the state of the art, where I analysed similar virtual tours to research centres and laboratories and identified the most fitting tools and software to develop the tour. The third phase represents the steps of the development of the virtual tour, which were the identification of places of interest for the virtual tour, capture of photos and videos, editing, creation of interactive multimedia content and assembly of the virtual tour. Finally, the last phase was the tests and validations, which consisted of the questionnaire answered by a sample of the target audience, which will be discussed later in this report.

3.5.2. Stitching, patching, and editing

The stitching and patching of the 360 images were all conducted in the virtual reality photography tool NadirPatch.

Figure 20 – Photo taken from Samsung Gear 360 before stitching

As seen in the figure above, the raw photos taken with Samsung Gear 360 are composed of two fisheye shots next to each other, one from each lens of the camera. To stitch these shots together, the “Gear 360 Stitching” feature in NadirPatch was used. It is simply need to upload the image intended to be stitched and download the respective equirectangular projection after the image has been rendered.

Figure 21 – Equirectangular projection of the 360 photo

The result of the stitching is an image with a 360-degree field of view horizontally and 180-degree vertically, commonly called “360 spherical panoramas”.

Since the tripod that held the camera was noticeable at the bottom of the pictures, it was also necessary to use the “Sphere patching tool” feature. A circular logo of the INL was uploaded along with the equirectangular projection, and after adjusting the size and angle of the logo for it to cover the whole tripod, the final image was created. The same process was repeated with the rest of the images used to create the tour.

Figure 22 – 360 spherical panorama with the INL's logo patch at the bottom

After all the 360 images were stitched and patched, GIMP was used to slightly increase the images' sharpness. For this, a simple Filters > Enhance > Sharpen (Unsharp Mask) command was used. The radius and amount were adjusted according to what looked best in each image.

3.5.3. Development of the prototype in Lapentor

The building of the virtual tour in Lapentor was without a doubt the most laborious part of the development of this project. It consisted of five steps:

1. Uploading the images;
2. Naming and organizing the scenes in the order of the tour's path;
3. Setting the default view in every scene;
4. Connecting the point hotspots;
5. Creating the hotspots.

The first step to start developing a virtual tour in Lapentor is to create and name a new project. After successfully creating the project, the software requires users to choose the intended images and select "make sphere" to process the still images. The rendering process takes a few seconds, and after all the images are uploaded, it's time to start constructing the tour.

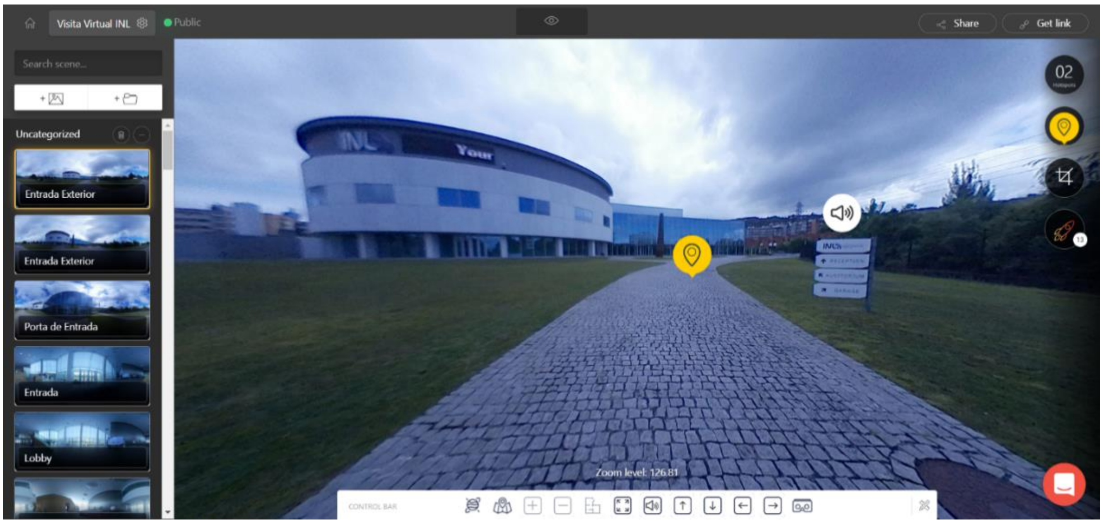


Figure 23 – Lapentor's project interface

Lapentor's project interface is extremely intuitive and easy to use. On the left side of the screen are the images uploaded, or "scenes". To facilitate the structuring and organizing of the tour, the scenes were named according to which place of the building they represent, for example, "exterior entry", "lobby", etc. The scenes were moved and organized in order to create the tour's path. The organization of the scenes is done by a simple drag and drop and the scenes can be searched by name. The connection of the scenes to one another is done through a point hotspot. Each scene has a point hotspot that takes viewers to the following scene and the previous one as well.

At the bottom of the screen is the control bar, where users can select different options to view the virtual tour:

Figure 24 – Lapentor's control bar

The colours of the control bar can be edited, and the colour chosen for this project was purple since is the primary colour used by the INL. The features included in the control bar are little planet (transforms the scene into a planet-like sphere), Google Maps, fullscreen, zoom in, zoom out, Floorplan, sound, arrows to move up, down, left, and right and simulated webVR mode. For real WebVR with headset tracking, a WebVR-API-capable desktop browser or mobile device and a VR headset are needed. Each one of these features can be activated or deactivated. For this tour, the zoom in and zoom out options and the Floorplan feature were deactivated.

At the top of the page on the left are the configurations of the project, where users can see all of the project's information:

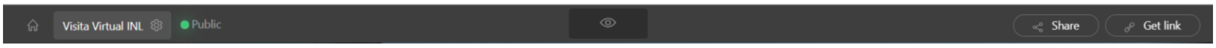


Figure 25 – Lapentor's top screen bar

The eye button at the top centre of the page is the preview button. By clicking on this button, a new tab is opened with the preview of the scene the user is working on, as well as the whole tour. This is a really useful feature to check if everything is working accordingly while editing the tour. At the top right of the page are the "share" and "get link" buttons. These buttons allow users to share the virtual tour on Facebook, Twitter, Google+, Reddit, and also through an embedded code or QR code. The "get link" option creates a link that users can also use to share the virtual tour.

On the right side of the page are the hotpot count, the hotspots, the view settings, and the power-ups:

Figure 26 – Lapentor's hotspots, view settings and power-ups

The hotspot count shows how many hotspots are in a particular scene the user is at. In the case of the image above, there are 6 hotspots in that scene: point, image, URL, audio and text hotspots.

There are 7 types of hotspots users can choose: point, directional sound, image, video, article, info, and URL hotspots. To insert these hotspots into the tour users can simply use a drag and drop system to drag them to the spot of the image they want.

Figure 27 – Lapentor's hotspots, view settings and power-ups

Lapentor allows users to choose the theme of hotspot they prefer among six different themes. The one used on this tour is called "Bubble", and even though the hotspots appear yellow on the editing, their colour was changed to white to fit in with the colour scheme of this virtual tour, which is purple and white.

The view settings allow users to set default view, limit, max zoom, min zoom and reset zoom:

Figure 28 – Lapentor's view settings

The default zoom for every scene is 90.00, but on this project, it was adjusted on every image to a point where it would provide a better initial view of the scene.

The 4th button on the right side of the screen is the power-ups option. Lapentor provides a total of 38 options of power-ups for the scene list, the control bar, plugins, and hotspots. This is one of the best features of Lapentor: the option of customization. Users can choose which type of hotspot, control bar or scene list themes they prefer, and customize them even further in terms of colour and position. There are also 21 plugins users can install on their virtual tour:

- Common buttons;
- Change scene effect;
- Auto transition;
- Chevron point hotspot;
- Little planet;
- Floorplan;
- Webvr;
- Google Maps;
- Background sound;
- Social share widget;
- Scene title;
- Gallery;
- Patch;
- Hotspot list;
- Scene navigation;
- Intro popup;
- Image placeholder;
- Gyroscope;
- Copyright;
- Lensflare;
- Custom code.

In this project, 13 of these plugins were installed: common buttons, change scene effect, auto-transition, chevron point hotspot, little planet, webvr, Google Maps, background sound and social share widget.

Below is an example of the cleanroom corridor scene of the prototype[10]. At the top of the screen is a drop-down menu that can be opened or closed with the available scenes and the respective names of the places they represent. The hotspots are scattered around the scene and the control bar is at the bottom of the screen. The point hotspots are different from the other ones because of the "chevron point hotspot" plugin installed, which transforms the point hotspots into arrows on the ground, which facilitates the user's navigation.

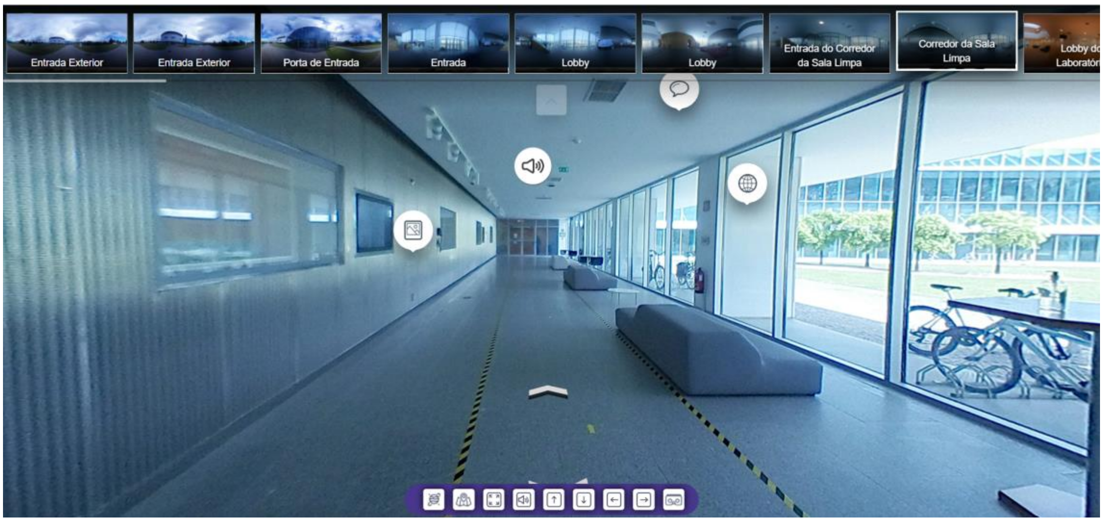


Figure 29 – Prototype's cleanroom corridor scene

Users can navigate through the tour's scenes using the drop-down menu or the point hotspots on the ground. The point hotspots connect every scene on the tour and allow users to move forward or backwards. The prototype has a total of 58 different scenes that users can explore, with some type of media content or hotspot incorporated into almost all of them.

[10] The virtual tour's prototype created in this project can be accessed and viewed at https://app.lapentor.com/sphere/visita-virtual-inl

4. Creating the gamification

The gamification is the important key element that transforms this virtual tour into an educational resource intended to communicate science in an unconventional and interactive way. The contents created are destined for students in the 8th to 11th grades and are meant to simplify complicated concepts like nanotechnology and science. This chapter explores the tools and software used to create the multimedia incorporated into the visit, and the steps followed to create each of the contents.

4.1. Planning the gamification in the virtual tour

As aforementioned, gamification can be defined as the use of game design elements, visuals, and mechanics in non-game contexts to promote user engagement (Attali, 2015). The incorporation of these game elements into this project is what turned this virtual visit into an educational tool designed to motivate students to learn more about science and nanotechnology.

The decision of which tools and software would be used to implement the gamification was crucial to deciding which types of gamification would be possible to include. Ideally, games with points and leaderboards would provide a more competitive and rewardable aspect that games provide, but it was not possible to find free software that would allow the implementation of those kind of mechanics. As such, the elements chosen to be included in this virtual tour were hotspots (image, audio, and text), videos, quizzes, games, and presentations.

The gamification of this virtual tour is not meant to be just about students playing games; it is about stimulating students to learn about topics that otherwise could seem difficult and tedious, and associate learning as a fun and positive thing.

4.2. Tools and Software

The tools to create the interactive media were the hardest to choose since it wasn't easy to find content creation software that didn't require a paid account or didn't leave a visible watermark on the content with the use of a free account. At first, we had in mind making interactive videos and quizzes in HP5[11] – an online tool to create, share and reuse interactive HTML5 content – but soon discovered it couldn't be used for free, so other alternatives had to be found. After that, I had the idea to make animated explainer videos simplifying concepts like nanotechnology or atoms, but never found free software to do

[11] HP5 available at https://h5p.org/

so. After all the search, Genially was the software used to create most of the content that involved interactive presentations and quizzes.

Software	Company	Description
Shotcut	Meltytech	Open-source video editor
Audacity	The Audacity Team	Audio editing and recovery software
Youtube	Google	Video sharing platform
Canva	Canva Pty Ltd	Graphic design platform
Genially	Genially Web S.L.	Tool for creating interactive content
Voicebooking	Voicebooking.com	Free voice over generator

Table 3 – Tools and software used to develop the gamification content

As depicted in the table displayed above, the six tools used to create the gamification were Shotcut, Genially, Youtube, Canva, Audacity and Voicebooking. To edit the videos and interviews it was used Shotcut and Adobe Audition, and to publish them it was used Youtube. To create the multimedia content, Canva, Genially and Voicebooking were the tools chosen.

4.2.1. Shotcut

Shotcut[12] is a free and open-source cross-platform video editing and encoding tool that has a simple interface and supports a wide range of formats such as FFmpeg, 4K, ProRes, DNxHD, among others. The software supports video, image and audio formats and uses a timeline for non-linear video editing of multiple tracks of different file formats. Shotcut's features include wide format support, video effects, editing features, codec and cross-platform independent, monitoring and display, and hardware support. It also provides extensive audio editing options like bass and treble adjustments, bandpass filters, gains adjustment, and more.

[12] Shotcut available at https://shotcut.org/

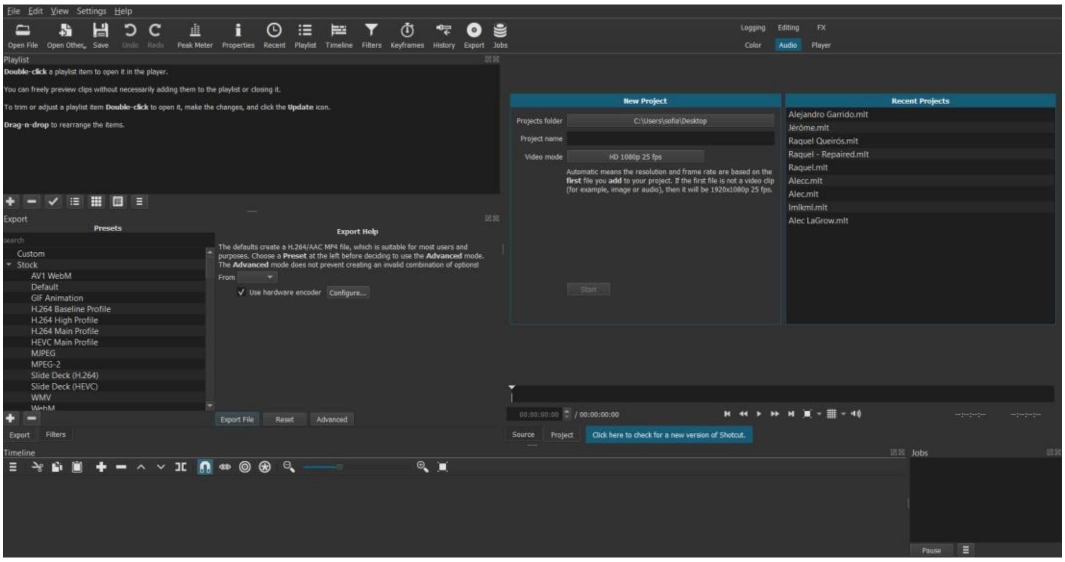


Figure 30 – Shotcut's interface

As a person who had never worked with a video editing tool before, I found Shotcut to be extremely intuitive and easy to learn and had no problems using the software. The design is very intuitive and customizable since the panels can be moved and docked or undocked. Shotcut is not a basic video editing software, but it is also not as complex as a professional program. The only negative aspect I found was that the filters can only be added one clip at a time, which can be a little time-consuming.

Before using Shotcut I started editing the videos with OpenShot[13], which at first seemed easier to utilize and had an interface with fewer features but I was experiencing problems when exporting the videos since the software would lag and the videos would come out with parts of the sound cut out. After deciding it was better to use another tool and searching for an alternative, I found Shotcut, which ended up working perfectly.

4.2.2. Audacity

Audacity[14] is a free multi-track audio editor and recorder software available mainly on Windows, Linux, macOS and other operating systems. Audacity is easy to use and has a very rudimental interface that allows recording from multiple sources and post-processing of all types of audio. It includes audio editing features like normalization, trimming, fading in, fading out, among others.

[13] OpenShot available at https://www.openshot.org/pt/
[14] Audacity available at https://www.audacityteam.org/

4.2.3. Youtube

YouTube[15] is a worldwide known online video sharing service and social media platform where users can watch, like, share, comment and upload their videos on any device.

To incorporate videos on the virtual tour there was a need to upload them onto a platform that could transform them into links, so a YouTube channel was created to be able to save and publish the videos created onto the virtual tour. The videos published on the YouTube channel are, however, hidden to the general public and can only be accessed through the respective link. Having the videos uploaded onto YouTube was the best option since it made the job of subtitling a lot easier because YouTube allows creating subtitles after uploading the videos.

4.2.4. Canva

Canva[16] is a cloud-based, free online graphic design platform that combines design, photo-editing, and layout. It has an intuitive drag and drop interface which is simple and easy to use. It allows users to create presentations, infographics, posters, resumes, photo collages, among other things. It has millions of images, fonts, templates, and illustrations that can be used on any platform versatility of the platform (browser or mobile) and by various people since users can collaborate on the same design. Canva was chosen for this project since it is like a basic free version of Photoshop that doesn’t require extensive photo editing knowledge and has thousands of templates available to use, making it easier to create visual content.

4.2.5. Genially

Genially[17] is an online tool for creating interactive content destined for companies, universities, education, and design. It offers over 1,300 templates to create presentations, infographics, gamification, interactive images, video presentations, guides, training materials, and more. Users can use Genially’s templates or start their work from scratch and add their own text, images, videos and external content – like YouTube videos, PDFs, google docs, social media posts, maps, etc. Genially’s creations can be downloaded, shared via link, or be embedded onto a webpage or online platform.

[15] Youtube available at https://www.youtube.com/
[16] Canva available on https://www.canva.com/
[17] Genially available at https://genial.ly/pt-br/

Although this tool can be used for free, it does leave a small but visible watermark on the creations and some templates can only be accessed through a paid account. Some of the templates created in this project were created through a premium account provided by our masters' Professor. Even though some content is premium, for students the price is very accessible (only 1,25€ per month billed annually).

4.2.6. Voicebooking

Voicebooking[18] is a voice agency that works as a webshop where users can book a voice-over for their writings. This website was found when searching for online free voice-over tools to use to create the audios of the virtual tour. The website has a voice-over generator[19] page with simple and free testing of voice-over texts that can be easily downloaded. The website allows users to choose the language of the text, and, for Portuguese, it has four voice-over options available – two female and two male options. The pitch and speed of the voiceovers can be adjusted to the user's preferences. To use the free voice-over generator the website does require users to create an account and be logged in, but it is a quick process.

This website was a huge help in creating the voice-over audios since recording them ourselves would take a lot of time and work. At first, since the visit is destined for students, we thought the best option was to use a teenager's voice, but after finding the website and experimenting with the available voices, we concluded that the male voice is more professional and fitted for the project.

4.3. Videos and interviews

The videos and interviews with the investigators were collected during two in-person visits to the INL. The scientists interviewed were selected by the communications team of INL and they each represented different research projects, so there could be obtained different points of view and the most information possible about different areas of investigation. The interviews were conducted with eight researchers:

Scientist	Research Group
Alex Bondarchuck	Advanced Electron Microscopy
Alec LaGrow	Advanced Electron Microscopy
Raquel Queiróz	Water Quality
Begoña Espiña	Water Quality
Alejandro Garrido	Food Quality and Safety

[18] Voicebooking available at https://www.voicebooking.com/
[19] Voicebooking's free voice over generator available at https://www.voicebooking.com/en/free-voice-over-generator

José Fernandes	Micro and Nanofabrication
Jérôme Borme	2D Materials and Devices
Manuel Bañobre-López	Nanomedicine

Table 4 – Scientists interviewed and respective research group

The interviews were recorded in the cleanroom corridor and the questions asked to the scientists were sent beforehand so they could have time to prepare the answers. The questions sent to the researchers were:

1. What is your research area and what does it consist of?
2. Can you give an example of what you do?
3. How does this area contribute to a better society?
4. Did you always want to be a scientist? What profession did you want to be when you were a child?
5. What led you to consider a scientific career?
6. What is the best part of your job?
7. In your opinion, what does it take to be a good scientist?
8. What advice would you give to a student who wants to pursue a scientific career?

The rest of the videos used on the virtual tour are either from the INL's YouTube page or recorded while the scientists were explaining the laboratories they work in and the research they develop there.

4.3.1. Editing process

As aforementioned, the videos and interviews were recorded using a Canon EOS 2000D camera and a tripod. The method used to record them was to initiate the video from the moment the scientists started talking and only pause after the whole interview was finished, without cuts, to avoid having to be starting and stopping the recording constantly due to errors or outside noises. The result of this method was large MP4 files that needed to be reduced to only the most important parts. An example of this is the uncut interview video of the scientist Jérôme Borme, which had a total length of 25 minutes and 12 seconds. After finishing all the editing, the final video ended up with 3 minutes and 9 seconds.

Figure 31 – Interview video before editing

Figure 32 – Interview video after editing

Since the recordings were made in the cleanroom corridor, which is the main transit point for all the laboratories in the INL, the interviewees would end up having to pause the sentences and start again due to people passing and background noises of doors opening and closing. This made the editing process harder, as we would have to watch the entire videos multiple times to write the timestamps of the important parts of the answers but was easier in terms of file organization and recording since we would have only one video per scientist and not a lot of videos for each question per scientist.

Before starting to edit the videos, it was necessary to create a tag name for each investigator to appear at the start of the video, and question screens depicting the questions they were answering. The tag names were made in Canva and contained the name, title, and research area of each scientist. An example of a tag name can be seen in figure 32 above. The question screens were also made in Canva using exclusively resources available on the tool.

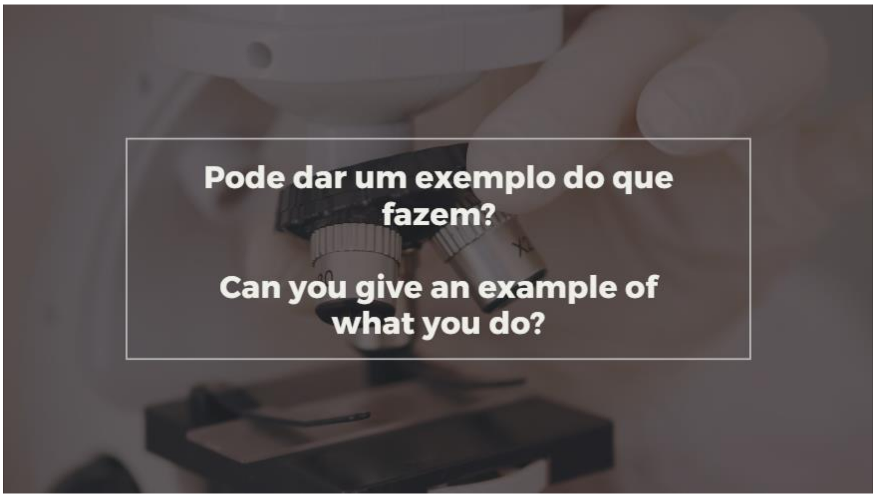


Figure 33 – Example of a question screen

Each question screen has 6 seconds and consists of a background video with the question in Portuguese and English. The questions fade in at the start of the video and fade out at the end, and each background video is different according to the question it represents. A dark filter was added on top of the videos to make the question more visible and the focal part of these screens.

It was also felt that it would be more natural to have a background song accompanying the screens instead of silence, so an instrumental song was chosen online, downloaded and incorporated into the screens during the editing. This song was edited in Audacity to fade in at the start of the screen and fade out at the end, in order to create a smoother transition in the video. To edit the song, the MP3 file was opened in Audacity, the beginning and the end of the audio file were selected, and the effects "fade-in" and "fade-out" were used. Audacity automatically reduces the volume of the track without having to select anything.

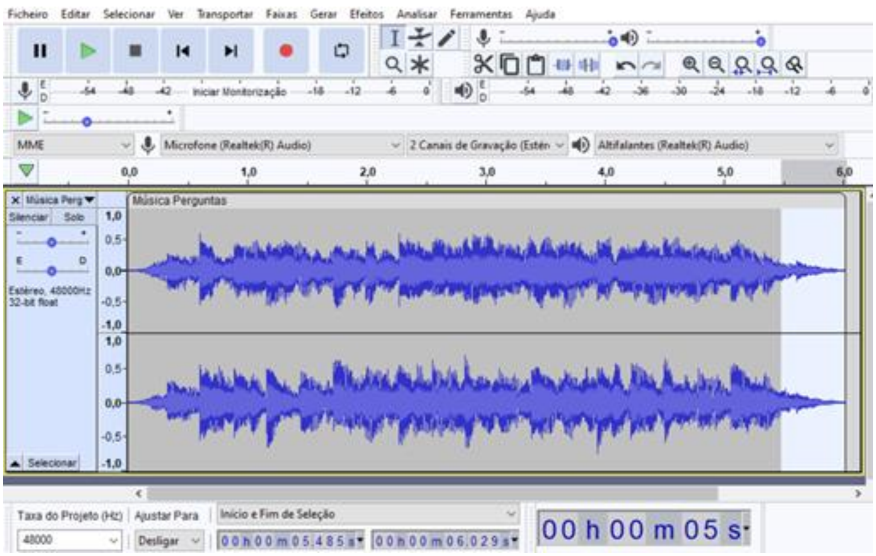


Figure 34 – Audio editing in Audacity

After having these components ready, it was time to start the editing of the videos. Firstly, the answers were separated to then insert the question screens before each answer. For this, the original MP4 file of the complete interview was opened in Shotcut, the answer was isolated from the video using the "split" option and the rest of the unwanted interview was deleted and only the question was exported. This process was repeated for all 8 questions of the interviews.

Figure 35 – Example of split feature in Shotcut

This process of separating each answer was repeated for all 8 interviews, and after having all the composing parts of the videos ready, it was all uploaded into Shotcut. A folder was created for each researcher to organize the components necessary to edit each interview. An example of one of these folders can be seen below; each of them contains the name tag of the researcher, the 8 question screens, the background song, and the 8 isolated answers.

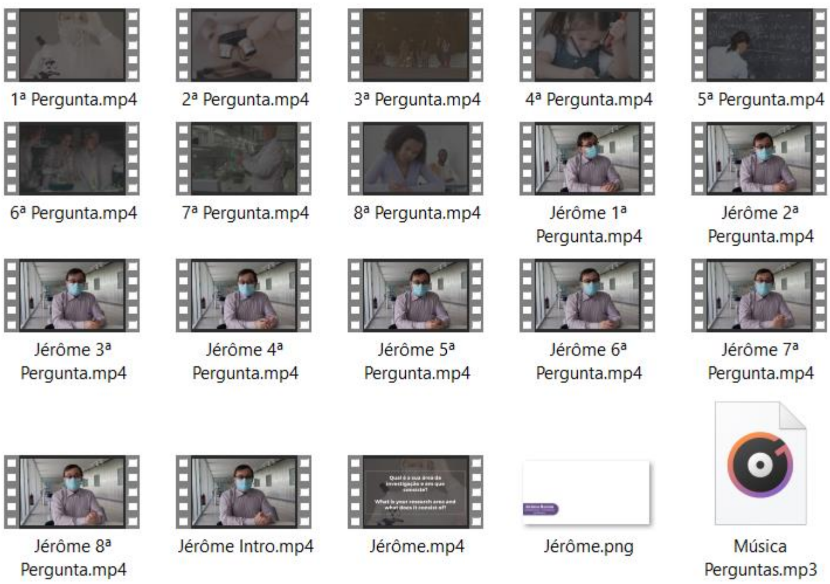


Figure 36 – Example of a folder containing all the editing components for the videos

Once all the files were uploaded in Shotcut, they were dragged to the timeline and organized according to the order of the interview: intro, question screen of the 1st question, answer to the 1st question, question screen of the 2nd question, and so on.

Figure 37 – Example of video editing in Shotcut

A new file track and audio tracks were added to the timeline to insert the background audio and the tag name. Fade-in and fade-out effects were added on all components to make the transitions smoother: for the tag name, the fade-in/fade-out was 00:02:00, for the question screens of 00:00:20 and 00:00:10 for the answers. The gain/volume of the song was also adjusted to -13. After all this was complete, the finished video was exported at 25fps and 85% quality.

The editing of the videos was a long process of trial and error, of trying different techniques and tools and searching for answers online until the desired video style was achieved.

4.3.2. Transcription and subtitling

To make the videos more inclusive and perceptive for everybody, one of the objectives was to have subtitling available on all the videos. Of the 8 scientists interviewed, 3 spoke in Portuguese, 2 in English and 3 in Spanish, so all the interviews had to be transcribed and then translated into Portuguese (which is the language of the virtual tour and the language spoken by the target audience of this project).

As mentioned before, to be able to embed the videos in the virtual tour through a link, they were uploaded on YouTube. For this, a Gmail account was created for this project to then make the designated YouTube channel. Luckily, YouTube has a feature that allows the subtitling of the videos after uploading, otherwise, they would have to be subtitled in the video editor.

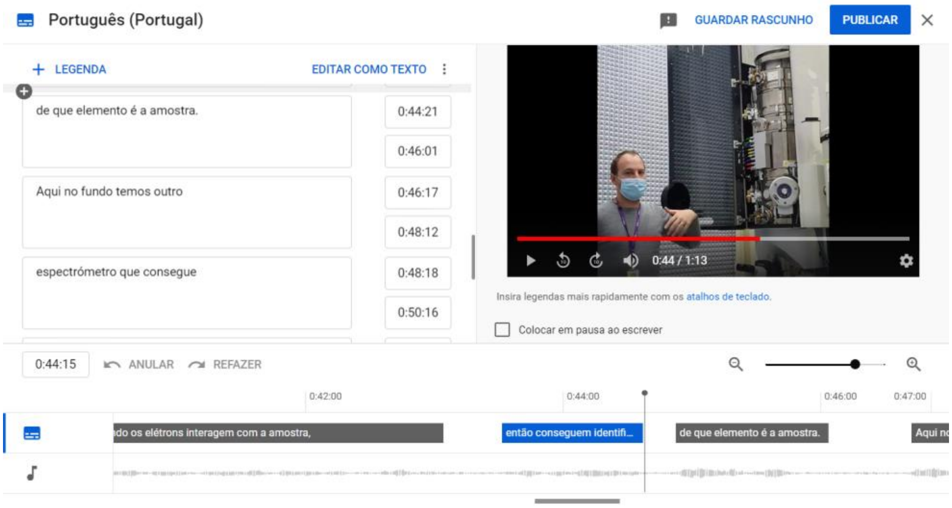


Figure 38 – Video subtitling in YouTube

The subtitling on YouTube is very simple and automatic, since the program provides an audio track that can be followed to better perceive when the subject is talking, so the subtitles only need to be written down and adjusted to the specific time frame. In total, the project's YouTube account has 23 videos that were edited, uploaded, and subtitled.

4.4. Audio, image, and text hotspots

The information included in all the audio, image, and text hotspots was gathered from the documents provided by the communications team of the INL, and the aim of these hotspots is to present this information in the easiest way possible. All the hotspots open in a window at the centre of the screen and can be closed in the "x" button in the top right corner.

The text hotspots are simple paragraphs of text with the most important keywords emphasized in bold. These hotspots usually give information about the laboratory they are positioned in, and the research developed there, as can be seen in figure 39 below, which reads "At the Eco-Nanotoxicology Laboratory, the Water Quality group develops different types of applications to detect nanomaterials and monitor the quality of water, purify it, and study the impact of nanomaterials on the water cycle and the environment.".

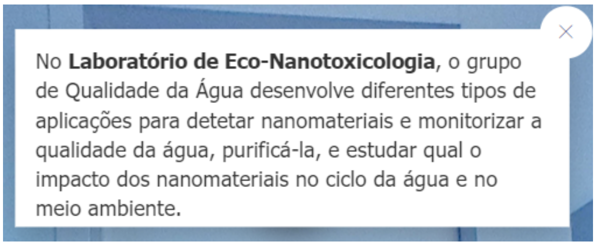


Figure 39 – Example of text hotspot

Image hotspots are meant to explain visually the concepts described in the text or audio hotspots. In figure 40 can be observed an image created in Canva explaining the microscopic scales. Other images created in Canva to be included in the hotspots can be viewed in appendix 1.

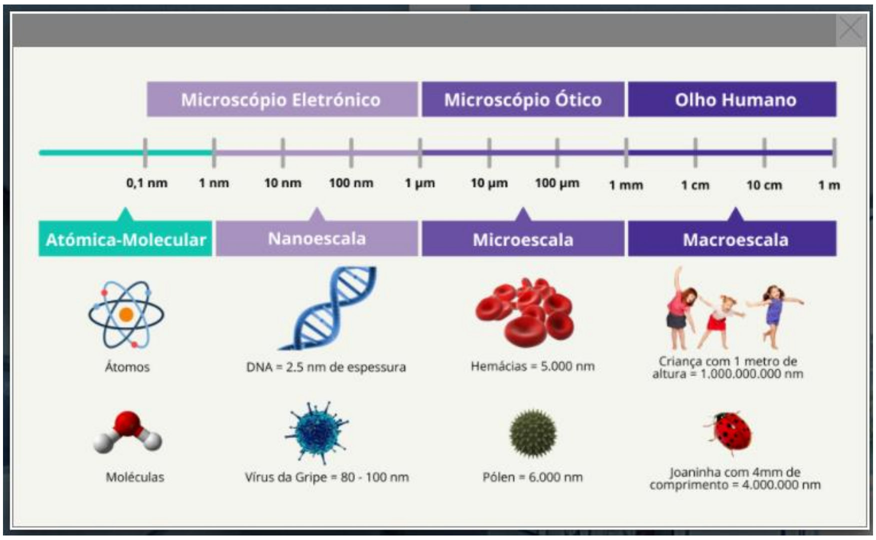


Figure 40 – Image hotspot

The audios for the audio hotspots were created in Voicebooking using a Portuguese male voice in the free voice-over generator. Although Voicebooking is free, it does require a login and has a maximum number of free projects, so various accounts had to be created. The tool is extremely easy to use, it just needs the selection of the language and voice, and a WAV file can be downloaded with the text in voice-over. The audio hotspots in the visit are designed to create a sort of storytelling effect and give users information about the scene they are in and the gamification present. The audio defaults to autoplay, but it can be turned off by clicking on the hotspot or the sound button in the control bar.

4.5. Quizzes and games

As aforementioned, the quizzes and games were created using Genially, which is a tool that provides templates for many types of interactive gamification. Each one of the contents created connects with subjects previously mentioned throughout the visit in either audio or text hotspots, as ways for students to consolidate the information learned in a more interactive and amusing way.

Below are some examples of quizzes and games created in this project. The INL quiz is the first interactive content that appears on the visit. It appears after the first scenes of the visit, where the students can hear about the creation and development of the INL through audio hotspots. This quiz contains questions relating to the information given on those hotspots, for example, "in what year was the INL created?", "in which city is this intergovernmental organization installed?" and "which two countries came up with the idea of building the INL together?". As the students answer the questions correctly, a picture of the INL is slowly uncovered on the right side of the screen.

Figure 41 – Quiz created in Genially about the INL

The letter soup is a simple but entertaining game that was created for students to remember the areas of research of the INL.

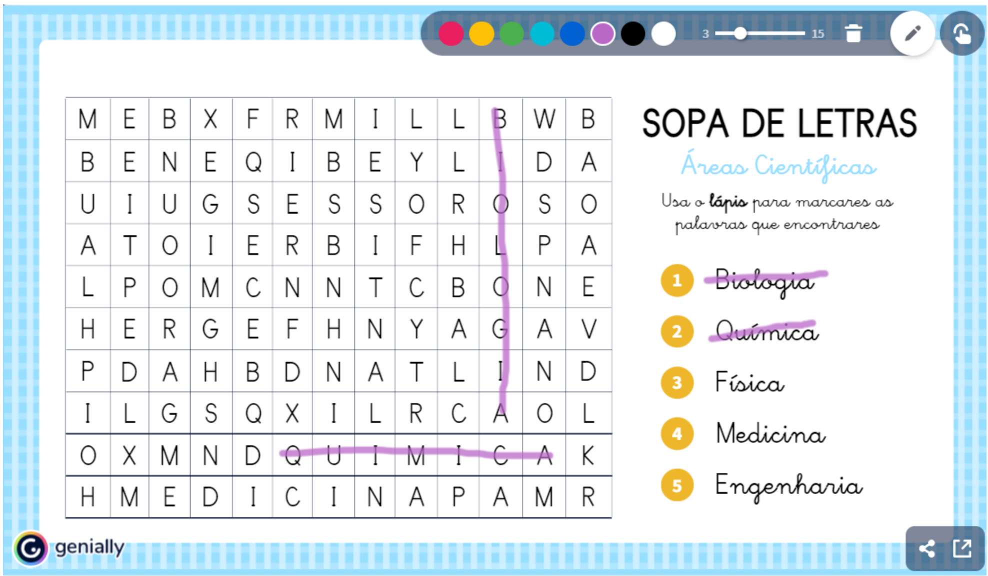


Figure 42 – Letter soup game created in Genially

The quiz below is about the way everyday things are seen under the microscope. This quiz is placed at the entrance of level -2, where the high accuracy laboratories and the units of advanced electron microscopy are set. The corridor and the laboratories of this level have hotspots and videos with more precise information about the microscopes used at INL; this quiz is only meant to be a fun way for students to be introduced to the subject of microscopes and to interact with them virtually.

Figure 43 – Quiz about images seen on the microscope

The goal regarding gamification was to have at least one form of it – hotspot, video, quiz, or game – in each one of the scenes of the visit, to make sure students understood what each scene was, what part of the INL it represents, and what type of research is being developed there. Since the visit ended up with 58 scenes, it was not possible to create that much content due to time limitations. As such, the quizzes and games created in Genially are only available in some of the most important laboratories and corridors.

5. Assessment and validation of the results

As a method of evaluation of the tour and consolidation of the project, a questionnaire was created to be answered by a sample of the target audience (students from 8th to 11th grades, with ages ranging from twelve to seventeen). The first part of the questionnaire is related to the students' perception of gamification-type learning and teaching. The second part was conducted to gain user feedback towards the virtual tour – which will allow us to make refinements to the prototype in the future – and to measure the tour's effectiveness and usability in terms of user satisfaction.

Ideally, there would also be a second questionnaire to be answered by students who have participated in the physical visits to the INL, in order to create a parallel between the two experiences. However, at the time of development of this project, that was not possible due to COVID-19 pandemic constraints, since neither the INL was hosting any visits, nor it was possible for us to find students who had taken the physical tour recently.

5.1. Creation and distribution of the questionnaire

Originally, the plan to validate the results of this project was to develop a small activity in classrooms for students from the 8^{th} to 11^{th} grades. This activity would start with a presentation of the project; then the students would interact with the virtual tour's prototype, and, in the end, it would be accessed their feedback and user experience in real-time. Since this was not possible, a questionnaire was created in Google Forms. The questionnaire starts with a consent form stating the goal of the project and that the subject's participation is voluntary, and is followed by two sets of questions. The first part consists of questions about the student's perception of science and technology, and about their opinion on new learning materials. After the first part, students can interact with the virtual tour and its gamification through a link of the tour. The second part serves to understand if the student's perception of science has changed after viewing the visit and to collect user feedback.

To distribute this questionnaire, the link to the Google Forms was sent to friends and family to share them with their acquaintances that would fit the target audience. It was also shared through the University of Minho's institutional email and sent to teachers of classes from the target audience to share them with their students.

It is important to mention that not all the questions of this questionnaire will be analysed in this report. The questionnaire was created in conjunction with my colleague Joana Fernandes and the questions relating to science communication and perception of science will be analysed in her report "Science

Communication: a strategic approach to the International Iberian Nanotechnology Laboratory". This report will explore the questions that have to do with the use of technology by students, the use of technology in the classroom, and the user feedback from users who have interacted with the virtual tour's prototype.

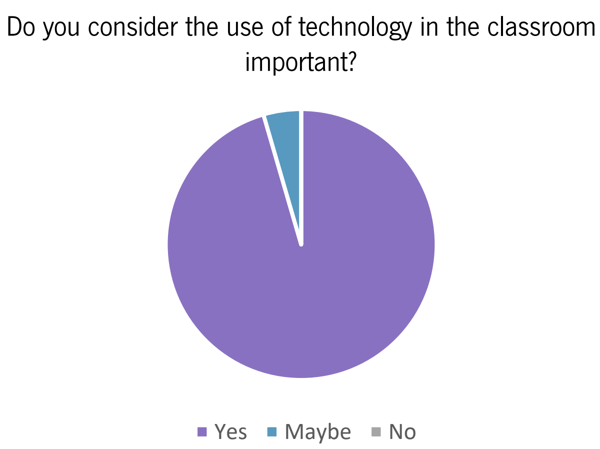
5.2. Analysis of the questions and interpretation of the results

The link to the Google Forms was available from November 9th of 2021 to December 12th of 2021. During this month, 22 subjects answered the questionnaire and interacted with the virtual tour. The sample pool consisted of 10 females and 12 males, aged 13 to 17, and most students that answered this questionnaire were attending the 9th grade.

Grades	Number of subjects
8th	1
9th	12
10th	3
11th	6

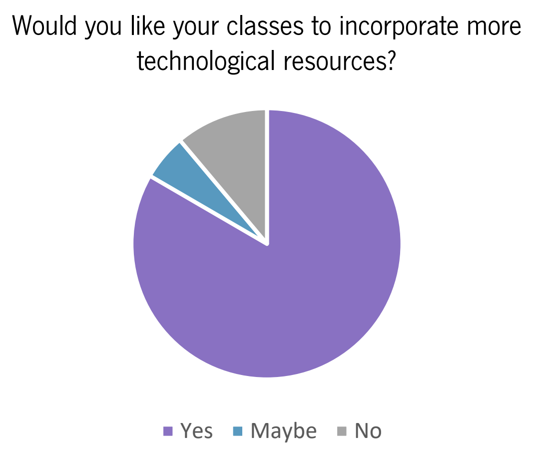
Table 5 – Number of subjects from each grade

From this point on, the questions presented in the questionnaire and the respective answers given by the students will be explored. These first set of questions are displayed before the subjects have any interaction with the virtual tour or know anything about it besides that it is to the International Iberian Nanotechnology Laboratory.



Graph 1 – "Do you consider the use of technology in the classroom important?"

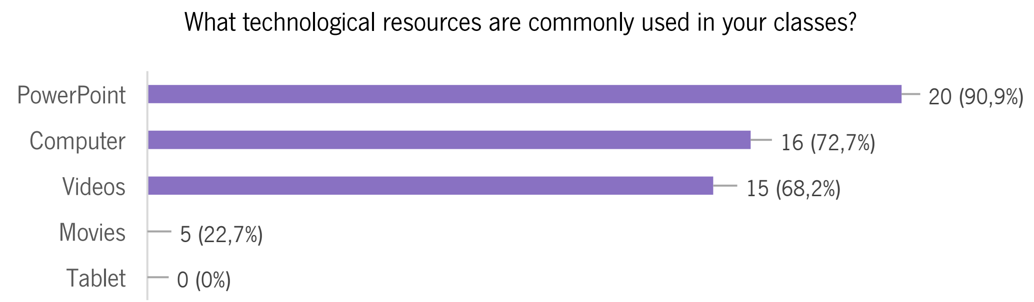
It is visible that most of today's students find the use of technology in the classroom to be an important aspect of learning. In this question, 21 of the 22 students in the sample group answered "yes" and 1 student answered "maybe".



Graph 2 – "Would you like your classes to incorporate more technological resources?"

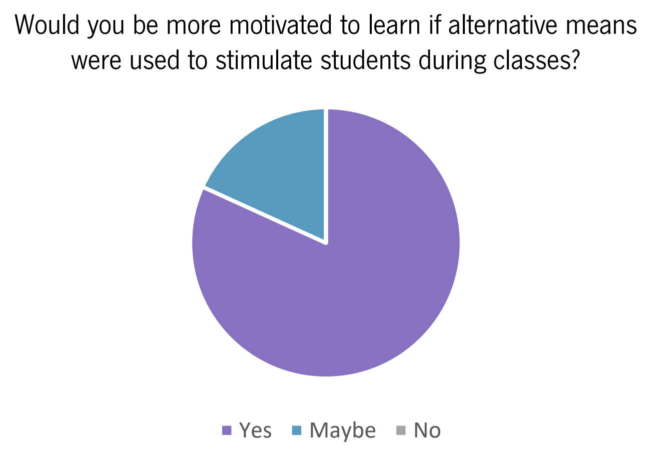
Following the last question, students were asked if they would like their classes to incorporate more technological resources, to which 15 students answered "yes", 5 students answered "maybe", and 2 students answered "no". Even though almost all students find technology to be an important resource in the classroom, it is visible that some don't think their classes need to incorporate it more, perhaps because these resources are already being used frequently.

The following question was only destined to be answered by individuals that answered "yes" in the last question and questioned which technological resources they would like to see incorporated into their classrooms. Most answers included PowerPoint presentations and videos, and some students mentioned the incorporation of equipment like phones, computers, projectors, and the update of old computers and better internet connection. One student mentioned the use of virtual manuals and the benefit they would represent, especially due to the weight of physical books that can be a struggle for some students.



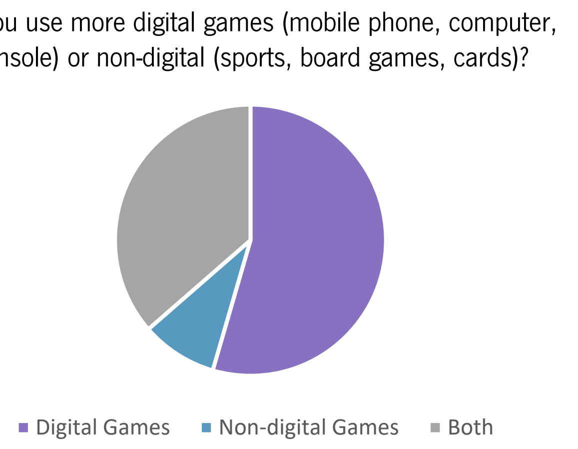
Graph 3 – "What technological resources are commonly used in your classroom?"

To better understand what technological resources students are most used to seeing, this question asked what resources are most used in their classrooms. In this question, there was no limit of answers selected, so subjects could select as many options as they needed. It can be concluded that the most used resource is PowerPoint presentations, followed by computers and videos.



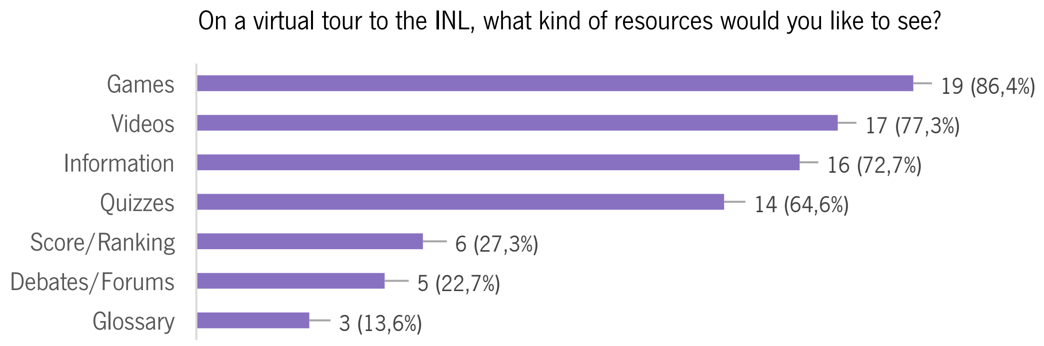
Graph 4 – "Would you be more motivated to learn if alternative means were used to stimulate students during classes?"

As a way to understand if technological resources can enhance students' motivation in the classroom, this question poses if they would be more motivated to learn if alternative means were used during classes, to which 18 students answered "yes" and 4 students answered "maybe".



Graph 5 – "Do you use more digital games (mobile phone, computer, console) or non-digital (sports, board games, cards)?"

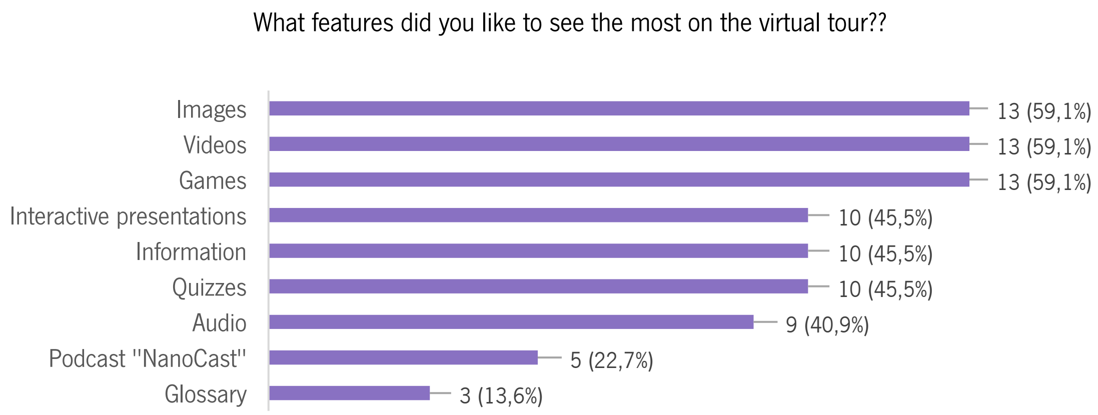
This question means to analyse if students prefer technological objects when it comes to their enjoyment and leisure activities. When asked if they use more digital or non-digital games, 12 students answered, "digital games", 8 students answered "both" and 2 students answered "non-digital". It can be assumed that even though a high number of students still use non-digital objects as forms of entertainment, the majority of students still chose technology as their favourite means of amusement.



Graph 6 – "On a virtual tour to the INL, what kind of resources would you like to see?"

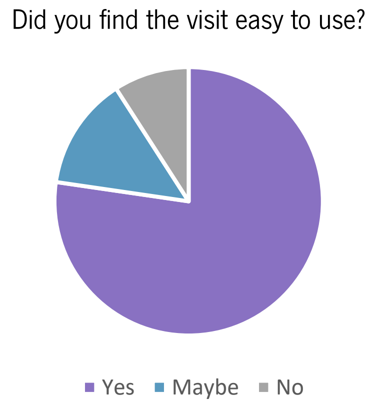
This question is asked before the subjects interact with the virtual tour and serves as a transition point between the technology-linked questions and the virtual tour ones. When asked what kind of resources they would like to see on a virtual tour to the INL, the majority of students chose "games", "videos", "information" and "quizzes", which interestingly, are all gamification forms present in the virtual tour developed on this project. A minority of students selected "score/rankings", "debates/forums" and "glossary".

At this point of the questionnaire begins the 2nd part, where subjects are informed that in this section they can interact with the virtual tour of the International Iberian Nanotechnology Laboratory and are given the link to do so. The only information they are provided is that throughout the visit they will find videos of some of the scientists of INL, as well as information hotspots, audios, quizzes, interactive presentations, a glossary, and a podcast, to make sure they don't miss anything.



Graph 7 – "What features did you like to see the most on the virtual tour?"

After having interacted with the virtual tour, students are asked what features they liked to see the most, to which 13 students chose “images”, “videos” and “games”, and 10 students chose “interactive presentations”, “information” and “quizzes”. These answers go hand in hand with the answers given in the last question, meaning that students are most interested in informational and interactive content.



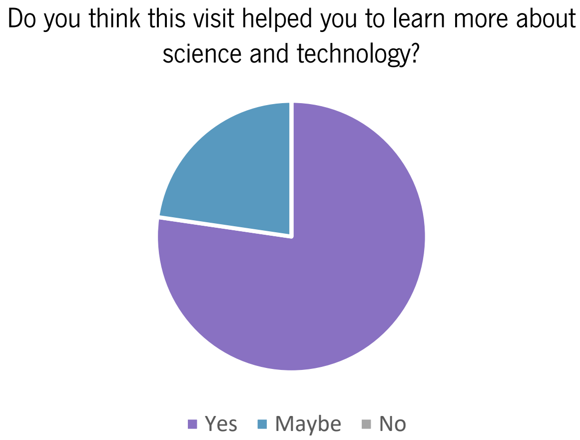
Graph 8 – “Did you find the visit easy to use?”

To perceive the usability of the visit, students were asked if they found the visit easy to use, to which 17 students answered “yes”, 3 students answered “maybe” and 2 students answered “no”. The negative answers may be due to a lack of previous in-depth explanation of the virtual tour, which is an aspect that could be changed.

After receiving feedback on the usability of the visit, it was also important to also understand what parts the students liked the most and the least, so the next two questions raised were “what was your favourite part of the visit, and what did you most enjoy seeing?” and “what problems did you have with the visit, and what parts did you like least?”, respectively.

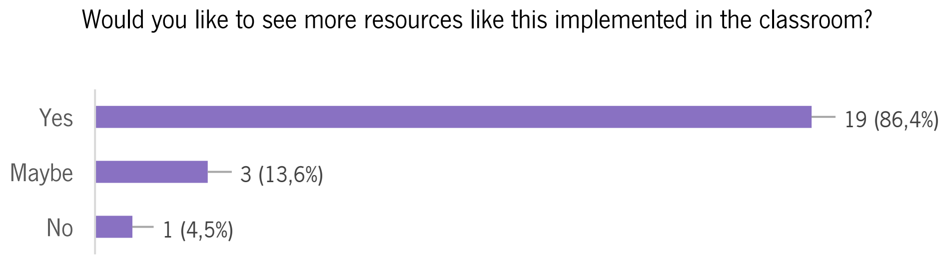
As for their favourite parts and what they most enjoyed seeing, the majority of students answered the opportunity to visit and see the laboratories from the inside, especially the cleanroom, since they didn’t have an opportunity to visit the INL yet. The second most mentioned thing were the interviews with the researchers and the quizzes and games. Some students also mentioned that the audios helped them understand the visit better.

As for their least favourite parts or problems faced, most students answered that they didn’t have any problems; however, 5 students did mention difficulties. One student said that the instructions in the quizzes could be confusing; another pointed out the fact that the visit doesn’t allow users to zoom in or zoom out, and it was also mentioned that the visit was hard to use on a phone and it was easy to get lost. An interesting feedback from one of the students was that the visit didn’t allow free mobility, specifically the use of the WASD[20] or arrow keys like in games. Since teenagers are used to playing games on the computer, it is normal they find more useful the use of keys and arrows to move around, instead of just the mousepad.



Graph 9 – "Do you think this visit helped you to learn more about science and technology?

This question was posed to understand if the virtual tour served its purpose as an educational resource for teaching science, to which it can be answered positively since the majority of students (17) answered "yes" and 5 answered "maybe".



Graph 10 – "Would you like to see more resources like this implemented in the classroom?"

Finally, to conclude the questionnaire, students were asked if they would like to see more resources like this implemented in the classroom, to which most of the sample group (19 students) answered "yes", 3 students answered "maybe", and 1 student answered "no".

Based on the answers given by the students to the questions of this questionnaire, it is safe to assume that this virtual tour served its purpose as a science learning tool and that students do think it would be beneficial for their education if more technological resources were implemented in the classroom.

[20] WASD are the four keyboard keys that are used to interact with video games in lieu of the arrow keys or a controller

6. Conclusion and future work

The closing chapter of this report aims to provide a final impression of the work, discuss whether the objectives have been achieved, and summarize the main results obtained. It will also be examined the limitations faced during the development of this prototype, and the improvements and work that can be accomplished in the future.

6.1. Conclusion

The students of today are not the same students of 10 years ago, so teaching methods should keep evolving as well to meet the needs of evermore different learners. Teenagers have been growing with and around digital technologies, so the introduction of these technologies in the classrooms can enhance the learning experience of learners who have been used to gamification and interactivity all their lives.

This project aimed to create a prototype of a gamified virtual tour to the International Iberian Nanotechnology Laboratory and identify the possibility of a virtual tour being an educational resource and an alternative for field trips. Based on the answers of the questionnaire conducted to 22 students of the target audience of this project (students from the 8th to 11th grades), it can be concluded that these subjects agree that technology should be used more in their classrooms, and that they would be more motivated to learn if so. Also, after interacting with the virtual tour's prototype, students stated that they did in fact learn more about science and the INL, and they would like to see more pedagogical tools like these implemented in their classes.

Field trips are known to be valuable learning tools, but can pose some impracticalities like time and organization constraints, logistical difficulties, and high monetary costs. Some particular limitations were also identified with the physical visits hosted by the INL, such as restrictions in age, field of study, and number of students. When faced with these problems, virtual tours can be an important asset that can overcome these issues. These resources are not meant to be a substitute for field trips, but an alternative for when these trips are not possible, and a way to encourage students to visit these places in person. With the prototype created in this project, students can become familiar with some of the most important places of the INL and visit laboratories that they would not be able to enter even in a physical visit, like the cleanroom. This virtual tour also allows users to obtain detailed information about the research areas and the scientists working there that can be revisited by users whenever they want.

The incorporation of gamification into this project was what differentiated this visit from a normal virtual tour, and what made it become an educational tool. The extensive documents of information provided by the INL's communications team about the INL, its research areas, and the work developed there were transformed into videos, images, information and audio hotspots, and interactive quizzes and games. These resources were meant to be a way of learning while escaping the monotonous teaching methods sometimes used, and it is safe to assume by the answers to the questionnaire that students found the hotspots, quizzes, games, and videos an interesting and appealing way of learning.

By detailing in depth all the steps taken during this project and all the tools and software used to create this prototype, it is hoped that this report can provide the help needed for other people who are looking to create their own virtual tours, be it for personal or academic reasons.

6.2. Improvements and future work

As with any project, there were certain problems and limitations that arose during the progress of this work that prevented the prototype from reaching the full potential that it could attain. These limitations were encountered in the initial planning phase of the project, in the development, and in the consolidation of the results with the questionnaires.

Firstly, the lack of previous experience creating virtual tours and using most of the software was an obstacle in the early research and developing phases. Not only was the search for the right software and tools a lengthy process, but also having to learn how to use them was a very time-consuming part.

During the development of the prototype, there were some ideas that had to be left out and could not be incorporated into the virtual tour. Some of these ideas included the aforementioned goal of having gamification in all scenes of the visit, as well as voice-overs in the form of voice hotspots creating a storyline and guiding users through the scenes. Another thing that was planned to be incorporated but ended up not being complete due to limitations of time was the use of the floorplan feature in Lapentor. This feature would allow users to see where they are in the building but would require extensive work drawing the building's plans for all three floors. Additionally, the impossibility to make zoom in and zoom out was mentioned in the user feedback, which was something that was chosen as such due to the lack of image quality. All of these points are things that can be improved in the future with more time.

Having to explain the project and obtain feedback from this virtual tour through Google Forms was not the best means to consolidate this research. The most appropriate method to explain our work and obtain the opinion of users would be through an in-person activity, which was not possible to schedule due to COVID-19 constraints faced at the time. The limited number of subjects that answered to the questionnaires also posed as a difficulty, since having a bigger sample size of the target audience would provide a more indubitable result.

Apart from the improvements that can be made to the prototype, other work in this area can be accomplished in the future. Throughout the elaboration of this work, there was an invite to integrate the research group "SIIS – Social Innovation and Interactive Systems", which is an R&D unit from ISEP and hosted by the Polytechnic of Porto, with the intent to act in emerging areas of interaction to provide improvements to society with social impact. I hope the insights and experience obtained during this project in turning conventional educational materials into interactive technological content can be of great use in future projects working with this research group.

During the development of this project, another opportunity arose to write the early planning stages in the form of a paper titled "Planning a Virtual Tour to a Research Center as an Educational Resource"[21] that was later presented in the international conference "ARTIIS 2021 – Advanced Research in Technologies, Information, Innovation and Sustainability". Since the successful presentation at this conference, invites to participate in other conferences emerged, such as the "ICITED 22 - The 2nd International Conference in Information Technology & Education" and the "IEEE - International Conference on Electrical, Computer and Energy Technologies (ICECET)". The invitations to participate in these conferences make me proud of this project and prototype, as well as sure of its qualities.

[21] Research paper available at https://link.springer.com/chapter/10.1007/978-3-030-90241-4_13

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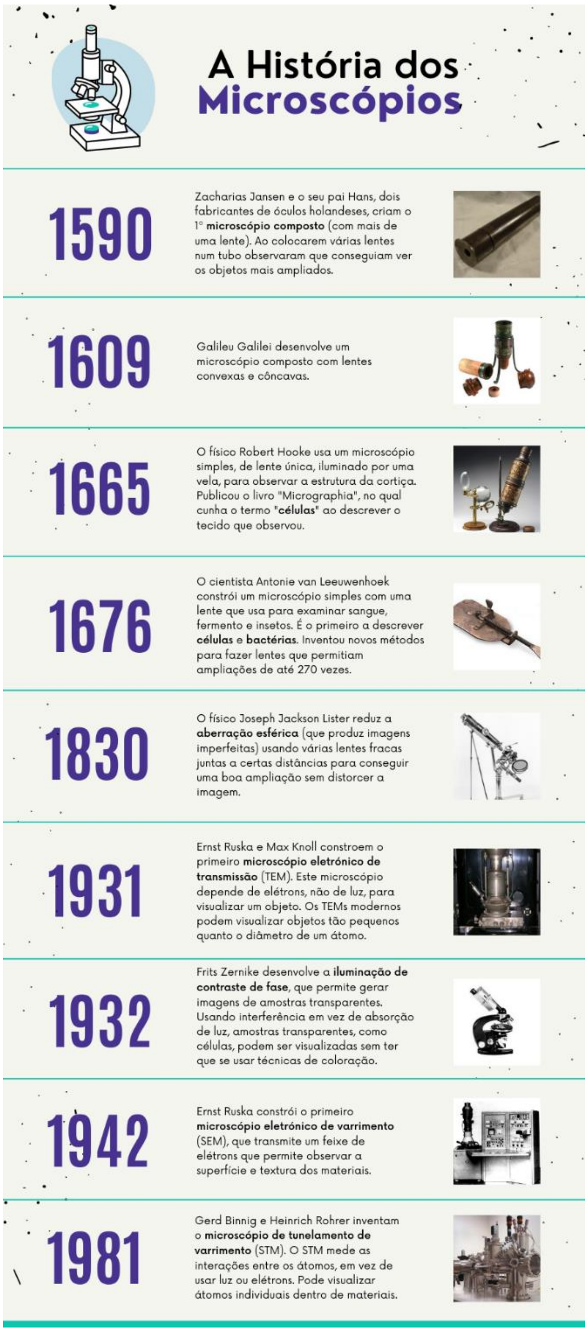
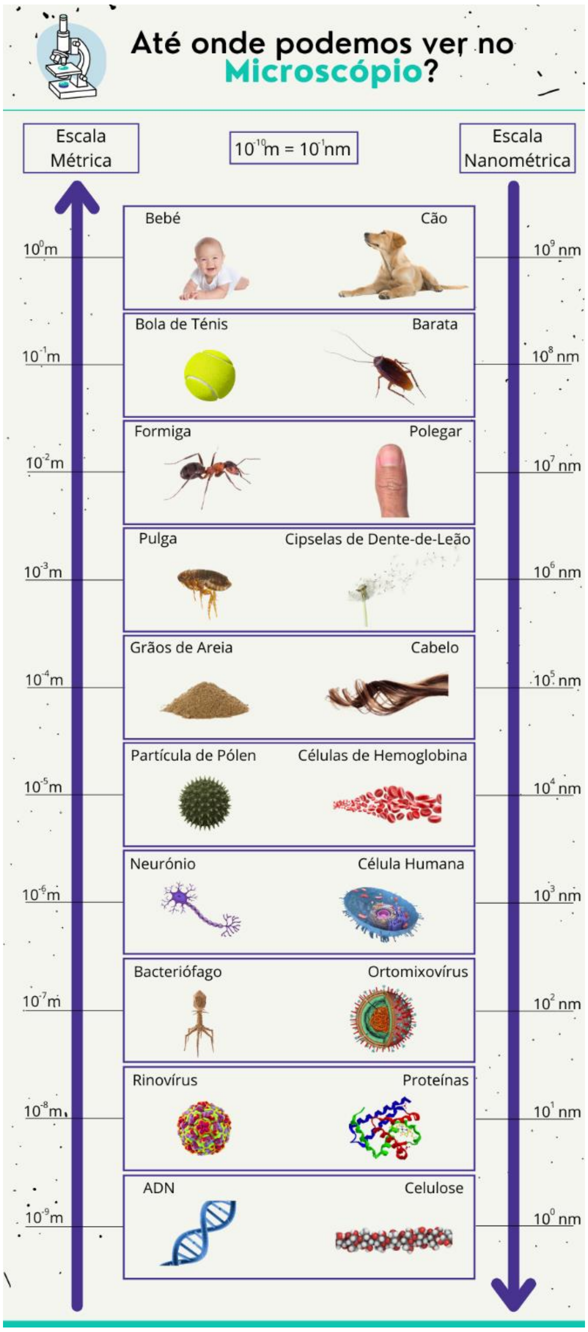
Appendix

Appendix 1 – Image hotspots created in Canva for the unit of advanced electron microscopy





Appendix 2 – Questionnaire translated from Portuguese to English

Secção 1 de 4

Form on the perception of science and technology

Welcome to our study.

You are taking part in a questionnaire carried out as part of a Master's in Digital Humanities project, centered on the creation of a Virtual Visit to the International Iberian Nanotechnology Laboratory (INL).

This questionnaire is divided into three parts:

- The first part consists of questions about your perception of science and technology, and your opinion about learning materials.

- In the second part you will be able to interact with the Virtual Tour and the material included in it.

- In the third part, we will try to understand if there has been any change in your perception of science, your opinion about scientists, and your feedback about the visit.

I was informed about the following:

1. My participation is voluntary.

2. I am aware of the absolute confidentiality rights and that data can be conveyed through scientific works, without making it possible for me to be identified.

I agree *

- Yes
- No

Secção 2 de 4

Part 1

This first part consists of simple questions about your perception of science and technology. Although there are questions that are not mandatory, we would appreciate it if you would answer as much as possible.

Thank you!

Age *

Texto de resposta curta

Gender *

- Female
- Male
- Non-binary
- Prefer not to say

Do you consider the use of technology in the classroom important? *

- Yes
- No
- Maybe

Would you like your classes to incorporate more technological resources? *

- Yes
- No
- Maybe

If you answered "Yes" to the question above, which technological features would you like to be incorporated?

Texto de resposta curta

What technological resources are commonly used in your classes?

- [ ] Computer
- [ ] Tablet
- [ ] Videos
- [ ] Movies
- [ ] PowerPoint presentations
- [ ] Outra opção...

Would you be more motivated to learn if alternative methods were used to stimulate students during classes? *

- ◯ Yes
- ◯ No
- ◯ Maybe

Do you use more digital games (mobile phone, computer, console) or non-digital (sports, board games, cards)? *

- ◯ Digital games
- ◯ Non digital
- ◯ Both

On a Virtual Tour of the INL, what kind of features would you like to see? Choose at least 3. *

- [ ] Games
- [ ] Debates/Forums
- [ ] Scoring/Ranking
- [ ] Information
- [ ] Quizzes
- [ ] Glossary
- [ ] Videos
- [ ] Outra opção...

Secção 3 de 4

Interaction with the Virtual Visit

In this section you can interact with the Virtual Visit to the International Iberian Nanotechnology Laboratory (INL), following the link: https://app.lapentor.com/sphere/visita-virtual-inl

During the visit you will find presentation videos of some of the scientists and the work they do there, as well as information hotspots and audios, quizzes, interactive presentations, a glossary and a podcast.

At the end of the visit, continue to answer the form.
Thanks!

Secção 4 de 4

Part 2

Now that you've interacted with the virtual tour, answer these simple questions about the platform's usability, and your opinion about the contents included in it.

Some questions will be repeated in order to check if your opinion has changed after you have seen the visit.

What features did you like the most on the virtual tour? *

- [ ] Games
- [ ] Quizzes
- [ ] Information
- [ ] Audio
- [ ] Videos
- [ ] Glossary
- [ ] Images
- [ ] Interactive presentations
- [ ] Podcast "NanoCast"

Did you find the virtual tour easy to use? *

- ○ Yes
- ○ No
- ○ Maybe

What was your favorite part of the visit, and what did you like to see the most? *

Texto de resposta longa

What problems did you have with the visit, and which parts did you like the least? *

Texto de resposta longa

Would you like to see more features of this kind implemented in the classroom? *

- [ ] Yes
- [ ] No
- [ ] Maybe