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MULTISENSORY GRAPHIC PRESENTATION APPROACHES OF SCIENTIFIC DATA

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Abstract: *The use of digitization and virtual, multisensory presentation techniques in the study of natural and environmental processes, industry, technology, history, medicine, etc., the basis of which is scientific data, complements development and research areas, accelerates and facilitates computer-assisted insight and interpretation of results. By dealing with digital information, we not only deepen the research process, but also expand the possibilities of information presentation outside scientific research circles, in society, thus bringing basic knowledge closer to different target groups through interpretive approaches of human-oriented design. Multimedia, interactive, multisensory media, and extended realities are a bridge between the scientific result and the user experience. These media raise awareness and teach people to live with the nature, in the environment, to use the scientific context through the creative design and delivery of digital content. This paper presents some starting points and guidelines of preparing graphic content in a way that holistically and multisensory engages the participants of the experience. At the end some examples of the application of graphical multisensory presentations are shown: documentation, popularization of science at micro and macro levels, analysis and measurement, simulation and training, animation and interactivity, 3D modelling and reconstruction, stylisation and interpretation, argumentation of physical realities and extension into the new reality.*

Key words: digitization, graphic presentation, multisensory, scientific data, experiencing

1. INTRODUCTION

"*The faster the technology goes forward, the deeper we have to go inside what we really are as humans.*", said composer, inventor, futurist and author Perttu Pölönen and he added that there is "*a need rising to redefine expertise as knowledge transmission is becoming more cross-dimensional and future competencies more abstract*".

In recent years, we have made great strides in understanding nature, the universe, the human body, consciousness, neuroscience, human cognition and affectivity, etc. Moreover, the technology that supports scientific advances is developing at an extraordinary speed all over the globe. The basis and starting points of everything are data, in science, that is, scientific data. The fact that basic sciences, natural sciences, engineering as well as humanities and cultural studies research areas are not isolated is shown by the increase of inter- and transdisciplinarity. Inter- and transdisciplinary approaches connect different sectors both horizontally and vertically, involve researchers investigating a given topic from different point of views, and thereby enrich knowledge in such a way that new connections between fields emerge while inviting further directions of development. This connectivity requires science and research to think about new methodological approaches, experimental arrangements, and interpretations of results on the one hand, and to think about the possibility of disseminating the results to the public on the other.

This paper addresses the possibilities of preparing and interpreting data as results of scientific research for presentation purposes to a broad public with the aim of making scientific knowledge tangible and understandable. The paper discusses graphic multisensory presentations in such a way that they are accessible, educative, and appealing to users (experiencers), holistically engage users' senses, and awaken feelings.

2. MULTISENSORY EXPERIENCE AND SCIENTIFIC DATA

Sensory experience is any experience that involves the communication channels of the five senses of sight, smell, taste, hearing, and touch in recognition, recall, perception, understanding, and internalized experience. Although the senses are usually considered as systems localized only in single parts of the body, such as seeing with the eyes, tasting with the mouth (tongue, taste buds), hearing with the ears,

etc., we know that the experience of "seeing" is not isolated to the image we see, but to the whole context of conditions, circumstances of viewing a particular image, as well as to phenomenology (inner seeing, intuition), which is also the subject of current modern research (Radin, 2009; Frederich, 2021). The same applies to the other senses.
In creating an experience, the presentation approach of graphic and interactive content is the one that has the greatest impact on engaging the senses in a product, service, or media. Presentation level also called surface level is the top level among the levels of experience design with which users (participants) interact most directly, and which reflects the goal, purpose, structure of the whole product, service or medium. This level is closely interwoven and must be connected with the other levels of experience design, i.e., the strategy level, the scope level, the structure level and the skeleton level (Garrett, 2010).
In exploring the ways in which scientific data (quantitative, qualitative) can be brought to a level that is accessible to the general public (and target audiences), we think of the transfer between the form in which the data is initially accessible (numbers, descriptions, symbols) and the form of the presentation medium that engages users through a single sense or a combination of senses and their interaction. The experience will be more complete and engaging if the user engages multiple senses and the whole body in the experience than if the user uses individual sensory channels (sight, smell, hearing) separately (Figure 1). Which senses we include in the experience and how intensively and comprehensively we invite the user's body into the experience depends, of course, on the purpose and goals of the product (service, medium) and the needs of the user. In addition, empathy is crucial in the planning, design, and development of a product, where we empathically "put ourselves in the shoes" of the user so that the product, service or medium offers the user what is really important to them (Yantis & Abrams, 2016).

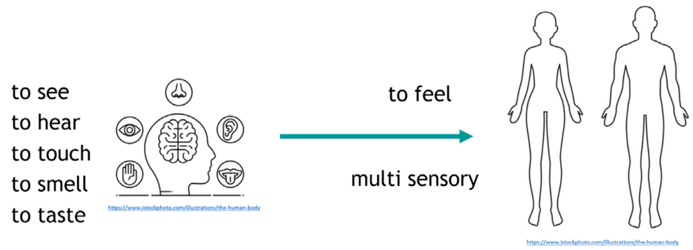


Figure 1: Schematic presentation of multisensory experience

Scientific data are the result of observations, calculations, and metric analyses. They represent in a particular way the information of scientific activities that investigate both intellectually and practically, through observation and experimentation the phenomena, structures, and behaviour of the physical and non-physical world. The data are usually taken from nature, the human body, the environment, society, history, etc., and must present and preserve the context of their meaning before being transposed and reinterpreted in the presentation mode. Graphic, digital and communication media are indispensable tools for presenting this information in scientific research (Shoshani & Rotem, 2009).
Regardless of the further use of scientific data, accuracy and precision are crucial starting point in data capture. For capture accuracy we select precise tools, capture techniques, which are placed in the methodological framework of the study. Figure 2 shows captures of bio-composite filaments for which computed tomography (CT), scanning electron microscope (SEM), optical microscopy, image analysis and image processing (2D and 3D) were used in order to analyse and produce final useful products (didactic tool).

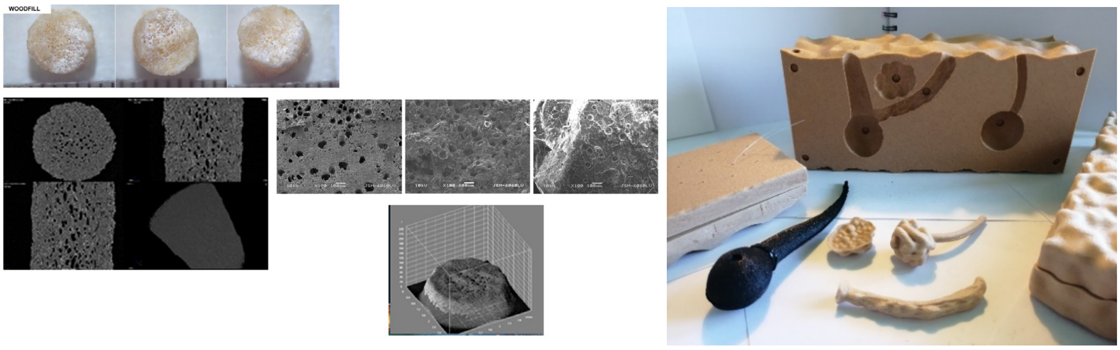


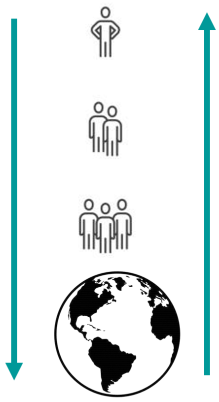
Figure 2: Images of bio-composite filaments (left) and final product (didactic tool, right), project: CEL.KROG, Discarded biomass potentials, Program "Exploitation of biomass potential for the development of advanced materials and bio-based products", researchers: Raša Urbas, Mirjam Leskovšek, Urška Stanković Elesini, Urška Vrabič Bordnjak, Diana Gregor Svetec, Helena Gabrijelčič Tomc, Deja Muck

2.1 Interpretation and stylisation

As in the analysis of scientific data for the purpose of summarizing findings and making syntheses, interpretation is an important process in translating scientific data into their more understandable representation. Interpretation for the purpose of scientific explanation involves the construction of scientific arguments that explain the data and make suggestions, while remaining reasonably faithful to the initial data as research findings. In interpretive approaches aimed at presenting the data to the general public, there is greater latitude in the presentation of the information, so that, depending on the audience and the design of the experience, it is simplified, generalized, highlighting what is necessary. Additionally, style of reinterpretation to the final presentation is also applied that includes the designer's (artist's) views on the subject (Figure 14). In this sense, interpretation involves knowledge of the needs of the users (participants) and a great deal of design, but also artistic approaches to the design of information and interaction (Knudson, 1995; Jameson & Baugher, 2022; Staiff, 2016).

3. FROM USER-CENTRED TO PLANET CENTRED DESIGN

The design approaches used may vary, but trends point to a simultaneous focus on the specific needs of a small group of participants (user-centred, participant-centred design) while incorporating the understanding and needs of humanity and the planet (human-centred, human-centred, and planet-centred design) presented in Figure 3 (Cennamo & Kalk, 2018; Stone et al., 2017). The applicability of approaches to multisensory graphical representation of scientific data is very broad and includes popular approaches in science, development and research, metrics, analytics, simulation, education, industry and engineering, natural sciences, medicine and healthcare, entertainment, art and design, rehabilitation, well-being, and social sciences (Eckert, 2019; Memarsadeghi et al., 2020; Bazarov et al., 2017; Lautenschlager & Rücklin, 2014).



https://www.freevector.com/vector/planet-earth
https://www.istockphoto.com/illustrations/one-person

Figure 3: From user centred to planet centred design

3.1 Content creation and level of engagement with the experience

The design of information, content and interactivity for multisensory presentation approaches is based on strategies that, considering the objectives of the solutions and the needs of the user, identify, articulate and implement opportunities by first considering the functioning of all the senses of the human body (perception and cognitive and affective processes), and only then finding the best solution for the presentation (and interpretation) of data. In the presentation mode, the relationship between physical and digital communication media can be different, with the aim of stimulating the senses at different levels. Charging the experience and thus stimulating the visual, auditory, tactile (as well as gustatory) senses through interactions is based on the principles of accessibility, repeatability, accuracy, precision, enrichment, augmentation, non-invasiveness, simplification and, as mentioned earlier, interpretation with some degree of stylization (Looring, 2020).

The degree and intensity of entering and dwelling in the experience can vary from partial involvement in the experience, which includes seeing, hearing, touching, tasting, smelling (as an isolated sensation or as a combination of individual channels), present in the so-called use of the medium (the user), through participation in the interaction (to participate, participants) and engagement, where the involvement of persons is both on a sensory level as well as on a cognitive and affective level, up to full immersion in the experience, so that the participant has the feeling of being in a "new reality" offered by a particular presentation method. The latter are examples of extended reality and virtual reality in particular (Figure 4). The short- and long-term effects of immersion in digital worlds are still the subject of research, but we assume that the combination of physical and digital media in presentation methods contributes to a more complete and "healthier" experience for people on a mental, emotional, and physical level (Stanković Elesini et al., 2021).

Figure 4: The possibilities of involving the user in the experience, from using the medium to complete immersion in a new reality

4. PRINCIPLES OF CREATING MULTISENSORY PRESENTATIONS

Multisensory presentations are a bridge between science and the participant/user experience. With creative design of multisensory content and its delivery, we can benefit nature, technologies, environment, society, etc. In our opinion the paradigm of design the experience that consider the participants senses more holistically include:

- planning alchemy of action of senses, so that the image, sound, touch, movement, etc. are interconnected in the experience,
- the design of information and communication media should consider visual, auditory, tactile language and kinaesthetic language, …
- the paradigm of “user that uses the product/media/service” is a “passive” form of interaction, instead the presence of the participant in the experience can be implemented in experience design,
- multisensory medium space is dynamic, and it is telling stories,
- storytelling is an excellent principle, to introduce into the presentation media, but let us also consider the principle of creating a story from the participant, which allows for greater intimacy between the product, the media, and the participant experience,
- let the participant conduct the experience instead of the experience offered as part of the product (creating participant's own reality of the product/media/service experience),
- in every step of consuming the product/media/service we invite the participant in (multisensory) interaction (directing the experience),
- the importance of subjectivity of participant’s experience is emphasized.

The following are some examples of the use of graphical representations involving different sensory channels, the starting point of which was scientific data. All products were created under the authorship of students of the Department of Information and Graphic Arts Technology, 1st and 2nd level study programme of Graphic and Media Technology and Graphic and Interactive Communication. The starting points of all presentations were scientific and/or technical records, captures, documentations, discussions, results, which in the further work steps included the study, the planning of the graphic language, the determination of the presentation content, the planning and design of interactions and the investigation of the possibility to achieve a multisensory experience, the design of information, the experience design and the integration of interactive graphic content in presentation platforms (3D players, web, social networks, mobile technologies, presentations in galleries, extended digital environments in museums, teaching and didactic tools in schools). Applications include documentation; popularisation of science at micro and macro levels; analysis and measurement; simulation and training; animated presentation and interaction; 3D modelling and reconstruction; interpretation and stylisation; augmentation of physical realities, and extension into the new reality (virtual reality).

4.1 Documentation

Documentation means the collection, study, categorization, and analysis of data about a particular phenomenon for the purpose of further use. Figure 5 shows the results of documentation of data about wooden statues (inventory of data about the statue, damages, recording by drone and cameras, photogrammetry) exhibited as Forma Viva in Kostanjevica na Krki (Slovenia). The work was carried out by students of graphic design and restoration under the guidance of mentors from the Department of textiles, graphic arts and design (NTF, UL) and the Academies of fine arts in Ljubljana, Tallinn and Zagreb, and took place within the two-year Erasmus+ project coordinated by the Božidar Jakac Gallery (Učakar et al., 2022).

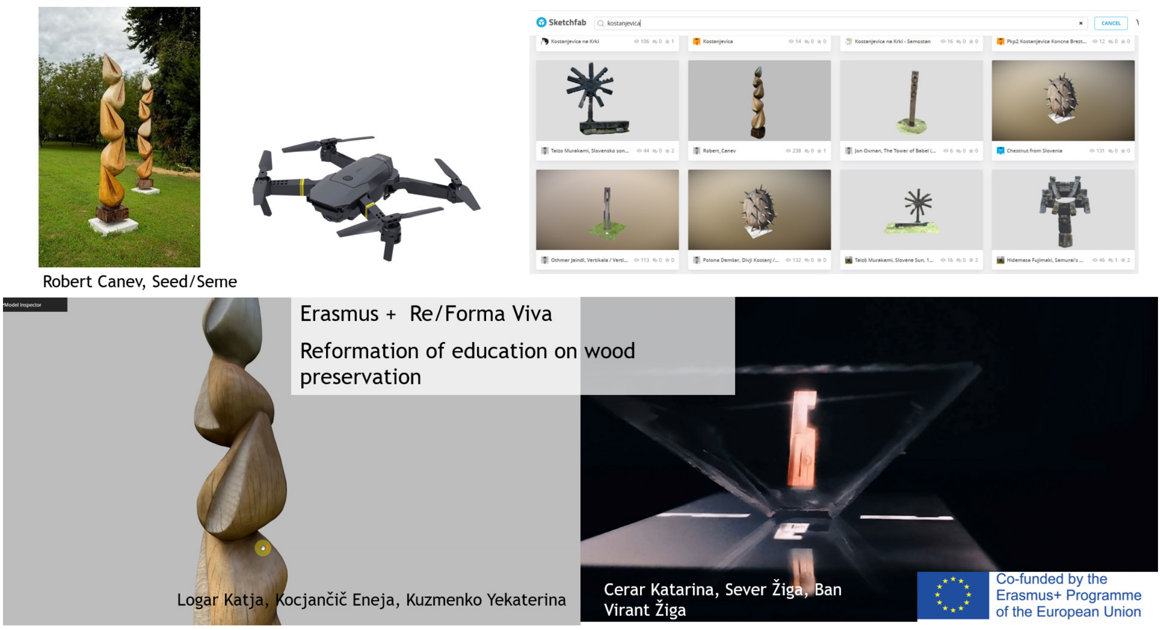


Figure 5: The results of documentation of data about wooden statues Forma Viva (Kostanjevica na Krki, Slovenia); authors: students of Chair of information and graphic arts design; mentors: Tanja Nuša Kočevar, Deja Muck, Andrej Učakar, Helena Gabrijelčič Tomc

4.2 At micro -level

Representations of science at the micro level include microscopic images and numerical and pictorial data of a microscopic nature. As shown in Figure 6 for the field of biology and the effect of a virus on a bacterium, the designer interpreted scientific findings (description of the infection, microscopic images of the course of the virus attack, microscopic images of the appearance of bacteria and viruses) through a computer-generated simulation of motion (animation), morphology, behavior, materials, textures, and final visualization.

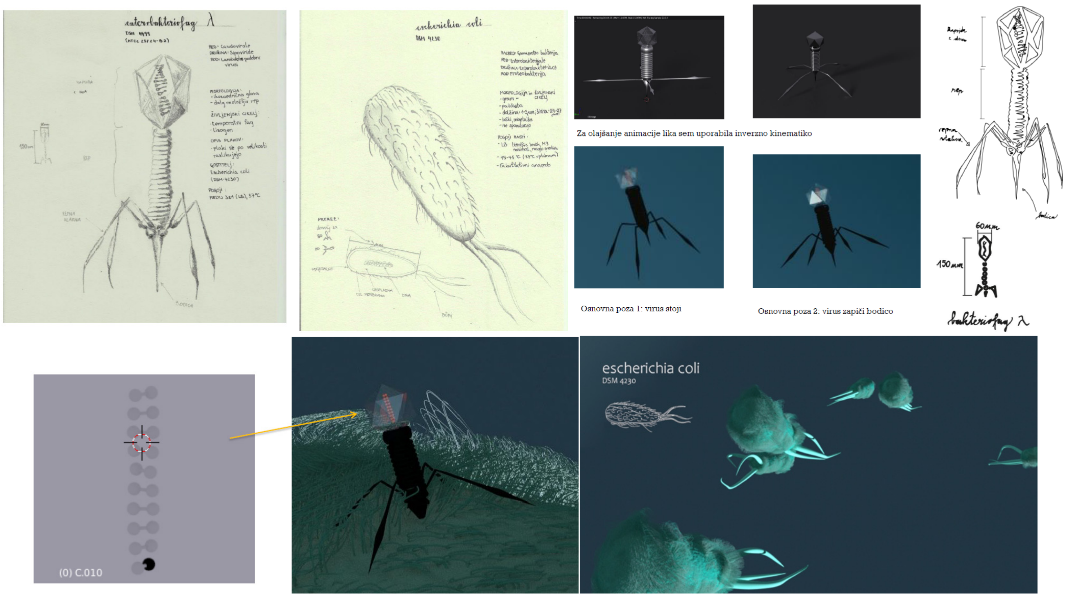


Figure 6: Presentation of the attack of virus on bacteria; author Polona Smolnikar, mentors: Tanja Nuša Kočevar, Andrej Iskra, Helena Gabrijelčič Tomc

4.3 Going on the scale of solar system

Not only at the micro level, digitally supported approaches also enable, on the basis of scientific data (distances between planets, perimeters and diameters of planets, surface morphology, textural and relief phenomena), an insight into phenomena that otherwise could not be observed from a human perspective. Figure 7 shows an interactive and educational walk through the system of the nearest planets to Earth.

Figure 7: Our solar sistem in visualisations presented as an interactive web site, author: Gal Černilogar, mentors: Tanja Nuša Kočevar, Andrej Iskra, Helena Gabrijelčič Tomc

4.4 Measuring and analysis

Photorealistic graphic visualizations are an excellent presentation medium of measurement and analysis results, allowing us to present to the public something that would otherwise be overlooked. Figure 8 shows a photorealistic visualization of a human face after it has been captured by a 3D scan and analysed in detail by 3D metrics (dimensions of eyes, nose, mouth, distance between facial elements) (Jančič, 2015).

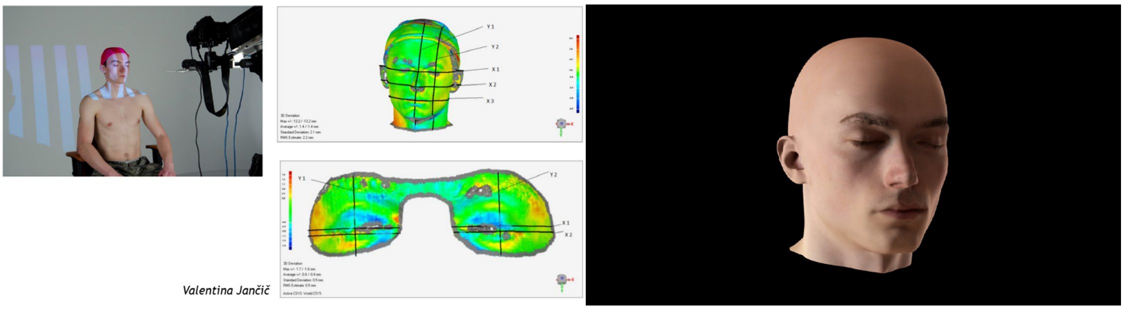


FIgure 8: Photorealistic visualisation of human head after detailed 3D metrical and analitical examination; author: Valentina Jančič, mentor: Helena Gabrijelčič Tomc

4.5 Simulation and training

Virtual reality solutions are about full immersion in the experience, making it a multisensory experience in the truest sense of the word. Figure 9 shows waste separation training, which was created with the help of documentation on the chemical and structural composition of each type of waste. The virtual simulation allows users to learn about waste types and the importance of separating waste. Moreover, educational virtual reality solution involves the user in the game by collecting points for cleaning up the environment (Štrumbelj, 2021).

Figure 9: Waste separation simulation and training; author: Gašper Štrumbelj, mentors: Deja Muck, Helena Gabrijelčič Tomc

4.6 Invitation to multisensory interact

Full immersion and a multisensory experience are enabled not only through fully digital solutions, but also through an effective combination of physical and digital media. Such an example is the multisensory learning tool about human skin (Figure 10), where the learner gains knowledge about the elements of the skin and how it works through tactile experience, observation of the skin's parts and the application of augmented reality (Smaraglia & Sulič, 2021). The research starting points were microscopic images of the skin and its structures, descriptions of the functioning of the skin, which were interpreted for the target group of pupils in the first triad of elementary school.

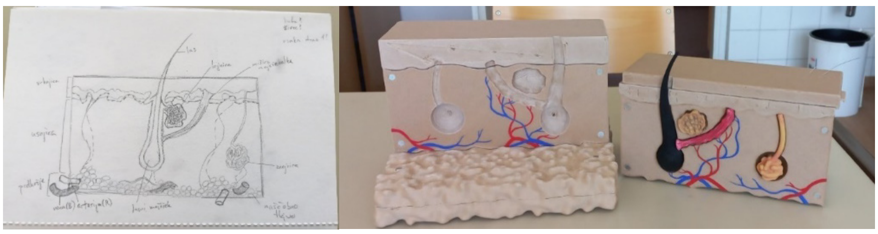


Figure 10 (part 1): Multisensory didactic tool for elementary school; authors: Matic Strgar, Sinja Stres, Simeon Perić, Jure Sulič, Celeste Sanja Smaraglia, mentors: Urša Stanković Elesini, Helena Gabrijelčič Tomc, Tanja Hrkač

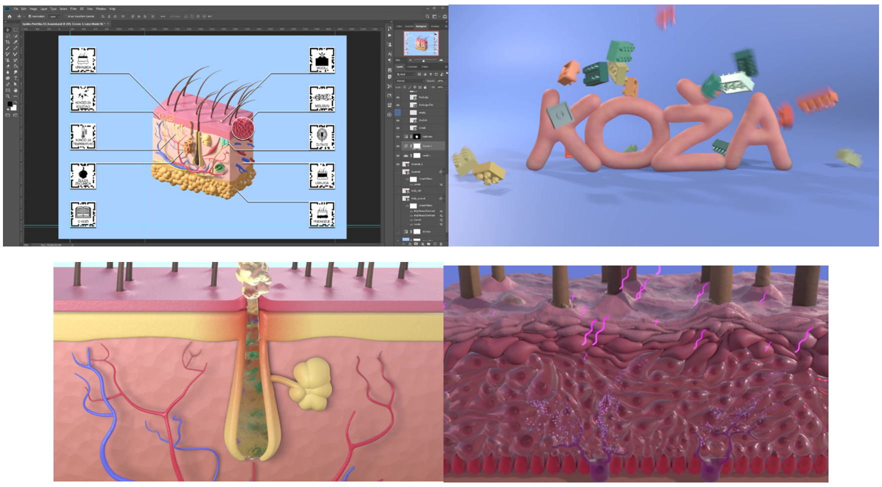


Figure 10 (part 2): Multisensory didactic tool for elementary school; authors: Matic Strgar, Sinja Stres, Simeon Perić, Jure Sulič, Celeste Sanja Smaraglia, mentors: Urša Stanković Elesini, Helena Gabrijelčič Tomc, Tanja Hrkač

4.7 Animated presentation

Animated presentations are probably one of the most commonly used multimedia content for showing technical procedures, scientific phenomena, etc. Their effect on better understanding and higher learning outcomes is proven in several researches (Mayer, 2001; Rias & Zaman, 2010; Principles of Multimedia, 2016; Hari Narayanan & Hegarti, 2016). Each scientific and technical field must be treated individually when transferred in audio-visual and interactive media. Figure 11 shows an example of a virtual classroom of a printing lab and an interactive pdf learning material where printing processes and parts of the printing equipment were exactly reproduced from the technical documentation of the machines (Perovšek et al., 2018).

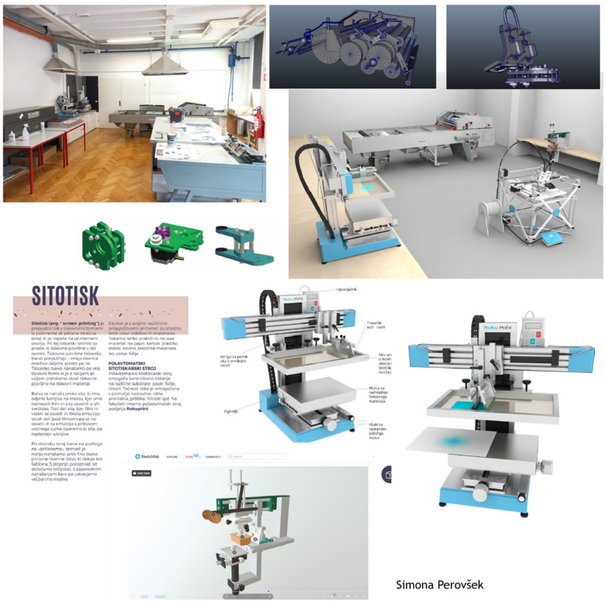


Figure 11: Virtual classroom of a printing lab with 3D educative animation; author Simona Perovšek, mentor: Helena Gabrijelčič Tomc

4.8 Modelling and reconstruction

In addition to 3D scanning and photogrammetry, modelling and reconstruction are used to recreate digital elements. They are used when 3D scanning, or photogrammetry are not possible or to complement them. The results of 3D modelling and reconstruction are generally more time consuming, but usually contain less detail. Figure 12 shows an example of the 3D reconstruction of the ancient city of

Petoviona (today's city of Ptuj in Slovenia), where the only possibility of recreation was modelling based on scientific hypotheses about the possible state of the city (floor plans, archaeological research, actual buildings do not exist) (Sotlar, 2021). 3D reconstruction of the ancient city is implemented in virtual tour (Burger, 2021) that allows the participant to experience the exhibition with greater engagement.

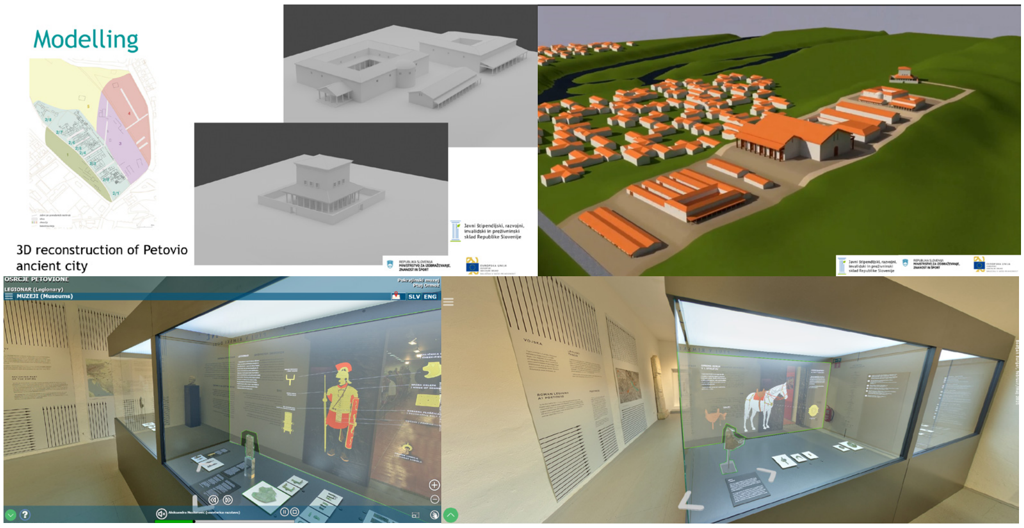


Figure 12: Modelling and visualisation of ancient city Poetovio with the virtual tour through exhibition, author Jerneja Sotlar, mentors: Helena Gabrijelčič Tomc, Tanja Nuša Kočevar, Aleksandra Nestorović

Figure 13 presents a 3D reconstruction of a sacral building that was never realized according to the plans of the famous Slovenian architect Jože Plečnik. The monument was dedicated to the Czech military leader Jan Žižka. The 3D printed model was created while taking into account the features of hand drawings, architectural plans and a photo of a 3D wooden model of poor quality (the wooden model has been lost). Here, it was necessary to introduce a lot of knowledge of the architect's style, references from scientific sources into the process in order to achieve a certain adequacy of the printed model. The 3D printed model is exhibited in the Plečnik House in Ljubljana (Škerjanc, 2019).

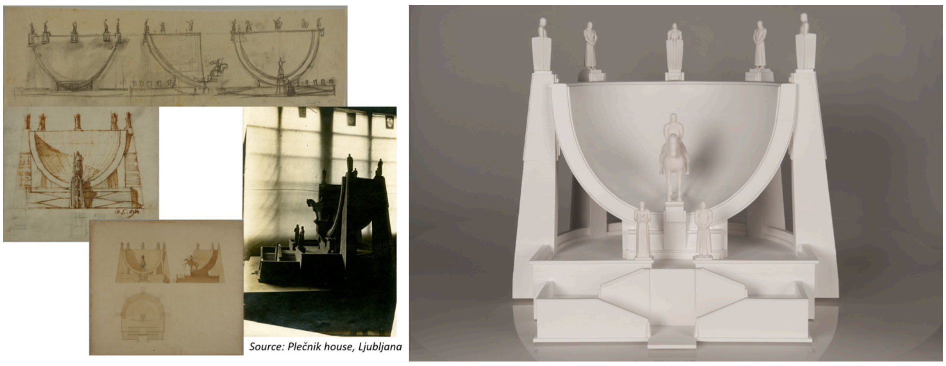


Figure 13: 3D printed model of reconstructed sacral monument dedicated to the Czech military leader Jan Žižka, authors: Anja Škerjanc, Helena Gabrijelčič Tomc, Matej Pivar, Tanja Nuša Kočevar

4.9 Interpretation and stylisation

Every operation of creating a presentation medium of scientific knowledge of greater clarity involves at least some simplifications, interpretations, and stylizations. The latter depend on the purpose of the presentation and the target audience. Interpretations and stylizations are judiciously planned design (including also artistic) interventions that, considering the meaning of the starting points of scientific results and the essence of the source information, introduce design elements and techniques in the final product with the goal of facilitating understanding of the meaning. Figure 14 shows an example of interpreting the incorporation of wooden cultural heritage data (wooden statues) into 3D animations and useful jewellery (Učakar et al., 2022).

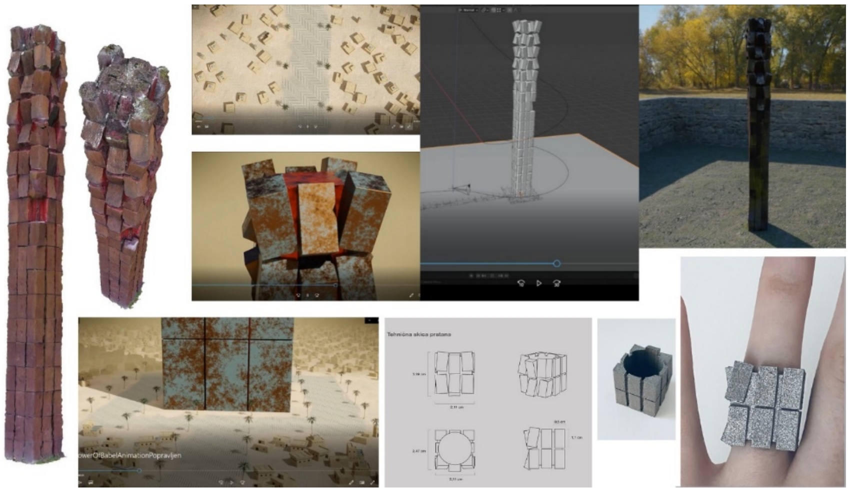


Figure 14: Interpretative approaches and stylisation of the digital data about wooden sculptures in 3D animation and jewellery; authors: Jernej Kalin, Kaja Bakan, mentors: Tanja Nuša Kočevar, Karin, Košak, Helena Gabrijelčič Tomc, Andrej Učakar, Andrej Iskra, Deja Muck

4.10 Augmentation of the physical realities and extension into the new reality

As mentioned earlier, extended reality technologies (XR) have emerged as one of the most promising ways to create a multisensory experience. Whether combining physical and digital reality (augmented reality, AR) or creating fully digital realities (virtual reality, VR), the participant is fully engaged in the experience, so that cognitive, affective, and kinaesthetic processes are guided by the content of the presentation medium. There is still some research to be done in this area to optimize the experience and the general use of these technologies (headsets, cybersickness), however we can say with certainty that these are technologies that open up new insights into science, technology, nature, people, etc. Figure 15 shows a virtual walk through a culturally significant and protected building Montanistika (in Ljubljana), whose floors and walls contain priceless geological heritage. In addition, the image also shows a mobile augmented reality project with educational cards, where the bodies of selected animals and their movements were captured, stylized and visualized for the purpose of educating about animal movements and behaviour (Vrhovnik et al., 2020; Bergant, 2022).

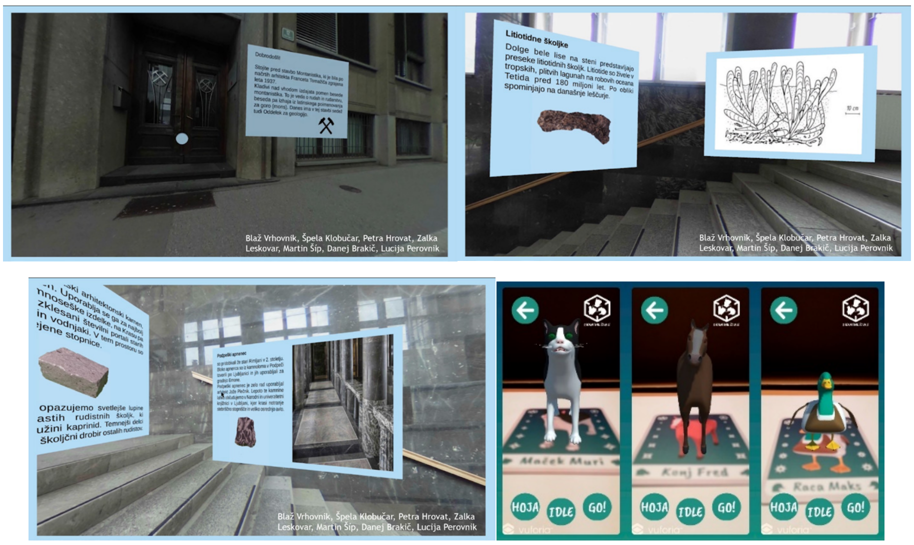


Figure 15: A virtual walk through the building Montanistika and a mobile augmented reality with the presentation of animal movements, author Marko Bergant, mentor: Helena Gabrijelčič Tomc

5. CONCLUSION

Although multisensory graphic presentations are not new, with the advancement of scientific data and their presentation new insights into the involving of somatic, perceptive, cognitive and affective processes in the experience keep inviting us to redefine the design of these communication media. The presentation layer is the surface level of interactive media, which we use to stimulate sight, hearing, smell, and taste to draw and hold the user into the experience. In an age of information overload, incorporating ethics and empathy is the key. To ensure that science and scientific data remain accessible to more than just researchers and consumers of scientific publications, their dissemination through media channels that are accessible to a broader audience is crucial. Perfecting graphic expression, incorporating the possibility of actively shaping a story on the part of the user, and understanding the dynamics of a multisensory medium are just some of the principles that go into planning, designing, and producing engaging multisensory graphic presentations.

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