ILLUSTRATING THE INVISIBLE: TOWARDS AN INCLUSIVE SOCIETY FOR BLIND AND PARTIALLY SIGHTED

Edited by Petra Černe Oven

UNIVERSITY OF LJUBLJANA
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I am frequently asked whether we encounter problems when engaging in interdisciplinary teams or in collaborations between sighted and visually impaired people. I answer succinctly: our association, the Nova Gorica Inter-Municipal Association of the Blind and Visually Impaired, does not experience any problems. The challenges do not stem from the differences between disciplines, nor from the varying visual abilities of the participants, but rather from the breadth of their inner perspectives. If we possess a sufficiently broad perspective, synergies become a given. As with each passing year our collaborations are more frequent and our experiences grow, the results are progressively improving. When both sides clarify their aspirations and explain the importance of their goals, communication begins to flow, leading to the proposal of solutions from both groups. In my experience, sighted individuals suggest very good solutions.

The biggest obstacle we face is fear, which often manifests itself in a clash of egos, trying to prove who is right; therefore, I find that the most important way to encourage any kind of dialogue is to listen to each other and empathize with our conversational partner. For example, the tactile gallery project with its exhibition *The Art Beyond the Visible*[1] presents a dialogue between Slovenian and Italian users and artists, including sculptors and painters. Although in this case we are referring to big and well-known names, all project collaborators make an indispensable contribution, as they provide Braille printing, create audio descriptions, prepare spaces using appropriate contrasts and arrange presentations in various media. Another similar example is the exhibition *Up Close*,[2] which is the result of our excellent collaboration with students from the Academy

1 More on the project: https://www.go2025.eu/en/projects/the-art-beyond-the-visible.

2 More on the project: https://www.mg-lj.si/en/exhibitions/3622/exhibition-up-close-preservation-protection-and-conservation-restoration-of-modern-and-contemporary-works-of-art.

of Fine Arts and Design of the University of Ljubljana and the Museum of Modern Art. A further instance is *Tolmin Peasant Uprising*, a three-dimensional, tactile illustration of Tone Kralj's painting *Count Coronini's Meeting with the Tolmin Rebels*, realised by Kristina Naglost as part of her master's thesis.

In accordance with the legislation, all projects must be accessible. This requirement is given greater consideration when organizations of people with disabilities are involved in a project; however, it tends to be less prioritized in other contexts, because in Slovenia, general awareness and information on the topic of accessibility still have a long way to go. The reason for *ad hoc* solutions, which despite being well-intentioned, prove to be non-beneficial, cannot be attributed to funding constraints. It is essential to incorporate these topics into the regular curriculum of institutions such as the Academy of Fine Arts and Design of the University of Ljubljana, and in educational programmes in general, as well as to explore them as subjects of research projects.

This necessarily raises the question of how to encourage empathy in designers. As Samo Turel, the Mayor of Nova Gorica, said in our Association's podcast: "It's about a shift in mentality; not because we are bound by the law, but because it's the right thing to do." What is crucial to this end is dialogue serving as an exchange of views; listening carefully is the first condition for enriching our awareness. I recognize great value in the productive challenge designers face in expressing their innovative ideas by drawing on users' needs. Returning to the tactile gallery mentioned earlier, it offers a remarkable experience for the blind and partially sighted, allowing them to realize that even the field of visual expression can open the door to all the other senses: they can smell wood and metal, touch different surfaces, and listen to the sounds generated by contact with various materials. This is how they explore not only statues but also paintings.

Designers can contribute by considering the accessibility needs of all vulnerable groups: the blind and partially sighted, the deaf and hard of hearing, the deaf-blind, wheelchair users, children, the elderly and mothers with young children. Some exhibitions are held in spaces that have a special appeal and significance, yet present physical challenges or inaccessibility issues. This poses the question of which audiences the exhibition aims to reach and who might be excluded. A common issue in adapting environments and materials is the tendency to focus on a single aspect, assuming that this sufficiently addresses the accessibility of the entire experience. However, solutions for people with visual impairments should always be comprehensively conceptualized and implemented. In this regard, our international connections serve as a valuable resource. As a result, during the tactile gallery project, we visited the Francesco Cavazza Institute for the Blind in Bologna, the Museo Tattile Statale Omero in Ancona, and the Monza City Museum, gathering knowledge and insights on the possible adaptations and different strategies aimed at enhancing accessibility for people with visual impairments, particularly the blind.

In relation to learning materials, it should be noted that they increasingly incorporate visual or design elements, which can have a negative effect for individuals with visual impairments, potentially causing them to work at a slower pace or with reduced efficiency. In an inclusion-oriented environment, all materials should be adapted for all vulnerable groups, including those with visual impairments.

As all designers are well-aware, sometimes the best solutions emerge when we turn the problem on its head. In the context where there is a constant emphasis on what a sighted society can and should do for people with visual impairments, it is important to emphasise that by working in this area, sighted individuals can build on their abilities and knowledge in ways they might not previously have imagined.

— Igor Miljavec,
President of the Nova Gorica Inter-Municipal Association
of the Blind and Visually Impaired

INTRODUCTION

DESIGN SHOULD NOT BE BLIND TO THE NEEDS OF AN INCLUSIVE SOCIETY

Petra Černe Oven

We would like to thank Jade Kathryn Smith from Prior Tactile Learning, UK for allowing us to use their Prior Learning Font, which is designed for visually impaired and blind children with additional needs – more details at www.priortactilelearning.com.

This scientific monograph is one of the results of a project that has its roots in the past but also contains a number of bold ideas for the future, and because of the scope of its research, we have placed it in the Visual Literacy research programme[1]. It explores the ability to understand, interpret, and create visual representations, as well as the ability to make critical judgements and communicate effectively using visual elements (Arnheim 1969, Sonesson 1989, Mitchell 1994, Hall 2013). Just as reading literacy is key to comprehending text, visual literacy is key to interpreting and evaluating visual information and its components (Flusser 2022).

In today's world, driven by digital tools and media landscapes, the use of visual language has become a necessity for everyone (Goddard 2024). Sight, the visual, and everything related to visual perception has long been prevalent in the Western tradition. As Åhlberg explains, "In our language, a host of idioms and metaphors – both dead and alive – in every-day language as well as in philosophical parlance bears witness to the importance of sight and vision as a source of knowledge and experience: we speak of *seeing*, in the sense of understanding, we have views about this or that, poets and philosophers have formulated *visions* of reality, we can be *clear-sighted, far-sighted* or *short-sighted*, we can gain *insight* into things or we can be *blind* to certain things, we *visualize* things we have not seen, we sometimes *overlook* things, we sometimes *see through* the invalid reasoning of others, and we hope that our own reasoning is perceptive and perspicuous." (Åhlberg, 1996, 9)

The fact is that people are more used to "understanding something if we can see it, rather than something we hear. It is a socio-political hegemonic ocularcentrism or visualism [...]. But certain things are easier to understand if they are visualised in a different way, with the help of sensory modalities other than sight." (Kiefer & Schiller, 2018) Given that the Visual Literacy research programme is concerned with exploring the visual, it therefore

1 The book is the result of the research programme P5-0452, Visual Literacy at the University of Ljubljana, Academy of Fine Arts and Design, co-funded by the Slovenian Research and Innovation Agency (ARIS).

seems at first glance strange that the project focuses on people with various visual impairments for whom the visual is virtually out of reach. This very contradiction was the starting point in our reasoning that in order to understand the visual, it is necessary to explore what is "beyond the visual".

The book is also an echo of the international summer workshop project called Kaverljag. **Aleš Sedmak**'s article entitled **The Concept of Kaverljag Workshops and Their Impact on Society** presents their rich history and describes the phenomenon of the Kaverljag workshops, which took place from 1998 to 2012 in the small village bearing the same name, located near Grintovec in the vicinity of Šmarje nad Koprom. The programme was aimed at students from European academies who explored current topics such as ecology, product usability, and the integration of art and science through scientific illustration and the wider field of visual communication. In a creative workshop environment, students developed practical ideas that led to tangible products, which were invariably received with enthusiasm and often influenced political and historical developments in the thematic areas they addressed in their work. Already in 2009, these workshops, in collaboration with partners, focused on finding ways to bring individual organisms closer to the blind and partially sighted with the help of tactile content. The result was the highly acclaimed books *Touch a Bird* (2009) and *Insects Up Close* (2012). The project involved a wide range of experts from different fields, working together with blind and partially sighted people to develop tools for learning about the natural environment. The programme was developed in close cooperation between the Academy of Fine Arts and Design at the University of Ljubljana (UL AFAD) and the Kaverljag Association.

Since the summer schools were discontinued in 2012, the former participants (now educators, many of whom also participated in the new edition) decided to re-launch the workshops in 2024, again with interdisciplinary participation of students from different fields of art, design, and biology. The project *Marine Organisms for the Blind and Partially Sighted*, led by UL AFAD in collaboration with several European institutions, once again brought together experts from the fields of biology, sustainability, didactics, typhlopedagogy, and art and design, as well as mentors and educators from five countries. This time we focused on creating tactile representations of marine organisms, as the sea is an area that is particularly inaccessible to the blind and partially sighted. The whole project was more ambitious, had a longer time frame, was organized in phases and has the potential for further development. In addition to analogue solutions, we wanted from the outset to take advantage of new technologies to improve the usability and accessibility of information on marine organisms for the blind and partially sighted. We also wanted to put more emphasis on methods that would give new insights for illustrators and designers who would like to venture into the specific field of design for the blind and partially sighted, in addition to concrete solutions. The aim was to develop a systematized process for the production of 3D printed tactile illustrations that would improve the accessibility of learning content for people with visual impairments.

In the book, this part of the process is described in detail in the article by **Zoja Čepin** and **Leon Rojk Štupar**, entitled **Kaverljag International Summer School from Students' Perspective**, where they describe in detail a system for creating 3D printed representations of organisms. The process of creating a tactile representation of organisms using 3D printing involves several key stages that ensure the accessibility, perceivability, and quality of the final product. The first phase is the research of the selected organism, which includes scientific illustration and analysis of anatomical features. Based on this, the illustration is stylized and reduced, maintaining biological accuracy while adapting the shape for tactile perception. The next step is to vectorize a simplified illustration following standardized criteria adapted for optimal touch perception. The authors present the transfer of vectors into 3D modelling software, the conversion into 3D form, and the technical specificities that contribute to a better tactile experience. As the project involved not only a basic illustration, but also a detail of the organism—e.g. a specific texture or body part that allows for a deeper understanding of the structure—different 3D printing technologies and materials were used to produce high-quality results. The authors present the final product in a structured way, combining all the elements into a tactile kit: the name of the organism in braille, a basic illustration, and an elaborate 3D detail. The article also describes the design of the presentations themselves in the gallery space, where the descriptions and sound clips have been adapted to further foster understanding. The project was tested and showcased at exhibitions, where users tested and confirmed the effectiveness of the method.

In her article **Scientific Illustration as a Pedagogical Tool in Interdisciplinary Projects**, **Marija Nabernik** describes how we can create the conditions to start exploring abstractions and making technological adaptations for 3D technologies. She approaches scientific illustration as an illustrator, but also as an educator, as scientific illustration is part of the curriculum at UL AFAD and—as detailed in this book—the students learn more about it through selected topics at workshops and summer schools. In the article, she discusses how the visual arts and science interact and how they can work together to help memorize content and create learning content and tools. Scientific illustration plays a key role in the education and understanding of scientific content. Most people have been exposed to it in books and textbooks since childhood, as it aids memorization and learning by visually conveying information, and it can be found in a wide range of fields in scientific and technical publications, medical manuals, natural history books, and a variety of textbooks and learning materials. Nabernik defines the differences between fiction and non-fiction illustration; explains its forms and expressive techniques; and touches upon various specific codes and conventions that allow for a common understanding, such as colour coding in medical illustrations or schematic geological maps. But the article also offers an outside perspective: it looks at pedagogical approaches to teaching scientific illustration, outlines how drawing can help improve understanding and observation, and how illustration can be used as a method to pursue a learning outcome. She also elaborates the process of working on the Marine Organisms for the Blind and Partially Sighted project, where many other expressive techniques were added to the process of producing tactile illustrations, which, because of their inherent qualities, offered a way to achieve the final results. Nabernik sees the project as a gateway to further possibilities for the wider use of scientific illustration in personalized education, in particular through the development of 3D printing, which enables the quick and easy production of personalized learning tools.

As the project was designed in an interdisciplinary way, it was crucial to gain knowledge and insights from other fields as well. In **What I Don't See, Doesn't Exist. Scientific Illustration as a Synergy Between Science and Art**, **Tim Prezelj** highlights research in cognitive science in recent years that has contributed significantly to the understanding of artistic creation. He points out that the development of science has guided art from the very beginning, especially scientific illustration, which is particularly important in fields such as chemistry and biology, where without visual models (e.g. the structure of atoms and molecules), specific processes cannot be explained, represented, and understood. This article introduces the different principles in the natural sciences, and the relationships between the visual models developed and the understanding of fundamental concepts in the natural sciences. However, since certain abstract concepts do not have a visual representation in themselves, their visual representation can therefore only be a model or depiction that guides understanding. Due to the nature of visual perception, this can also be misleading. Prezelj points out that in this sense we are all "blind" to certain aspects of reality, but that this manifests itself in different ways. The article then focuses on imparting knowledge to the blind and partially sighted, especially those with congenital difficulties who have more difficulty forming normatively accepted mental representations of abstract concepts. This is a major challenge, but the author stresses that the development of visualizations for the blind and partially sighted is therefore crucial, as it is they who can shed light on new aspects of scientific concepts that sighted people may overlook.

In her article **Perception of People with Visual Impairments**, typhlopedagogue **Mateja Maljevac**, who opened the door to the world of the blind and partially sighted through her participation in the project, presents the complex challenges posed by blindness, partial sight, and visual impairment. To begin with, the article notes that it is already difficult to define these challenges uniformly across disciplines. In the Slovenian school system, the pedagogical definition is oriented towards the specific visual abilities of children, which allows for the adaptation of the educational process and creates an inclusive environment, as children with visual impairments need content to replace visual information in order to actively participate in society. The author describes the importance of developing tactile perception, as this plays a key role in the holistic development of children as they learn about the world around them through play and interaction. Extended curriculum activities should promote concrete and language-rich experiences, as this enables the understanding of fundamental concepts. This article presents effective strategies for working with children with visual impairments, including tactile modelling and audio-description, enabling children to explore and interpret information. Audio-description increases the accessibility of cultural resources and tactile content promotes fine motor development. Only in sum do all these elements create a supportive framework that fosters children's independence and success and, in the author's view, only the conscious design of learning content and the adaptation of teaching methods can significantly contribute to the successful integration of children with visual impairments into the modern education system.

To work with blind and partially sighted people, a designer needs to develop not only expertise but also empathy, which has been recognized as an important element in design theory for at least 50 years (Stephan, 2023), as it can significantly help designers in making decisions. In this book, we demonstrate the above with a hugely successful project for the blind and partially sighted, presented by **Lech Kolasiński** in his paper **From Empathy in Design to Social Inclusion**. The article deals with the social inclusion of people with disabilities using universal design. It focuses on the fourth principle of universal design – information perception. The author first explains the role and importance of empathy in the design process, as well as in the comprehensive education of designers. The second part of the article entails a case study of tactile information design for the University of Krakow botanical garden, describing both the design process and the associated challenges and decisions that led to a socially inclusive design solution. The article introduces us to the importance of multisensory experience in the memorization process of the blind and partially sighted and the role of intersemiotic translation in the design of tactile graphics. The design solution proves the thesis of combining visual communication with tactile graphics as a real and noteworthy design compromise.

In her article **Inclusive Design and the Importance of Visual Literacy for Designers Creating for the Blind or Partially Sighted**, **Petra Černe Oven** discusses inclusive design and the theoretical approaches behind the Kaverljag International Summer School 2024. Although there have been design projects for the blind and partially sighted in Slovenia for quite some time, she points out that research in this field is scarce. The reasons for this are the small number of projects in general; the fact that design for the blind and partially sighted is not predominantly process-driven; the frequent absence of designers in projects; and the lack of interdisciplinary cooperation between disciplines. The article therefore introduces the main themes related to the field of design for the blind: inclusive design, the role of empathy in design, legibility and readability, and starts to map the basic guidelines in the field of visual communication design for the blind and partially sighted. The article also aims to contribute to the establishment of a theoretical basis for the development of an interdisciplinary curriculum for visual communication designers and students in other fields of study, emphasizing inclusion and mainstreaming vulnerable groups. In conclusion, the article lays out the possibilities for further expanding research in the field of visual literacy in combination with the field of design for the blind and partially sighted. The way we perceive our world is strongly influenced by the sensory constructs that surround us, especially visual ones, and these often lead us to believe that what they reflect is social reality. (O'Shea, 2024) In the absence of an environment adapted to people with needs different from the statistical majority, their undeniable presence and even right to be present can be quickly dismissed.

It is precisely the connection with users, codesigning with them, and seeking an in-depth understanding of their needs that can be a challenge for many projects, whether the design is embedded in an academic or economic milieu. This can also be the point at which projects either succeed or fail to deliver quality solutions. With this in mind, the book also presents insights from the users' perspective. In his article **Our View on the Collaboration Between Blind and Partially Sighted People and Designers and What We Can Achieve Together**, **Tomaž Wraber** shares his personal experience of partial sight and blindness in an engaging tone and systematically demonstrates the importance of accessible design through his experience of being on a number of national and international bodies. His story begins with the early diagnosis of his partial sight, and his parents who made it possible for him to attend a mainstream school. This gave him a broad cultural and intellectual base that helped him cope with his sight loss later in life. He points out that rehabilitation is crucial for people with sight loss, but also attaches equal importance to the role of society in ensuring accessibility. The author looks in detail at various aspects of accessibility, from architectural adaptations to the design of digital content, and is critical of the lack of inclusive design. He pays particular attention to the design of visual communication, signs, and typography, pointing out that designers should also take visually impaired users into account when designing. Using a number of examples (tactile communication in space and on products, adapted keyboards, and audio-descriptions), the article demonstrates how well-thought-out design can improve the lives of blind and partially sighted people. In conclusion, the author shares the view that designing accessible environments is not just a technical issue, but a reflection of society's empathy and willingness to include all people equally in private and public life.

In addition to the scientific contributions and a detailed description of the processes and methods of preparing tactile illustrations, the book also offers a visual flowchart of the **Steps of the Visualization Process for the Blind and Partially Sighted in the Case of the Kaverljag International Summer School 2024**, where we summarize the most important stages of the process for ease of understanding. In the article **Testing and Proposed Improvements to the Tactile Illustration System**, we briefly describe the results obtained from testing the materials with blind, partially sighted, and deafblind users, and touch on possible future improvements of the methods. One of the important articles in the book is certainly the one entitled **Brief Recommendations for Designing (Tactile) Illustrations for People with Visual Impairments**, where, based on the interdisciplinary collaboration of a number of authors and the past experiences of individuals and the Kaverljag workshops, we have highlighted the key elements that influence the design of tactile illustrations. Thus, this scientific monograph is not only aimed at professionals and students in the fields covered, but also at professionals and lay people in other fields (therapists, personal care attendants, educators, special needs professionals, etc.) who work with blind and partially sighted people and want to know more about design for the blind and partially sighted, and thus encourage others to take up such projects in the future. We hope that the book will help to improve the accessibility of educational content, while at the same time (re)emphasizing the importance of interdisciplinary and international cooperation in tackling societal challenges that can only be solved with expertise, empathy, and much-needed social responsibility.

Postscript

The language in which we communicate has several layers and different tones to address the reader. Professionals in the field sometimes use different terms to convey the same thing. Because of the interdisciplinary nature of the project that was the focal point of this book, we have chosen to keep the original terminology used by the individual authors, who come from different fields of expertise and have different experiences of the subject, or in other words: we have not homogenized some of the terms used by the authors in the book. Instead, the terms used in the articles have been chosen according to the context of the article, with the aim of providing the reader with a positive reading experience and the best possible flow of the information contained in the article.

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THE CONCEPT OF KAVERLJAG WORKSHOPS AND THEIR IMPACT ON SOCIETY

Aleš Sedmak

Keywords
artistic-ecological-educational project, visual communication, natural and scientific illustration, interdisciplinarity, multiculturalism, design, socially responsible design.

Abstract

The Kaverljag Workshops have been held continuously since 1998 in the tiny village of Kaverljag, located above Koper near Grintovec and Šmarje. The international summer workshops are intended for students of European academies and focus on current issues, especially ecology, the utility of products, and the integration and synergy of fine arts and various scientific disciplines. With the help of scientific illustration and visual communication, one of the most pervasive media of our time, students search for their own practical solutions in a creative workshop environment, resulting in tangible products. In 2009, we decided to work with partners to find solutions on how to present biological organisms to blind and partially sighted people, so that they can learn about at least part of their surroundings by using the sense of touch. We have published two books *Dotakni se ptice* (Touch a Bird, 2009) and *Žuželke od blizu* (Insects Up Close, 2012), and developed art and typeface foundations for creating materials for blind and partially sighted people. The project brought together biologists, communicologists, designers, and illustrators and blind and partially sighted people, in order to create aids that will help blind and partially sighted people learn about the natural environment, and in particular the organisms living in it. The programme was planned, developed, and implemented in close cooperation with the Academy of Fine Arts and Design of the University of Ljubljana *(hereinafter "UL AFAD")*. In 2024, we are continuing our work, as we want to expand the range of content accessible to blind and partially sighted people with illustrations of marine organisms. This time we are expanding content beyond the medium of books and we want to use new technologies to increase the usefulness and accessibility of information about marine organisms.

THE ROLE OF VISUAL COMMUNICATIONS

As early as 1542, in the editorial in his famous book on herbs, Leonhart Fuchs wrote that "pictures, illustrations, can convey information far more clearly than the most eloquent man can with words" (Lee, 1999, 6). Today, with the world swarming with numerous communication forms and techniques, the image is once again becoming an important means of messaging and communication.

One can quickly see that an aggressive language of visual communication is dominating. I agree with the general observation that we live in a culture dominated by images, visual simulations, illusions, copies, reproductions, imitations, and fantasies; in short, we live in an age of visual communication. Consequently, there is more and more visual data created every day, and thus a growing need to manage it. There are increasing warnings that "our culture is increasingly becoming the product of what we are looking at, not what we are reading" (Mitchell, 2009, 19).

Anyone can be captivated by an image; illustration is powerful and great for conveying a variety of information, including of a scientific nature, especially in the field of environmental awareness. The role of scientific illustration is therefore very important in promoting environmental awareness and education, and it has a very direct impact on environmental issues. A well-done illustration in a popular science text not only provides accurate information, but does this in a friendly way, thereby making studying interesting and enjoyable, rather than a chore.

Already in the 4th century BC, Aristotle discussed in his *Poetics* why imitation is pleasing to man, why we enjoy looking at perfect images of an object. He attributes this pleasure to the human joy of learning, because, in his view, people enjoy looking at images because they teach us so much and because they tell us the meaning of something. Aristotle also finds pleasure in identification.[1]

Scientific illustration is neither art nor science, it is both. Inevitably, the two must be interrelated, both in content and form, if

1 The thought is taken from Ernst Gombrich.

the information is to be scientifically objective. In addition to artistic skills, an illustrator of scientific illustrations must also have a command of the scientific language. They must communicate with the scientist and understand what he or she is asking of them in order to know what to communicate with their illustrations.[2]

By using a variety of methods, (scientific) illustration often allows the reader to "see" information that is normally not visible. Scientific illustration must often meet two requirements: to be accurate and present information clearly. It would be more appropriate to say that such illustrations are useful in helping the reader "see" information within the context of a particular theory or scientific truth. It should be built on a solid foundation of scientific knowledge, knowledge of artistic techniques, and clear visual communication. Or to quote Žarko Vrezec: "In observing and drawing a piece of the animal kingdom, I was particularly fascinated by the fact that nothing in nature is an end in itself, nothing is there for beauty's sake alone. All the colourful morphological markings on the wings of butterflies, all the dazzling structures on the shells of beetles, all the ornaments on the wings of birds – they all have an important function in the various strategies of self-preservation, reproduction and feeding in the inexorable, cruel struggle for survival. In short, all the artistic sensations, all the spectacular patterns available when drawing a piece of nature, are strictly functional, nothing is unnecessary…" (Vrezec, 2010, n.p.).

Another field that perhaps encroaches on space and nature even more, and has an enormous and specific impact, is design. As cultural mediators, designers mostly work in a depoliticized way, without being aware of their impact on society, culture, and the environment. Design as a profession and one of the pillars of creative industries and cognitive capitalism in general is stuck in a narcissistic position of market-driven egotism, unable to reflect on the consequences.

2 Taken from an interview with Pedro Salgado.

The visual communication design profession is in need of fundamental change. In a time of radical uncertainty and environmental degradation, visual communication, institutionalized through the academic and business professions, has not developed its communication potential. It operates in ways that maintain the status quo or even exacerbate the situation. For visual communication to change, we need to fundamentally alter our thinking, develop new theory and refocus our practice. (Vodeb, 2012)

The third important reason for careful consideration is that nature is increasingly under threat. Caring for the environment is one of the fundamental tasks of the future. People will only change their behaviour if they can find reasons for it in terms of health, money, morality, ethics, or prestige. Communication and education are essential to motivate us to preserve the quality of the natural and cultural environment (biodiversity, clean water, air, sound), a beautiful view (visual ecology, urban ecology), etc., and thus a better culture of living.

As mentioned above, communication in the public space, mainly through mass media (from printed books to electronic media), decisively influences an individual's perception, world view and, consequently, their actions. Especially today, when we are more dependent on information than ever before in the history of mankind. Visual communication plays a decisive role in this context because it is much more dynamic, because it includes moving images as well as static ones, because it enables virtual travel through space, because it reads fast, and because its language is universal, as it transcends the barrier of national languages. And yet, education and the development of theoretical foundations in the field of visual communication have been neglected.

These were the reasons for the creation of the Kaverljag programme, which was developed gradually from year to year, based on experience, feedback from participants and the professional public, and above all in interdisciplinary cooperation. The students who took part in the Kaverljag Workshops project (designers, illustrators, communicologists, film directors, etc.) had the opportunity to acquire valuable information in the field of ecology and the protection of nature and natural heritage, which they could pass on in their work after finishing their studies, and thus raise awareness on ecology themselves.

The project's focus on ecology has been an important feature of most activities and contents under the Kaverljag programme. To this end, we founded the Kaverljag Association and, in cooperation with the UL AFAD, we developed programmes in the field of scientific and popular science illustration and socially responsible design. The role of Prof. Zdravko Papič was crucial in this process. Each year, we have looked for pressing issues in the field of natural sciences and ecology, and from 2009, also created content for a very neglected social group, blind and partially sighted people.

The success of our programme lies in the co-operation between social and natural sciences. In the project, students from the humanities are confronted with natural sciences and environmental protection, and vice versa, students from natural sciences are confronted with the social science aspects of environmental protection. It provokes a shift in the way people think, in their awareness of the environment, which is a prerequisite for ecology. Through the workshops and the results of these workshops, we are trying to achieve a shift in this way of thinking.

At the Kaverljag workshops we try to strike a balance between scientific illustration, painting practice (study drawing, colour study, etc.) and a clear visual message, and socially responsible design, especially in the field of environmental protection and social sustainability.

KAVERLJAG INTERNATIONAL SUMMER SCHOOL

I have been working in the field of illustration since 1987. My work focuses on scientific and popular science illustration. The very first illustrations impressed the client and the volume of my commissions has increased considerably. In addition to botanical and natural science illustrations and complex maps (*Atlas of Slovenia* for primary and secondary schools), illustrating mathematics posed a particular challenge. This type of natural science illustration requires additional study, is very time-consuming and requires specific discipline and close collaboration with the scientist or author of the content.

In the academic year 1997/98, Zdravko Papič, a professor of illustration at the UL AFAD, and I discussed the idea of offering students an additional programme of scientific illustration in the form of summer workshops, which we would organize at the studio in Kaverljag, a small hamlet in the village of Grintovec near Šmarje nad Koprom. Also at that time, the United Nations (UN) declared 1998 the *Year of the Ocean*, and the Marine Biology Station Piran (hereinafter "MBS") was tasked with actively participating in this global campaign. Another important event was that in 1998 the MBS in Piran celebrated three decades of its existence and decided to solemnly celebrate its anniversary with a large-scale exhibition. In order to carry out both tasks as successfully as possible and to showcase their achievements, they wanted to collaborate with experts in the visual field, i.e. illustrators and designers. And these are two fields that have been intensively developed at the UL AFAD's Department of Design. Thus, the idea of co-operation between the two institutions arose. The study of scientific illustration, i.e. the illustration of scientific texts, was a novelty in this field, both for the Academy and for the MBS.

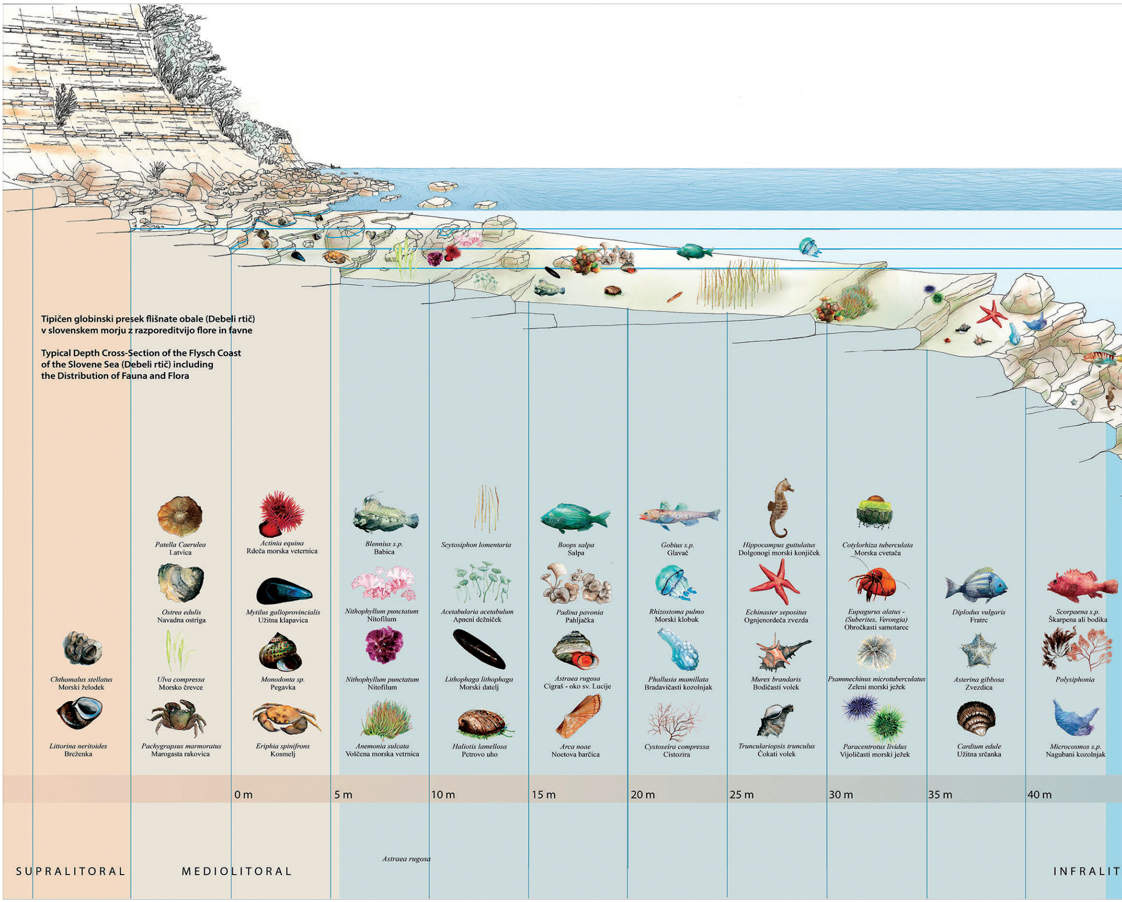
The Year of the Ocean campaign and the 30th anniversary of the MBS was a good start for the co-operation between an established scientific institution, in this case the Marine Biological Station in Piran, and the UL AFAD, and the point of contact was my studio in Kaverljag. From that year onwards, the Kaverljag workshops were held continuously until 2012.

In **Kaverljag Workshop 001** entitled *The Sea and Scientific Illustration*, the students, under the expert guidance of their mentors, professors from the Academy, and lecturers and scientists from the MBS, created illustrations and the concept of the MBS's exhibition

Figure 1: Kaverljag Workshop 001 – The Sea and Scientific Illustration, 1998, by Aleš Sedmak (personal archive)

Figure 3: *Škocjanski Zatok* poster, by Zsuzsanna Borogdai, 1999 (Kaverljag Association archive)

Figure 4: *Tourism is Us...* poster, by Nika and Jana Urbas, 2000 (photo by Jaka Kramberger, Kaverljag Association archive)



Tipičen globinski presek flišnate obale (Debeli rtič)
v slovenskem morju z razporeditvijo flore in favne
Typical Depth Cross-Section of the Flysch Coast
of the Slovene Sea (Debeli rtič) including
the Distribution of Fauna and Flora
Chthamalus stellatus
Morski želodek
Littorina neritoides
Breženka
Patella Caerulea
Latvica
Ostrea edulis
Navadna ostriga
Ulva compressa
Morsko črevce
Pachygrapsus marmoratus
Marogasta rakovica
Actinia equina
Rdeča morska veternica
Mytilus galloprovincialis
Užitna klapavica
Monodonta sp.
Pegavka
Eriphia spinifrons
Kosmelj
Blennius s.p.
Babica
Nithophyllum punctatum
Nitofilum
Nithophyllum punctatum
Nitofilum
Anemonia sulcata
Voščena morska vetrnica
Scytosiphon lomentaria
Acetabularia acetabulum
Apneni dežniček
Lithophaga lithophaga
Morski datelj
Haliotis lamellosa
Petrovo uho
Boops salpa
Salpa
Padina pavonia
Pahljačka
Astraea rugosa
Cigraš - oko sv. Lucije
Arca noae
Noetova barčica
Gobius s.p.
Glavač
Rhizostoma pulmo
Morski klobuk
Phallusia mamillata
Bradavičasti kozolnjak
Cystoseira compressa
Cistozira
Hippocampus guttulatus
Dolgonogi morski konjiček
Echinaster sepositus
Ognjenordeča zvezda
Murex brandaris
Bodičasti volek
Truncularioposis trunculus
Čokati volek
Cotylorhiza tuberculata
Morska cvetača
Eupagurus alatus -
(Suberites, Verongia)
Obročkasti samotarec
Psammechinus microtuberculatus
Zeleni morski ježek
Paracentrotus lividus
Vijoličasti morski ježek
Diplodus vulgaris
Fratrc
Asterina gibbosa
Zvezdica
Cardium edule
Užitna srčanka
Scorpaena s.p.
Škarpena ali bodika
Polysiphonia
Microcosmos s.p.
Nagubani kozolnjak
0 m
5 m
10 m
15 m
20 m
25 m
30 m
35 m
40 m
Astraea rugosa
SUPRALITORAL
MEDIOLITORAL
INFRALIT

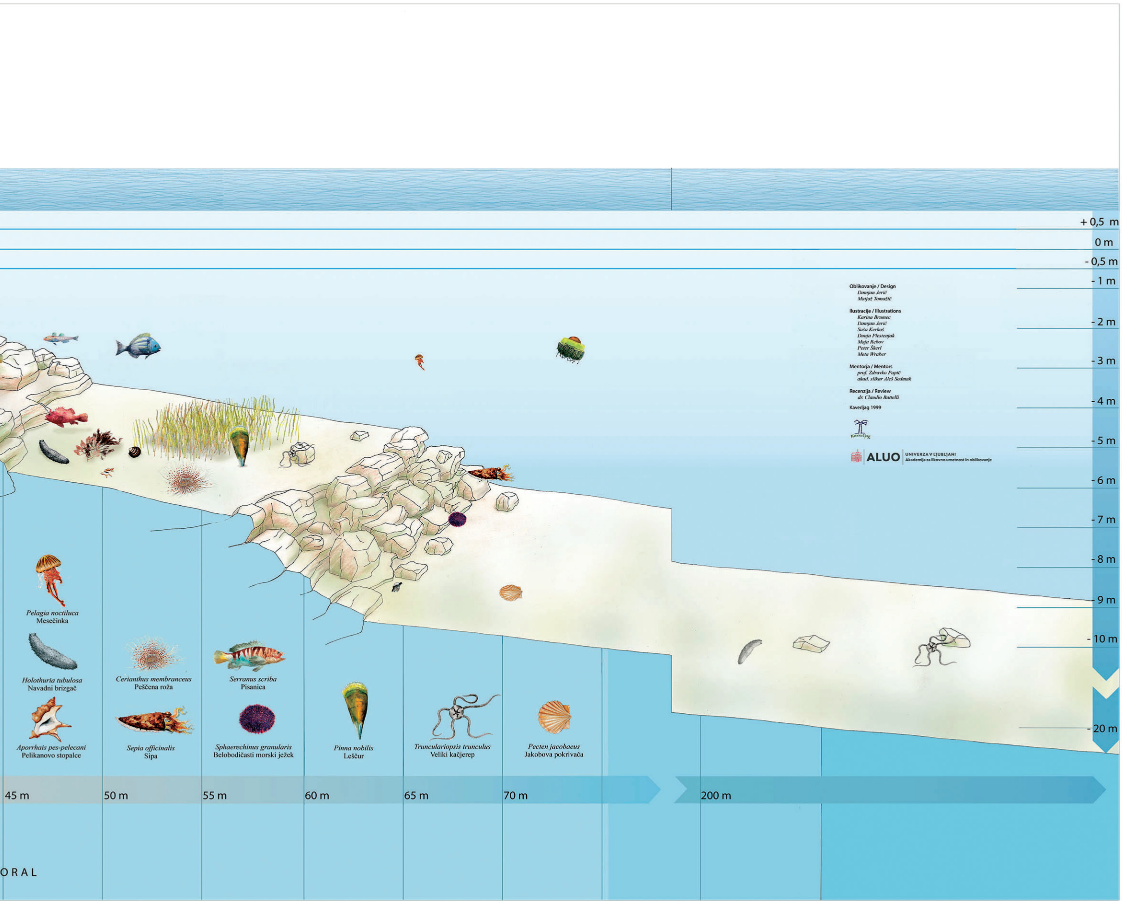


Figure 5: Typical Depth Cross-Section of the Flysch Coast of the Slovene Sea (Debeli Rtič) Including the Distribution of Flora and Fauna, Design: Damijan Jerič, Matjaž Tomažič; Illustrations: Narvika Bavcon, Karina Brumec, Andreja Čeligoj, Saša Kerkoš, Dunja Plestenjak, Maja Rebov, Peter Škerlj, Meta Wraber, 1999 (Kaverljag Association archive)

Figure 6: *What You Pour, You Drink* poster, by Igor Nardin, 2001 (Kaverljag Association archive)

Figure 7: *Koper* poster, by Lidija Skenderovic, 2002 (Kaverljag Association archive)

Figure 8: Location signage (Kaverljag Association archive)

Figure 9: Participants and Mentors of the International Kaverljag Workshop 016 – Insects for the Blind and Partially Sighted, 2011 (photo by Aleš Sedmak, personal archive)

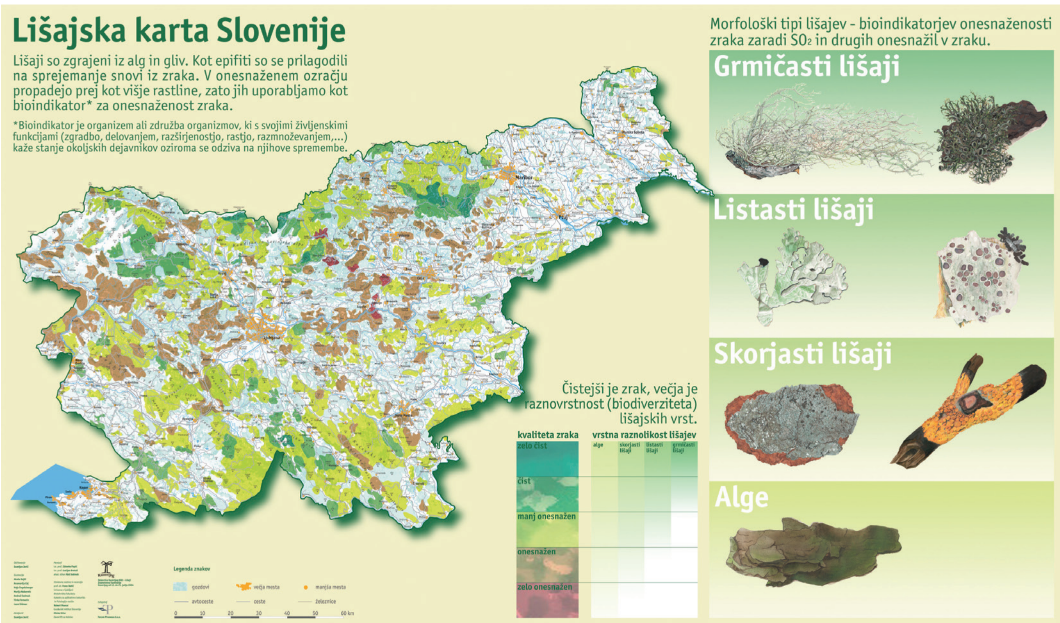


Figure 10: *Lichen Map of Slovenia*, by Akaša Bojič, Anamarija Cej, Neja Engelsberger, Jaka Kramberger, Marija Nabernik, Igor Nardin, Andraž Sedmak, Jure Slivnik, Tinka Tomazin, Leon Vidmar, 2004 (Kaverljag Association archive)

Figure 11: Moth *(Eriogaster catax)*, by Lech Kolasiński, 2011
(Kaverljag Association archive)

Figure 12: Little Bittern *(Ixobrychus minutus)*,
by Zarja Menart, 2009 (Kaverljag Association archive)

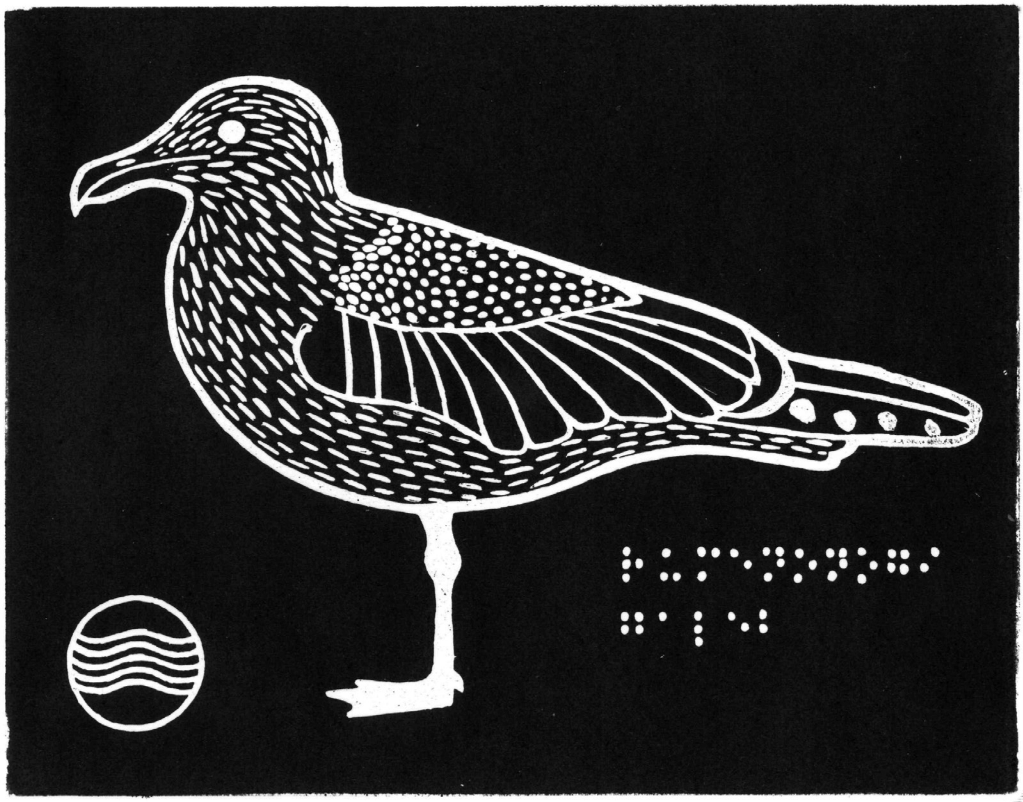


Figure 13: Herring Gull *(Larus argentatus)*,
by Zarja Menart, 2009 (Kaverljag Association archive)

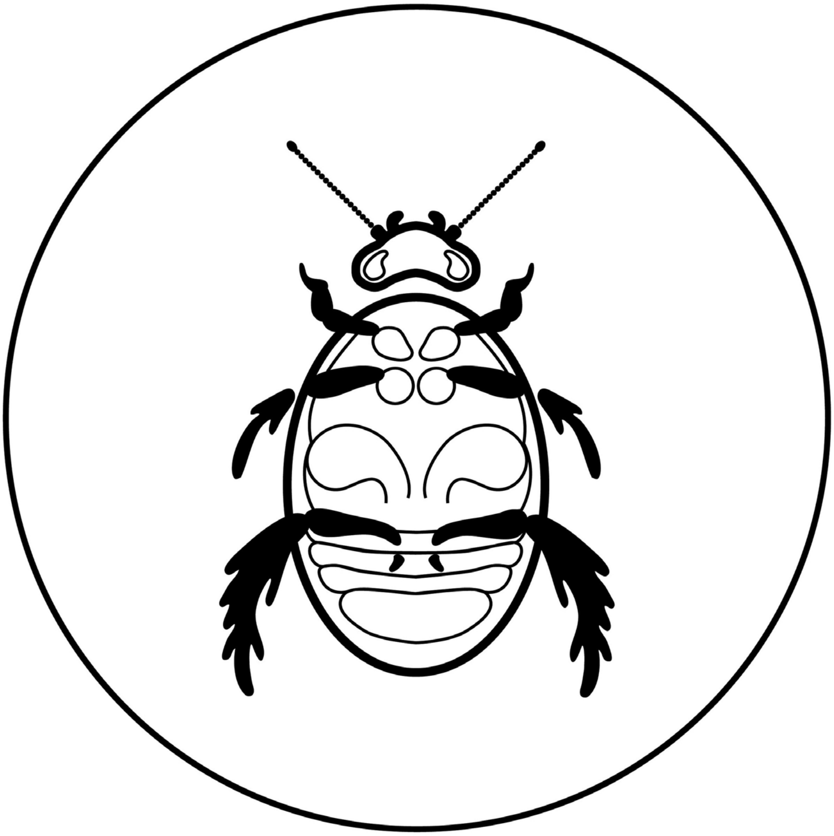


Figure 14: Banded Water Beetle *(Graphoderus bilineatus)*,
from the book *Žuželke od blizu* (Insects Up Close),
vector drawing and design by Hana Jesih, 2012
(Kaverljag Association archive)

as well as its visual identity and individual design elements (a poster, an invitation, a banner, an informative viewing card, a model of a part of the Slovenian coastline, etc.). The collaboration between the scientists and artists resulted in the exhibition *Colours of the Bay*, which was held in various settings at the Meduza II Gallery in Piran (July 1998), the UL AFAD's Department of Design (October 1998), and the Insula Gallery in Izola (December 1998), at the Municipal Gallery in Piran (April 1999), and at the National Institute of Biology in Ljubljana (December 1999), and a large panoramic illustration, *Typical Vertical Section of a Flysch Coastline (Debeli rtič) in Slovenia with its Flora and Fauna*, which is still used as in primary and secondary schools.

> *"The exhibition was dedicated to the treasures of our little corner of the sea, which are often not recognized, not least because we like to compare them with the more southern parts of the Adriatic Sea. It also emphasized the fragility and vulnerability of this ecosystem and our commitment to get to know it in all its nuances and to fight for its preservation. A large part of the exhibition was devoted to showing the main features of the Gulf of Trieste and its ecosystem: from the physical and chemical characteristics, sediments, organisms, the peculiarities of the seabed and the water column above it to the unusual phenomena and the various types of pollution.*
> *Nature has inspired many artists past and present, but before man invented photography, illustrations—paintings and drawings of organisms, nature, and natural phenomena—were the only way to capture and preserve its visual image. This is one of the reasons why art has been so important in the development of the natural sciences and why illustration is still a powerful tool for communication today." (Malej, 2024, 60–62)*

Already at the first workshop in 1998, we could observe the intensive filling of Škocjanski zatok to create a new area for expanding the city and the port of Koper. It was then that we decided on the theme of the next **Kaverljag Workshop 002 – Škocjanski zatok**.

The Škocjanski zatok bay is a wetland created by the expansion of the city of Koper and its port. The bay provides shelter for many bird species and, as the only semi-saline wetland in Slovenia, is a unique and very sensitive habitat. Prof. Tugo Šušnik, an academic painter and a mentor at the Kaverljag Workshop, beautifully put the essence of what we do into words: "The interplay of urbanism and ecology has almost dramatic proportions in this landscape, and is a fitting backdrop for contemplation and creativity, for thinking about human existence, about its direct role in the increasingly complex problem of nature conservation. The uniqueness of the 'Zatok' ecosystem in Slovenia is undeniable, as is the violent 'visual' encroaching of the city into this unique combination of freshwater and saltwater ecosystems. Here, then, is an opportunity to see, depict, document and comment on the issues of our very near future in all their disturbing dimensions, using a variety of visual media."

Our aim was to use visual means/tools to demonstrate and raise awareness of the potentially devastating consequences of the collapse of Škocjanski zatok. We wanted the citizens of Koper and all those interested to experience it as part of our natural heritage and a vital habitat for many plant and animal species.

We set up an exhibition of provocative posters at the UL AFAD's Department of Design (October 1999), in the Praetorian Palace in Koper (October–November 1999) and in the lobby of the Ministry of the Environment and Spatial Planning (November–December 1999), which also influenced the future fate of Škocjanski zatok. Among other things, the poster exhibition contributed to the Ministry's decision to declare Škocjanski zatok a national park!

One of the reasons for the creation of the project **Kaverljag 003 – Clean Environment** in 2000 was the increasingly ecologically threatened landscape. Istria, with its particular climate, vegetation, and culture, is increasingly exposed to various changes and the influx of modern nomads (tourists) along the coast (especially in summer). On the other hand, as an empty and decaying hinterland, without the right energy and incentive for development, Istria has become an ideal place for illegal dump sites. That is why we chose the issue of illegal dump sites and their negative consequences for the air, soil, groundwater resources, the aesthetic appearance of the landscape, and tourism as the topic of this workshop.

We produced a series of posters and various visual messages and communicated them to the general public through media and exhibitions.

By including environmental themes in the next workshop, we also wanted to draw attention to the potential dangers and increased risk to the habitat and to encourage a better attitude towards the environment, especially clean groundwater resources. Respecting and protecting our only, and also the cleanest, water source in the coastal region is the only way to prevent the region from becoming totally dependent on other, foreign water sources. Clean drinking water is becoming an invaluable commodity and a major asset for a region or a country.

In **Kaverljag Workshop 004 – Clean Environment, Clean Waters**, we developed a year-long marketing strategy and concrete design solutions for the conservation and protection of groundwater resources in the Coastal-Karst Region. The programme was aimed at raising awareness about the importance of clean water.

In 2002, we focused on the Sečovlje salt pans and the architectural heritage of Koper in **Kaverljag Workshop 005 – Cum Grano Salis**. The first thematic set focused on the Sečovlje salt pans, a distinctive environment characterized by the coexistence of natural and cultural heritage. The project was aimed at encouraging people to think that the salt-making identity we have inherited should be passed on to our descendants. The second thematic set focused on Koper and its architectural heritage, which is, unfortunately, largely forgotten and neglected. That is why the main objective of both projects was to draw people's attention to our region's rich natural and cultural heritage.

The workshop was implemented as part of the CEEPUS programme (Central European Exchanging Programme for University Studies) and in addition to UL AFAD, the participating institutions were: the University of Technology, Faculty of Fine Arts, Brno, Academy of Fine Arts, Krakow, Academy of Fine Arts Zagreb, University of Art and Design, Cluj, and Moholy-Nagy University of Art and Design Budapest (MOME). We included additional content in the programme: promotion of the individual schools, both in terms of presenting creative achievements and the diversity and special features of pedagogical processes. The meeting was aimed at networking and exchanging pedagogical and creative experiences of academies in Central Europe. The aim of the workshop was also to establish and promote mobility of students and professors in Central Europe and to take advantage of intellectual and friendly connections and opportunities.

The following year's **Kaverljag Workshop 006 – Educational Trail Along the River Dragonja** was intended for recipients of the Zois scholarship. Throughout the individual programmes, we have developed a method of translating theory into practice, as a model for delivering natural and ecological content to social science students, and vice versa, delivering insights from a social science perspective to students of natural sciences. The workshop was attended by students – Zois scholarship holders from the Biotechnical Faculty, the Faculty of Education, the Faculty of Arts, the Faculty of Social Sciences, and the Academy of Fine Arts at the University of Ljubljana.

The Dragonja river basin is one of Istria's ecological and natural gems. It is still home to native animal and plant species, and the landscape is also unique: with its hill-valley relief it creates an incredible illusion of movement. This part of the Slovenian coastal region is thus vital and useful for environmental, biological, forestry, geographical, geological, and, last but not least, artistic debates. We decided to organize an interdisciplinary workshop based on illustration, biology, and much more.

The main aim of the project was to create a learning trail along the River Dragonja, to evaluate and promote the natural resources of the protected area, the future Dragonja Landscape Park. Thereby, we wanted to indirectly support the conservation and protection of this unique natural environment and to strengthen cross-border cooperation between Italy and Slovenia.

In 2004, we implemented four projects:

Kaverljag Workshop 007 – Lichens The National Education Institute Slovenia invited us to dedicate one of our workshops to lichens. Lichens are made of algae and fungi. Like rhododendrons, they have no cover tissues, but like epiphytes, they have adapted to absorbing substances from the air. In polluted atmospheres, they decay earlier than taller plants, and are therefore used as a differential diagnostic tool and serve as a bioindicator of clean air.

The aim of the workshop was to present lichens and their importance in determining air quality by employing the visual language of illustration, design, and photography and to produce a *Lichen Map of Slovenia*, which has been and continues to be an excellent teaching aid in primary schools.

Kaverljag Workshop 008 was also part of the CEEPUS programme and aimed to bring together professors and students from art academies in Zagreb, Katowice, Krakow, Budapest, and Ljubljana. As in 2002, we continued to promote the individual schools in 2004. The programme was aimed at contributing to the promotion of a cultural space common to all European peoples. In doing so, we wanted to support creativity and mobility in culture and education, openness and the flow of arts and culture, and foster an intercultural and international dialogue.

Kaverljag Workshop 009 – Two Sculptures in Two Coastal Towns The year 2004 marked 50 years since the signing of the London Memorandum, which had a decisive impact on relations and development on both sides of the southern border. At the invitation of the municipal administrations of Izola and Piran, we wanted to use the project *Two Sculptures in Two Coastal Towns* to highlight the importance of this event that happened 50 years ago and to raise awareness of the presence and importance of the sea that Slovenia gained with this memorandum.

The sculptures symbolize openness to the sea and a willingness to communicate openly. A group of eight young artists, students of the UL AFAD and the Faculty of Education, aimed to create a new and unique message based on a positive attitude towards the environment and the times in which we live. The unveiling ceremony of the monument *Loners 1:2:6:21* in Lucija and the monument *The Sovereignty of the Free Territory Belongs to the People of This Territory* in Izola took place on Tuesday, 5 October 2004.

Kaverljag Workshop 010 – CEEPUS 05 Ethnology of Slovenian Istria A meeting of professors and students from art academies in Krakow, Budapest, Cluj-Napoca, and Ljubljana. The meeting was a continuation of the 2004 programme and was primarily aimed at networking and exchanging teaching and creative experiences. Socializing and getting to know each other allows new ideas for a creative approach in the pedagogical process. The second objective was to produce posters and various promotional materials on the ethnology of Slovenian Istria. The result was a series of humorous posters, where, after a ten-day stay in Slovenian Istria, the participants translated their emotions into a visually effective message, and two brochures, a kind of visual travelogue through the history of Istria in the language of symbols that have been preserved to this day.

The Škocjan Caves were added to the UNESCO World Heritage List in 1986 due to their profound importance for the world's natural heritage. On the occasion of the 20th anniversary of its entry on the list, in 2006, the Škocjan Caves Park wanted to present the special features of Škocjan Caves in the form of a panoramic illustration. In **Kaverljag Workshop 011 – Škocjan Caves,** we produced a series of illustrations and one large panoramic illustration – a cross-section of the Great Valley with a section of the cave featuring drawings of the special features found there: the plant and animal species and the diversity of habitat types from the surface to the bottom of the cave in sections.

Workshop Kaverljag 012 – Hrastovlje Park of Indigenous Animals and Plants I and **Workshop Kaverljag 013 – Hrastovlje Park of Indigenous Animals and Plants II**

In the Hrastovlje Valley, local and municipal decision-makers planned to create a nature learning park to host a collection of material on rural culture and indigenous endangered flora and fauna. The park was supposed to be educational, familiarize future generations with their cultural heritage, and be of interest to tourists who want to learn more about our culture and traditions, as well as to casual visitors and people who want to spend quality time in the countryside.

In cooperation with the Department of Landscape Architecture of the Biotechnical Faculty, and the Moholy-Nagy University of Art and Design (MOME) in Budapest, we worked with two groups of students to explore the natural and cultural-historical patterns of Slovenian Istria, as a basis for finding new programmes of interest to tourists. The programme was designed to support the newly created landscape park in the Hrastovlje Valley and contribute towards creating its visual identity.

The project has built on the results of the cross-border project "Park Sloge", founded by the Park Sloge Association in Milje. The work in the workshop also touched on other protected areas (Škocjanski zatok, Sečovlje salt pans, Dragonja Landscape Park, Kraški rob).

In 2009, for the first time, we were confronted with the difficulties that blind and partially sighted people have in getting to know and perceiving the natural world. The **Kaverljag Workshop 014 – Flora and Fauna of Slovenian Istria for the Blind and Partially Sighted People** (Visual Communication for the Blind and Partially Sighted People) was a new milestone in the development of the programmes.

The Škocjanski zatok Nature Reserve is of vital importance due to its rich flora and fauna that include numerous rare and endangered species and its unique location in the immediate vicinity of the city of Koper, which provides excellent opportunities for recreation, education, and experiencing nature. The objectives of the institution managing the reserve, the Bird Watching and Bird Study Association of Slovenia (hereinafter "BWBSAS"), pay special consideration to people with disabilities and blind and partially sighted people. A long-standing problem is how to guide blind and partially sighted people along the Škocjanski zatok educational trail, a trail that presents a completely new experience for them, and how to introduce them to the rich fauna and flora using the sense of touch. This is also a big challenge for artists and illustrators who base their experience on sight.

In cooperation with BWBSAS, we decided to dedicate this workshop to finding creative solutions on how to present the area's most common organisms in the form of relief illustrations and thus enable blind and partially sighted people to get to know at least a part of the natural beauty and diversity of this habitat by using the sense of touch. This was an important decision that has also influenced the future development of the Kaverljag programme. We brought together biologists, communicologists, illustrators, and students of art academies with blind and partially sighted people, in order to create tools that will help the latter learn about the flora and fauna of Škocjanski zatok. It is about highlighting the challenges that marginalized groups face, about creating a more welcoming environment, and educating blind and partially sighted people. The project also provided the opportunity to learn about science for target groups that were previously excluded.

Experts, BWBSAS staff, naturalists, conservationists, and ornithologists guided us around Škocjanski zatok and shared their extensive knowledge. Members of the Inter-Municipal Association of the Blind and Partially Sighted Koper and their expert staff elaborated on how blind and partially sighted people perceive the world, and the increased sensitivity of their other senses, such as hearing and especially touch.

We gradually developed the bird's visual image from a simple, stylized form to a very rich and realistic image. Blind and partially sighted people used touch to follow the increasingly complex form and gave feedback on what details they could still sense. Using this and similar methods, we have forged the key to creating effective science illustrations for blind and partially sighted people.

The lectures in the first part of the workshop provided expert and reliable information that served as a basis for the creative work that followed. In the second part of the workshop, different art solutions were proposed for depicting the most common birds living in Škocjanski zatok: a series of drawings and sketches, colour illustrations, stencils for intaglio and blind printing, jigsaw puzzles, paper leaflets, origami, cut-outs, etc. A mock-up of a "new book" was also created for sighted youngsters, where they can identify the illustrations using the sense of touch and thus get close to the world of blind people for a moment. This is a very innovative book for sighted people so they can put themselves in the shoes of blind people. As with all the workshops, we organized a press conference and an open house day.

Creating visual communication for the blind and partially sighted requires very specific approaches. But working with the blind and partially sighted has been a remarkably positive experience, with all participants expressing a desire to continue with similar projects. This is also evident from the solutions, the scientific illustrations for the blind and partially sighted, and also from the subsequent activities, as several of the participants – students at the time – decided to dedicate their diploma to this topic and to continue creating content for the blind and partially sighted in their career.

After the workshop, in 2010, we began editing the material and preparing the publication of the book *Dotakni se ptice* (Touch a Bird). This was a very demanding editorial, design, and printing (technological) job. It measures 27 x 23 cm, has 16 pages/sheets bound with spiral binding. In the introductory text, I talk about the project and Borut Mozetič describes ten different birds. The text is typeset in large print (24 pt) for the partially sighted people and in braille for the blind people. The book was published by the Kaverljag Association and designed by me, with illustrations by Anita Lozar, Zarja Menart, Mitja Mihelič, Lucija Pale, Tanja Prevejšek, Aleš Sedmak, and Judit Voros. The text in braille was written by Blaž Pavlin and the book was printed in Koper at the Stražar printing house in 2010. The book was made possible by various funders, sponsors, and donors: European Agricultural Fund for Rural Development – EAFRD; Municipality of Koper; Luka Koper; Intesa Sanpaolo Bank, Vzajemna insurance company.

The book presentation and the exhibition of the illustrations took place on the premises of the Community Association of Šmarje in March and April 2010. The book was warmly received by visitors and the media. Experts in the field of visual impairments often gave feedback on the book, for instance Aksinja Kermauner, PhD, in her letter from 10 May 2010:

> *"Dear Sir or Madam,*
> *Today I took your book to school and showed it to the most critical audience – our children. They examined it with great interest and were avid with excitement!!!*
> *Congratulations on a really beautiful and useful creation!"*

Concurrently with the development of the programme for blind and partially sighted people, we continued with the CEEPUS programme in line with the objectives set in 2002, 2004, and 2005, and upgraded it with content of vital importance for Slovenia, the Carniolan honey bee, and carried out **Kaverljag Workshop 015 – Apis Mellifera Carnica.** The Carniolan honey bee (*Apis mellifera carnica*), is a breed of honey bee (*Apis mellifera*) native to the Balkan Peninsula. It is the second most common honey bee breed in the world and for historical reasons, the Gorenjska region (Upper Carniola, Slovenia) is recognized as its home. By pollinating plants, bees are indispensable for food production and biodiversity. They pollinate most plants and fruit trees, allowing plant species to develop, thrive and spread, and also have an important impact on food production. Humans and their activities, especially intensive farming, pose one of the biggest threats to bees. In Slovenia, an average of 23% of bees died in 2009–2010, and we need to be aware that bee health is something that should be advocated by everyone, from farmers and beekeepers, politicians and workers to gardeners around the world, not just locally or nationally, but globally. Therefore, the popularization of this important issue was a very important topic to be addressed at the workshop.

International Kaverljag Workshop 016 – Insects for the Blind and Partially Sighted People

In 2011, addressing a request from the Institute for Blind and Partially Sighted Youth in Ljubljana, now the Centre IRIS – Centre for Education, Rehabilitation, Inclusion and Counselling for the Blind and Partially Sighted, we focused on insects.

We continued with the programme from 2009 and 2010 and realized from the very beginning that insects are particularly difficult to depict, as blind and partially sighted people cannot touch live animals. The illustrations and, subsequently, the book for blind and partially sighted people are a big challenge, especially for visual artists who essentially deal with sight and vision. The experience and the results of the previous workshop were a great foundation for us to continue our work.

This was a very holistic and comprehensive project, as it works on several levels. First, we educated the young workshop participants on insects, a small part of nature that plays an important role. An important aspect of the project was to also encourage solidarity and promote tolerance among young people, in particular with a view to strengthening social cohesion. And the third important aspect of the workshop was to provide blind and partially sighted people with tactile illustrations in the form of a book introducing them to insects. Creating a quality work of art, especially one that has a lasting benefit for certain target groups, has a very positive effect on young authors. Based on our experience, we can see that there is a noticeable difference between students who have been involved in workshops and those who have not. The former have a much more positive attitude towards creative work and their studies than the latter.

In an interdisciplinary multicultural eight-day workshop, which took place between 8 and 16 July 2011 in Kaverljag, in collaboration with partners from Italy (Academy of Fine Art of Lecce), Poland (Jan Matejko Academy of Fine Art, Krakow), Hungary (Moholy-Nagy University of Art and Design, Budapest), and Slovenia (UL AFAD), as well as colleagues from the National Institute of Biology (NIB), the Inter-Municipal Association of the Blind and Partially Sighted Koper (IMABP Koper) and the Union of the Blind and Partially Sighted of Slovenia (UBPSS), we searched for creative solutions and produced relief illustrations. Nineteen students and eight tutors from Poland, Hungary, Italy, and Slovenia took part in the workshop. The young participants were able to combine their theoretical and practical knowledge with the opportunity to understand differently abled people. As in the previous workshop, the project connected young people with experts in visual communication, illustration, and biology, and blind and partially sighted people.

By opening up borders and offering young people the opportunity to learn about and interact with different cultures, the classes, meetings, and gatherings were aimed at strengthening young people's positive awareness of other cultures. Through discussions, art techniques, group work, presentations, and cuisine, young people encountered different cultures. This fostered creativity and mobility in culture and education, the openness and flow of arts and culture, intercultural and international dialogue, and developed a sense of tolerance and understanding of diversity (otherness).

Expert presentations of the perception of the environment of blind and partially sighted people, their direct involvement in the workshop programme, socializing with the participants, communication, and, finally, the creation of a medium for blind and partially sighted people to facilitate their perception of the living world and help to overcome prejudices against differently abled people, especially blind and partially sighted people. With an annual programme of workshops, the project develops a sense of tolerance and understanding of diversity and fosters young people's willingness to help others, especially people with visual impairments.

Through in-depth work at the workshop and in subsequent activities, we built upon the results of the workshop and developed standards for presenting science content to people with visual impairments. And standards are crucial for readers with visual impairments.

Insects are small, so we chose to present each insect in life-size and enlarged scale. We cannot get as much information from the sense of touch alone, compared to sight, so students reduced the amount of information to better present a particular type of insect. When we reduced the amount of data and only highlighted the essential visual features, we provided more quality information to help people identify a particular insect. We have depicted them in a typified way, as we have found that individual, artistic interpretation can overload the perception of blind and partially sighted people and thus prevent a clear picture of the depicted object.

In order to make it easier and quicker for blind and partially sighted people to recognize the features of each insect, we decided on uniform rules for creating illustrations, which resulted in a consistent book design. A frame separates the illustrations from the text. The motif is centrally positioned in the frame for easy orientation and the insect is always facing upwards. All insects are illustrated from a bird's-eye view. Despite the differences that can be observed between insect specimens in nature, the left and right sides of the insect are illustrated symmetrically. There is at least 1 cm of space between the frame and the motif so that a blind or partially sighted person can distinguish between the object of observation and the orientation aid.

Due to the vast illustrative material (the workshop produced a series of over 180 illustrations, of which over 60 are relief prints), we considered the idea of making two books in the days after the workshop. Due to the complexity of the preparations for printing and the printing itself, we were limited in scope and could have presented 12 insects in one image with corresponding text in braille. In this case, users would only be able to obtain certain information by touching. The second concept was to present the insect in all its developmental stages (larva, adult), highlighting the difference between the male and female specimens, the top and bottom view, and thus offering more information about the individual insect. This contextual approach was possible because the workshop participants illustrated both male and female specimens of a particular species and highlighted the difference between the sexes. We chose the latter concept because it is also more appropriate from a professional point of view and closer to the concept of natural history and popular science illustration.

INSECTS UP CLOSE

The final product of the project, the book *Žuželke od blizu* (Insects Up Close), measures 42 x 30 cm in size, has 24 pages and a Japanese spiral-bound cover. The introductory text by Al Vrezec, PhD, introduces the insects of Natura 2000. The book contains descriptions and illustrations of three different insects. The text is in large print (24 pt) for the partially sighted people and in braille for the blind people. The book was published by the Kaverljag Association, designed by Hana Jesih under the supervision of Prof. Zdravko Papič, and printed in Krakow by Rafarl s.c. in 2012, with special paper and clichés made in Germany. The book was made possible by various funders, sponsors, and donors: European Youth in Action Programme, Public Fund of the Republic of Slovenia for Cultural Activities, Municipality of Koper, Adriatic Slovenica, Intesa Sanpaolo Bank, Nova Ljubljanska banka, A. Mlinar d.o.o., Rotary Club Koper, Association of Lions Clubs, Distrikt 129, Slovenia. The book has received a lot of attention, including from the media and especially from those for whom it is intended. Here is one piece of feedback we received:

"The book 'Žuželke od blizu' is a precious gift from the authors, not only for the blind and partially sighted, but also for sighted children, teachers, and all book lovers. In the book, blind and partially sighted people will find a presentation of three virtually unknown insects which, I dare say, they have no chance of seeing anywhere else, except in this specially adapted technique. A short and concise description of the insect is followed by several typical pictures showing the insect in life-size and enlarged scale and from different angles. The quality of the illustrations is impressive, as it is clear at first glance that they could only have been created on the basis of the author's excellent knowledge of tactile sensory in general and the specific perceptual needs and abilities of people with visual impairments. As such, the book can serve as a very good teaching aid. Blind and partially sighted children will be able to learn about the structure and characteristics of insects, learn orientation on paper and in space, practice touch, and become familiar with the characteristics of a tactile image. By flipping through the book, sighted children will be able to enter the world of their blind and partially sighted peers, empathize with their needs, and test their own sense of touch. Teachers will be able to use it to enrich their lessons in different subjects and to contribute to education for harmony between different people."

Sonja Pungertnik,
BSc in Defectology, radio presenter (blind since birth)

IN CONCLUSION

We chose natural sciences and ecology as the theme of the International Kaverljag Workshops. Already in 1998, we recognized that these are two topics that are crucial for our future in the broadest sense of the word. They are also interdisciplinary in nature, involving a range of natural and social sciences, and offer an excellent opportunity for students to try their hand at scientific illustration and visual communication design.

Another objective for the workshops was multiculturalism and integration in the European space. Getting to know different national cultures and concepts preserves and strengthens national and cultural specificities, while on the other hand allowing an understanding of these cultures. We have collaborated intensively with the faculties and academies involved in the CEEPUS programme. The workshops were aimed at students and professors from Slovenia and other European countries, where small groups (teams) developed their ideas into useful products.

A third important objective was socially responsible communication with different target groups, educating and raising awareness among young people about environmental conservation and promoting tolerant attitudes towards the differently minded, as well as people with different social and cultural backgrounds.

The work was carried out under the mentorship of an expert committee of professors from the UL AFAD, Department of Design, now the Department of Visual Communication Design, scientists, and other experts and in a unique milieu away from the usual faculty premises and studios, where students could focus exclusively on the task at hand.

The project also focused on developing specific educational work methods, such as teamwork and group problem-solving, by introducing the methodology of scientific research, delivering information and content effectively, and providing optimal conditions for creative work. This includes the rhythm of lectures, studio work, meals, rest periods, field visits, the quality of equipment and materials, and a team spirit. We have thus developed a precise and efficient method for the eight-day workshop, which allows the participants to be extremely creative and productive. One important aspect is the search for fresh and unconventional approaches and ideas in visual communication. The aim of each workshop was to develop a communication and illustration strategy and concrete design solutions for the content selected that year. Here is a brief note from one of the visiting professors sharing his experience:

"In 1995 I started teaching at the CEEPUS organization as a guest lecturer in the international exchange programme for professors and students at the universities of Budapest and Ljubljana.
After getting to know the professors, a few workshops and exchanges, I came to Kaverljag in 1999...
From then on, almost every summer, if we were able to, we would get on a school bus and head towards Kaverljag.
The environment, the programmes, the expert lectures, and above all the eco-cultural approach were unforgettable every time, which immediately motivated all the students and colleagues from the foreign academies to work towards the 'worthy' goal. The free spirit and the atmosphere that were present throughout the workshops in Kaverljag flowed freely among the workshop participants. The creative spirit and mood helped foster inclusion, education, and friendship.
Koper, Soline, Hrastovlje, iced wine, unforgettable cuisine. It was there I learned that the Boškarin and the grey Hungarian cattle are of the same bloodline, that helping the blind and partially sighted to gain 'visual' experience can even be the subject of a diploma. Interdisciplinary discovery and learning about nature has been and continues to be a great experience, a valuable learning lesson.
But there is something I haven't mentioned yet ... The fact that all this has been possible is certainly thanks to Aleš Sedmak, Neva, and their family."

László György Pálfi,
retired professor at MOME

If scientific illustration allows the reader to "see" information that we cannot normally see, blind and partially sighted people can only touch it, so the illustrator has the challenging and important task of creating information for those who cannot see.

In 2012, the Kaverljag programme was discontinued, but it was revived by former students and workshop participants, now professors at the academies in Krakow, Budapest, Lecce, and Ljubljana, and the Kaverljag International Summer School programme continues in a renewed and upgraded form.

I would like to thank Prof. Lech Kolasinski from the University of the National Education Commission in Krakow, Prof. László Nagy from the Moholy-Nagy University of Art and Design in Budapest (MOME), Prof. Antonio Rollo from the Academy of Fine Arts of Bari, and above all, Assist. Prof. Marija Nabernik and the team of professors from UL AFAD for making the continuation of this programme a reality.

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FOCUSED OVERVIEW OF A SYSTEM FOR PRODUCING TACTILE REPRESENTATIONS OF ORGANISMS USING 3D PRINTING TECHNOLOGY

KAVERLJAG INTERNATIONAL SUMMER SCHOOL 2024 FROM THE STUDENTS' PERSPECTIVE

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Keywords
International Summer School Kaverljag 2024, tactile illustration, 3D printing, marine organisms, user-centred design, stylization, reduction

Abstract

The paper provides a comprehensive description of the processes involved in the International Summer School Kaverljag 2024, with a particular emphasis on the procedure for creating three-dimensional printed representations of organisms. The creation of a tactile representation of organisms using three-dimensional printing entails multiple pivotal stages that guarantee the accessibility, perceptibility, and quality of the end product. The initial phase encompasses the study of the selected organism, incorporating scientific illustration and the analysis of anatomical characteristics. The illustration is then stylized and reduced, maintaining biological accuracy while adapting the shape for tactile perception. The next step involves vectorizing a simplified illustration following standardized criteria adapted for optimal tactile sensing. The authors present the transfer of vectors into 3D modelling software, the conversion into 3D form and the technical adaptations that contribute to a better tactile experience. The project encompassed not only the basic illustration but also the intricacies of the organism, such as specific textures or body parts, thereby facilitating a better comprehension. The project integrated diverse 3D printing technologies and materials to ensure optimal outcomes. The authors present the final product in a systematic manner, incorporating all the elements in a tactile kit: the organism's name in braille, the basic illustration, and the detailed three-dimensional component. The article provides a structured presentation of the 3D printing technologies and materials employed in the project, emphasizing the integration of tactile elements to enhance the viewer's experience. The article also describes the design of the exhibition, where tailored descriptions and sound clips have been used to further enhance understanding.

Project leads:

→ Marija Nabernik, Aleš Sedmak

Project lead organizations:

→ Academy of Fine Arts and Design, University of Ljubljana, Ljubljana, Slovenia
→ Kaverljag Society, Šmarje, Slovenija

Project partners:

→ Academy of Fine Arts of Bari (Accademia di Belle Arti di Bari), Bari, Italy
→ Moholy-Nagy University of Art and Design – MOME (Moholy-Nagy Művészeti Egyetem), Budapest, Hungary
→ Faculty of Art, University of the National Education Commission (Wydział Sztuki, Uniwersytet Komisji Edukacji Narodowej w Krakowie), Krakow, Poland
→ Academy of Arts and Culture in Osijek (Akademija za umjetnost i kulturu u Osijeku), Osijek, Croatia
→ Center of Illustration (Center ilustracije), Ljubljana, Slovenia

Participating institutions:

→ Union of the Blind and Partially Sighted of Slovenia (UBPSS)
→ National Institute of Biology (NIB)
→ Marine Biology Station Piran, Slovenia
→ Faculty of Education, University of Primorska (Pedagoška fakulteta, Univerza na Primorskem), Slovenia

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→ Aleš Sedmak, academic painter, president of the Kaverljag Society

Guest lecturers:

- → Prof. Dr. Lech Kolasiński, Faculty of Art, University of the National Education Commission, Krakow
- → Mag. Tim Prezelj, Faculty of Education, University of Ljubljana
- → Prof. Antonio Rollo, Academy of Fine Arts of Bari
- → Dr. Claudio Batelli, Faculty of Education, University of Primorska, Education Institute of the Republic of Slovenia, Koper
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- → The project was supported by the Municipality of Koper.

Results:

- → *What I Look at and What I See: Marine organisms for people with visual impairments*, exhibition, Center of Illustration Gallery, Ljubljana, 10 September–6 October 2024.
- → Visits to institutions, schools and guided tours of the exhibition.
- → *What I Look at and What I See: Marine organisms for people with visual impairments*, Insula Gallery, Izola, Slovenia, 10 October–6 November 2024.
- → Visits to institutions, schools and guided tours of the exhibition.

1. INTRODUCTION

A group of six students, including three illustration students and one industrial design student from the Academy of Fine Arts and Design, University of Ljubljana, as well as two biology students from the Biotechnical Faculty, University of Ljubljana, participated in the Kaverljag Summer School and in the subsequent phases of preparing the exhibition. Collaborating in such a large team was for us an almost new experience. Now that the work is completed, one of the biology students and the industrial design student have shared their impressions in this monograph, hoping that their experiences will contribute to future initiatives for blind and partially sighted people. In the present article, we focus primarily on the aspects that are not emphasized in other parts of this work. We discuss the overall organization of the Summer School and present the details of the systematic approach developed for creating tactile illustrations with 3D printing technology.

2. WHO SHOULD BE INVOLVED IN A PROJECT WHEN WORKING WITH THE VISUALLY IMPAIRED, AND WHY?

Society and technology are constantly evolving, influencing each other. This relationship is evident in all spheres. For instance, the development of infrastructure and transportation has led to globalization, and, through a positive feedback loop, globalization accelerates the technological advancements that enable it. A similar interdependence can be observed, for example, in the way human relations change in response to the development of communication technologies. Adaptations for marginalized groups must keep pace with all these changes, but simultaneously, new technologies offer new possibilities for adaptations. Consequently, adaptations must be a part of a continuous process of updating and adjusting to social and technological change, rather than being the subject of a one-off project.

Therefore, the development of adaptations for people with visual impairments—who represent a marginalized group—is also an ongoing and dynamic process. Developments in technology require new adaptations. Braille books and the invention of braille typewriters (braillers) enabled blind people to communicate in writing; however, with the advent of computers and the internet, this no longer sufficed. Braille keyboards and braille displays, in a way a counterpart to e-readers, were introduced. The emergence of touchscreen smartphones without keyboards presents a new challenge; nevertheless, it can be overcome through software solutions. Some smartphones can play back the text displayed on the screen, and an increasing number of websites and applications also offer different accessibility settings, such as changing text size and contrast. There is rapid development. Who therefore needs to be involved in work on such projects, and what insights can we gain from them?

(Future) experts: The time scope for developing adaptations extends beyond the lifetime of an individual, and if the project is an intergenerational initiative, this ensures succession. The participation of students in the project enables the transfer of knowledge to younger generations newly entering the workforce. By familiarizing ourselves with people who are different from the 'standard' human being already at the level of sensory experience, our perspective is broadened. We examine what the statistically average person is and find that none of us actually corresponds to the archetypes. We begin to think more open-mindedly and act through considering different perspectives, gaining experiences that drive us to co-creating an inclusive society.

International dimension: The inclusion of people with visual impairments in society is a challenge on a global scale and must be addressed as such. It is not sensible to limit our search for solutions to a single country. That is why, besides Slovenian participants, the Summer School also brought together students, lecturers, and mentors from four other European countries: Croatia, Italy, Hungary, and Poland. Through the international exchange of knowledge and experiences, the project promotes a more efficient way of finding better solutions, bringing us closer to a unified system for producing materials aimed at the blind and partially sighted at the international level.

Interdisciplinarity: The production of illustrations is primarily the task of the illustrator. However, the success of such an integrated project requires collaboration between multiple disciplines. The participating illustrators needed knowledge of marine organisms. For this reason, they were provided with lectures on marine biology and visited the Marine Biological Station as well as the Piran Aquarium, Slovenia. Throughout the process, the collaboration of two biology students provided an opportunity for expert advice. Next, we deepened our understanding of the target users. The lectures were given by various experts with experience in creating solutions for the blind and partially sighted. Moreover, the illustrators' skill sets varied: some participants specialize in traditional illustration, others lean towards digital work, and a few practise 3-dimensional modelling. The industrial designer student also played a key role in the project, managing the practical aspects of the implementation phase, handling technical details, and finalizing the exhibition layout.

Challenges of working in a team

For the students, the project served as an introduction to the process of creating materials for the blind and partially sighted. Simultaneously, the project offered our student group general insights into the experience of collaborating on a large-scale project. In this way, we realized that general organizational skills are extremely important. To begin with, all participants need to be aware of the project's objective. Understanding the end goal facilitates our intermediate decision making, ultimately leading to the optimal outcome. The project should also be headed by a clearly identified manager. This person delegates tasks to the other participants and monitors their work. To ensure that the work is coordinated, all participants are kept properly informed. Communication noise, word-of-mouth transmission of information, and lack of information are best avoided by implementing an organized information system. In practice, this simply entails scheduling regular meetings attended by all the participants. Meetings are the occasion for discussing and agreeing, and, more importantly, reaching agreements. When addressing an issue, it is crucial to not only adopt a concretely defined solution but also assign a specific individual or team to implement it. These are just some of the simple and purely pragmatic rules that ensure the success of a well-conceived project.

3. DEVELOPING A SYSTEMATIC APPROACH TO 3D-PRINTED TACTILE REPRESENTATIONS OF ORGANISMS FOR PEOPLE WITH VISUAL IMPAIRMENTS

Following the International Summer School, a small group of students continued the project, establishing a preliminary system for creating tactile representations of organisms using 3D printing technology. Developing tactile content within a unified system is crucial for three reasons: accessibility, perception efficiency, and quality. Various learning aids for people with visual impairments are often handmade in one or a few copies as they are designed for specific individuals. Authors of such aids aim to mitigate the lack of accessible didactic materials. Although these examples of tactile content are particularly important, they remain inaccessible to a broader user base due to their production methods. Information in this type of content is usually presented inconsistently, affecting the efficiency and speed of perception. The implementation of uniform methods for presenting and organizing information, along with maintaining content credibility, contributes to the third aspect: the quality of the material. In the case of tactile illustrations of marine organisms, quality derives from anatomical accuracy.

The basic starting point for the preliminary version of the system is represented by the two tactile books—*Dotakni se ptice* (Touch a Bird) in *Žuželke od blizu* (Insects up Close)—which are the results of the previous Kaverljag Summer Schools, and the thirteen sets of illustrations of organisms produced during the International Summer School 2024.[1] The project differs from previous ones both in its subject matter (marine organisms) and in the choice of production technology. To create tactile representations, it relies on the use of 3D technology, specifically 3D modelling and 3D printing. This technology was chosen for its widespread use, low production costs and ease of reproduction, enhancing accessibility and enabling creation of materials in line with the interests of target audience. The system for producing tactile representations of organisms integrates a tactile simplified illustration of the whole organism, a 3-dimensional detail of a certain part of the organism, the species name of the organism in braille and an accompanying text describing the organism.

The established system guidelines were applied to a set of illustrations of five marine animal species produced during the International Summer School. The choice of species was challenging, as marine life is very diverse but at the same time poorly known. Despite covering most of the Earth's surface, only a small percentage of the seabed has been explored by mankind. First, we limited the selection to Slovenian species and, in the next step, excluded the organisms that are easier to represent in other ways. For example, it

1 For a more detailed description and information on the production process, see article by Assist. Prof. Mag. Marija Nabernik, p. 102.

is not sensible to design teaching aids for fish, as they can be experienced more effectively and holistically if they are simply purchased from a fishmonger. Similarly, bivalve and gastropod molluscs are best represented by their shells. From the remaining groups of organisms, we selected those in which reduction would not result in substantial information loss. In practice, this means that we opted for species with at least a slightly flattened body structure; the starfish meets this criterion, while the barrel jellyfish does not, as it is difficult to represent in two dimensions. In the final stage, we selected organisms that are as different from each other in body structure as possible, to best capture the rich diversity of marine life. The final selection of organisms consisted of the common cuttlefish (*Sepia officinalis*), the long-snouted seahorse (*Hippocampus guttulatus*), the Mediterranean green crab (*Carcinus aestuarii*), the green chiton (*Chiton olivaceus*), and the smooth brittle star (*Ophioderma longicaudum*).

The five tactile representations prepared under the first version of the system were presented during two exhibitions (*What I Look at and What I See: Marine organisms for people with visual impairments*, exhibition, Center of Illustration Gallery, and *What I Look at and What I See: Marine organisms for people with visual impairments*, exhibition, Insula Gallery) and evaluated through testing involving visually impaired individuals.

Presentation of the process for creating tactile representations

The following section describes the process for creating tactile representations using the long-snouted seahorse (*Hippocampus guttulatus*) and the Mediterranean green crab (*Carcinius aesturaii*) as examples. The respective illustrations were realized under the first version of the system developed for creating tactile representations with 3D technology. Each of the five tactile representations includes the Slovenian name of the organism printed in braille, a simplified illustration of the organism that is distinguishable from the background, and a detail, i.e. a realistic, magnified representation of a part of the organism.

Tactile illustration

Prior to simplifying the illustration, it is essential for the designer to gain a deeper understanding of the organism and, if possible, represent it in a scientific illustration. Subsequent to this, the designer proceeds with stylization and reduction, taking into account both the biological and the graphical aspects. Through this process, it is important to maximize the clarity of the representation while retaining enough anatomical detail to ensure that the illustration is not misleading. These two aspects conflict; on one extreme, the illustration becomes overly stylized, resulting in an unscientific representation, while on the other, photorealistic accuracy is achieved, where noise overwhelms the information.

Concurrent with the simplification process is the development of a description for the selected species, which explains the animal's biology and relates it to its physical structure. Moreover, it provides guidance on how to explore the illustration through the sense of touch. The texts were written by the two biology students involved in the project. For less familiar animals, the description begins by situating the organism within the tree of life, highlighting related species or the broader group to which it belongs. This provides a general understanding of the animal's approximate identity. What follows is a description of the physical structure of the species. The individual body parts are listed in sequence according to their position on the animal's body; in this manner the text seamlessly guides the user through tactile exploration of the illustration, avoiding interruptions. Next, the animal's ecology is briefly outlined, focusing on its habitat and diet. Lastly, information regarding the animal's size is presented. The descriptions were also included in the exhibition as audio recordings, which visitors could listen to through headphones located near the tactile representations.

Description of the long-snouted seahorse:

The seahorse is an unusual fish. It owes its name to the shape of its head, which resembles that of a horse. Its head is positioned perpendicular to the body, and its mouth extends into a snout. There are also a pair of tiny fins on the head. It has a dorsal fin growing out of its back, and another very small fin just beneath its abdomen. It has no tail fin, which makes it a poor swimmer. It lives among seagrass, which it holds on to with its prehensile tail. By swimming slowly, it inconspicuously approaches tiny crustaceans and other small organisms, sucking them up with its snout. The eggs are taken care of by the male seahorse. Until they hatch, it carries them in a special embryo sac located at the lower part of its abdomen. The seahorse grows up to 14 centimetres in length.

Description of the Mediterranean green crab:

The Mediterranean green crab has a strong, flattened, pentagon-shaped shell. At the front of the shell, it has short antennae, and alongside these, eyestalks with eyes that can retract into the eye sockets. The sides of the shell feature spikes offering additional protection. It moves with four pairs of legs, while the fifth pair of appendages consists of pincers that it can use to pinch. It uses them for both defence and picking up food. It is most commonly found on sandy, silty banks, where it hides between individual stones. It also often roams on land. It is not picky and feeds on what it finds: dead organisms, small animals, and algae. It can grow up to six centimetres.

The next step involves adapting the simplified vector illustration. First, the size is determined. The organism should be positioned on the surface so that the outermost parts of the illustration touch the edge of an imaginary 17 cm diameter circle. The suggested dimension is based on the size of an adult's two hands (as people with visual impairments typically use both hands simultaneously for tactile exploration) as well as on the constraints posed by the size of the printing area (printers commonly use a 20 × 20 cm plate). The subsequent step entails dividing the illustration into areas featuring broader 1.5 mm lines to represent prominent elements, such as the organism's outline and distinct anatomical features; narrower 0.75 mm lines for details like texture representation, patterns, and minor structures; and planar elements to depict features such as eyes, appendages, fins, or to distinguish different organism parts. When editing an illustration for the visually impaired, symmetry should be considered where anatomically appropriate (e.g. the symmetric arrangement of walking appendages versus the differing sizes of the left and right crab pincers). It is important that the method for adapting illustrations is uniform and consistently applied to all organisms. Finally, the appropriately sized illustration is positioned at the centre of a larger circle with a diameter of 19 cm. This circle defines the boundary of the tactile area and clearly separates the illustration from the text in braille and the representation of an individual detail.

The next step involves transferring the vector illustration into 3D modelling software and converting it into a solid by means of the 'extrude' command to add thickness. The circle with the diameter of 19 cm is 1 mm thick and has an edge that is 1.5 mm wide and 2 mm thick. The illustration rises 1 mm above the surface. The edges are rounded using various tools available in the selected program to create a more pleasant and secure feeling when experiencing the image through tactile perception.

The last phase is the production of the tactile illustration using material extrusion technology, more specifically fused deposition modelling (FDM). The selected technology offers the possibility of producing models from thermoplastics, which are heated and transformed into a semi-liquid form as they enter the extruding head. The melted thermoplastic strands are bonded together within the same layer and between adjacent layers through a process of polymer fusion or sintering. The size of the nozzle is an important factor in limiting the printing scope, as it determines the accuracy of the printed design. In the case of illustration printing, the chosen technology offers the advantage of simple post-processing, which is frequently not necessary (Muck 2015, 71–80). A commonly noted disadvantage of the technology is the stepped transitions

Figure 1: Participants and mentors of the Kaverljag
International Summer School 2024
(Petra Černe Oven, personal archive, 2024)

Figure 2: Long-snouted seahorse
(Petra Černe Oven, personal archive, 2024)

Figure 3: Mediterranean green crab
(public domain, online source:
https://en.wikipedia.org/wiki/Carcinus_aestuarii)

Figure 4: Long-snouted seahorse, print
(Žiga Gorišek, project archive, 2024)

Figure 5: Long-snouted seahorse, embossed print
(Žiga Gorišek, project archive, 2024)

Figure 6: Mediterranean green crab, print
(Žiga Gorišek, project archive, 2024)

Figure 7: Mediterranean green crab, embossed print
(Žiga Gorišek, project archive, 2024)

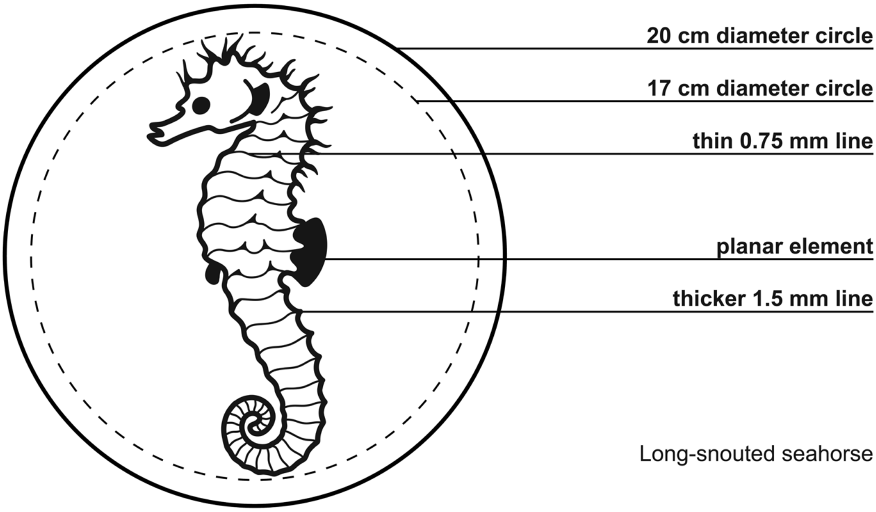

Figure 8: Long-snouted seahorse, vector illustration
(Zoja Čepin, personal archive, 2024)

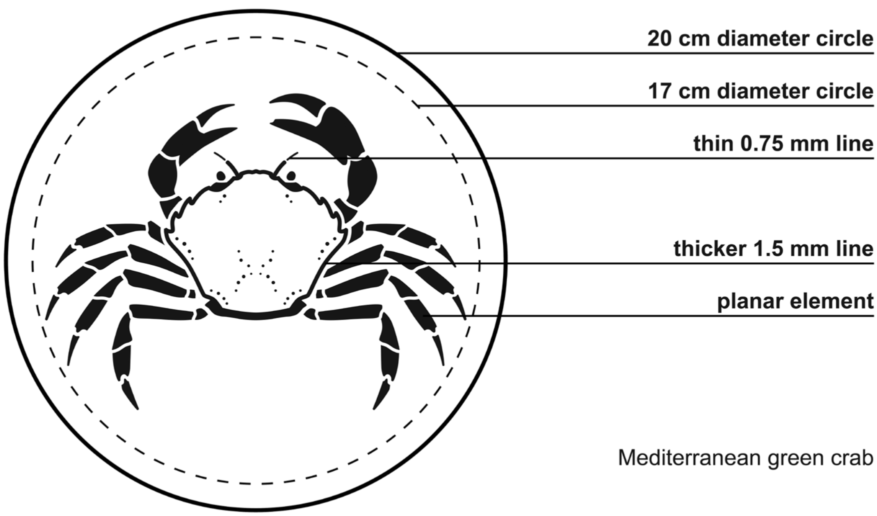

Figure 9: Mediterranean green crab, vector illustration
(Zoja Čepin, personal archive, 2024)

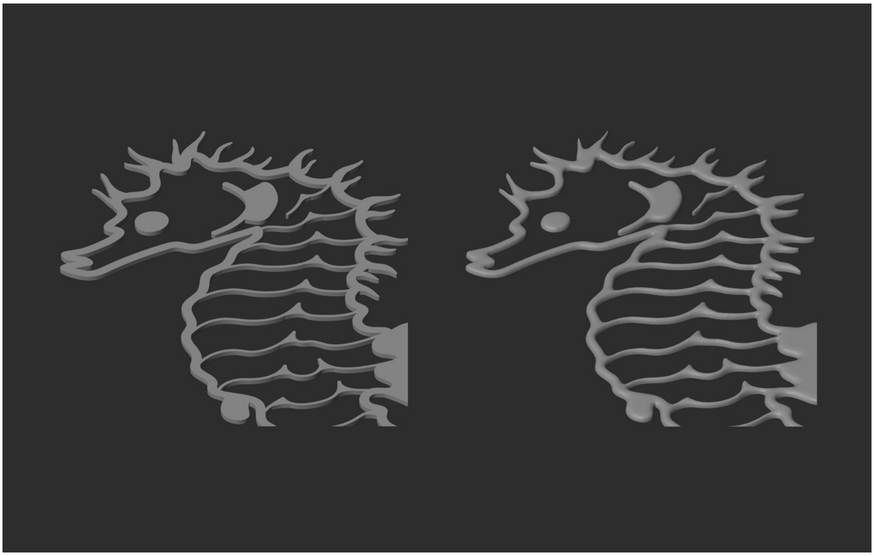

Figure 10: Long-snouted seahorse, rounding the 3D model edges (Damir Omić, personal archive, 2024)

Figure 11: Mediterranean green crab, rounding the 3D model edges (Damir Omić, personal archive, 2024)

Figure 12: Detail accompanying the illustration
of the long-snouted seahorse
(Žiga Gorišek, project archive, 2024)

Figure 13: Detail accompanying the illustration
of the Mediterranean green crab
(Žiga Gorišek, project archive, 2024)

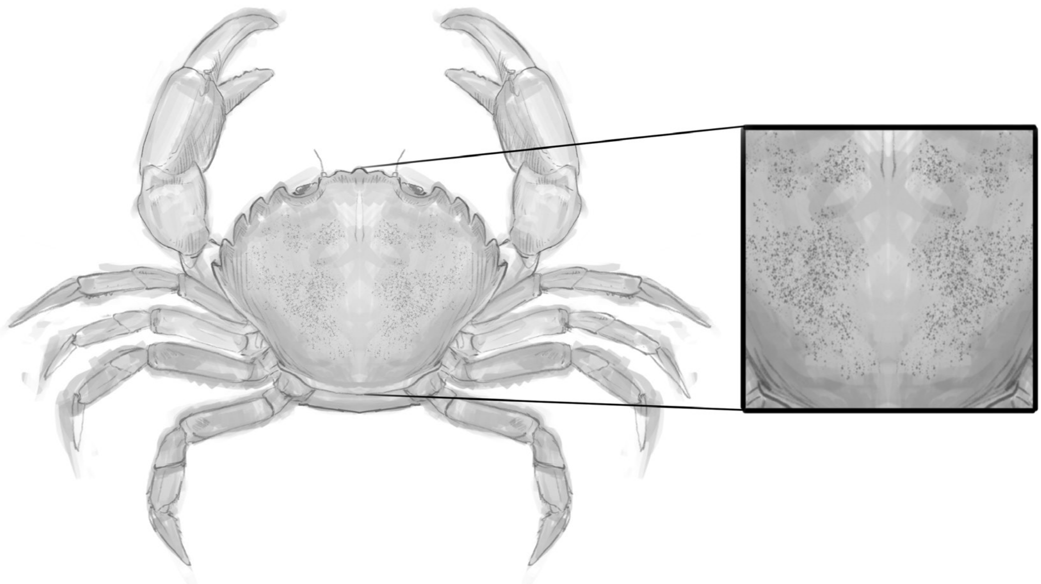

Figure 14: Sketch for producing
the detail of the long-snouted seahorse
(Ana Turičnik, personal archive, 2024)

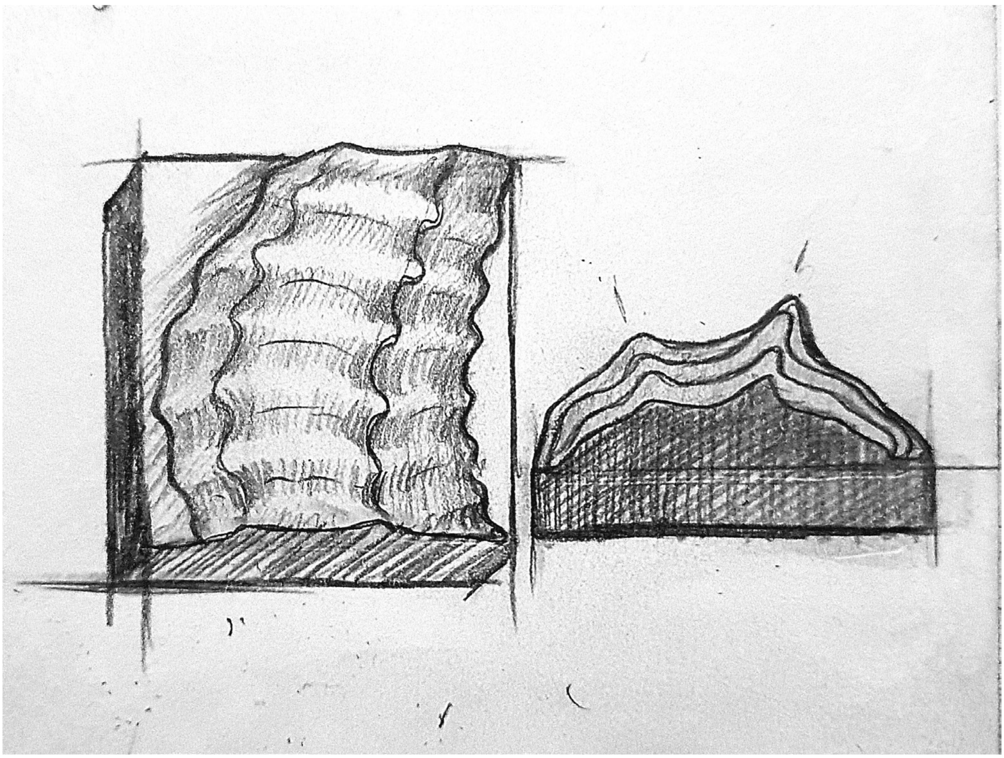

Figure 15: Sketch for producing
the detail of the Mediterranean green crab
(Damir Omić, personal archive, 2024)

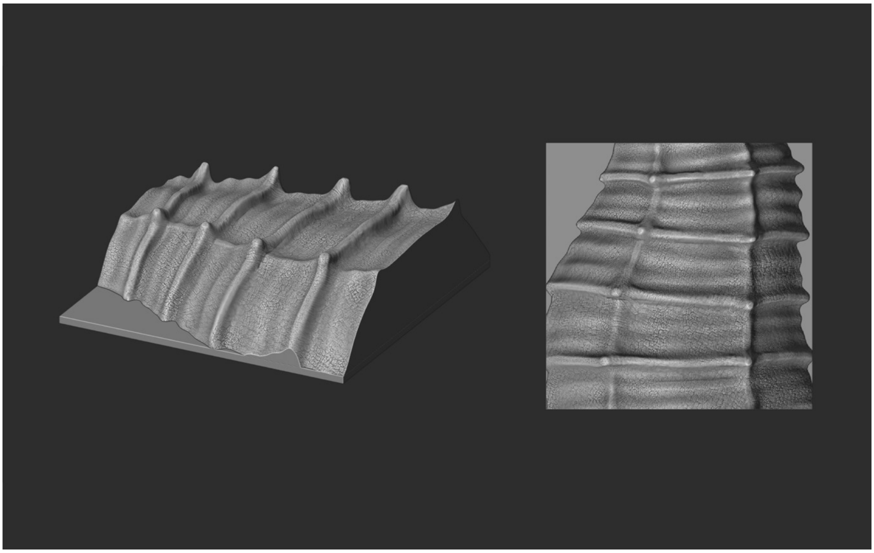

Figure 16: 3D model of the detail, long-snouted seahorse
(Damir Omić, personal archive, 2024)

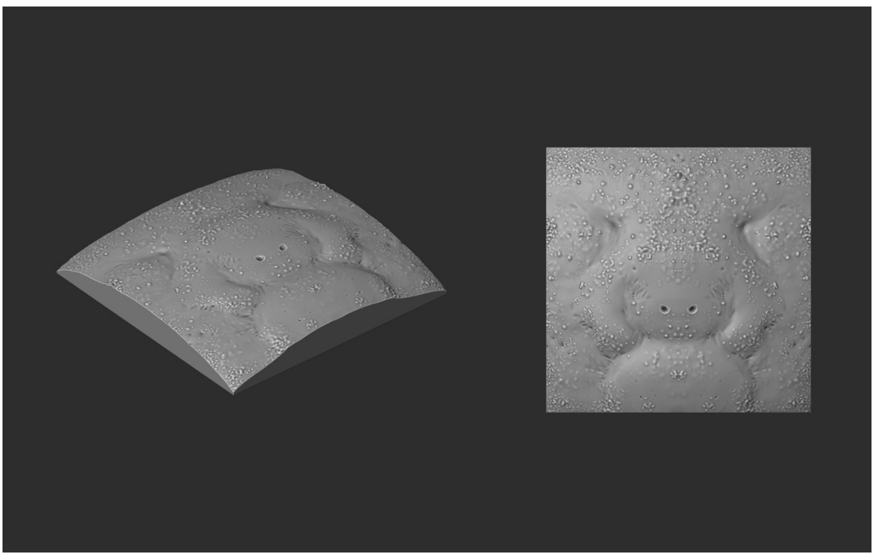

Figure 17: 3D model of the detail, Mediterranean green crab
(Damir Omić, personal archive, 2024)

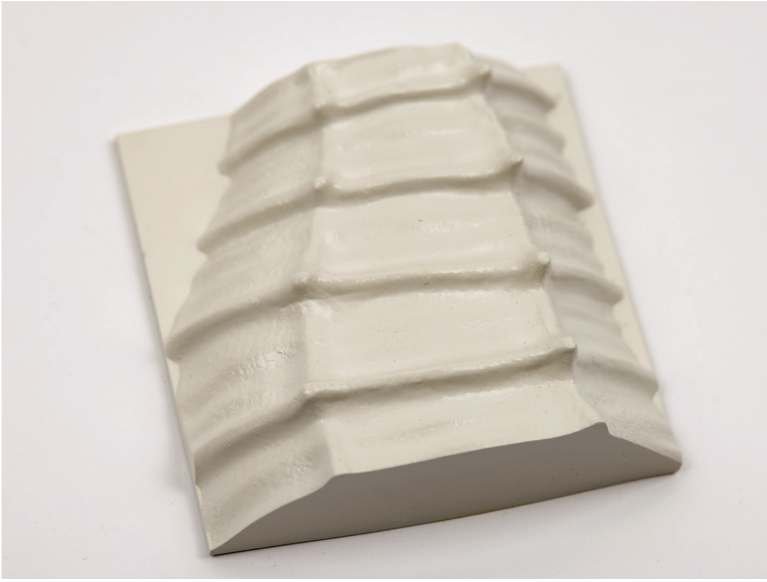

Figure 18: Long-snouted seahorse, detail
(Žiga Gorišek, project archive, 2024)

Figure 19: Mediterranean green crab, detail
(Žiga Gorišek, project archive, 2024)

Figure 20: Long-snouted seahorse,
tactile representation in a form of a plate
(Žiga Gorišek, project archive, 2024)

Figure 21: Mediterranean green crab,
tactile representation in a form of a plate
(Žiga Gorišek, project archive, 2024)

Figure 22: Exhibition *What I Look at and What I See*,
exhibition at the Center of Illustration Gallery
(Žiga Gorišek, project archive, 2024)

Figure 23: Presentation of the
long-snouted seahorse at the exhibition
(Žiga Gorišek, project archive, 2024)

Figure 24: A visitor at the exhibition *What I Look at and What I See*
(Žiga Gorišek, project archive, 2024)

Figure 25: Visitors at the exhibition *What I Look at and What I See*
(Žiga Gorišek, project archive, 2024)

between layers; however, these did not interfere with the tactile perception process when using a 0.4 mm nozzle. The model in the photographs is made from PLA.

Detail – a realistic representation of part of an organism

The detail serves as a supplementary element to the tactile illustration, providing insight into a part of the organism with an interesting surface. The incorporation of a realistic representation of a part of an organism part enhances the tactile exploration of the organism. The perception of the simplified form is thus enriched by realistic complexity, enabling people with visual impairments to obtain more information about the organism.

The first phase consisting of the selection of the detail of the organism is based on identifying a key element for understanding the organism, while also ensuring it is tactilely engaging. There is no uniform method of identifying the detail to be represented, as the choice depends on each individual organism. When possible, the representation from the most representative view is preferred (for marine organisms, typically from above, but sometimes from the side or front).

Subsequently, a sketch of the selected part of the organism part is prepared, which serves as the foundation for the design in the 3D modelling software. During the sketching process, the enlargement and placement of the segment on a 9 × 9 cm square surface are determined.

The solid is created in the selected 3D modelling software. Compared to creating a tactile illustration model, constructing a detail model requires a better knowledge of the software, as more complex, organic structures predominate. The surfaces of organic models mostly feature rounded edges and are therefore composed of a large number of polygons. The greater the number of polygons, the more accurate the model. If the produced model will be fixed, it is essential to identify the fixation method and design the undersurface of the model accordingly.

The subsequent step involves producing the model using technology based on vat photopolymerization, particularly stereolithography apparatus (SLA). The printing process entails curing of the photopolymer using a guided external light source (laser or DLP projector). The light source scans the surface of the liquid photopolymer and cures the model's walls. Next, a new layer of liquid filament is evenly levelled, and the photopolymer surface is allowed to settle completely. The process is repeated for each subsequent layer. SLA is an 'additive' technology and as such requires a base and support structures to ensure successful production of a model. Supports need to be printed for all model parts with an angle of inclination less than 30 degrees or greater than 150 degrees. After the completion of printing, post-processing follows, with the primary step being additional UV curing. The irradiation process imparts the final strength to the model. The advantages offered by the chosen technology are high-quality surface and precision, enabling the printing of details and braille. The primary disadvantage concerning the creation of the accompanying detail lies in the complex, time-consuming processing, which also has an adverse ecological impact (Muck 2015, 82–88). For the creation of the model, photosensitive resin was used.

A set of tactile representations

To enhance the efficiency and speed of perception, the final stage of creating a tactile representation of an organism consisted of assembling all elements into a set. The method presented below arises from the need to produce tactile representations for the exhibition. Future project development could focus on exploring alternative methods for organizing and linking the different parts of an organism, as well as storing a larger collection of organism representations.

The individual elements of the organism representation are arranged on an A3-sized panel. At the top, there is a plaque with the name of the organism printed in braille; below, a circular base features a simplified illustration of the organism; and, finally, at the bottom of the panel, a realistic, enlarged representation of a section of the organism is displayed within a square. The uniformity achieved through color and texture of all elements enhances the tactile distinction between the touchable elements and the empty space on the panel.

Exhibition *What I Look at and What I See*

The results of our work were presented at the exhibition *What I Look at and What I see: Marine organisms for people with visual impairments*. It was opened at the Center of Illustration (Stritarjeva ulica 7, Ljubljana), where it was held between 10 September and 6 October 2024. Subsequently, it moved to the Insula Gallery (Smrekarjeva ulica 20, Izola), where it was displayed between 9 October and 6 November. The exhibition's content aimed to showcase the diverse living world of the Slovenian part of the Adriatic Sea. More than 20 species of marine animals and algae were represented. Although a substantial portion of the content was adapted for people with visual impairments, the exhibition was also intended for a general audience, promoting awareness of the importance of inclusive design.

The atmosphere was created by the sounds of the sea played through loudspeakers. On the walls of the exhibition space, we displayed the original works by the participants of the Kaverljag Summer School—linoprints and embossed prints—along with the results of intermediate stages in the creative process—sketches, watercolors, and digital drawings. The centrepiece of the exhibition was the representation of five marine animals in the form of tactile sets, uniformly produced following the system described in this article. Since tactile illustrations are easier to explore on a fixed horizontal surface, we placed the sets on shelves at a height slightly above one meter, rather than adopting the conventional wall display method. The sets were not fixed, allowing individuals, including children, who might have difficulty accessing the shelves, to try interacting with them. Each set was accompanied by a description of the animal's biology, available in printed text form and as an audio track played through headphones.

4. LOOKING FORWARD

The project, carried out within the context of the International Summer School Kaverljag 2024, was conceived very broadly with the intent to establish a system for improving the accessibility of illustrated didactic materials for people with visual impairments. Although the project was designed for a clearly defined target group—individuals with visual impairments—the outcomes of the International Summer School also appeal to a wider audience. Through both exhibitions, we introduced visitors to the experience of perceiving information by touch and hearing and encouraged them to explore alternative ways of 'seeing'. Tactile representations, in particular, offer sighted people the opportunity to learn about organisms in a different manner. These materials also resonate well with children, who, in addition to visual information, commonly rely on tactile feedback. Inclusive design thus demonstrates that, through careful consideration and involvement of marginalized groups, it is possible to enhance the experience not only for the target user but also for the wider public.

By incorporating new technology, the foundational work developed by previous Kaverljag Summer Schools has served as the basis for a preliminary version of the system to produce 3D printed representations. It is crucial that the project does not stop at this point, but instead offers a launchpad for designing a system that will be freely available on an international scale. The refinement of the existing system should be guided by the insights obtained during the development of tactile representations and their testing with users.

By developing the solution and expanding the range of organisms (currently, only five species are adapted according to the system), students of illustration and other disciplines acquire one of the key skills for designing didactic materials tailored to people with visual impairments: the ability to simplify, which is associated with highlighting key information. Through the process of designing tactile content, students gain competences that enable them to identify the essential aspects in an information-saturated world and communicate them in a comprehensible way. The presented project of the International Summer School can thus serve as a potential reference for choosing project topics that challenge students, professors and external collaborators of the Academy of Fine Arts, University of Ljubljana. Engaging in learning and exploration through inclusive design, where users actively participate in the work process of an interdisciplinary group, empowers students to acquire skills of collaboration, develop empathy, and gain experience with proactive engagement in addressing social issues.

By taking part in projects like these, we become aware of the urgency to contribute to the societal development, both as design students and as members of the broader society. The inclusion of marginalized groups is not optional; it is a duty of contemporary society. Hence, progress in this field is essential, and through such interdisciplinary, international, multicultural, and intergenerational projects, we work towards the ideal of a society that values equality and provides equal opportunities for all.

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SCIENTIFIC ILLUSTRATION AS A PEDAGOGICAL TOOL IN INTERDISCIPLINARY PROJECTS

Marija Nabernik

Keywords

visual communication, non-fiction illustration, scientific illustration, drawing as a teaching method, natural sciences, interdisciplinarity

Abstract

We first encounter scientific illustration at a very early age, when we get our hands on our first popular science picture book, or when entering the education system. Most of us learn from scientific illustration, and some of us create it. Among the latter are students of illustration at the Academy of Fine Arts and Design in Ljubljana. Scientific illustration is part of our curriculum, and we also explore it further in specific workshops and summer schools. In this paper, we will present the methods used in this learning process. We will discuss how the visual arts and science are connected and how they can work together to help us understand, create, and design educational content and teaching aids. We will define scientific illustration and its place in the field of illustration. We will explore its forms and expressive techniques. We will touch upon established codes and conventions in depicting images. Our focus will be on the use of illustration as a method in pursuit of a learning outcome. We will introduce the drawing method used in teaching natural science illustration. The process of working on the project Marine Organisms for the Blind and Partially Sighted, where we created tactile illustrations for the blind and partially sighted, will be presented in detail. In this project, we also involved expressive techniques that had specific properties which had the potential to achieve the desired final result.

SCIENCE – SCIENTIFIC ILLUSTRATION – FINE ART

Science and art have always inspired each other, even intertwined at times. This is beautifully illustrated by the still popular book Art Forms in Nature (*Kunstformen der Natur*, 1899–1904) by Ernst Haeckel (1834–1919), which has both scientific and artistic value.

It was made possible by the scientific invention of the microscope, which gave the author an insight into the world of the microorganisms he then painted. Many artists of the time were inspired by his work. Among them were Wassily Kandinsky (1866–1944) and Paul Klee (1879–1940) (Prezelj, 2019, 92–102). Even though the works belong to the field of scientific illustration, as they faithfully reproduce reality and document biology, a new, aesthetic way of systematizing forms emerges here. Haeckel's popularity coincided with the dramatic industrialization in the West, which caused artists to look to nature for inspiration in an increasingly urban landscape. Thus, his work became a reference for the Art Nouveau movement. Artists such as Émile Gallé, the famous Catalan modernist architect Antoni Gaudí, the "father of the skyscraper" Louis Sullivan, the designer Louis Comfort Tiffany (Tiffany's) and the architect René Binet, who designed the monumental gates of the 1900 Paris World's Fair, all looked to Haeckel's illustrations for inspiration (Kazior, 2021).

Scientific illustration has become an inspiration for other genres of fine art in the aforementioned cases, but it is also a genre of fine art itself, found in business, science, and art (Sedmak, 2014, 3).

FICTION AND NON-FICTION ILLUSTRATION

Illustration belongs to the field of visual communication (Male, 2019, 9). Its creation involves a multi-layered design process. In addition to an excellent knowledge of the subject matter and visual language, one must take into account the interests of the client and the level of visual literacy of the target audience. At the same time, illustration is an open art form, allowing for original authorial approaches and enhancements to the themes covered.

Basically, illustration can be divided according to the subject matter it deals with. The most basic division is between fiction and non-fiction illustration. The former is in dialogue with fiction and the latter with non-fiction literature. The former is clearly focused on the creative expression of the illustrator, the latter on the precise presentation of information. The facts presented in non-fiction illustration must be accurate and well explained; the illustration merely reflects them in another language – that of the visual arts.

Let us think more broadly about illustration and try to define it in terms of its roles. These cover the different fields that the illustrations pertain to. These are: storytelling, documentation, education, reference, commentary, advertising, and identity, which are considered as the basic categories of illustration according to illustrator, academic, and professor Alan Male (Male, 2017). According to this interpretation, non-fiction illustration would fall under the documentation, education, and reference categories of illustration.

In the book *History of Illustration*, they highlight four categories: to document (to visually record a thing or person), to narrate (to explain as well as to entertain), to persuade (to establish, maintain or discredit ideas), and to embellish (to enhance life or to concretize it through decoding) (Doyle, Grove, Sherman 2018, 17).

Non-fiction illustration covers all genres of literature that primarily deliver knowledge: non-fiction, professional literature, informational literature, scientific and popular science literature, and instructional literature. Non-fiction literature has its own laws regarding content delivery, but the artistic value of the author's storytelling could also classify some of these works as fiction. But this is not its primary purpose; these are essentially works that offer knowledge about the world, and the author's style, when providing the readers with information and explanations, can be helpful in understanding the subject (Bilban, 2024, 20–25).

The same applies to illustration that accompanies such texts. It has the role of conveying information, and its aesthetic value can at best aid this informative function, but this is not the primary purpose of illustration. Often, when we read information from an image, we do not pay attention to the aesthetic aspect at all, or we only note it in passing – so if we are not distracted by anything, all is well. The authorial or aesthetic value of a non-fiction illustration is most noticeable when it is taken out of its educational context. When the original illustration created for a botanical handbook is displayed on a gallery wall, its artistic value may be more prominent, while its educational function will be in the background.

AREAS OF NON-FICTION ILLUSTRATION

Depending on the content that the illustration depicts, several further divisions can be made. Non-fiction illustration is divided according to the sciences it covers: exact and natural sciences, technical (engineering) sciences, medical sciences, agricultural (biotechnical) sciences, social sciences, humanities, and arts.

Depending on the target audience for which the illustration is intended, we speak of scientific and popular science illustration. When the content, and therefore the accompanying illustration, is explicitly intended to communicate scientific content to a wider audience, we can speak of popular science illustration.

FORMS OF ILLUSTRATION DEPICTING REALITY

Scientific illustration, when naturalistic, can show a typical specimen (of a plant, animal, mineral, etc.) and not necessarily a random one, as a photograph can do perfectly when created by a skilled documentary photographer. When it is informative in nature, it can become purely schematic and focus on individual parts (morphology, anatomy, layers, etc.), usually explaining these in words next to indexes or in a legend alongside the illustration, using letters or numbers in the image. When explaining a temporal sequence, it uses a sequence of pictures—similar to a comic strip—thus depicting the progression. Using this method, an illustration depicting the life cycle of an amphibian, for example, can use sequences to show a temporal progression, development, and growth all in one picture. Conceptual illustration is perhaps the

	NON-FICTION (scientific, popular science illustration)
AREAS	→ EXACT AND NATURAL SCIENCES: mathematics, logic, cybernetics, physics, mechanics, astronomy, chemistry, biology, botany, zoology, genetics, biochemistry, biophysics, ecology, geology, meteorology, geophysics, geography. → TECHNICAL (ENGINEERING) SCIENCES: metallurgy, mining, mechanical engineering, civil engineering, electrical engineering, electronics, computer science, aeronautics, chemical technology, textile technology, geodesy, civil technology. → MEDICAL SCIENCES: medical science, microbiology, dental medicine, pharmacy. → AGRICULTURAL (BIOTECHNICAL) SCIENCES: agronomy, forestry, wood science, food technology, veterinary medicine. → SOCIAL SCIENCES: political science, economics, statistics, informatics, communication studies, sociology, history, archaeology, geography, ethnology, anthropology. → HUMANITIES AND ARTS: philosophy, aesthetics, philology, linguistics, psychology, pedagogy, didactics, literary and art history, musicology.
ROLES	→ DOCUMENTATION → REFERENCE → EDUCATION
EXAMPLES	Educational posters, textbooks, workbooks, teaching materials, board games, manuals, technical monographs, lectures, technical manuals, dioramas, medicine packaging, graphic summaries of scientific papers, etc.

Table 1: The table shows the different areas of non-fiction illustration, what its roles are and some practical examples of illustrations.

most challenging form of non-fiction illustration. In such a case, one must summarize an entire research project, or an entire article, in a single image. This type of illustration is multi-layered and requires the author's in-depth knowledge of both the subject and the visual language, together with all its codes of understanding. Illustrators use conceptual illustration when creating graphic summaries of content.

ILLUSTRATION TECHNIQUES

Nowadays, without thinking too much, we have to say that digital techniques are the first choice among expressive techniques for illustrators. Vector and bitmap drawings have been joined here by 3D modelling. Illustrations are also still made using classical painting techniques such as pencil, crayon, watercolour, ink, tempera, gouache, acrylics, oil paint, pastels and oil pastels, or in combinations thereof. In the past, but less frequently today, illustrators have used graphic techniques such as woodcut, etching, or lithography. In the past, these were of particular interest because of their reproductive value and have strongly influenced the field of illustration throughout history. Reproductive techniques have also dictated the form of illustrations, their appearance, and the methods of reduction and stylization. Illustrations can also be made using image-capture techniques. In his book *The Scientific Image*, Harry Robin calls this method auto-illustration (Robin, 1992). Photography, as well as other image capturing devices (e.g. X-ray, MRI, radar, etc.) can be an excellent tool for creating a non-fiction illustration in a work that intends to display a naturalistic image from the environment or a snapshot of a circumstance, a measurement. In all other cases, we are closer to reality using the other illustration techniques.

CODES AND CONVENTIONS IN SCIENTIFIC ILLUSTRATION

From the perspective of today's visually overloaded world, the historical example of colour coding for artists and scientists detailed below is perhaps unusual but extremely interesting.

In 1814, a very interesting booklet entitled *Werner's Nomenclature of Colours* was published in Edinburgh. It was reissued in 1821, with additions, and adapted to be particularly useful to artists and scientists. It was written by Abraham Gottlob Werner (1749–1817), an eminent mineralogist and geologist. He is also known for his book on the external characteristics of fossils and minerals, published in 1774. In this book, he creates a scheme for identifying minerals by key characteristics, especially colours. Werner's pupil Robert Jameson (1774–1854) linked colours to specific minerals, which served as a starting point for art teacher Patrick Syme (1774–1845), who named and described colours for the colour charts in the aforementioned book published in 1821. The nomenclature is a system, arranged in a table, that numbers, names, and arranges the colours in a colour pattern and then describes them using animals, plants, and minerals. Today it is hard to imagine why this would be so important, but in the days before photography, scientists and illustrators dealt with very different problems than today. They were on research expeditions recording and describing new findings and they needed a system that would provide a common language, even when it came to colour. The specimens they brought back from their expeditions often faded over the years and had to be described precisely. The nomenclature was widely used by artists and scientists of the time, including the young Charles Darwin (1809–1882), who took a copy of the booklet with him on his voyage on the HMS Beagle in 1831–36. He used it to help him with the terminology used to describe his discoveries. He wrote that he consistently compared colours using the booklet in order to portray them as accurately as possible. The use of the nomenclature also marks his writing style, with phrases such as "hyacinth red" or "chestnut brown" (Syme, 2018, 4–51).

Visual codes in science have almost always evolved to meet practical needs. Unlike the previous example, which describes colours consistently according to a realistic image, colours can also deviate from reality. As an example, the distinction between veins and arteries in medical illustrations is made using blue and red. We know that in reality all blood vessels look very much alike. In photographs, it would be difficult to distinguish them. But that is exactly why in medical illustrations, which sometimes also depict surgical procedures, it is even more important to use an illustrative colour system that leaves no doubt: the cool blue against the warm red is accurate in interpreting the positions of veins and arteries. If veins are blue and arteries are red, what colour will the nervous system be, what colour the lymphatic system, and so on? The colours in the codes are usually based on reality but deviate when they are given an additional purpose of differentiation.

In addition to colour codes, we also have texture systems. An example of this can be found in geological illustrations. On geological maps of the surface, one can see areas marked with different patterns that indicate different geological materials on the Earth's surface. The patterns represent the usual lithology of rocks. Geological maps use systematized patterns for rocks such as sandstone, shale, mudstone, conglomerate, granite, breccia, volcanic ash, or limestone. They vary from parallel lines, dashed patterns, crossed lines, point patterns, patterns with circles, or curves. Again, this is an agreed use of artistic language within the discipline. Here, new meanings and content are attributed to the patterns according to convention.

ADAPTATIONS OF ILLUSTRATIONS FOR THE BLIND AND PARTIALLY SIGHTED

When creating illustrations for a specific target audience, we need to pay attention to their needs. In the case of designing or illustrating for the blind and partially sighted, we have adapted the material to a system that some of them are already familiar with and used to, which means that the experience will be easier for them. And that is the braille writing system. It already has set rules that we can follow when designing illustrations. One of these is the thickness of the line we use. So, the thickness of the line comes from the diameter of the dot in braille. The image can be read by touch with the help of relief. For those who can still perceive light to a certain percentage, it takes into account the contrast of the image. The greatest contrast is achieved with black against white.

When designing illustrations for the blind and partially sighted, the starting point was the previous Kaverljag summer schools, which resulted in two tactile books *Dotakni se ptice* (Touch a Bird) and *Žuželke od blizu* (Insects Up Close), where they also came up with some useful and measurable results in workshop formats.

If most visual codes in science have developed gradually, out of practical needs and by convention, here rigorous testing with users is crucial. They tell you how much detail they can still sense by touch and what helps them in perceiving and understanding the image.

INTEGRATING DRAWING AS A LEARNING METHOD IN INTERDISCIPLINARY PROJECTS

For many years now, as an introduction to the field of non-fiction illustration, I have been using a quick drawing-by-description exercise in which I give illustration students a brief description of a plant or animal, which they then try to summarize in a sketch based on the description alone. For example, in an introduction to botanical illustration for third year illustration students, we do this exercise using descriptions of plants. We focus on plants that are familiar to us on account of their everyday use, such as food crops, fruit plants, or herbs. I deliberately do not disclose the name of the plant in the description – I merely give the students a description written by experts. It refers to the plant's size, the arrangement of its leaves and their shapes; to its flowers, fruits, stems, and also to the underground parts, if necessary. The descriptions have about 1000 characters (including spaces). They can be read quickly and students can refer back to the text as they draw.

When students start reading the descriptions, they first notice that they are not familiar with the terminology of botany. They try to figure out what the words mean from the context, as they have to focus on drawing. For example, what does it mean that a plant is right-handed, what are glaucous leaves, what is a rosette on a plant, where is the pistil located, etc.? They try to draw what they understand, the way they understand it. They try to interpret the words they read and link them into a logical image based on their general knowledge of plants.

The results are always similar. The "mistakes" they make in the interpretation create completely new plants – imaginary plants. Looking at the actual plant next to the students' drawings, we often have to laugh. Horseradish turns into beetroot, tomatoes into berries. They realize that, beside knowledge, good observational skills are crucial when creating scientific illustrations.

After the exercise, students listen to a lecture on botanical illustration, and are introduced to historical aspects of the development of botanical illustration, as well as examples of plant depictions through time. These include depictions of plants in early pharmacopoeias. One of the best known is the pharmacopoeia by Pedanius Dioscorides (ca. 40–90 AD), *De Materia Medica* – also known as the first botanical book. The book was reproduced and circulated among researchers from 78 AD onwards and is considered to be the forerunner of all botanical books. From the sixth century onwards, illustrations can be also be found in the transcriptions of his manuscripts (Lee, 1999, 20).

The first illustrated manuscript based on Dioscorides' work is dated before 512. It is considered to be the oldest version, presenting almost the entire text, which is accompanied, among other things, by original illustrations of plants. The manuscript is known by several titles, deriving from its ownership, which has changed several times over the centuries; Codex Aniciae Julianae, after its first owner, the Byzantine princess Juliana Anicia (died 527), Codex Cnastantinopolitanus, Codex C, Codex Byzantinus, after Constantinople or Byzantium (today's Istanbul, where the manuscript was kept for almost a thousand years), and finally Codex Vindobonesis or Vienna Dioscorides after the Austrian city of Vienna, where it has been kept since 1569 (Lack, 2018, 22–24).

The book, which was translated and later copied and printed in many languages, is mostly accompanied by illustrations. However, the authors of these illustrations created them purely on the basis of the descriptions, losing the educational, documentary role of the illustrations and sticking to a purely decorative one. If we want to capture information of an educational nature in an illustration, we need in-depth knowledge and understanding of the subject, only then can we depict it. Only later annotated reprints of the *De materia medica*,

Figure 1: Drawing marine organisms from descriptions alone
(Petra Černe Oven, project archive, 2024)

Figure 2: Illustrations of marine life: scientific illustration and graphics
(Nik Erik Neubauer, project archive, 2024)

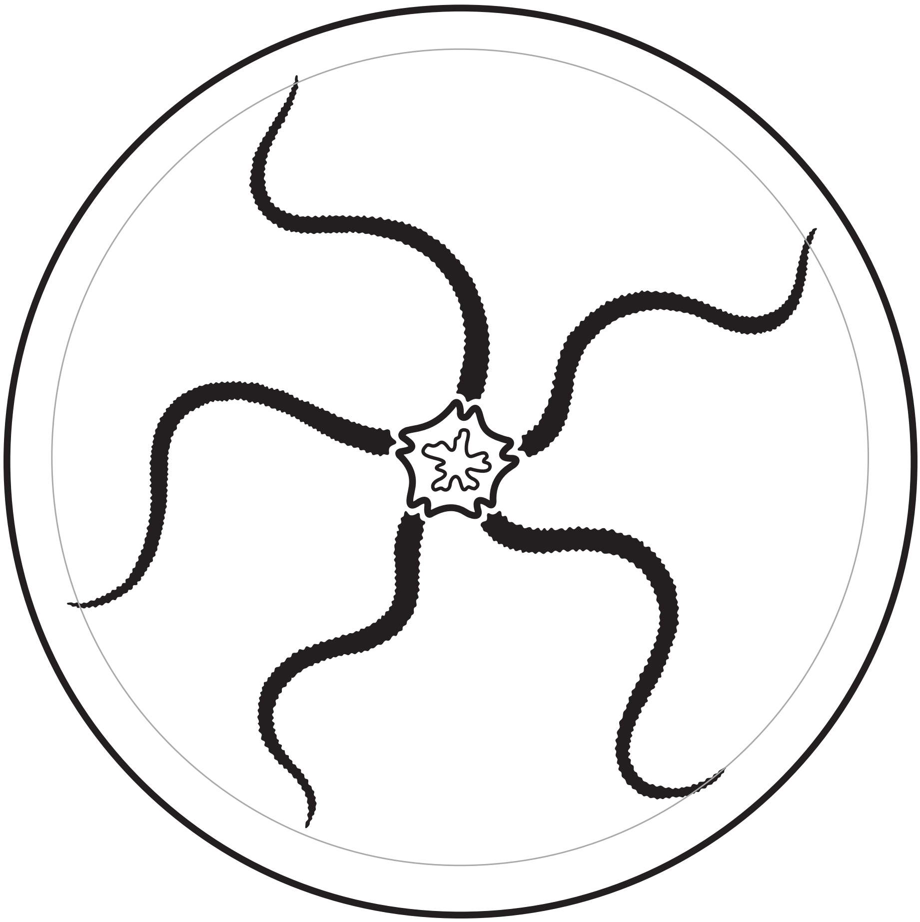

Figure 3: Vector drawing
(Ana Turičnik, project archive, 2024)

Figure 4: Illustrations in 3D print
(Petra Černe Oven, project archive, 2024)

such as that of Pietro Andrea Mattioli, are accompanied by illustrations, which have a documentary, educational, even taxonomic role (Aitken 2007, 57–60).

The exercise of drawing from descriptions, which seems logical in the training of illustrators entering the world of scientific illustration, can be applied to students who have no drawing background with quite similar results. I carried it out with a group of biology and landscape architecture students. The results were quite similar, even though some students had more botanical background and less drawing background and others had knowledge in both areas. I carried out a similar exercise with a group of professors and students of education, this time using descriptions of insects. The results are always similar.

In these exercises, the participants learned that description alone does not provide enough information to identify plant and animal species – let alone to be able to depict them scientifically. This requires more in-depth knowledge. If you know the plant or animal and are provided with a description, it's a bit easier, but it's still difficult to be precise. We are sloppy observers, and this is even more apparent when we try to draw something from memory. Participants who were experts in botany or entomology or marine organisms also reported that drawing requires a completely different kind of attention compared to observing or learning. Once they have learned to draw something based on observation and study, they also have a different attention to detail or a different focus when observing, leading to a keener eye for detail. Because without the necessary information, drawing is mere guesswork. Although the drawings depict plants and animals, the illustrations are more fiction than reality, even though they are based on descriptions by experts. Thus, through a practical example, we realize that in order to create a realistic non-fiction illustration, we need to go a few steps further. The basis is, of course, a background in art. In addition to the textual description, we need to know the subject in detail. It is best to observe it in nature, in the field. Where this is not possible, we can visit greenhouses, zoos, museums, and herbariums, analyse specimens, and compare our work with existing illustrations and photographic material. When drawing, we can consult experts in the relevant field. This is the only way to pay attention to the key elements that make an illustration professional. It may also happen that during the drawing process we highlight a detail that an expert has maybe not yet noticed and thus investigates it further.

The exercise is certainly useful for future scientific illustrators, but it is also interesting for researchers. In fact, processes occur during drawing and depicting that help in understanding and remembering content in a different way.

WORKING METHODS FOR CREATING ILLUSTRATIONS OF MARINE ORGANISMS FOR THE BLIND AND PARTIALLY SIGHTED

In the project Kaverljag International Summer School, where we worked on depictions of marine organisms for the blind and partially sighted, we tried a variety of depiction techniques on the way to the final results. Why?

Careful planning helps you achieve your goals faster and with greater precision. Sketching with pencils allows us to take quick notes when learning about organisms and studying them in the field. Gouache and watercolour are considered time-consuming techniques, but they allow the artist time to think while creating. They also allow a high level of detail, which helps to study the subject in detail through painting. Understanding detail is key in the simplifications and stylizations of forms that are required in graphic depictions. The chosen graphic technique of linocut forces us to reduce/simplify shapes and at the same time allows us to convert lines and shapes into relief form. In our case, it also serves as a sketch for conversion into a vector drawing, which is the basis for modelling in three dimensions. In this case, printing in three dimensions is the final technique used for creating the illustrations, as it allows us to reproduce them easily.

Context and Preparation Through Research

Already before the summer school began, a small group of students had started researching topics in biology and design for the blind and partially sighted. At the summer school, an extended group first learned theory by attending lectures, field trips, and by way of experiential learning with a typhopedagogue, and then got down to practical work – illustration.

A Quick Exercise in Drawing from Descriptions to Get into the Topic

Before getting into scientific illustration in both the theoretical and practical sense, we carried out the aforementioned quick exercise in drawing from descriptions. Just like in the case with plants or insects, the descriptions outlined visible features but did not reveal the name of the animal, this time a marine organism. Students from various design, art and biology disciplines (both first and second cycle) took part in the drawing exercise. Again, we realized that we would need to delve deeper into the subject matter if we wanted to create illustrations of marine organisms.

Learning About Organisms by Sketching and Study Drawing

Two biology students drew up a list of organisms found in the Mediterranean Sea. From this list, the participants then chose which marine organism they wanted to illustrate. Our work also included observations in the field, in this case at the seaside. There, we were able to study some of the organisms in more detail. Although we saw most of them in the aquarium in their recreated natural environment. Already at this stage, we began with visual recording – sketching, in addition to observation and note-taking. The result were study drawings that outline the basic shapes of the marine organisms, interesting details, and their habitats. The key to learning about animals is to observe how they behave in their natural environment, even when they are random specimens. But our aim is to depict a typical representative of the selected species.

Exact Depiction with Scientific Illustration

After the study drawings, we moved on to scientific illustrations of the organisms. Here, we learned about their typical features from reading the descriptions. We paid attention to what was written and took this into account in the reduction we made when drawing. With the help of reduction, we emphasized details that have an important differentiating advantage. The aim was to create a taxonomic illustration that would help us identify species. In practice, this means that we have to identify the organism shown in the illustration in the field, despite potential deviations. We therefore looked for averages between several organisms of the same species and highlighted key features that would help in recognizing certain species.

Reduction and Stylization for Easier Shape Identification

This is usually where the work of the scientific illustrator ends, because they arrive at a result that gives a consistent, factual picture of reality in a documentary way. But in our case, we had to translate the image in such a way that the information it contained would be understandable to people with or without visual impairments. In order to adapt the illustration in this direction, additional stylization was needed.

We carefully considered which were the most characteristic features we wanted to depict and focused on them. We consulted an expert and checked anatomical and other biological aspects to consider in the depiction of the specimens.

Reflecting on the Tactile Through Graphic Technique

In pursuit of the result, we used the graphic technique of linocut printing. Linocut is basically a more modern version of woodcut – historically one of the earliest rendering techniques for illustrations in reproduced books. Letterpress printing is closely linked to the development of scientific illustration, but the reasons for its use in this case were of a more practical nature. The creation of the linocut produced a matrix with deep incisions which was tactile in itself. It allowed us to print in colour or in relief when printing on damp paper. We also chose linocut because the use of special tools such as carving knives and linoleum material forced us to simplify the shapes. Even when transferring the image on the matrix (linoleum), it was necessary to simplify the shape and to make it monochrome. Once the image was drawn, it was then cut into the material. It is a process that takes time, but also allows for reflection. The tool itself led us to a specific type of stylization inherent in the letterpress technique. In our case, we cut out the image and not the background, so when we print it on paper, we get a protruding line, which is also tactile. In the case of linocut, therefore, it is possible to trace both the matrix and the print using the sense of touch – both of which we exhibited for visitors and test groups of blind and partially sighted people. We created a print with black ink and a print without ink where only the relief is visible.

Continuation of the Project in a Smaller Group

In total, the workshop produced 13 sets of illustrations of organisms, which were later exhibited. Participants of the summer school depicted a marine organism in colour—either as a habitat or a scientific illustration—and then executed it in a graphic technique with two prints – one in relief without colour and one in black and white.[1]

So, the summer school provided us with the starting materials for further work on the project. This was again carried out with a small group of students, consisting of three illustration students, an industrial design student, and two biologists. Our aim was not just to create depictions, but to find solutions to make them as accessible as possible to our target users.

1 For more information on the illustrations, see the article Kaverljag International Summer School 2024, p. 64 in this publication. (editor's note)

We have selected illustrations of five typical but diverse marine organisms: the seahorse, the crab, the chiton, the cuttlefish, and the brittle star. The biologists have prepared unified descriptions of all five organisms, highlighting typical features, which we have taken into account in the final illustrations.

The stylized images of the animals already provided an excellent starting point for conversion into a digital vector format. The basic building block of a vector drawing is the Bezier curve.[2] This is essentially a line defined by mathematical models. Most such curves consist of open points called anchor points, which are controlled by control arms that represent a tangent to the line (Caplin, 2003, 73). The lines of the drawings in the illustrations are further refined using vector lines. This helps to unify illustrations by different authors through the technique of illustration.

At this stage, we meet again as a group and define uniform parameters for all five illustrations. These include scale, defining the thickness of the lines in the dots, defining the plot to line ratio, unifying the common elements of several illustrations (e.g. the eyes of organisms), a unified artistic approach to similar situations (how to show the knuckles, how to attach the limbs to the body, etc.). We technically define the format and the position of the illustration within it. To make orientation within the format easier, we have placed the illustrations in a circle, and the realistic snippets, depicting a part of the organism without stylization, in a smaller square. The positions of the circle and the square are the same in all five illustrations, as uniformity helps blind and partially sighted people to orient themselves.

The illustration was then converted into a protruding relief shape that can be printed using a 3D printer. Here again, technical adjustments were needed as the edges of the drawing were

2 Bézier curves are named after Pierre Bézier, a French engineer and mathematician who developed the method in the 1960s while working for Renault.

too sharp in the transfer to a relief and would not have provided a positive experience for the user. The students further reworked the illustrations by skimming the edges and making them more pleasant to the touch.

The resulting illustrations are suitable for test groups, who answer a series of questions using guided questionnaires to help us refine our starting point in developing guidelines for creating scientific illustrations for the blind and partially sighted.

The tests have provided us with results that can be used to transform each scientific illustration into a tactile form.

CONCLUSION

Illustration can be created in a wide range of traditional and digital techniques, it can be an original or a printed image, and it can be in two or three dimensions, depending on what it is communicating. The "WHAT" (content) and the "HOW" (medium) are not the determining factors, it is the "WHY" (role, purpose) that determines whether an image is an illustration (Doyle, Grove, Sherman 2018, 17).

The role of the illustrations we created during the project is distinctly educational and places the illustrations we created within the scope of natural science illustration.

The main goal of the project Marine Organisms for the Blind and Partially Sighted is not only to raise awareness about nature conservation, but also to find new approaches in visual communication in the field of scientific illustration. Non-fiction literature is accompanied by non-fiction, scientific, and popular science illustrations. With various projects on the same theme, we have pursued the goal of establishing a model that could be used to adapt scientific illustrations for educating the blind and partially sighted. Using the example of marine illustration, we have got much closer to this goal. We defined the steps, including procedures and techniques, that can be usefully applied in teaching future scientific illustrators, with the aim that they will help us create functional and accessible collections of educational illustrations. We know that illustrated books for the blind and partially sighted are a rarity and we want to expand the range of content available to them. The rapidly developing 3D printing technologies and the availability of such printers in libraries are opening up new opportunities. With a foundation of properly prepared material, such educational content could be accessible on demand, extending learning opportunities for the blind and partially sighted.

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WHAT I DON'T SEE, DOESN'T EXIST SCIENTIFIC ILLUSTRATION AS A SYNERGY BETWEEN SCIENCE AND ART

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Keywords
visual models in science, scientific illustration for the blind and partially sighted, science as art, subjectivity in science, cognitive aspects of scientific illustration

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Abstract

In recent years, advances in cognitive science have been rapidly expanding our comprehension of artistic creation, yet, since the beginning, the development of science itself has been guided by art, especially scientific illustration. This is particularly pronounced in biology and chemistry, where concepts cannot be imagined without visual models such as the structure of atoms and molecules. Similarly, much of biology is based on the principle that structure (dependent on form) determines function. The field's reliance on the visual conception of scientific models not only profoundly impacts our professional comprehension of fundamental scientific concepts but also poses a major challenge in communicating knowledge to the blind and partially sighted, especially those with congenital impairment, who have more difficulties in forming normatively accepted mental representations of abstract concepts. As they do not form a visual image, their visual representation can only correspond to a model or scheme, which guides understanding but may also be misleading due to the nature of visual perception. In this sense, we are all 'blind' to certain aspects of reality, though this manifests in various ways. Developing visualizations for the blind and partially sighted is essential, as these individuals can illuminate new aspects of scientific concepts that may be overlooked by the sighted.

THE IMPORTANCE OF A SCIENTIFIC APPROACH IN ART RESEARCH

Although visual representation in science may seem to play only a supporting role by illustrating otherwise highly objective findings, this is far from being the case. Visual art, in particular scientific illustration, serves not only to depict but also significantly guides our understanding of specific scientific concepts and directions. Despite having been separate worlds in the past, which still holds largely true today, art and science converge at least in their theoretical or philosophical cores, which is perhaps most evident in the field of experimental aesthetics, founded by the 19th-century German philosopher, physicist and experimental psychologist Gustav Theodor Fechner (1801–1887). He conducted experimental and scientific studies on individuals' experiences and behaviours resulting from exposure to works of art. In doing so, he shifted an originally philosophical field into the realm of empirically measurable natural sciences, both conceptually and methodologically (Berlyne 1974).

In the 20th century, experimental aesthetics evolved primarily towards cognitive psychology and neuroscience. The modern offshoots of this interdisciplinary field, psycho- and neuroaesthetics, investigate the perception, creation and individual responses to art through neurobiological experiments. Furthermore, they examine the interactions of humans (and other animals) with objects and scenes that trigger intense and diverse emotions related to aesthetic judgement and creativity. It is a distinctly transdisciplinary field, which is gaining increasing significance across various other disciplines, including education and medicine (Skov et al 2018; Chatterjee and Vartanian 2014). The founder of neuroaesthetics is the British neurobiologist Semir Zeki, who sees art as an example of the diversity among individuals' brains. The origins of this diversity can be identified, among others, through neurological approaches which can also aid in uncovering the mechanisms behind our ability to create and experience art (Zeki 1999, 2001 and 2002). Professor Zeki even argues that artistic creation actually serves as alternative means of exploring the brain. In one of his statements, Zeki asserts:

> The artist is in a sense, a neuroscientist, exploring the potentials and capacities of the brain, though with different tools. How such creations can arouse aesthetic experiences can only be fully understood in neural terms. Such an understanding is now well within our reach. (Miller and Miller, in: Shimamura and Palmer 2012, 357)

THE IMPORTANCE OF SUBJECTIVITY AND AESTHETIC PRINCIPLES IN SCIENCE

The presented view completely merges the originally highly theoretical philosophical field of aesthetics with the experimental scientific field of (neuro)biology. From this perspective, neuroaesthetics directly integrates two seemingly separate philosophical disciplines, aesthetics and the philosophy of science, which, from a theoretical standpoint, primarily intersect on the question of the extent to which reality is (or can be) objective or subject due to an individual's conception (Nagel 1974). In defining this problem from the stance of theory of science and philosophy, a key contribution was made by Zeki's contemporaries Thomas Samuel Kuhn (1922–1996) and Karl Raimund Popper (1902–1994). Kuhn defined the development of science as a sequence of small revolutionary changes that gradually destroy the existing paradigms and establish new ones. According to Kuhn, psychological and social factors are significantly more important for scientific revolutions than empirical scientific evidence, knowledge and arguments (Kuhn 2012). Consequently, scientific development and its history are strongly dependent on subjective factors. Popper, however, completely altered the direction of science development with his theory of critical rationalism, which opposes the previously established principle of demonstrability. He based the scientific method on the principle of refutability, which posits that within experimental sciences, particularly the empirical sciences, a theory cannot be confirmed but only refuted. From this point of view, only refutable scientific theories and findings are relevant (Popper 2012 and 2014). Thus, Popper definitively confirmed the dynamic nature of science and the importance of alternative interpretations.

Subsequently, building on the theory of critical rationalism, the Austrian philosopher Paul Karl Feyerabend (1924–1994) became the first who, within his own theory, directly placed science in the context of art by positioning the philosophy of science in the realm of aesthetics. While neuroaesthetics introduces the scientific method into the study of art, Feyerabend's model, conversely, highlights the importance of aesthetic principles in science (Feyerabend 2008, 93–95).

The background of intersections and unification of art and science have been contemplated by various Slovenian intellectuals, both in the past and in recent times. The status of the interconnection between science and art has been efficiently described by the Slovenian physicist and educator Gorazd Planinšič:

> The common view of science and art is that science is rational, objective and impersonal, while art is subjective and linked to emotions; moreover, scientific theories are believed to emerge directly from observations of the physical real world, while art is considered an expression of the human mind and emotions. Such a perspective is obviously wrong. [...] Art and science are two ways of viewing the world. Both require a continuous comparison and verification of the real world around us against our mental images, representations and ideas formed in our minds. What is crucial to art and science is the ability to perceive, observe and, most importantly, interpret and generate new mental images. Experimentation is key to both fields, although it performs different roles. In natural science, experimentation serves to continually anchor theory to reality, whereas in art it promotes the development of new modes of expression.
>
> (Planinšič 2008, 150, as cited in Campbell 2004 and Trstenjak, 1981)

In terms of the presented theory, both science and art engage in experimental exploration of the world, though their conceptual starting points and thus methodological approaches differ. In (natural) science, which includes biology, experimental approaches can be roughly divided into two groups. Scientific research typically involves *experiments that are controlled as precisely as possible* and conducted primarily in an adapted environment, i.e. a laboratory. In the context of art, this can be viewed as a type of scientific atelier or studio. The alternative is creating art outdoors or *en plein air*, where artists and their creative work are exposed to unpredictable natural conditions. In science, this corresponds to a *natural experiment*, which usually involves observing and describing the state of the (natural) environment. Describing phenomena on this basis has flourished several times in the past, most recently in the 20th century under the influence of the philosophy of logical empiricism, which argues that the logical integration of information acquired through the senses provides a correct picture of reality (Bogen 2009). The dilemmas and historical dynamics of logical empiricism in science and art were also explored by Feyerabend in his work *Science as Art* (*Wissenschaft als Kunst* 1984). He concentrated on the limitations and superficiality deriving from the idea of reflecting as accurately as possible the state of things (the theory of mimesis) or reproducing the mere physical manifestation of ideas. In the domain of art, this approach had already been criticized in Book 10 of Plato's *The Republic* (Feyerabend 2008, 95). The original idea of accurately representing reality through the medium of thought, without any addition by the author, is characteristic of both art and science. While art has succeeded in distancing from this idea, it continues to be highly present in certain facets of science, although substantial shifts can be observed. Creativity is also gaining prominence in scientific work, and significant scientific discoveries are increasingly credited not only to strict adherence to scientific procedures but, more importantly, to bold flashes of brilliance from scientists, as Feyerabend notes:

> […] [G]reat science is not very different from great art. Clearly, expertise is needed in both cases. However, creative ideas are also demanded; in other words, neither scientists nor artists have to suppress their personality but can leverage it to their advantage in their research
>
> (Feyerabend 2008, 101–103).

The result of scientific work are theories that aid in explaining the scientific view of reality, which, according to Popper's theory of scientific revolutions, can lead to progress only if it evolves over time, rather than simply expanding or accumulating. This is eloquently summed up by the thought: "The stone age did not end because the word ran out of stones" (*The Economist* 1999, 59). If new theories were not presented to both the professional and general public by their authors and proponents, science would serve only itself as a sort of 'scientific larpurlartism'. The importance of presenting scientific findings, which inevitably involves an element of subjectivity, is also emphasized by Miran Možina and Urban Kordeš in one of their writings:

> Reality and cognition are linked in a circular manner, always leading us to specific individuals or groups within a specific space and time, to a special world. (Možina and Kordeš 1998, 228–229) We defend our beliefs through a social process of conversation, attempting to persuade others to believe as we do. To understand the nature of human cognition is to recognize cognition as means of justification and defending of our beliefs, rather than to provide an increasingly accurate representation of Reality.
>
> (Možina and Kordeš 1998, 238)

THE BLESSING AND THE CURSE OF MODELS IN SCIENCE

Findings and conclusions are thus interpreted using models (Frigg and Hartmann 2006; Van Fraassen 2010) or as the versatile Slovenian researcher and university professor Milica Kač wrote:

> […] We conveniently forget it is only a model and often not a 'Ding an sich' (a thing in itself). This oversight sooner or later boomerangs back on us […]. Natural science entails the observation and study of nature, which cares little whether we have a suitable model. The first duty of a scientist is therefore to recognize the model. Their second duty is to become acquainted with the model and to accept its limitations very seriously and with all responsibility […]
>
> (Kač, in: Raspor (ed.) 2013, 353).

Hence, we must be aware that despite our efforts to learn about objective reality, we still depend on subjective representations that are limited by our individual past experiences and cognitive schemata. Consequently, this means that any model, no matter how narrowly defined, will always be vague to some extent. A fuzzy concept defines an idea whose meaning can vary significantly depending on the context or conditions of use. Such a concept is objectively semantically fuzzy, but can give a sense of exactness due to its definable meaning, which can be better specified by providing a further explanation and establishing the context of use (Behlohlavek and Klir 2011). The study of the characteristics of fuzzy concepts and language pertains to the field of 'fuzzy semantics' (Zadeh 1971).

To better illustrate this, let us consider the example of a tree, which the Dictionary of Standard Slovenian (*Slovar slovenskega knjižnega jezika*) defines as 'a woody plant with a trunk and branches'. In practice, this description encompasses a number of similar yet diverse entities; for instance, trees include spruce and beech, which differ significantly in a number of characteristics. If we focus on the spruce, the Dictionary narrows its description to 'a coniferous tree with dark green pointed needles, pendulous cones and reddish-brown fissured bark'. Even though this narrows the meaning, a significant amount of ambiguity remains, which merely shifts from general characteristics, such as leaves or needles, to more specific ones, such as the shape or type of needles.

Thus, if several people talk about a tree or even a specific spruce, each subject of the conversation will create and operate with their own unique mental image of the object, regardless of how narrowly the image is formally defined (de Saussure 2018). The image an individual forms of a particular concept is primarily influenced by spatio-temporal and socio-cultural factors and therefore depends on their cognitive background. This means that the only way to approach objectivity—and make a fuzzy concept 'crisper' (i.e. clearly defined)—is through a combination of precise definition, understanding and consideration of the cognitive background of stakeholders (Reiss and Sprenger 2020).

In the case of more tangible concepts, such as trees, the phenomenon of vagueness is less pronounced. However, science often deals with highly abstract concepts, whose models can only be based on analogies with more tangible concepts. This, in turn, introduces additional vagueness or variability into the already cognitively conditioned understanding of individual concepts when reconciling abstract concepts between different stakeholders (Reiss and Sprenger 2020).

THE IMPORTANCE OF SCIENTIFIC ILLUSTRATION AND VISUAL MODELS IN UNDERSTANDING SCIENTIFIC CONCEPTS

Of all the senses, humans rely most on vision. It also dominates the field of scientific research, where the adage 'seeing is believing' is often invoked. As a result, science, at least traditionally, has been most closely linked to visual art, which encompasses a group of artistic genres that similarly rely primarily on vision (Jenks 2002). There are a number of other artistic genres that are perceived through the remaining senses. For instance, music is linked to hearing, while the literary arts are mainly associated with cognitive processes involved in abstract thinking (Bacci and Melcher 2011). Recently, the combination of different artistic genres and the development of new techniques, materials and expressive possibilities has given rise to numerous alternative forms of creativity. These have generated their own domains of contemporary visual arts, with photography as perhaps the most prominent example, alongside installation art, video and other new media (Brakeley and Sam 1979), which are gradually but steadily entering the realm of scientific illustration, as they broaden the range of expressive possibilities and interpretation. In this way they engage an individual's multi-sensory potential to familiarize a broader audience with concepts in a more holistic and inclusive manner. The importance of visualization, interpretation and dissemination of scientific knowledge has also been recognized and emphasized by Gorazd Planinšič in his discussion:

> Science needs art to communicate its achievements to the professional and lay public. Today, the presentation of scientific achievements [...] is increasingly reliant on visual communication (through images, caricatures, films, computer simulations and animations), which can be more effective if the basic principles of design are understood and observed.
> (Planinšič 2008, 151)

This statement by Gorazd Planinšič holds significant relevance within the observed context. Indeed, the presentation of scientific achievements has always relied heavily on visual communication, which shapes our (subconscious) understanding of the concept introduced by the author through imagery and, even more significantly, influences how it is positioned within the broader context of the scientific canon (Heil 1983). Since the relationship between science and art is one of mutual support or 'symbiosis', it is clear that art also needs science for its development (Planinšič 2008, 151). The erroneous drawing of conclusions, which often sidetracks us in this context, primarily results from a superficial, one-sided understanding of this interdependence; according to this misconception, art merely enhances the added value of science, while being entirely reliant on science for the material resources and tools needed for the materialization of ideas. The shortcoming of this view lies in its neglect of science's dependence on art at the level of ideas, which subsequently lead to the development of technology, from which art, in turn, can benefit. The question is therefore similar to the dilemma of 'what allows what to exist – does the chicken precede the egg or vice versa'.

Depending on the nature of the models underlying individual fields of natural science, these fields can be divided into two broad groups. The first comprises fields such as mathematics and physics, which rely mainly on abstract models that do not necessarily require visualization to be understood. The second group, on the other hand, includes domains such as chemistry and biology, which rely almost exclusively on visual models. The entire contextual framework of chemistry and biology is founded on the structure of the atom and, consequently, that of molecules, as well as on the structure of biological elements at various organizational levels (ranging from molecular and cellular to tissue, organic, organismic and, last but not least, ecological levels) (Kozma and Russell 2005).

The structure and geometry of these elements determine both their aesthetics (i.e. their form) and their function, which is why basic patterns of form can be recognized in biology. These patterns occur in different contexts, and their combination creates the diversity of living beings (Siber and Ziherl 2017). One of the oldest and most prevalent geometric patterns in nature is the Fibonacci sequence, discovered by the Italian mathematician Leonardo Fibonacci (c. 1170–1240) as early as in 1202. The Fibonacci sequence is a sequence in which each succeeding term is the sum of the two preceding terms ($F_0 = 0$, $F_1 = 1$; $F_n = F_{n-1} + F_{n-2}$ for $n > 1$). Its pattern can be used to explain most biological spiral structures (Al-Suwaiyel et al. 2006). By studying soap bubbles and foam, the Belgian physicist Joseph Plateau (1801–1883) solved the mathematical problem of boundary conditions by attempting to identify the smallest surface area of a surface stretched over a given contour in space (Neimark and Vignes-Adler 1995). This finding is crucial, in particular, for understanding the shape of sessile aquatic organisms. The German psychologist Adolf Zeising (1810–1876) discovered that the individual elements composing the bodies of living organ-

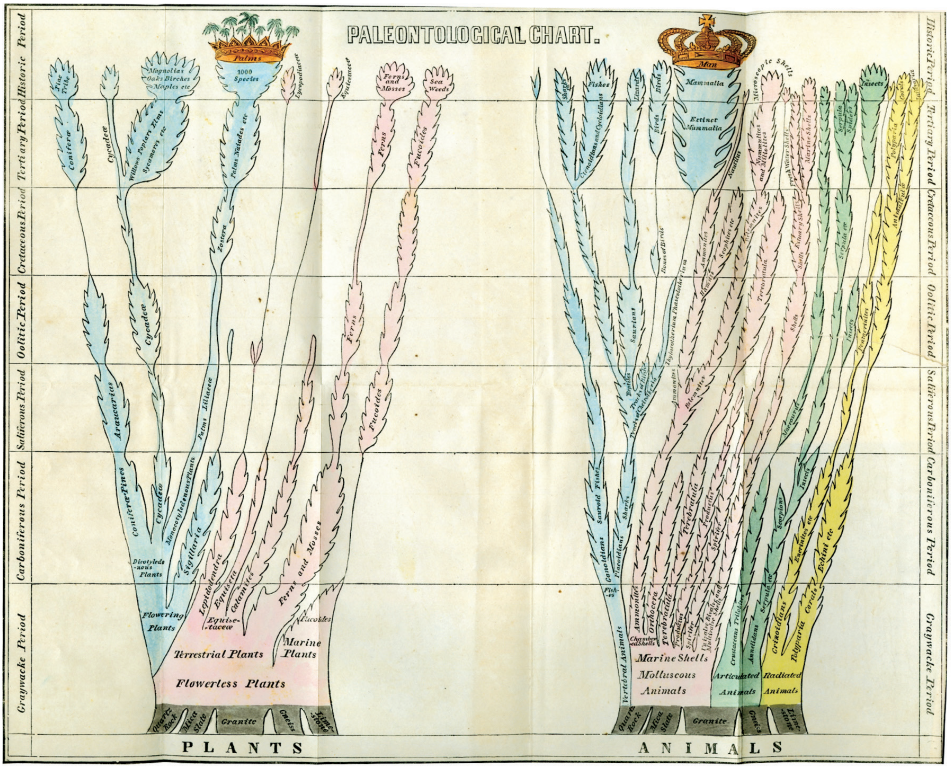

Figure 1: Edward Hitchcock: graphic representation of the system of life, i.e. a fold-out *paleontological chart* with humans at its top as the crown of creation, published in *Elementary Geology* in 1840 (Source: Wikipedia, CC).

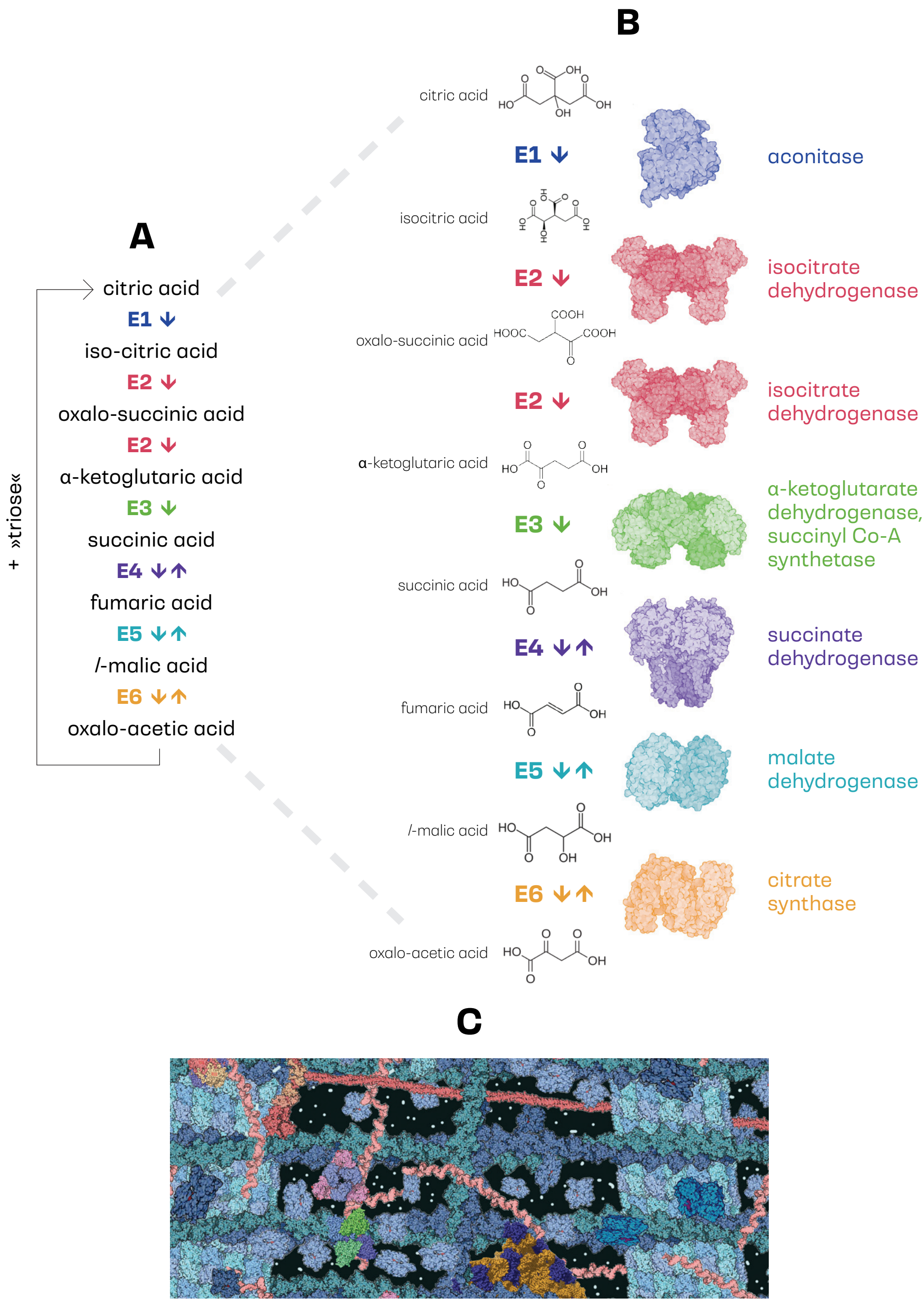

Figure 2: Model representing the cycle of citric acid.

A The first diagram of the citric acid cycle, published in 1937, based on the article by Hans Adolf Krebs and William Arthur Johnson (Krebs and Johnson 1937).

B A more representative model showing the structures of the individual enzymes, hidden behind the arrows, and the organic acids.

C A model attempting to present a more realistic image of the inside of a cell, crowded with different particles, which are not (necessarily) mechanically connected to each other.

isms are arranged according to the golden section (Zeising 1855). In 1952, the British mathematician Alan Turing (1912–1954) published a book titled *The Chemical Basis of Morphogenesis*, in which he presented an analysis of the mechanisms necessary for pattern formation in living organisms during the process of morphogenesis. He hypothesized the oscillatory nature of chemical processes, more specifically the Belousov-Zhabotinsky reaction. Reactions that present oscillations between inhibition and activation lead to the formation of various dotted, striped and spiral patterns in living organisms. Thus, the mathematician explained the growth pattern of most plant rosettes and the patterns observed on the surface of animal skin (zebra stripes, Dalmatian spots, etc.) (Turing 1990). Later, in 1968, the Hungarian theoretical biologist Aristid Lindenmayer (1925–1989) developed the L-system, which explains the fractal growth patterns in plants. The L-system is an alphabet of symbols that can be combined according to production rules to expand the string of symbols, transforming them into geometric patterns (Iannaccone and Khokha 1996).

On the basis of these examples, it can be deduced that chemical and biological processes are often translated into structure-independent (linguistic) forms by abstract mathematical and physical models. However, the understanding of these processes relies primarily on the presentation and comprehension of the underlying structural, visual models. The geometry of biological forms thus represents one of the closest points of convergence between biological science and art. In the following, we will examine two more abstract examples that further illustrate how neglecting the importance of visual representation can influence our perception of reality.

AN EXAMPLE OF THE PROBLEM OF VISUALIZING THE CLASSIFICATION OF ORGANISMS INTO A SYSTEM, I.E. THE TREE OF LIFE

Since the dawn of time, humanity has had a tendency to systematize. In the field of biology, this led to the emergence of a sub-discipline known as systematics, which focuses on the classification of living organisms into a system. Many natural scientists continue to organize organisms within the model called the 'tree of life'. In the tree of life, organisms are arranged forming a vertical composition, according to the analogy of a tree's growth. In different interpretations of the tree of life, humans are, in general, consistently placed on the highest branch. This approach was also applied by the American geologist Edward Hitchcock (1793–1864) in his 1840 work *Elementary Geology*, which is considered one of the first demonstrations of the idea that different recent organisms are related. Hitchcock further biblically emphasized the human's position with a crown (Figure 1), which is in line with a passage from Genesis (Gen. 1:27–28).

Such value-based hierarchical representations of the systemization of life on Earth, combined with other circumstances, subsequently led to biological anthropocentrism, the consequences of which are still evident today (Hitchcock 1856). In Western cultures, vertically ordered systems are linked to hierarchy, while horizontal axis is associated with equality. Therefore, the distinctly upright composition implicitly conveys the idea that the species represented higher in the tree are more evolved, more important or superior to those lower in the 'canopy'.

AN EXAMPLE OF A PROBLEM OF VISUALIZING BIOCHEMICAL PROCESSES

A more contemporary example of the disregard for the importance of visual interpretation can be found in biochemistry and molecular biology. In both scientific disciplines, visualization is often facilitated by diagrams of reactions occurring in living systems. These reactions, catalysed by enzymes, are typically represented as a chain or sequence, which can form a metabolic pathway, cycle or spiral (Nelson and Cox 2009). In these representations, it appears as if reactions (or enzymes themselves) link individual molecules into a complete chain. A well-known example of such metabolic processes is the citric acid cycle (Figure 2). The way to its discovery led to two Nobel Prizes for achievements in physiology or medicine. The first was awarded to Albert Szent-Györgyi (1893–1986) in 1937 for his research on fumaric acid and the second to Hans Adolf Krebs (1900–1981), who in 1937, assisted by his PhD student William Arthur Johnson, reconstructed the cycle (Krebs 1970). These representations suggest that metabolic pathways are similar to railway connections, leaving very limited freedom to the system. In reality, it is a free system where individual molecules move within the solution, and reactions, if concatenated, are linked thermodynamically rather than mechanically, as shown by the aforementioned representations. In this respect, a more fitting analogy would be that of air traffic, where the projected routes, unlike railway connections, are not absolute and allow for the free movement of bodies through space.

SCIENTIFIC ILLUSTRATION IN THE CONTEXT OF VISUAL DEFICITS

The two examples above clearly demonstrate how our understanding of scientific reality is based on its visualization and underscore the important and responsible role of scientific illustration, particularly in interpreting complex chemical and biological models. Thus, illustration is not merely a tool for communicating and popularizing science, as might be erroneously inferred from one of Gorazd Planinšič's statements (Planinšič 2008, 151) but rather an inseparable part of science itself.

Due to the interconnected processing of information received by brain from the different senses, some people may develop synaesthesia or unusual connections between certain areas of the cerebral cortex. This leads to an atypical perception, where a characteristic of a stimulus is assigned an additional characteristic, often from a different sensory modality (e.g. a colour is assigned to a particular sound), which does not replace the other. It is an automatic, involuntary and unidirectional phenomenon that can assume many forms. The additional characteristic can also arise within the same modality; for instance, a synesthete may attribute an additional visual characteristic, such as colour, to the visual stimulus of the letter 'A' (Ward 2013). The stimulus does not need to be entirely physically present—a synesthete can taste a word even in a situation where they can perceive it 'on the tip of their tongue' (Simner and Ward 2006). Synaesthesia involves an inducer, which triggers a perceptual event, and an associated concurrent, which refers to the additional sensory characteristics. For example, in a person who perceives blue when hearing the tone C, the tone C is the trigger and the colour blue is the concurrent (Grossenbacher and Lovelace 2001). For most synesthetes, this phenomenon is unidirectional; for instance, a particular tone is associated with a particular colour, but the colour is not heard when it is seen (Mills 1999). The concurrent is usually consistent and stable, whereas the inducer can be more flexible. For example, the visual perception of the letter 'B' might always trigger the perception of a specific shade of red, regardless of the font in which it is written (Grossenbacher and Lovelace 2001).

Many inducers are symbols (Glicksohn et al. 1992), which also appear in scientific illustration. Scientific illustration aims to harness the 'synaesthetic potential' present in everyone. This gives it a key advantage over photography, which merely captures the physical image as perceived by the camera or our eyes, including all details, whether more or less important. The brain then looks for certain patterns in these details, and the process itself differs slightly from person to person. Understanding the key cognitive processes of image formation in our brains allows for illustrations that guide and emphasize the desired patterns, muting the irrelevant ones, thereby facilitating a more unambiguous comprehension of the model itself. This implies that the (scientific) illustrator's task is to create using primarily the material processed by our brains, rather than simply recreating the image perceived by our eyes.

This poses the question of how to present chemistry and biology, which are based on visual models, to individuals who are blind or partially sighted. When it comes to abstract concepts, even the sighted are, in a way, 'blind' and rely on creating visual models, which, in principle, assist in better understanding these invisible and intangible ideas. However, for the blind and partially sighted even very concrete elements, such as the shape and structure of individual organisms, present a challenge. The extent of the barrier between a blind or partially sighted individual and the classical visual models in science varies depending on the nature of the cause (aetiology) and reasons for the absence or lack of vision, which differ despite resulting in a similar consequence, that is, a more or less severe visual impairment. Impairment can derive from a defect in the sensory organ (the eye), the nerve that transmits visual information to the relevant brain centres or the visual cortex, which is the key centre for processing visual information. The perceived image is, in fact, the product of a number of brain processes that shape its final form and, ultimately, influence its impact on other cognitive processes, such as emotional reactions and memory.

In relation to this, recent findings have explained the long-known phenomenon of a reflex reaction upon perceiving certain shapes (e.g. elongated and uneven) that are associated with innate fears (e.g. of snakes), even in individuals with visual cortex damage, who lack the ability to form a visual image of perceived objects. These individuals, although unable to see the shape, respond to it due to the existence of an afferent pathway from the pulvinar to the amygdala. This pathway enables a defensive fear response to certain evolutionarily relevant forms that pose an imminent threat (McFadyen et al. 2019).

Besides the various aetiologies leading to partial sightedness or even blindness, these conditions also have diverse underlying causes. They can occur as a loss or deterioration of a person's vision, potentially giving rise to the development of synaesthesia, in which the lost modality (i.e. vision) becomes a concurrent. Although the primary source of information is no longer present, the visual cortex, if preserved, can develop a multimodal connection with other parts of the brain over time (ranging from days to years) (Ward 2013). In practice, a person may, for example, see a specific visual image simultaneously with a particular touch, sound or other stimulus.

The second group consists of individuals with congenital partial sightedness or blindness who have never had the chance to form a visual representation comparable to that of sighted people. While this group comprises a relatively small portion of the population, their cases are the most challenging in the examined context. As their world and the visual world of the sighted never intersect, it is nearly impossible to create a pictorial translation between the two. If a field is almost entirely reliant on visual models, it is virtually inaccessible to people with congenital blindness. Consequently, they are deprived of a large part of the scientific canon, which remains unavailable to them due to the absence of a mechanism for its perception, processing and further contextualization.

EXCEPTIONS WHICH INDEED PROVE THE RULE

At a global level, there are a few (congenitally) blind or partially sighted individuals who have built successful scientific careers, including in chemistry and biology, such as Dr Cary Supalo, Dr Henry Wedler, Dr Stephanie DeLuca and Dr Geerat J. Vermeij (Minkara 2024). Nevertheless, their proportion is still negligible compared to the total population of blind and partially sighted people. A key reason for this is the insufficient accessibility of fundamental models pertaining to the observed scientific fields, which becomes evident as early as in primary education. Blind and partially sighted students in Slovenia, who are usually enrolled in adapted educational programmes, primarily learn chemistry and biology through descriptive methods. Although some structure-oriented models can be partially translated into 3D images or text accessible in braille, a complete adaptation is nearly impossible, particularly within the normative context of sighted individuals, which prevails in the scientific community (*Independent science* 2024).

Many blind and partially sighted students do not pursue their education in a mainstream grammar school programme culminating in the general baccalaureate, which is the most common educational route among their sighted peers. An even smaller number of blind and partially sighted students opt for chemistry or biology as a baccalaureate subject. Consequently, in Slovenia, this issue is seldom tackled on a conceptual and professional level. The severity of the challenges faced by the blind and partially in comprehending chemical and biological concepts has been recently underscored by the case of a student with progressive vision loss. Alongside her sighted peers, she attended the mainstream grammar school in Ljutomer, choosing chemistry as the elective baccalaureate subject to complete the educational programme (Tomažin 2023). Despite the general baccalaureate subject catalogue providing for special needs adaptations (Alif et al. 2021), a significant barrier was encountered in this instance concerning a foundational chemistry concept: molecular structure. According to the student's chemistry teacher, she had previously struggled to follow lessons in science subjects such as chemistry and biology, mainly due to the lack of appropriately adapted learning materials (Tomažin 2023).

Despite an extensive search, the educators and the two students who prepared the final project found no suitable system which would enable the blind and visually impaired to engage in structural chemistry learning and co-creation, compelling them to address this challenge themselves. Building upon the SMILES computer program, they developed a linear notation for chemical compounds, using the already established linear mathematical notation system as a reference. Unlike chemistry, mathematics is based to a greater extent on abstract models, which makes it more accessible to the blind and partially sighted. The proposed linear notation for chemical compounds was annotated with the feedback from a sample group of blind and partially sighted people and suitably adjusted according to their comments (Tomažin 2023).

The obtained linear structural notation of chemical formulae can be used to represent most compounds, though not all of them as foreseen by the IUPAC nomenclature. Additionally, some otherwise feasible notations of compounds present readability challenges and are more difficult for blind and partially sighted people to recognize. The project's main objective was primarily practical:

to enable blind and partially sighted students to undertake their final examinations and to follow chemistry and biology lessons on a daily basis (Tomažin 2023). Despite the notable success of the case in question, it is essential to acknowledge that the student's vision loss was gradual, allowing her to acquire at least fundamental visual experience prior to vision loss, which contributed to her ability to tackle structural chemistry with some more ease. The challenge, particularly difficult by itself, is even harder for people who have been blind since birth.

INSTEAD OF A CONCLUSION: THE POTENTIAL FOR CONTRIBUTIONS BY THE BLIND AND PARTIALLY SIGHTED IN SHAPING VISUAL MODELS

In biology, similarly to chemistry, despite the advancements in molecular techniques, the classification of organisms and the study of their properties primarily rely on their structure and appearance. The differences between individual organisms are often very subtle and part of a broader context that, in the conventional format, is largely, if not entirely, inaccessible to the blind and partially sighted. This issue has also been addressed by the exceptional Brazilian photographer Sebastião Salgado, whose emotionally charged photographic expression transcends mere documentation of reality. Salgado's primary focus lies in environmental and anthropological photography, which he has recently aimed to make more accessible to the blind and partially sighted by undertaking a project that has led to a special edition of a relief photography book. Despite the extreme difficulties in attempting to enable a comprehensive understanding of natural science concepts, which are already challenging for the sighted, there nevertheless exist approaches to overcome barriers for the blind and partially sighted (Salgado 2023), ultimately benefiting everyone.

From the outset, sighted people are influenced by a long-standing history of conceptualization, where the available models may present a single, occasionally rather problematic interpretation amidst a variety of potential ones. The majority of alternative interpretations do not come to the fore or even see the light of day due to the predominance of established models, hence it is crucial that we strive towards 'visualizing' chemical and biological concepts in a manner that is accessible to blind and partially sighted people. The blind and partially sighted can provide us with an alternative view of established natural science concepts or even develop new approaches that do not yet exist. Projects like the International Summer School in Kaverljag, Slovenia, with its transdisciplinary team and methodological approach, have proven effective in this regard on several occasions, not least in the development of the linear notation for chemical compounds' structural formulae, as presented above.

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PERCEPTION OF PEOPLE WITH VISUAL IMPAIRMENTS

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Keywords
people with visual impairments,
tactile content, audio description,
children with visual impairments

Abstract

Blindness, partial sightedness, and cortical/cerebral visual impairment pose complex challenges and are difficult to define in a single manner. In the Slovenian school system, the pedagogical definition focuses on the specific visual abilities of children, serving as the basis for adapting the educational process and creating an inclusive environment. Children with visual impairments require content that offers an alternative to visual information, enabling them to participate actively in society. The development of tactile perception has a key role in their holistic development; through play and interaction, they learn about the world around them. Extended curriculum activities should promote concrete and language-rich experiences, as this enables the comprehension of fundamental concepts. Effective strategies for working with children with visual impairments include tactile modelling and audio description, which facilitate children's exploration and interpretation of information. Audio description enhances the accessibility of cultural resources, while tactile content promotes the development of fine motor skills. Together, these elements create a supportive framework that fosters children's independence and success. The conscious design of learning content and adaptation of teaching methods are crucial for successfully including children with visual impairments in the modern education system.

INTRODUCTION

In recent decades, societal attitudes towards people with special needs have shifted significantly. Rather than being marginalized and pitied for their disabilities, they are now recognized as having an equal role in society. However, to ensure they have equal opportunities in life compared to individuals with no sensory impairments, content and materials need to be adapted into an accessible format. In school environments and everyday life, adaptations consistent with Universal Design are progressively becoming more widespread. By fostering an appropriate physical, didactic, social, and curricular environment, we can develop an inclusive society. Universal Design for Learning has proven to be an effective approach to creating accessible and inclusive learning environments. This concept is based on scientific insights into how humans learn. The main goal of Universal Design for Learning is to create a learning environment with a variety of options that allows the majority of learners to actively participate without additional adaptations (CAST 2024). Nevertheless, in the case of people with visual impairments, it is important to consider that the primary sense for discovering the world is impaired and, as a consequence, other senses need to be enhanced. Content has to be adapted primarily by using touch and sound, and less typically, smell and taste (Schmidt 2014).

PEDAGOGICAL DEFINITION OF VISUAL IMPAIRMENTS

There is no single and globally recognized definition of blindness, partial sightedness, and cortical/cerebral visual impairment (CVI); however, definitions can be roughly divided into two categories, medical (e.g. the World Health Organization definition, the Slovenian definition by the Extended Expert College for Ophthalmology) and pedagogical (e.g. the Criteria for the Definition of the Type and Degree of Deficits, Barriers and Disorders of Children with Special Needs, prepared by the Education Institute of the Republic of Slovenia). In the local school setting, the Slovenian pedagogical definition of blindness, partial sightedness, and CVI (Stirn Kranjc et al. 2015) serves as the legal foundation for pedagogical work with special needs students and their environment. This definition differs from the medical ones as it includes CVI, a category that has not yet been defined in the medical field.

Blind and partially sighted children as well as those with cortical visual impairment are children who have reduced visual acuity, a narrowed field of vision or cortical visual impairment. The criterion for assessing the visual field is based on perimetry records.

Partially sighted child

A *partially sighted child* has a visual acuity of 5 to 30 per cent or a narrowing of the visual field in all meridians exceeding 10 degrees to 20 degrees inclusive around the fixation point, regardless of visual acuity. A distinction is made between a moderately partially sighted child and a severely partially sighted child.

A *moderately partially sighted child* has a visual acuity of 10 to 30 per cent. They require a partially adapted educational environment and, if necessary, adapted teaching and educational aids, specialized training in communication techniques and/or orientation. Under suitable conditions, they can perceive visual information. They follow the method designed for the partially sighted and can maintain the same work pace as sighted peers, provided that materials are adapted or reading aids are utilized.

A *severely partially sighted child* has a visual acuity of 5 to less than 10 per cent or a narrowing of the visual field exceeding 10 degrees to 20 degrees inclusive around the fixation point, regardless of visual acuity. They require an adapted educational environment and didactic aids as well as specialized training in communication techniques, orientation, and social skills. Most of the learning is performed through visual information, following the method designed for the partially sighted. They can read black print if materials are adapted or reading aids are utilized, although their reading is impeded and slower.

Blind child

A *blind child* has a visual acuity of less than 5 per cent or a narrowing of the visual field to 10 degrees or less around the fixation point, regardless of visual acuity.

A *blind child with residual vision* has a visual acuity of 2 to less than 5 per cent or a narrowing of the visual field exceeding 5 degrees to 10 degrees inclusive around the fixation point, regardless of visual acuity. They require an adapted educational environment and didactic aids, adapted aids focusing on communication techniques, additional didactic aids for acquiring abstract concepts and physical quantities, and aids designed for the blind to assist in orientation and daily life activities. In addition, they need specialized training in social skills, orientation, and communication techniques. They follow a combined method incorporating in part the method designed for the blind and in part the method for partially sighted. Their work pace is significantly slower compared to that of sighted peers.

A *blind child with residual vision* has a visual acuity of light projection of less than 2 per cent or a narrowing of the visual field around the fixation point to 5 degrees or less, regardless of visual acuity. They require an adapted educational environment and didactic aids, adapted aids focusing on communication techniques, additional didactic aids for acquiring abstract concepts and physical quantities, and aids designed for the blind to assist in orientation and daily life activities. Moreover, they need specialized training in social skills, orientation, and communication techniques. They follow a combined method incorporating mainly the method designed for the blind and in part the method for the partially sighted. Their work pace is significantly slower compared to that of sighted peers.

Totally blind child: perception of light negative or positive with negative projection. They require continuous specialized training for daily life activities, an adapted educational environment, adapted learning aids focusing on communication techniques, which entails the use of Braille, additional didactic aids for acquiring abstract concepts and physical quantities, and aids designed for the blind to assist in orientation and daily life activities. In motor activities, they are noticeably slower than their sighted peers. As they do not learn by imitation, a professional approach is required for them to acquire new motor actions and skills. A totally blind child follows the method designed for the blind; learning occurs through tactile and auditory perceptual pathways.

Child with cortical visual impairment (CVI)

CVI results from a disease and/or dysfunction of the central nervous system. Impairment may be present in cases of partially or fully preserved visual acuity, either unilaterally or bilaterally, and in cases of partially or fully preserved visual field, either unilaterally or bilaterally.

CVI is characterized by: visual attention problems, visual complexity problems, gaze and fixation disturbances, delayed and slowed visual response, absent or atypical visual response (e.g. reactions to imminent danger), inadequate visuomotor behaviour (e.g. eye-hand co-ordination), inefficient visual perception, visual agnosia. The assessment of CVI requires medical results demonstrating central nervous system impairment that are obtained by objective examinations such as clinical, neuroradiological, neurophysiological, laboratory, genetic, and other examinations (Stirn Kranjc et al. 2015, 8–9).

SENSE DEVELOPMENT IN CHILDREN WITH VISUAL IMPAIRMENTS

The sensory perception and motor skills of the child are crucial for their holistic development (Anderson, Boigon, David and deWaard 2007; Roe 2008). According to Piaget's theory (Piaget 1929, 1959, 1964, as cited in Marjanovič Umek, Zupančič, Kavčič and Fekonja 2009), there are two main levels of intellectual development in pre-school children. In the first two years, children experience the sensorimotor stage of cognitive development, during which they acquire basic concepts related to object permanence, spatial relationships, strategies for achieving desired goals, and imitation. During this stage, visual, auditory, olfactory, gustatory, tactile, kinaesthetic, and haptic sensory perceptions are extremely important, and any absence or impairment of perception attributable to a sense organ is a risk factor in development. Around the age of two, children begin to organize the people and events in their world as they develop the ability to classify by shape, colour, size, and function. In the case of children with visual impairments, it is necessary that vision-dependent concepts (e.g. facial expressions, body movements) are presented in a very explicit way using concrete material. A child with visual impairment needs concrete sensory and language-rich experiences in order to acquire information that they would otherwise obtain through vision.

Play is the primary means through which children develop their senses. Games involving the sense of hearing enable children to acquire information about actions happening in their immediate and distant surroundings, which is crucial for the development of selective perception, sound recognition, and the ability to determine the direction and distance of various sounds. Games focusing on touch expose children to information about objects in their surroundings. Games aimed at developing the senses of smell and taste are especially valuable for blind children, as these perceptions can sometimes compensate for visual information (e.g. identifying food by smell) and foster awareness related to everyday objects (Zrljić and Košta 2008).

FOSTERING THE DEVELOPMENT OF TACTILE PERCEPTION IN PEOPLE WITH VISUAL IMPAIRMENTS

Studies (e.g. Brambring 2001, 2006, 2007) have shown that children with visual impairments tend to have lower levels of physical fitness and less developed motor skills compared to their sighted peers. There is a connection between motor skill development, which includes tactile perception, and the presence of emotional and behavioural disorders in people with visual impairments. Motor skills have a preventive effect on emotional and behavioural issues. Unlike teaching groups of sighted children, one-to-one instruction proves most effective for students with blindness and partial sightedness. Techniques such as physical guidance and tactile modelling play an important role in enabling people with blindness or visual impairment to form a mental picture of movement (O'Connell, Lieberman and Petersen 2006). Tactile perception can be analytical or synthetic. In analytical exploration, the child analyses individual components to construct an image of the object. Conversely, in synthetic exploration, the child first takes hold of the entire object and then identifies it based on this interaction. As the majority of learning occurs through the synthetic approach, blind children, who frequently adopt the analytical approach, require additional time to comprehend the world (Zrljić and Košta 2008). People with CVI need the opportunity to perceive others' actions by touching the body parts or objects involved in these actions. Teaching through touch is one of the most common methods for instructing students with visual impairments. The effective implementation of tactile strategies necessitates a comprehensive consideration of each learner's specific needs, the learning environment, and the specific tasks. It is crucial to dedicate enough time to present the tactile information and to systematically evaluate the adaptations, which contributes to a successful learning process. Miniature models serve as a useful tool in tactile modelling. Their small size contributes to the ease of use, but it is important to consider that they may not reflect the actual reality when explored through touch. For instance, a small plastic dog does not have the same tactile characteristics as a real dog. When designing tactile adaptations, it is therefore important to avoid misconceptions. People with visual impairments primarily need accessible tactile information. As touch offers only a fraction of the whole, the individual must integrate a series of tactile impressions to comprehend what the sighted perceive through vision (Downing and Chen 2003).

TACTILE PICTURE BOOKS

Children acquire knowledge and explore the world through play and imagination. Picture books have a significant role during the pre-school period. While there is an abundance of picture books available on the market for sighted children, their illustrations are often less suitable for children with visual impairments. Consequently, children with visual impairments are deprived of the visual experience they should gain from images during reading. Tactile picture books are therefore particularly important for children, as they stimulate their sense of touch, preparing them for learning Braille (Kermauner 2014). Illustrations are crucial for familiarizing children with unknown information, facilitating their comprehension of the text and enabling them to learn about the realities beyond their direct experience, such as tropical animals or historical figures (Lamb 1995, as cited in Tajnikar 2019). Schmidt (2014) defines tactile picture books as books containing illustrations designed to be perceived by children through touch. These books typically include Braille and enlarged text. By using tactile picture books, children learn to recognize and interpret various shapes. This contributes to the development of their fine motor skills and tactile perception, which are crucial abilities for people with blindness. Furthermore, these books serve as aids that prepare younger children for Braille learning and can be considered a preliminary step in gaining literacy. The technology used to produce tactile pictures has changed over time, as have the materials. Tactile pictures continue the tradition dating back to the late 19th century. Initially, these pictures featured relief figures printed on heavy paper, using a variety of cut-out wooden moulds. Later, materials evolved, allowing for a more pronounced relief. In the 1960s, paper was replaced by plastic in the thermoforming process, enabling the creation of similar moulds. Tactile pictures are simple outline drawings consisting of raised lines or surfaces with various textures, creating a perceptible relief. In tactile pictures, details are eliminated as light, shadows, and perspective are not representable.

A tactile picture is thus any visual element that is accessible to tactile perception; the information each individual can extract from the image depends on the tactile threshold, which is an individual-specific ability. Tactile pictures are important for the development of children with visual impairment. They should not exceed A4 size and should feature generalized motifs to ensure unambiguous recognition. Tactile pictures should present strong colour contrasts for individuals with residual vision, and the proportions should correspond to real life. Materials should evoke the actual image of the object and be safe to use. The utilization of tactile pictures is intended to enhance sensory acuity, train motor skills, promote the understanding of shapes, and gain new experiences related to daily life. It is crucial to add texts in media that visually impaired children can read. When creating a tactile picture book, the size of the surface should be suitable to accommodate two outstretched hands, allowing the child to easily reach the entire image. The information in the tactile picture should not be smaller than the size of a Braille cell, and the books should be in A4 landscape format. When portraying natural objects, such as animals and trees, the correct size proportions have to be respected. For example, a cat should not appear larger than a wolf, and the size of a flower should not exceed that of a tree. All limbs of animals and people have to be visible, meaning that figures are to be depicted either from the front or from the side. When choosing colours and materials, it is recommended to use strong, contrasting colours that children with residual vision can still perceive. Soft objects should be depicted with soft materials and cold objects with smooth materials. When using materials, it is important to ensure safety: sharp parts of the tactile picture should be protected, smaller parts should be firmly attached, and materials should be non-toxic and easy to clean (Kermauner 2014, Kermauner n.d.). Schmidt (2014) further explains that a tactile illustration is an abstracted image featuring lines of varying thickness and solid planes with different patterns and textures. The image can be divided into several pictures, which combined form a whole; however, it is still an obvious abstraction of the world presented in two dimensions.

Creating tactile content for people with visual impairments requires adherence to guidelines to ensure effective perception and interpretation through touch. Küssel (2019) prepared a set of recommendations that are also applicable to the creation of tactile maps, which can be considered tactile pictures of a higher level.

① Universally accessible formats: When designing tactile content, it is important to consider universally accessible formats, ensuring ease of use for all. Braille and relief shapes are essential for adapting information to people with visual impairments. It is also important to consider the size and shape of the font to ensure good legibility.

② Tactile marks and symbols: The standards for adapting tactile content also include certain tactile marks and symbols that aid in understanding of the territorial conditions on the tactile map. Brock et al. (2015) highlight the importance of implementing uniform tactile symbols to simplify the interpretation of geographic information.

③ Use of contrasting materials: Contrasting materials help to distinguish between different parts of the tactile map. Contrasts between relief surfaces, colours, and other materials enhance the clarity and distinctiveness of information.

④ Systematic organization of information: Tactile map preparation for people with visual impairments requires a systematic organization of information to enable logical reading and comprehension of spatial relationships.

⑤ Incorporating technological innovation: Modern technologies such as graphics embossers, 3D printing, and other technologies offer additional opportunities to improve the quality of tactile maps. New technology is driving increased accessibility and usability of tactile content.

Downing and Chen (2003) highlight the following steps that need to be performed when communicating through touch:

- → Select the message that you want to communicate to the child (e.g. greeting, reassurance, encouragement, praise, redirection, demonstration).
- → Decide how best to communicate that message through the type of touch (i.e. duration, pressure, movement) and where to touch the child (e.g. back of hand, shoulder, or knee).
- → Identify how you will let the child know that you are close (e.g. by saying their name) before touching them (e.g. on the elbow).
- → Discuss with the child whether and how to tactilely examine an item (e.g. a turtle).
- → Decide whether and how to use tactile modelling (e.g. by asking a classmate to show how to blow up a balloon).
- → Observe the child's reactions to your tactile interactions and modify the interaction accordingly.
- → Identify how you will end the interaction (e.g. let the child know that you are leaving by giving them a double pat on the shoulder).

TACTILE MODELLING

In tactile modelling, the child decides when to touch the teacher/peer/aide/object. Tactile modelling gives the child the opportunity to feel and explore another's or a model's body in the direction of a particular movement. For example, the child feels the movement of the instructor's legs during each dance step. If the instructor is much larger than the child, a peer can act as a model, provided that they have consented to this role beforehand. Tactile modelling is beneficial as it often clarifies the mechanics of the movement more comprehensively than explanation alone. In addition, tactile modelling gives the student control of the learning process by providing a choice of the specific components of a performance to focus on. Instead of being manipulated, the child can take the lead, feel the movement, and control the information input (O'Connell et al. 2006).

ADAPTATION INTO BRAILLE

Braille is a standardized script designed for the blind, composed of Braille dots as the fundamental elements of the Braille cell. In Slovenia, two size standards are in use: Marburg Medium and Marburg Large. A Braille cell is a space accommodating either six Braille dots or eight Braille dots in eight-dot Braille, also referred to as computer Braille. Individual letters, numbers, and symbols are represented with a combination of Braille dots. In six-dot Braille, there are only 64 possible combinations within the cells, therefore Braille prefixes are used to avoid a double meaning of a single character. The size, height, and proportions within the Braille cell and between the Braille dots are precisely defined in order to facilitate reading with a single finger pad (Gregorc et al. 2016). Sighted children can easily identify the location of the text on the page, therefore the text position is not crucial. On the other hand, Braille readers benefit from being able to find the text in its expected location. Braille text should be printed on stiff paper, and words should not be divided or arranged as individual units. When designing texts for children with blindness, particular attention has to be paid to the choice of adhesive, as glue can diminish the sharpness of Braille dots. For children who are not yet literate in Braille or read black print, it may also be advantageous to include a high-quality printed version of the text. This allows parents, teachers, peers, and others to read the story to children with blindness (Lewis and Tolla 2003).

AUDIO DESCRIPTION

Audio description is a common approach to adapting content for people with visual impairments. Various authors (e.g. Snyder 2010; Snyder 2023; Le linee guida di DescriVedendo n.d.) are relatively unanimous in their definition of audio description and the identification of elements practitioners should consider. They define audio description as a process that enables people with visual impairments to better understand visual content, such as films, theatre performances, or exhibitions. It is a form of narration that describes what a sighted person naturally perceives, bringing visual content in theatre, television, films, and other art forms closer to people with visual impairments. This narration is incorporated into the soundtrack to describe important visual details that cannot be understood solely from the main soundtrack. The narration illustrates the visual content, which is essential for its understanding, and provides information about actions, characters, scene changes, and other visual content. Using concise, vivid, and imaginative expressions, describers convey information that is inaccessible or only partially accessible to some individuals. Audio description can also benefit individuals who prefer using audio equipment to obtain information or can access only the audio recording of an event or production.

The audio describer should approach their task like a journalist, providing a faithful account of the facts. They can describe who is in the image and what they look like, including age, hair, body structure, and clothing, and characteristics such as ethnicity and race, if relevant. It is also essential to provide an account of what is happening. The describer's decision about what to describe is based on their understanding of the needs associated with blindness. The description progresses from the general to the specific, as the describer integrates information about colour and direction and focuses on essential elements that enable the viewer to understand the image.

In addition, it is important to identify the time and place of the actions as well as describing the weather conditions and location. The audio describer should use clear, concise, and relaxed language and avoid the expression "we see". They should be mindful of the audience, use a variety of verbs, and avoid ambiguity. Moreover, they should objectively summarize the visual aspects of the image and use metaphors and similes to describe shapes and sizes. The audio describer's voice conveys meaning, as messages are mostly communicated through non-verbal cues such as gestures and facial expressions. It is important for the pronunciation to be correct, clear, and understandable, and for the voice to match the pace and energy of the material. When describing works of art, the goal is to make them accessible, which requires the use of precise and coherent expressions. The description should begin by emphasizing the dimensions, detailing the technique and materials, and defining both the subject of the work and its perspective. It is also important to agree on the descriptive sequence and location of the parts as well as to accurately describe postures, shapes and features, light, and colour.

CONCLUSION

Blindness, partial sightedness, and CVI pose complex challenges, rendering them difficult to define in a single manner. The Slovenian school system utilizes a pedagogical definition that focuses on the specific visual abilities of children, which allows for a more efficient adaptation of the educational process. This approach is essential for creating an inclusive environment that acknowledges the diverse experiences and abilities of individuals, ensuring that everyone has equal opportunities for learning and development. People with visual impairments require content that is adapted to meet their needs and provides an alternative to visual information, enabling them to participate actively in society.

The development of the senses, especially tactile perception, has an essential role in the holistic development of children with visual impairments. Children learn about the world around them by gaining experiences through play and interaction with different materials. These activities enable the development of motor skills and the acquisition of cognitive concepts, which are often linked to visual information. Therefore, it is particularly important that the extended curriculum for people with visual impairments includes activities designed to promote concrete and language-rich experiences, which enable children to acquire fundamental concepts and understanding of the world around them. One of the fundamental strategies in teaching children with visual impairment is the application of tactile perception. Sighted individuals can use tactile modelling and adapted teaching aids to enable children with visual impairments to explore and comprehend concepts through touch. Tactile picture books, tactile pictures, and other tactile content are essential for fostering the development of children's fine motor skills and tactile perception, enhancing their ability to efficiently perceive and interpret information through touch. Through realistic and accurate tactile content, children with special needs can comprehend and navigate the world they live in.

After developing an acute sense of touch, a person with blindness can acquire information through Braille, which virtually eliminates limitations to tactile learning about the world. In addition, the technique of audio description is another key tool that enables children with visual impairments to experience content that would otherwise be difficult to access. Audio description involves interpreting visual content "in real time", making it impossible to be thoroughly prepared in advance. This increases the accessibility of cultural and educational resources, promoting children's active participation in various activities.

While smell and taste are among the first senses to develop, they play a secondary role compared to touch and hearing in the education of individuals with visual impairments. Nonetheless, these senses serve as important complements, enhancing the overall experience and contributing to its precision.

The adaptations provided by professionals are crucial for fostering children's independence and success in education as well as in their everyday lives later on. Understanding the specific needs and challenges faced by children with visual impairments is a prerequisite for creating a learning environment that is not only accessible but also challenging, empowering them to reach their full potential and to actively participate in society.

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FROM EMPATHY IN DESIGN TO SOCIAL INCLUSION

Lech Kolasiński

Keywords
accessibility, empathy, design, typhlographics, universal design, aesthetics of touch

Abstract

The article concerns the social inclusion of people with special needs using universal design. It is related to the fourth principle of universal design, which is Perceptible Information. The first part explains the role of empathy in the design process and in the education of designers. The second part presents a case study: Comprehensive Typhlographic Solution for the Botanical Garden of the Jagiellonian University in Krakow and describes the design process, its challenges, and decisions leading to a socially inclusive design solution. The article takes into account the importance of multisensory experience in the process of memorization in blind people and the role of intersemiotic translation in the design of tactile graphics. The design solution proves the thesis of combining visual communication with tactile graphics as a real and noteworthy design compromise.

INTRODUCTION, ON PROCESS DESIGN.

Every person constantly, more or less consciously, changes reality, even when, by limiting the vegetative activities of his organism to sleep, a person takes oxygen from the environment, changes the chemical composition of his environment. However, we do not consider each of us in every action to be the cause of changes in reality. Consciousness or unconsciousness of action is not a reason for recognizing agency.

(Pawłowski, 2001, 126)

Design has been a secret knowledge for centuries. Often, specific behaviours have been designed into the culture and religion, habits, and traditions themselves. This means that regardless of the place on Earth, behaviours inscribed in tradition were and continue to be intended to ensure the well-being and health of the societies that cultivate them. If we start thinking, we can find examples of customs that affect a society designed with the happiness of that society in mind. Eating with chopsticks is Confucianism – an activity inscribed in the tradition of the Far East. Due to their design, it is difficult to eat quickly with chopsticks. In other words, the speed of eating can be regulated by the design of the tool we use. Eating slower will make us healthier. The design of a fork can force a specific positioning of the hand, and thus the way in which a specific group of users eats. Andrzej Pawłowski writes, "that 'things' (objects in design – author's note) are not an end in themselves, that they only serve to implement processes, and these, as important, must first and foremost become the subject of design" (Pawłowski, 2001, 168). Therefore, processes are designed that are hidden behind products or services. The design of a fork has an impact on the eating process. If we design a fork in a specific way and we manage to introduce this product as a leading one for a specific group of people. We can use this design to influence the habits of these people.

Social inclusion is a process, so it can be designed. In other words, every time we design any element of accessibility, whether it is a ramp, typhlographics, website accessibility or a toilet, we design the target: social inclusion of people with special needs. We then influence the shape of the entire process of social inclusion and this influence can be good or bad. In this text, I want to focus on how empathy as an essential feature of a designer can and should influence the process of social inclusion.

In the first part of this article, I will focus on the relationship between design, empathy, social change, and a method for building empathy in design students. In the second part, I will present a case study of my own universal solution in the field of tactile graphics.

EMPATIA A PERCEPCJA.

To understand what empathy means to a designer, we need to delve a bit into the phenomenon of perception. This will help us see how empathy helps develop perception and ultimately influences design. Awareness of the environment is largely determined by its perception. Perception is the process of evaluating and interpreting sensory stimuli. The ability to select information, separating what is necessary for survival from what is irrelevant is the basic task of the perception process. Therefore, we define elements that are useful to us in everyday functioning, first learning to notice those on which our safety depends. Information reaching us is carefully segregated by the perceptual system, and some of the stimuli reaching us are received instinctively. Perception is gaining awareness of the environment, which gives us the ability to act in it. Being aware of the environment, we can influence it, and therefore design change in this environment. The very considerations about what and how we perceive can also affect the perception process. In other words, we can question what we "perceive" and, as a result, discover other features of the environment that we had not previously paid attention to in the process of selecting information. Empathy is helpful in discovering features of the environment that we had not previously paid attention to.

Empathy is the ability to feel the mental states of others (emotional empathy) as well as the ability to accept their way of thinking, to look at reality from their perspective (cognitive empathy). An important element of empathy is the ability to imagine the perspective of thought belonging to another person. Empathy can and does have an impact on our perceptual processes. Here, in someone else's shoes, I imagine what it's like to be here and now in their life situation, having certain opportunities and limitations, having specific experiences that shaped them. I am not able to fully understand the needs and way of thinking of this person, but by getting to know another point of view, I enrich my perceptual system. I am able to identify elements of the environment that I did not notice before. Because I have knowledge about my own and, thanks to empathy, about others' ways of interpreting reality, I can notice other previously overlooked elements of it. Since perception consists of processes, it means that we can design it. In other words: science, language, culture, art are elements that design perception. By learning to speak, we learn to describe reality and thus understand it better. However, we are no longer able to return to the previous way of perceiving reality. Our perceptual process has been enriched by linguistic skills, so now perception depends on language. Going a step further, we should ask whether we can project empathy itself as an element of perception? Because if so, it would mean that we probably will no longer be able to perceive without empathy.

DESIGNING EMPATHY IN YOUNG DESIGNERS

Design in the field of design, UX, and architecture is primarily about finding and solving user problems. Teaching design must therefore be teaching empathy, used in practice to analyse user needs. After all, every best design solution starts with a design problem. Finding it requires observation and the participation of users in the design process. Teaching design is providing feedback on the problem selected by the design student. The student independently searches for a solution and must find it without being guided to a design solution. In the course of their search, they contact users and discover technological and workshop solutions. In other words, they collect experiences that help in solving problems. Empathy-developing experiences include participatory design, i.e. designing a solution together with a group of users who have a similar need or design problem to solve. For example, when designing a city square for a group of people, residents of the area can be included in the design team. This can take the form of social consultations on the project, already at the stage of its assumptions. This approach will allow us to responsibly determine the needs of interested recipients of the project and avoid design errors. We will design a square differently in an ageing district of the city, and differently in a newly built one full of married couples with children.

There are also designed tools that force empathy through the experience of a situation. This experience can be overwhelming, but it allows us to get to know a different point of view and become aware of new ways of perceiving reality.

INVISIBLE SPACES

Decisions depend on consciousness. In my opinion, the best solution that touched upon empathy and built multisensory awareness is the *Invisible Exhibition*. In Warsaw, Budapest, Prague, and Stockholm (since 2016) you can visit such an exhibition. It is an exhibition that you visit in complete darkness with a blind guide.

After the initial moment of panic, because "we are in a new space and we cannot see", there is a sudden opening to the interpretation of reality through other senses. To what we did not pay attention to before. First, we move along the wall, listening to the instructions of a blind guide. If we gather our courage, we can walk through the middle of the room without the help of the wall, exposing ourselves to obstacles. Previously, when walking through the room, I would notice the carpet, I knew that there would be a change of ground, my perceptive system recognized the obstacle before it appeared and ignored the feeling of the change of ground as insignificant. It didn't really occur to me to pay attention to this feeling in my everyday life. For a blind person, the change of ground is an obvious navigation point, one of the most important points of reference. At the Invisible Exhibition, for the first time since childhood, I sank into the carpet.

This experience drew my attention to the richness of the world, on which my survival does not depend, that I had previously ignored. It allowed me to expand my perception by consciously paying attention to touch and, in a broader perspective, to pay attention to the other senses pushed into the subconscious. Because, after all, I might not have paid attention to the information coming from other senses in various life situations. Thanks to this, I became a better designer. In other words: the experience of participating in the Invisible Exhibition developed my empathy. This experience should be mandatory in design schools and for all people dealing with broadly understood accessibility. Even if it does not ultimately increase the participant's empathy, it will certainly help increase their sensory awareness. After this experience, the participant will pay attention to more non-visual information.

CASE STUDY: **TACTILE TEACHING MATERIALS FOR VISUALLY IMPAIRED AND BLIND PEOPLE PREPARED FOR THE BOTANICAL GARDEN OF THE JAGIELLONIAN UNIVERSITY IN KRAKOW.**

My design path related to designing for the blind began in my fourth year of studies. As an Erasmus student in Italy, I came across a design workshop for the blind: "Kaverljag workshop 016 – Insects for the blind and partially sighted", an international workshop of non-fiction illustration in Slovenia in 2011 (Vrezec, 2012). This experience had a huge impact on the choice of my further path. The workshops prepared by Prof. Zdravko Papič and Aleš Sedmak pushed me into the world of designing for the blind, unknown to me so far. However, the aesthetic layer of the book created after the workshops made the greatest impression on me. It resulted directly from the function and readability for the blind, but due to the selection of technology, simplicity, and design discipline, it had a unique aesthetic character. The following case study is a description of a doctoral thesis conducted at the Faculty of Industrial Design of the Krakow Academy of Fine Arts in Krakow under the supervision of Prof. Czesława Frejlich and fully implemented in 2019.

Typhlographs are sometimes treated as an unpleasant addition to the work of a designer creating an exhibition arrangement or visual communication of space. That is why I decided to explore this design path to prove that it can be interesting and creative. I will use the example of a project carried out as part of my doctoral thesis titled *Tactile Didactic Materials for Visually Impaired and Blind People Prepared for the Botanical Garden of the Jagiellonian University in Krakow. fully implemented as Comprehensive Typhlographic Solution for the Botanical Garden of the Jagiellonian University in Krakow*. Its primary goal was to integrate blind and sighted people, which can be achieved thanks to tactile graphics. The design solution was to be characterized by readability and aesthetics for blind and sighted people. Other goals of the work were to criticize and expand the scope of tactile graphics design methods. The whole took into account the guidelines for designing tactile graphics, combining them with the principles of creating visual communication. An important part of the work was to examine the readability of the created tactile graphics and select the material so that it would be harmonious with the visual appearance of the garden. The project refers to the historical visual communication of the institution through the material used and does not interfere with the reception of specimens in the garden. Placing it in the Victoria greenhouse complex (where the plant specimens that are its subject are located) stimulates all the senses of a blind person. This in turn allows for better memorization of information in the field of botany. The typhlographics are enriched with an easy-to-use audio application, thanks to which the recipient can listen to the audio description.

INTERSEMIOTIC TRANSLATION

People with visual impairments base their knowledge of visual phenomena on the cultural description. This is due to the need to understand the omnipresent visual language. Part of their knowledge of the world is not formulated on the basis of experience, it is expanded by "stories about seeing" confirmed empirically. Transparency is a phenomenon that cannot be described without an example. We need to find a way to connect the experience of transparency with its concept, so that it makes sense. Parchment on a sheet of paper printed in Braille allows a person blind from birth to understand the concept of transparency: the convex inscription remains legible. We are able to build such an experience. The concept of transparency will become clear, experienced through another sense. This is what intersemiotic translation (from one system of signs to another) from one sense to another is all about. On this principle, visual phenomena can be explained to blind people, but can auditory phenomena be explained visually? It is possible: echo is a phenomenon inaccessible to deaf people, but mirror infinity can explain the principle of this phenomenon to them. A designer should set himself challenges.

After analysing the differences and similarities of the perception process, as well as existing solutions prepared for the main target group (blind people), I focused on preparing design assumptions. I wanted to bring about a meeting of blind and sighted people around universal adaptations, so that the information conveyed by graphics would enrich both, giving them a field of understanding.

TACTILE GRAPHICS

Creating typhlographics is a combination of graphic design using a drawing synthesis of the illustrated object with the construction of replicable objects in the form of relief illustrations. In order to fulfil an integrative function, illustrations should also be aesthetic for the sighted. We design an object whose visual aesthetic qualities should be in accordance with our sensitivity and sense of beauty. If blind people rely on information about the visual world, and we, as specialists, tell them that the proposed solution is aesthetic, they will take us at our word. This is a huge responsibility—as well as a challenge for ourselves. It is often an adaptation for the blind that draws the attention of the sighted to an object on the educational path.

Another function of tactile graphics can be to satisfy the need for touch in sighted people, especially since in most institutions you can't touch anything. When designing tactile graphics, you have quite a lot of freedom in terms of its appearance. Of course, it has to be contrasting due to the needs of those with visual impairments. Therefore, in terms of visual communication, a blind person leaves us complete freedom—the designer's dream is seemingly fulfilled. In the case of the legibility of tactile graphics, however, we must absolutely introduce the comments of blind people who check its legibility by touch. The results of the tactile graphic legibility test can impose certain image simplifications on us, which will affect its appearance as visual communication. From my experience, I conclude that the functionality resulting from the image simplifications created during the tactile verification of tactile graphics with a control group builds a very synthetic and clear drawing. Such a drawing should be aesthetic in itself, but the choice of the material and the lack of graphic awareness of tactile educators can spoil this impression.

SCIENTIFIC ILLUSTRATION

Scientific illustration, or more precisely its subfield botanical illustration, is related to the communication of specific (defining) details of studied specimens using visual means. It can be used to convey anatomy and explain the biological functions of organisms. Such illustrations allow for the presentation of details: from the representation of the entire organism to its microscopic close-ups. A botanical illustration is a visual interpretation of a selected organism, not its mimetic representation, but rather a showing of the “truth about it”. This type of illustration shows the plant in an idealized form, non-existent in nature. At the same time, it presents all stages of the plant's development and its cross-sections. Thanks to this, the recipient can, based on such an illustration, recognize the found specimen. Botanical illustration seems ideal for translation into the language of tactile graphics. Of course, some simplifications have to be made in this process, but information about the plant can be written down in subsequent illustrations. The design work in the design of tactile graphics draws largely from scientific illustration. Its goal is to design a simplified, legible, and aesthetic (for blind and sighted people) solution that conveys the "truth" about the presented object. Drawing conventions must be rejected and the presented object must be shown in a projection (projections). The abstractness of the phenomena of vision described earlier has a fundamental impact on the way graphics are translated.

WHERE? LOCATION.

When I was thinking about a place where I could implement my thesis about combining visual communication with typhlographics, I contacted the director of the Botanical Garden, Prof. Józef Mitka. The garden is visited by blind people more often than museums.

We planned to create ten typhlographic representations of plants from the oldest greenhouse complex, Victoria. This choice resulted from the location of the greenhouse complex close to the entrance to the garden and the ease of finding it on the 9.6 ha of the park. We wanted to create a publicly accessible educational path that would be intended for both sighted and blind people. This complex of buildings provided such an opportunity. Placing the adaptation in the closed microclimates of the greenhouse should trigger a multisensory experience for blind people, just as it does for sighted people. The planned reconstruction of the greenhouse resulted in the implementation of the project. Representations of tropical plants have not yet been implemented in Poland in the form of relief graphics. Due to toxins secreted by

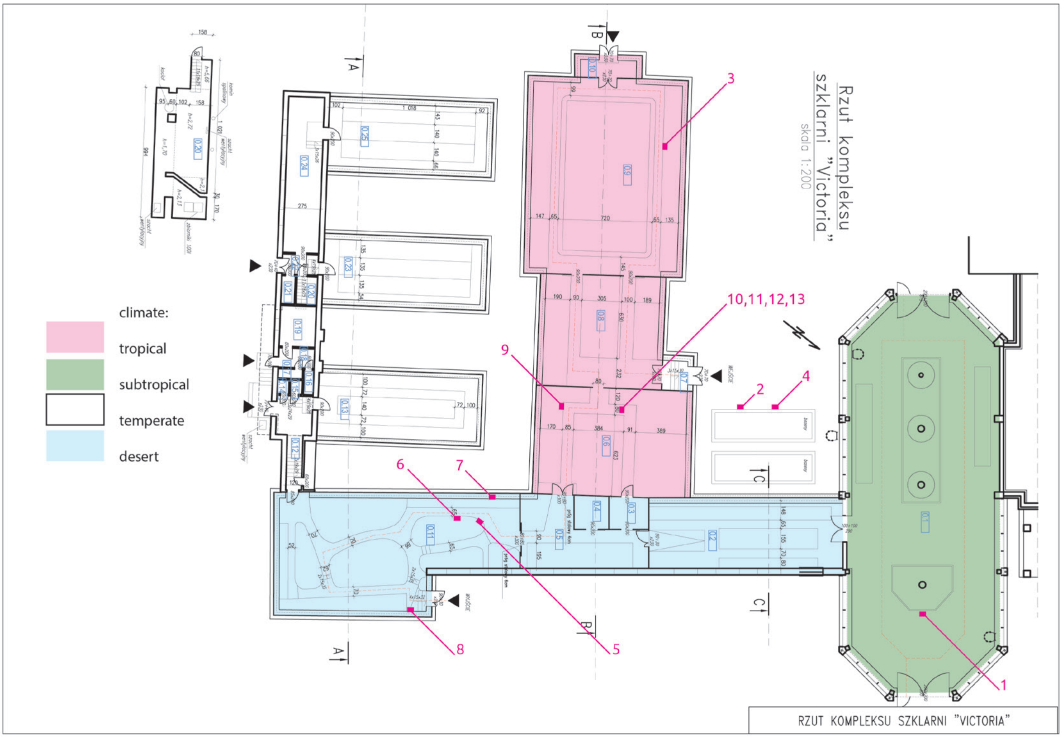

Figure 1: Location of illustrations in the Victoria greenhouse complex.

Figure 2: Educational boards in the Jagiellonian University Botanical Garden. (personal archive)

Figure 3: Porcelain tablet from the Botanical Garden of the Jagiellonian University. (personal archive)

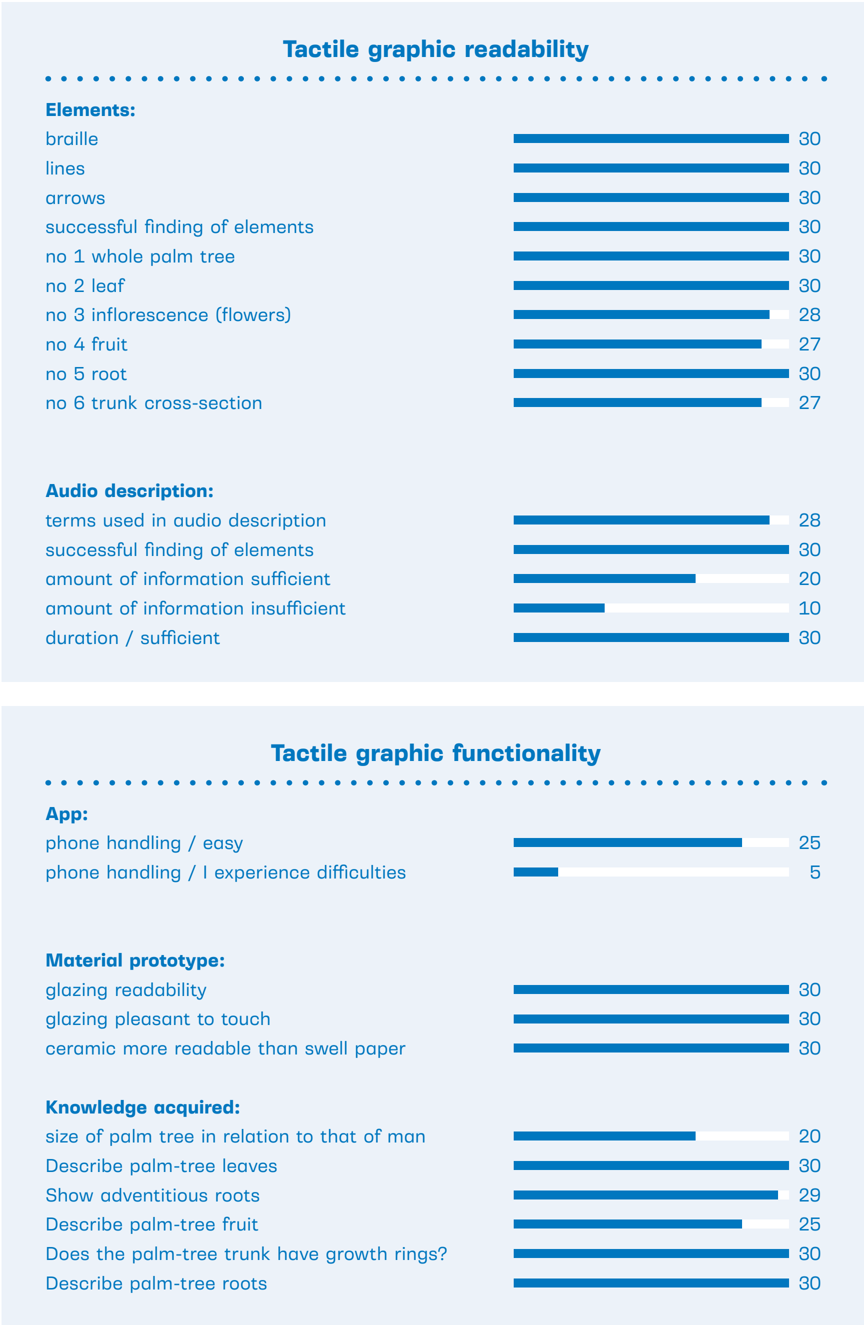

Figure 4: Adaptation readability test results: number of people who found the element readable out of 30 people tested.

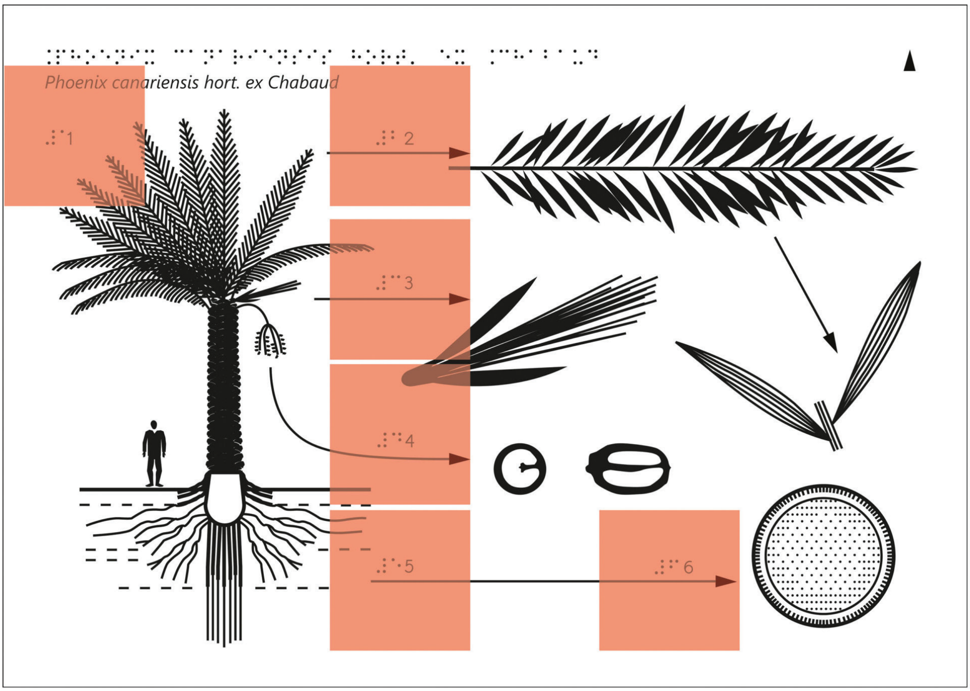

Figure 5: Location of NFC chips on typhlography.
(personal archive)

Figure 6: Adaptation of *Cereus Repandus Haw.*
in the Botanical Garden

some plants, it is not allowed to touch or pick any specimens in the garden. Safely distinguishing plants that can be touched from the rest is not possible with such a huge number of specimens. Tactile illustrations in the greenhouse thus help satisfy the need for tactile confirmation of what we see for the first time, and provide sighted people with a substitute for such confirmation.

WHAT? SELECTION OF SPECIMENS.

The selection of specimens to be adapted to the needs of blind people was made by the garden staff. The selection from a huge number of species was conditioned by additional guidelines. First of all, a typhlographic presentation of plants from one genus, whose visual representations are very similar formally, would not provide blind people with additional information. For example, the club-moss (*Cereus Mill.*) is a genus comprising 48 species of succulents from the cactus family. Yes, some plants from this genus differ significantly from each other, but most representatives differ in the colour of their flowers or the density and length of their thorns. With a high level of generalization, necessary for creating tactile graphics, these details may become illegible. In such cases, one species was selected that is suitable for a relatively easy presentation. In addition, plants should be selected that are not only interesting, but also allow for a biology lesson, raising issues related to the structure, reproduction, taxonomy of flora, etc. The choice of an object may also result from its uniqueness.

HOW? VISUAL COMMUNICATION IN THE JAGIELLONIAN UNIVERSITY BOTANICAL GARDEN.

Visual communication in the Jagiellonian University Botanical Garden was inconsistent, it was created as a result of subsequent projects written for specific parts of this institution, and is often created independently by the institution's employees. Analysing subsequent visual solutions in the park, I decided that the only solution that would meet the project's assumptions would be to refer to historical ceramic plaques describing the specimens collected here. They have a unique character, resulting from their form and material (porcelain). Regardless of the changes that have occurred over the years, they will always fit this place, and they are already associated with it, unlike other communication solutions of this type.

HOW? PROJECT.

The design work began with a preliminary sketch of the typhlographics. It was made using a swell form machine and special swelling paper. I developed it based on my previous several years of experience with convex graphics. During my work, I used my database of proven textures and lines in the form of a printout (relief). This allowed me to verify the design by touch. The work was consulted with specialists from the Department for the Disabled at the Jagiellonian University. In parallel, audio description, the NFC application, and, after initial verification of the design, half of the ceramic prototype were created. Completing half allowed for reducing costs at this stage of the project and gave the opportunity to test the material and different levels of relief convexity. Then, I prepared a readability survey sheet and conducted a pilot survey (3 people) and a target survey (30 people) of people blind from birth and blinded in different age groups. The survey includes questions about: the readability of individual parts of the tactile graphics (Braille, subsequent parts of the illustration), the ease of working with the NFC application, other tactile graphics available on the market, knowledge gained by touching the adaptation, differences between the swelling print and the material prototype, aesthetic feelings related to touching the tactile graphics. During the pilot implementation of the survey, I made video recordings of the movement of the hands of the examined person while reading the tactile graphics. After making corrections after the pilot survey, the tactile graphics turned out to be fully readable.

The NFC application was to allow the use of audio descriptions by placing the phone on the spot where the special chip was placed. As can be expected, this significantly simplifies the reception of the tactile graphics, but the arrangement of the chips becomes another design challenge. The NFC chip has a range of 6 cm. In order for the reader (phone) not to confuse subsequent chips with each other, it is necessary to separate their ranges by approximately 1 cm. The arrangement of the chips therefore imposed a grid in which all the illustrations should be placed. In order to check the correctness of this grid, it was necessary to make preliminary designs of the remaining tactile graphics. The palm *Phoenix canariensis hort. ex Chabaud*, the main prototype, fits into a vertical rectangle, the lucky tree *Crassula ovata (P. Mill.) Druce* rather into a square, and similar differences also occur between subsequent enlargements or cross-sections of parts of these plants, present in the adaptations.

Taking care of the coherence of the entire system, I decided to keep:

→ the same margin, triangle informing about the orientation of the typhlographics, and the main caption for the entire series of adaptations.
→ for adaptations presenting whole plants together with their structure, an additional grid resulting from the arrangement of NFC chips, designed so that they remain aesthetically coherent and legible.
→ for the adaptation presenting a comparison of fern leaves, a separate arrangement of NFC chips, because referring to the above-mentioned series would negatively affect legibility.

At this stage of the work, an idea emerged to enhance the multisensory experience of plant typhlographics by including sounds from their place of origin in the audio description. The composition of sounds from the Canary Islands was made by Marcin Pawlukiewicz, who deals with, among other things, the sound recording of documentaries. It was added to the audio description files, dominates at the beginning of the main description of the plant, then forms the background for the narrator. This cooperation developed during the implementation of the project. The challenge was to compose sounds distinguishable for similar conditions of occurrence of specimens. One of the most interesting solutions turned out to be the use of cultural meanings of plants, for example in the target implementation of *Nelumbo nucifera Gaertn.*—the Indian lotus—was commented on with the sounds of a Buddhist temple.

HOW? MATERIAL.

The ceramic prototype made for the doctoral thesis met its assumptions, and was aesthetic and legible. In the legibility surveys related to the project, as well as during later meetings with people with visual impairments, the material used to make the prototype was described as aesthetically pleasing to the touch, more pleasant than typhlographic thermoplastics and tactile graphics made of puffy paper or plastic. However, during the implementation of the project, based on new experiences from the completed work, together with Bogdan Kosak, we managed to refine the technology of making porcelain typhlographics and significantly increase their legibility. This required design changes and the development of new technological procedures, including deepening the relief in milled plaster matrices. We achieved the best results in the case of two representations of cacti, where you can feel the pricks of the thorns, but they are not sharp enough to pierce the skin.

During its implementation, the project was expanded to include a simplified map of the entire garden and a detailed plan of the Victoria greenhouse complex. This is the simplest possible system, consisting of general and more detailed elements. Due to their size (60 × 80 cm), the plan and map were made of epoxy, but their appearance imitates ceramic solutions. Making such large slabs with precise relief in porcelain would require the development of a new technological path, which would be irrational in terms of cost and would not allow it to fit into the project's time frame. The map and plan were enriched with a simple audio system: using two buttons, we can listen to basic information about the application's capabilities, how to install it (for iOS and Android), and how to use it. Additionally, the legend was also made in English, so that in the future we could add only the audio application in English (or another language) and a chip leading to a link in the store, from which it can be downloaded for free. The maps are also equipped with a set of NFC tags, so that a sighted person can familiarize themselves with specific rooms of the greenhouse or parts of the garden using the app.

DESIGN COMPROMISE

With the opening of the Jagiellonian University Botanical Garden in spring 2020, a system of typhlographics combined with visual communication was presented, supported by an application, also equipped with printed descriptions for people who do not use phones. This is a compromise resulting from the challenge: combining two different worlds, while maintaining minimal loss for each of them. A blind person can listen to audio files on the Garden's website before going there. A blind person selects from one to three illustrations during one trip. Familiarizing themselves with the whole thing at once (the estimated time of using typhlographics is 30–40 minutes) would be too tiring. A blind person starts the application and, standing in front of the illustration, holds the phone with the NFC reader to the triangle orienting the convex graphic to hear the technical description (instructions for use together with the arrangement of parts of the illustration). Then, they select the fragments that interest them. Listening to the subsequent recordings, they put the phone on the shelf that slides out on the right. The typhlographics are placed at a height that is also convenient for people with mobility impairments, who use wheelchairs. A blind person who prefers to use the texts in Braille can pull them out of a pocket placed behind the illustration. Sighted people can also use the audio application to deepen their knowledge of selected specimens.

SOCIAL INCLUSION

"To see" must be like predicting the future [...]. *Because you already know now that there will be a tree in a moment, and I will only know later, only when I approach the tree and touch it*.[1]

Predicting the future, or rather influencing it, through design is largely the domain of designers. A designer should see challenges, analyse them, and find a solution that has the greatest impact on the target group. A product becomes better not because it is different from others. It is better because of its purpose, function, and availability. The individual character of a product becomes secondary to its function.

Blind people move mainly in memory, it is memory that tells them about space. For them, space takes place in time. I am close to saying that it is not touch, hearing, or smell that replaces sight for blind people, but memory. The project prepared for the Botanical Garden is intended to inscribe the largest possible number of images into the memory of blind people, which, together with descriptions and feelings, should create a coherent introduction to the world of plants.

As a result, social integration of people with visual disabilities may occur. This is a long-term process. The project opens up the possibility of further implementation of similar solutions in other institutions. The project caught the attention of the Polish accessibility and design community as well as typhlopedagogues. They increasingly want to establish co-operation with visual communication designers. As a result of the project I implemented, more projects with a coherent visual and haptic layer began to be created. This project proves that in accordance with the principles of creating typhlographs, it is possible to design as aesthetic objects for sighted people, partially taking over the functions of visual communication. "Material truth" should be added to these principles in this field. In institutions where it is not allowed to touch

1 Explanation of a blind girl – author's note.

exhibits, tactile graphics can satisfy the need for touch in sighted people. If the object is visually encouraging, it will also be a place to expand experiences with touch, a place of meeting and mutual understanding between blind and sighted people.

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INCLUSIVE DESIGN AND THE IMPORTANCE OF VISUAL LITERACY FOR DESIGNERS CREATING FOR THE BLIND OR PARTIALLY SIGHTED

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Keywords
inclusive design, universal design, tactile illustration, blind and partially sighted, visual literacy, empathy.

Abstract

The article discusses inclusive design and the theoretical approaches underpinning the Kaverljag 2024 International Summer School. Although there have been design projects for the blind and partially sighted in Slovenia for quite some time, research in this field remains limited. The lack of research can be attributed to several factors: a limited number of research projects focusing on this area, the predominance of non-process-guided design for the blind and partially sighted, frequent exclusion of designers from projects, and a typical lack of interdisciplinary collaboration between fields in such projects. This contribution introduces the main topics related to the design for the blind— i.e. inclusive design, the role of empathy in design, readability, and legibility—and begins mapping the basic guidelines for visual communication design adapted to the needs of blind and partially sighted people. The article is not only intended for visual communication design students or experts in the field, but also for individuals from other areas (therapists, aides, educators, special needs specialists, etc.) who collaborate with blind and partially sighted people and wish to learn more about design tailored to this group as well as gain insights into interdisciplinary project management. The aim of the article is to contribute to the establishment of a theoretical foundation which informs the development of a visual communication design curriculum that emphasizes inclusivity and prioritizes the needs of vulnerable groups. In conclusion, the text underlines the potential for further expanding research in the realm of visual literacy by exploring its intersection with design for the blind and partially sighted.

INTRODUCTION

In Slovenia, there have been numerous past initiatives aimed at promoting culture and projects for the blind and partially sighted, particularly within the museum and gallery sectors. Professionals in these fields have organized various symposia and collaborated with experts from other domains, as well as with representatives of the blind and partially sighted communities. For instance, in 1993, the Celje Regional Museum staged the exhibition *Please Touch the Objects*. During the same decade, both the Kočevje Regional Museum and the Škofja Loka Museum were pioneers in this area (Šuštar, 2007). Moreover, the Faculty of Natural Sciences and Engineering, University of Ljubljana, researched the effectiveness of graphics designed for the blind and partially sighted (Urbas 2017). In the same field, the Academy of Fine Arts, University of Ljubljana, conducted an international research project, *Up Close* (2020–2023), in cooperation with Ljubljana's Museum of Modern Art and Zagreb's Museum of Contemporary Art under the leadership of Prof Tamara Trček Pečak.

In the sphere of design, there were similar initiatives twenty years ago, as is well described in Aleš Sedmak's contribution in this publication. The Kaverljag International Summer School 2024 project, which is part of the 'Visual Literacy' research programme at the Academy of Fine Arts and Design, University of Ljubljana, builds upon and further develops these initiatives.

We initiated this project within the contemporary context and society, which, over the past twenty years, has undergone significant transformations in the realm of visual communication. It is important to recognize that the discipline of design is grounded in 20th-century principles, and much of the activity has developed on the assumption that design must support endless economic growth—though there are some exceptions. Contemporary curricula should emphasize and bolster these exceptions, equipping young people with the tools to actively contribute to the necessary societal changes through design. The young generation belongs to a post-capitalist, post-anthropocene world and must be empowered to navigate this reality. Exercising caution about concepts of anthropocene design, which has proven dangerous and detrimental in the broader design context, our project, centring on this reflection, follows theories of inclusive design aimed at bringing vulnerable groups to the forefront in an equitable and inclusive manner. In doing so, we introduced the important element of developing more rigorous scientific methods and thorough result testing. Another reason for relaunching this 'dormant' project is both very logical and pragmatic: new generations of students are entering the educational process at the Academy of Fine Arts, University of Ljubljana, and it is essential to provide them with literacy in empathy and inclusion.

Although the 'Visual Literacy' research programme encompasses all aspects related to visual perception, the paradigm was flipped for this specific project segment: we began considering how to translate visual elements into alternative formats for individuals with no or limited visual perception. This contribution could also be titled 'Visual Literacy for Designers Creating for the Blind and Partially Sighted', as it covers the basics or the 'grammar' of designing for individuals with visual impairments.

An additional purpose of the present article is to outline the context of the project conducted as part of the Kaverljag International Summer School and underscore key research methods designers can adopt to facilitate effective communication with the visually impaired. Moreover, practical guidance is provided on designing projects in this domain. The main topics discussed concern inclusive design, the role of empathy in design, research in design for the blind and partially sighted, basic guidelines concerning visual communication design for the blind and partially sighted, and potential avenues for further exploration and research in this domain.

The reasons for this are clear: there is a limited number of research projects in Slovenia focused on this area; design for the blind and partially sighted is predominantly not process-guided; designers are frequently excluded from projects; such projects typically lack interdisciplinary collaboration between fields. Hence, it is important to stress that this article is not only intended for visual communication design students or experts in the field, but also for individuals from other areas (therapists, aides, educators, relatives, special needs specialists, etc.) who collaborate with blind and partially sighted people and wish to learn more about design tailored to this group as well as gain insights into interdisciplinary project management.

WHAT DO I MEAN BY 'DESIGN'?

As we know, visual communication design constitutes only a fraction of the broader field of design activity, which Herbert Simon eloquently describes in his book, *The Sciences of the Artificial*: "Everyone designs who devises courses of action aimed at changing existing situations into preferred ones. The intellectual activity that produces material artefacts is no different fundamentally from the one that prescribes remedies for a sick patient or the one that devises a new sales plan for a company or a social welfare policy for a state" (Simon 1996, 111). In this article, the word 'design' will therefore be used as broadly as possible.

The British designer Norman Potter identifies three categories within the domain of design: things, places, and messages (Potter 2018). Visual communication thus represents only a small portion of the design we are exposed to on a daily basis. Although the 'visual' is particularly relevant in our context, it is essential to adopt a broader perspective for reflection within the undertaken project.

Neuroscience has long confirmed the dominant role of visualization in human cognition and numerous studies focus on visual information processing. Half of the nerve fibres in our brain are associated with vision, and when our eyes are open, vision accounts for two-thirds of the brain's electrical activity, enabling rapid image recognition. This is by no means good news for this type of projects dedicated to the blind and partially sighted. However, it is evident that the scientific perspective in Western culture exhibits a certain degree of bias due to the disproportionate representation of vision research, as modern technologies are better equipped to obtain quantitative data on sight compared to other sensory modalities (hearing, touch, smell, and taste). This is also highlighted by Hutmacher, who notes that "there were more studies on visual memory than studies on the memory of all other sensory modalities combined. Second, while there were still a considerable number of studies on auditory memory, research on olfactory, gustatory, and haptic memory was even more limited" (Hutmacher 2019, 1).

Thus, this article will also address communication that occurs through different modalities. The designer's work encompasses a multitude of additional factors that influence the transmission of information: the story, the message, the emotions evoked by the project, and the connection people form between the image and the experiences intrinsic to themselves, their environment, and their feelings.

In this context, an important question arises: how and on what scale (limited or wider public) is the project intended to influence people and, furthermore, do we aim to tackle the issue by proposing a highly professional solution (considering that many adaptations for the blind and partially sighted fail to meet the professional standards of the design field)? This leads to the key question: what is good design? One perspective is offered by the British photographer, artist, and activist Platon Antoniou in his film *Abstract: The Art of Design*: "You are looking for a moment when you feel you are as close to the soul as possible. That's what good design is." (Netflix 2017) But to get close to other people's souls we need to slow our pace and reflect on their needs. This consideration should be central to design.

DESIGN FOR ALL

To begin, we turn to the visionary designer, critic, and activist Victor Papanek (1923–1998). His famous book *Design for the Real World: Human Ecology and Social Change* (1971) presents a radical vision of design, in which inclusivity, sustainability, and social justice are more important than consumerism and commerce. Since its original publication, the work has seen numerous reprints and continues to be one of the most widely read books on design. Among Papanek's most powerful and well-known statements is that "[t]here are professions more harmful than industrial design, but only a very few of them. And possibly only one profession is phonier. Advertising design, in persuading people to buy things they don't need, with money they don't have, in order to impress others who don't care, is probably the phoniest field in existence today" (Papanek 1997, xi). It is clear that the author was not very sympathetic to certain aspects of the (modernistic and capitalist-oriented) design profession. Why? One of Papanek's approaches was to challenge conventional thinking about 'ordinary people' by prioritizing all users, which is why he frequently designed for individuals with disabilities. He was convinced that "all people are handicapped in some minor or major way, throughout or for part of their lives" (Papanek 1997, 68), arguing that we should see "the whole mosaic that forms society, instead of the individual pieces we call minorities" (which, already at the initial stage of the process, become excluded from the 'general population' as 'different'). Drawing from our own everyday experiences, most of us can likely resonate with these conclusions.[1] In other words, promoting accessibility and inclusion benefits society as a whole. Therefore, design must always focus on the extremes of society, as this approach caters for the needs of all.

Inclusive, universal and accessible design

While in the past the terms inclusive, universal, and accessible design were primarily associated with physical space, focusing on the organization and accessibility of urban centres and architecture, over the past 20 years, these concepts have also been applied to virtual online spaces. The great development of information

1 For instance, consider the times we were three years old and tried to climb into an adult chair; when our child used crutches; when we helped an elderly person climb the stairs; or when we tried to board a bus with a newborn in a pram.

technologies and the widespread use of IT media have also led to an increase in research within this field. What can be observed is that individual disciplinary silos have begun to develop their own terminology and definitions in this area, which may vary across disciplines or industries. For the purpose of the present discussion, we will try to establish the fundamental characteristics of the three most common concepts, i.e. inclusive design, universal design, and accessibility.

Accessibility addresses discriminatory aspects and refers to ensuring that space, services, objects, interfaces, and technologies are usable by persons with disabilities (including hearing, cognitive, physical, and visual impairments). Of the observed terms, 'accessibility' is the one that refers the most to "compliance with official norms and standards, thus being mainly objective in nature" (Iwarsson 2003, 61).

Accessibility typically focuses on specific adaptations and represents a basic minimum—a level that should be accessible to everyone; however, the term is often erroneously used as a synonym for inclusive and universal design. "Web accessibility means that people with disabilities can equally perceive, understand, navigate, and interact with websites and tools. It also means that they can contribute equally without barriers" (W3C 2024).

Inclusive design

In response to the documents developed by countries in the past,[2] a number of organizations, initiatives, and companies actively working in the field of inclusive design have emerged.[3] The term is frequently associated with standards and legislation aimed at ensuring accessibility. Over the past decade, most of the work in establishing criteria and standards for inclusive design in the visual field has been led by institutions and associations focusing on

2 For example, the Standard Rules on the Equalization of Opportunities for Persons with Disabilities (United Nations 1994).

3 Design for All (EDeAN) is the European umbrella organization for e-accessibility, established in 2002 under the leadership of the European Commission and the European Member States. It promotes design for all, particularly in information technologies.

the web. One such organization is the Web Accessibility Initiative (WAI), operating under the umbrella of the World Wide Web Consortium (W3C). If accessibility was previously primarily oriented towards removing physical barriers, with inclusive design the focus has started to shift towards recognizing other diversities (arising from culture, gender, religions, etc.). Today, inclusive design consists in methodologies "to create products that understand and enable people of all backgrounds and abilities. Inclusive design may address accessibility, age, culture, economic situation, education, gender, geographic location, language and race. The focus is on fulfilling as many user needs as possible, not just as many users as possible" (Joyce 2022).[4]

Universal design

Universal design also began to develop rapidly under the influence of other social movements against the discrimination of groups that had been pushed to the margins of society. The coinage of the term 'universal design' is attributed to Ron Mace, who defined it as "a way of designing a building or facility at little or no extra cost so it is both attractive and functional for all people disabled or not" (Mace 1985, 147). Initially, universal design was applied in architecture and construction with the focus on ensuring physical access and enabling basic life functions for people with special needs.

In contrast to inclusive design, universal design seeks to create a unified experience that maximizes accessibility and usability for individuals of all ages, abilities, and life circumstances.[5] The principles drawn up by the universal design advocacy group are intended to guide all aspects of design, including the environment, products, and communications. According to the document's drafters, the principles can be applied "to evaluate existing designs,

4 A typical example of race-conscious adaptation in everyday life is the redesign of social media icons or 'likes' to include individuals with different skin colours.

5 A common example of universal design is the implementation of kerbs or ramps on pavements, which are not only essential for people in wheelchairs but are used by everyone else. In the realm of visual design, a positive example is the Kindle e-reader, which allows the user to adjust the font size of the text according to the lighting conditions and their specific needs.

guide the design process and educate both designers and consumers about the characteristics of more usable products and environments" (Connell et al. 1997).

These principles include:

① Equitable use: The design is useful and marketable to people with diverse abilities.
② Flexibility in use: The design accommodates a wide range of individual preferences and abilities.
③ Simple and intuitive use: Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.
④ Perceptible information: The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.
⑤ Tolerance for error: The design minimizes hazards and the adverse consequences of accidental or unintended actions.
⑥ Low physical effort: The design can be used efficiently and comfortably and with a minimum of fatigue.
⑦ Size and space for approach and use: Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility"

(Connell et al. 1997).

However, since some people have unusual or conflicting needs (for example, a person with poor eyesight requires bright light, while another might be light-sensitive), universal design cannot simultaneously satisfy every need for every person in every situation. For this reason, the principles of universal design need to be applied in some projects—especially where the investment costs of implementing different solutions for various target groups would be prohibitive. In contrast, in other areas, where situations cannot be adequately addressed by universal design and tailoring solutions to individual user needs is more feasible and practical, a better approach is to explore the requirements of specific user groups and customize solutions through inclusive design.

Based on what has been presented so far, it is evident that while there are overlaps and complementarities between the terms and fields, there are also some differences. Only when we understand the principles of accessibility (discriminatory aspects of an equivalent experience for people with disabilities), respect the parameters of inclusive design and, if possible, adhere to universal design, can we begin to precisely design the usability and user experience, be it for tangible products, digital products, or services. The aim of this process is to create efficient, effective, and satisfying products, experiences, and services.

Other user-centred design principles

All of the above is merely a selection of the most basic theoretical approaches in this broad field. User-centred design, participatory design, universal design, inclusive design, and design-for-all methodologies have long been present in the field of design, driven by the goals of efficiency, profitability, and product growth. However, works published at the turn of the millennium started expressing doubts as to whether designers' reliance on standards and guidelines alone could produce satisfactory results when designing for marginalized groups, the elderly, and people with disabilities. One of the new concepts, called 'user-sensitive inclusive design' (as opposed to user-centred design), proposes a slightly different direction by emphasizing the designers' need to develop authentic empathy for their user groups. The term 'sensitive' replaces the expression 'user-centred', suggesting it is rarely possible to design a product that is truly accessible to all potential users, but at the same time, 'sensitive' also implies a different relationship with users than 'centred'. The shift in the concept highlights that users are first and foremost human beings with whom designers need to develop an empathetic relationship, rather than treating them as 'subjects' for user experience tests (Newell 2011, 237). This mentality is not entirely new in the field of information and service design in the Slovenian cultural space, as empathy plays an important role in both methodological approaches. The naming itself and the concept have also influenced certain ideas of our project, which will be discussed later.

STATISTICS

Why is all of the above particularly important for our western, ageing society? According to the World Health Organization, an estimated 2.2 billion people worldwide experience vision impairment, with at least one billion of these cases being preventable or reversible (WHO 2019). In today's world, with a population of 8.2 billion, "there were an estimated 253 million people with visual impairment […]. Of these, 36 million were blind and a further 217 million had moderate to severe visual impairment" (Ackland 2017, 71).

A summarization of data for Europe, based on statistics from the European Blind Union (EBU), is equally alarming: "There are estimated to be over 30 million blind and partially sighted persons in geographical Europe. An average of 1 in 30 Europeans experience sight loss. There are four times as many partially sighted persons as blind persons. […] Women are more at risk of becoming blind or partially sighted than men. Sight loss is closely related to old age. One in three senior citizens over 65 faces sight loss. 90 percent of visually impaired persons is over the age of 65" (EBU 2024).

According to the data of the Union of the Blind and Partially Sighted of Slovenia, more than 10,000 individuals in Slovenia are categorized as blind and partially sighted; nonetheless, this number is definitely much higher as not everyone joins dedicated organizations (UBPSS 2024). Given the rapid growth of the elderly population, it can only be anticipated that these statistics will worsen. Failure to design systems according to the methodologies explored above could hence result in an increasing number of people being excluded from everyday life. It is crucial to recognize that well-designed products, services, and messages go beyond the mere transmission of information to people. Educational materials, for example, are also a prerequisite for social inclusion and participation in cultural life. When working with individuals with visual impairments, it is necessary to prioritize their empowerment, their opportunities to act independently, and their autonomy. However, there is another crucial quality that designers must possess, and that is empathy.

EMPATHY IN DESIGN

What is empathy? Empathy poetically means 'to step into another's world', 'to put oneself in someone's shoes', essentially, to share and understand another person's emotional experience. Daniel Stewart Butterfield, a Canadian businessman and the founder of Flickr and Slack, has made empathy a prerequisite for good design; "It's very difficult to design something for someone if you have no empathy" (InCap 2022). Empathy in design is also part of the research approach. It is an ability that designers develop through research, aimed at gaining full comprehension of users' challenges, their needs, and desires. This understanding, in turn, serves as the basis for designing the best solutions for users. Designers strive for empathy by exploring users' worlds in depth to accurately identify their problems and generate innovative ideas for life-enhancing solutions. How? Empathy towards the user does not only entail understanding their abilities, but also their context. This process can be facilitated by excellent tools, which, despite being initially developed for digital products, can easily be adapted for any project provided there is understanding of service design. One such example is the Empathy map (IDF 2024), which assists in recording needs and insights in a structured manner.

In a pedagogical context (such as the international summer schools discussed in this publication), this means that participants meet blind and partially sighted people and collaborate with them. Moreover, they gain first-hand experience of how these individuals see, feel, and perceive as well as explore the possibilities for performing specific everyday activities when faced with such conditions.[6] While it is true that a deeper understanding of the blind

6 At the Kaverljag International Summer School 2024, interactive workshops for participants were prepared by the visual impairment educator Dr Mateja Maljevac.

and partially sighted would ideally require long-term interactions, these short collaborations undoubtedly provide more value than a purely theoretical approach to projects. Engaging with and relating to the blind and partially sighted naturally increases the designer's empathy, which fosters understanding for developing successful project solutions. Conducting additional research activities (in-depth interviews, testing, and repeating the projects) allows us to gather information about the goals of the blind and partially sighted and apply our skills, planning, and creativity to help them achieve their objectives.

The designers' attitude plays a crucial role as it is essential to recognize that blind people are simply individuals with different needs. They do not want sympathy nor do they want pity, and despite their differences, we must ensure that they enjoy the same rights as everyone else. In this regard, the right to communication and information is one of the most important.

At the same time, it is necessary to highlight that the word 'user' does not completely fulfil the intended role and does not create the right connection. The designer has to establish a personal connection, which enables them to adopt a more specific approach to the work ahead. Personal engagement is key and can be enhanced by altering the words we use. For example, if we substitute the neutral, detached word 'user' with the name of someone we personally know, we will automatically assume a different attitude towards the project. Whether it is our best friend, 'my sister', 'your boyfriend', 'his mother' etc., the situation somewhat changes. By focusing on individuals we know personally, we can more easily reflect on their behaviours and circumstances (beyond health aspects) but also on their expectations regarding the use of the product we are designing and the ways they will interact with it. In this way, we can facilitate better knowledge acquisition and contribute to a higher-quality (or more engaging) learning experience for the blind and partially sighted. When we put ourselves in the users' shoes, we realize that the question of who we are communicating to can be particularly significant, as there is no such thing as a 'statistical user', and the blind and partially sighted form a completely heterogeneous group. They have different life experiences, knowledge, needs, and desires.

The theme of 'different perspectives' is aptly illustrated in the ancient story Blind Men and an Elephant.[7] A group of blind men heard that a strange animal had been brought to the town. They had never come across an elephant and none of them were aware of its shape and form. Out of curiosity, they said: "We must inspect and know it by touch, of which we are capable". So, they sought it out, and when they found, it they groped about it. The first person, whose hand landed on the trunk, said, "An elephant is like a thick snake." Another who felt its tail, described it as a rope. The one who touched its tusk stated that an elephant is that which is hard, smooth, and like a spear. The fourth man, who placed his hand upon its side, said that an elephant is a wall. The fifth, whose hand was upon its leg, said, an elephant is a pillar like a tree trunk. As for the one whose hand reached its ear, it seemed like a kind of fan (Wikipedia 2024).

Their descriptions of the elephant differed as they had different perspectives. The moral of the parable highlights a common human tendency to claim absolute truth based on one's own limited, subjective experiences, while disregarding the limited and subjective experiences of others, which may be equally true. In the story, the blind men eventually realize that they were all partly correct and partly wrong, effectively demonstrating that although an individual's subjective experience is true, it may not represent the totality of truth.

For designers, this parable is very insightful. It is as a call to develop a more profound understanding of the individuals we design for and to appreciate the various perspectives on the same observed subject. In other words: the blind and partially sighted, like all people, are unique individuals with distinct and diverse qualities.

7 The story originated in India around 500 BCE, eventually spreading across various religious traditions and through different versions. It is present in both Hindu and Buddhist texts.

PRACTICAL PRINCIPLES FOR DESIGNING VISUAL COMMUNICATIONS FOR THE BLIND AND PARTIALLY SIGHTED

The following sections present basic information on the visual perception of blind and partially sighted people, along with principles to consider when designing for this population. The design should also acknowledge that the blind and partially sighted are a particularly heterogeneous group composed of individuals with diverse needs, experiences, perceptions, and knowledge of the communication topic. Consequently, creating an equally effective experience for everyone simultaneously can be a significant challenge.[8] However, it is possible to approach accessibility by focusing on the specific components that constitute the communication elements.

Given the nature of the impairment, communication for the blind and partially sighted is typically associated with the sense of touch. It is one of the earliest developed senses of a new human being. A child first experiences the world and seeks contact with their mother through touch, which suggests that in a way it is our primary sense, yet it is often insufficiently noticed, remaining outside conscious awareness for many sighted individuals. In contrast, the blind can efficiently rely on touch. They begin by gently feeling and testing surfaces, familiarizing themselves with materials and wanting them to be within their reach. Once they establish a relationship, they focus on the details. This is why designers should embrace using different materials, as this adds information for the tactile perception and allows for a different experience. In doing so, it is necessary to prioritize safety: the materials and manufacturing methods must guarantee that the object is safe to touch and handle. Special attention must be given to details, such as edges and sharpness, to prevent injuries to the reader.

The writing system used by blind people is braille,[9] which remains one of the important tools for obtaining information and

8 An elderly person, who may have other co-morbidities, can experience a decline in finger sensitivity over time. Thus, physical predispositions of individual target groups have to be carefully considered.

9 Braille has only been in use for about 200 years. It is startling that for centuries, when literacy was already present in the population, the blind were completely excluded from society, even though they lacked only one of their senses.

fosters emancipated participation in society. Therefore, whenever it is possible to add textual descriptions, they should be incorporated for the blind. Braille comprises several types. In Slovenia, the established standard of Slovenian braille is contained in the document of the Commission for Slovenian Braille (Gregorc et al. 2016). These rules provide a standard ensuring that blind and partially sighted people can consistently access the same materials. This standard also serves as the foundation for developing all other relationships in the visual world for the blind.

Although the challenge of reading for the blind has been solved by the introduction of braille and tactile content, it is important to note that blind people represent a relatively small proportion of all individuals with visual impairments, i.e. less than 2%. Furthermore, the use of braille is declining as the percentage of individuals who are born blind is relatively low and many people lose their vision in their senior years, thus, rather than learning braille, they often rely on other assistive (digital) tools. This is why it seems logical to design in parallel for the partially sighted. Due to the nature of tactile perception, it is important to note that all elements (illustrations and text in braille) should always be convex, not concave, to enhance tactile exploration. When designing lengthier contents, especially if they combine Latin script and braille, it is crucial to account for the considerably larger space required by braille.

General insights

The general insights that apply to effective user perception in visual communication design are, in most cases, also a relevant basis when designing for the blind and partially sighted; however, these insights have to be adapted according to the genre, purpose, context, content, and target audience. Concentrating on the field of tactile illustration, the importance of prioritizing effectiveness, perception, clarity, and functionality becomes readily apparent. This does not imply that illustration should sacrifice its appeal, semantic value, and aesthetics, but rather that attention should be paid to certain predispositions to ensure communication occurs and becomes accessible to the blind and partially sighted. Given that these materials are often used for educational purposes, they represent one of the key elements in any project the designer undertakes. The content must be methodologically and didactically adapted to the target group of the blind and partially sighted for whom it is being designed.

Due to the non-homogeneous nature of the group, the most effective projects are frequently those combining visual and tactile images with embossed convex elements printed in a contrasting colour, which enhances the visual experience for the partially sighted. It is advisable that images in didactic materials are accompanied by text in both braille and a contrasting colour in relation to the background. It is necessary to always consider that individuals with visual impairments require additional time to explore materials through touch and vision as their analytical process involves progressing from the whole to the details or vice versa. For this reason, the volume of content needs to be adapted accordingly. This calls for interdisciplinary collaboration and the inclusion of visual impairment educators or other specialists, as they have significantly more experience in this area than designers.

The tactile illustration should be as simple as possible, stripped of irrelevant or secondary information, but not to the point where this becomes detrimental to the content it conveys.[10] To ensure clarity, the illustration should not include an excessive number of details or feature decorative elements. Additionally, care should be taken not to overuse other graphic elements that may be distracting to the blind. Based on the genre (educational materials, fiction) or the target group (children, adults) it is necessary to determine to what extent an illustration can be abstracted and typified to represent the object as a pictogram,

10 For more information on tactile scientific illustration, see the article by Marija Nabernik, p. 102, in this publication.

thereby enhancing recognition and understanding. In this process, information can be included at several semantic levels (main information, secondary information, etc.).

Since blind people perceive space differently from sighted people, perspective is to be avoided when representing objects, as it is distracting for the blind. The position of objects is also relevant; each object should always face upwards, and the left and right sides should be symmetrical.

There is a variety of technical possibilities for creating tactile illustrations. Helena Jakoubě discusses embossed illustrations featuring exposed dots of varying heights. Combined, these dots create a type of 3D-image with surfaces of different heights that transition organically—as if it were a relief map composed of individual convex dots (Jakoubě 2012, 14). The heights can be colour-coded to match the natural colour scale, the original illustration, or an accompanying legend. In this manner, more complex information can be provided. When selecting technology and materials, it is always important to base the choices on users' needs. For instance, in the context of designing publications this translates into opting for matte paper as the substrate (instead of glossy).

Formats

People who have been blind since birth have an extremely sensitive sense of touch and often use both hands to gather tactile information. The design should account for the ergonomics of the human body, ensuring that the illustration's size does not exceed the area covered by two outstretched adult hands placed on the object's surface. When designing for children, the size of the format should be adapted accordingly. Especially for individuals who have lost their sight later in life and have prior visual experience, it is important to maintain natural proportions (whenever feasible and sensible) when presenting real objects. If this is not possible, an understandable scale or legend may be added in the margin. In case of information where sequence is essential (e.g. wayfinding), we can assist the blind by indicating the starting point where they should begin exploring through touch.

Colour and contrast

Contrast refers to the difference in brightness between the foreground and background colours. It depends on and is related to the size, distance, and illumination of the object to be perceived. As maximum contrast is achieved with either white on a black background or vice versa, people with visual impairments often prefer black text on a white background or black text on a yellow background. In projects designed for the visually impaired, contrast has a crucial role, as, for example, low contrast text is more difficult to discern than high contrast text. The same principle extends to visual elements and, in the case of digital products, to any interactive elements that facilitate the functional use of the product (such as buttons on websites or within applications). For such elements, the minimum colour contrast should be three times higher (RNIB 2024, 9). A sufficient difference in colour shade or brightness helps distinguish foreground from background; however, when contrast is reduced, the ability to differentiate between these two visual components becomes impaired. Therefore, it is beneficial to use saturated colours and strong contrasts, as they significantly improve clarity for people with visual impairments.

Complementary colour pairs (red-green, purple-yellow, blue-orange, etc.) should be avoided. The RNIB points out that, "[t]he two combinations that cause the most difficulty are red and green or yellow and violet/purple. These can be quite jarring if used closely together especially if similar tonal contrast is used. Complementary colour combinations can be used together if there is enough tonal contrast between the two colours" (RNIB 2024b). Similarly, insufficient contrast between shades of other colours is inappropriate and should be avoided. Furthermore, specific visual impairment conditions (glaucoma, cataract, diabetic retinopathy, presbyopia, glare sensitivity, colour blindness,[11] etc.) need to be taken into consideration. Advanced simulation tools already exist to assist in this process (Mays 2024).

11 There are many different types of colour blindness, although it most commonly affects the ability to distinguish between red, yellow, and green.

When using negative text (e.g. white text on a black background), it is necessary to consider the increased eye strain it causes. To alleviate this effect and ensure clarity, the font size needs to be enlarged (and the typeface weight potentially adjusted). Similarly, in illustrations, contours, outlines, and lines can emphasize certain elements or eliminate the need to rely on colour as an information carrier. Alternatively, a colour scheme adapted to various forms of colour blindness can be implemented at the onset of the project.

Typography and layout design

In typography and graphic design, general rules for creating clearly legible texts, which encompass both micro-typography and macro-typography, can be used as guidelines and further adapted to accommodate the needs of the blind and partially sighted. Likewise, information design theory can prove helpful in situations where perception, functionality, responsiveness, and message are of primary importance and impact information effectiveness; equally relevant in this context are the laws of visual art theory and gestalt, familiar to every professional illustrator and designer.

Consistency is one of the main rules aimed at ensuring text readability. The use of elements must be consistent throughout all pages (e.g. of a book), as this facilitates easier navigation for the blind and partially sighted. It is important to bear in mind that excessive information can be detrimental and presenting information requires meticulous prioritization. In this regard, hierarchy and editorial decisions on which details to include or exclude play a key role. Often, information can be clearly organized into hierarchical units such as headings and sub-headings; however, it is also possible to incorporate different layers of information, which the user can either choose to read or skip.[12] Longer texts should be broken down into readable, interconnected paragraphs, allowing the reader to take a breath and pause. Columns can often be a use-

12 A good example are footnotes.

ful means for improving layout, provided they are not used alongside braille. Columns should be adequately spaced to prevent confusion for the user. Although these conventions have been present in written documents since the existence of human records and have further evolved with the invention of printing, they are often overlooked in the transition to digital technologies.

Experience in designing for the blind and partially sighted reveal that it is frequently necessary to adhere to very basic design levels, as the process of reading braille or exploring tactile illustrations through touch is more time-consuming and demands greater effort from the reader compared to the visual perception of a sighted individual. To cater to the needs of blind people, it is therefore crucial that information (for example, at an exhibition) is presented in a multi-layered format: title, basic information, and a brief description followed by more comprehensive descriptions that are also suitable for sighted people. This approach offers the blind and partially sighted the possibility to choose the level of information that aligns with their interests.

Readability and legibility are not only concerned with the size and shape of the type, but also with all the related parameters: inter-letter, inter-word, and inter-line spacing, colour, the medium of the text, the light conditions for reading, and the content transmitted by words. It is generally accepted that lines with generous vertical intervening white space are more readable.

Left-aligned text, allows the eye to move more quickly to the next line. Centre-justified text is an example of poor practice, as in most technologies it leads to automatic word spacing, which hinders reading fluency. Lines should not be excessively long, as it becomes difficult for readers to find the beginning of the next line when their gaze returns to the left. Experts have defined 'moderate' line lengths as those containing between 50 and 70 characters per line (Dyson 2023). Moreover, although vertical text direction is achievable with modern digital tools, it poses readability challenges and should be strictly avoided when designing content for the blind and partially sighted.

In addition, the text in braille should be clearly separated from other elements on the page, making for an easy reading experience. Braille differs from the Latin script, which is read line by line, and it cannot be arranged in columns. Certain typographic conventions relevant to Latin-script typography, for example numbered lists, also apply to braille. Mathematics and physics can be typeset in the same way. Tables, on the other hand, are usually translated into a numbered list. Other formatting conventions may also be used, e.g. emphasizing certain elements, such as paragraphs or subheadings, to achieve quicker and clearer orientation.

When designers consider production, it is important that elements are arranged in such a way that they are not placed near folds, as the materials need to remain flat (to accommodate the partially sighted who may use magnifying glasses). In printed publications, the binding should permit the material to open completely. Although coil binding has become a standard for publications intended for blind and partially sighted people due to its low production costs, its functionality issues (such binding deteriorates rapidly) highlight the necessity of implementing more innovative solutions.

Text and other graphic elements should be of sufficient size to ensure clear visibility, while avoiding excessive enlargement that could hinder the ability to view the entire image or sentence at once. It is necessary to ensure that visual elements (e.g. text, graphics) are adequately sized to be visible without the need to bring the product close to the eye. This cannot be achieved without testing with the blind and partially sighted. Professionals working with the blind and partially sighted recommend using font sizes ranging from 16 to 20 points, as this range has been identified as the most suitable[13] (RNIB 2024a).

However, it is not only the overall size of an image that determines how clear it is. To ensure that users can distinguish im-

13 This is a generalized rule: a typeface may have more or less legible weights and different x-heights that improve its legibility, therefore it is always necessary to consider all parameters simultaneously. For instance, a 10 points letter in one typeface may visually appear larger than a 12 points letter in another typeface.

age features or its parts, typefaces should be carefully chosen. For example, letter recognition involves distinguishing the strokes in a letter. When examining the letter itself, the ratio between thick strokes and thin strokes (modulation), which should not be in contrast, and the size of the white space within the letter are significant factors that determine readability and legibility. In addition, it is important to avoid narrow typefaces, typefaces with very thin strokes (as very light letters can reduce legibility by making it more challenging to distinguish letter shapes), and typefaces with extremely thick stroke weight. Bold or semi-bold typeface weights promote successful reading. It general, italic, and decorative typefaces are less useful, particularly when designing projects for blind and partially sighted people.

In typography, it is common practice to use serif typefaces for longer text blocks and monoline sans serif typefaces for shorter texts, labels, and (indoor) signs.[14] These typefaces are also generally preferred by the blind and partially sighted, the most optimal being the typeface weights creating clear, geometric letterforms.[15] Nonetheless, another determining factor in choosing the most suitable typeface is the context of the project.

When examining the basic building blocks of typography, attention must also be given to the individual additional characters that make up the set, as certain numbers, like 3, 5, 8, 0, and 6, can be difficult to read in some typefaces, potentially leading to errors. Moreover, it is necessary to be aware of 'dangerous' character combinations within texts, such as l – 1, O – 0, and 3 – 8, as these can be easily mixed up. Research suggests that longer texts typeset entirely in capital letters (majuscules) are more difficult to read, as capital letters lack the variation found in lower-case letters (minuscules).

14 From the perspective of typographic professionals, these rules are very simplistic, as readability and legibility have been extensively researched within the field of typography. This is particularly true today, as modern research approaches in conjunction with neurology, psychology, and various measurement technologies, make such studies possible. In the context of this publication, it is unfortunately not possible to address details. For more information, see research and publications by authors Sofie Beier, Mary Dyson, and Ann Bessemanns.

15 For a personal view on this topic, see the contribution by Tomaž Wraber, p. 222, in this publication.

However, as mentioned earlier, all the parameters of the material being designed influence all the other elements; for this reason, it is crucial to view them as a whole and, most importantly, test our designs with users.

Although many designers dislike adhering to rules, when designing for the blind and partially sighted, it is crucial to prioritize simplicity of form, contextualization and functionality, otherwise the content will fail to serve its intended purpose. Designers who succeed in this area will be those capable of effectively integrating constraints into the initial project brief, leveraging them as a foundation for innovative and creative solutions. This approach often leads to excellence both in terms of usability and distinctive aesthetics that derives from these constraints.

THE WIDER CONTEXT OF THE PROJECT AND TESTING

By designing legible materials, we support people's ability to access information and effectively carry out activities and tasks. At the same time, it is also widely acknowledged that typefaces fulfil two roles: a functional role related to legibility and an aesthetic role that determines the typeface's suitability for a certain purpose based on the meaning conveyed by its visual form. This second role has also been described with other terms: atmospheric value, semantic qualities, and identity (of a product, exhibition, book, etc.). While braille does not possess these qualities, even visually clean and legible typefaces have limited expressiveness. To ensure that blind and partially sighted people receive information about atmosphere and semantic properties, such information must be communicated in alternative ways. Although for the partially sighted vision remains the primary sense (regardless of how diminished), in the case of the blind it is possible to engage other senses beyond touch. Hearing, smell, and taste can be important components for multisensory enrichment that enhances the user's experience.[16] This incorporation

16 Although we leveraged some of these possibilities in the exhibitions of materials developed during the Kaverljag International Summer School 2024, there remains considerable potential for innovative design solutions.

naturally involves interdisciplinary collaboration with other experts in the fields of gamification, nudge theory, architecture, performing arts, music, etc.

In all of these projects, it is also necessary to consider the wider context of information reception: in what manner will the visualizations be truly accessible? How will they be presented? And how will interpretation be facilitated—will it be guided, accompanied, independent, or part of a wider educational project? Long-standing experience in the museum field confirms that every project poses its own challenges. Although the principles outlined above address good design tailored to the blind and partially sighted, it is essential to recognize that every individual has unique needs and attitudes that influence their response to the prepared materials. Curator David Kožuh from the Goriški Muzej Regional Museum, who has extensive experience in this field, even claims that "it is better if a guide leads the blind and partially sighted than attempting to adapt the exhibition for a self-guided tour" (RTV SLO 2023). A trained guide can offer a personal approach and create an interactive experience, which proves to be the most effective option. Therefore, design solutions can also be the cornerstone for a well-designed exhibition and a well-orchestrated event that integrates multiple communication channels. A combination of all these elements allows for accommodating a wide array of diverse needs.

CLOSING REMARKS

Given the heterogeneity of the user group and the wide range of needs, it is important to acknowledge that all the specifics outlined above may not be entirely applicable to every individual. Each individual has unique needs, and ideally, the approach should be tailored to accommodate these requirements. Therefore, it is crucial that designers adopt a variety of research methods in the early stages of a project.[17] The duality within the project (understanding

17 For a more detailed description of the process of the Kaverljag International Summer School 2024, see the scheme on page 247.

of the material we communicate and the users for whom we design) can only be explored with a tailored repertoire of methods. Initially, designers should investigate secondary literature and subsequently conduct observations in order to learn how to listen to others' perspectives and to acknowledge their own prejudices and judgements based on personal viewpoints and experiences. Further information should be gained through gathering insights, interviewing, generating ideas, collaborating or co-designing with users, etc. Only a project conceived in this manner, with a perspective on what modern technology has to offer,[18] can provide effective solutions in the design phase, provided that it is subject to repetitions and frequent testing.

Despite familiarity with the design tools, innovative thinking is only possible in an interdisciplinary group setting which encourages collaboration throughout the entire project life cycle. An interesting question to explore in the future is how to identify the unique strengths of blind individuals compared to sighted people, understand how they form their mental representation of the world, and integrate these insights into design projects. This would only be possible through the active participation of blind and partially sighted persons in all phases of the project. It would also be beneficial to further develop the project in collaboration with experts from the fields of neurology and the visual arts, as implementing robust testing methods would undoubtedly yield more tangible results regarding our performance.

Organizing the project in this manner may open opportunities for different reflections within the domain of visual literacy, such as rethinking the concept of imagery, which includes questioning what exactly mental representations are and to

18 For this purpose, during the Kaverljag International Summer School, we applied the cost-effective technology of 3D printing. Our goal is to establish a library of 3D-printable files for popular science illustrations at the Academy of Fine Arts and Design, University of Ljubljana, given the positive feedback from testing the project results, which also offer an excellent learning opportunity for students.

what extent it is necessary to present the blind with 'realistic' visual images as perceived by the sighted? In his book *Design as Art*, Bruno Munari writes that "'Copying nature' is one thing and understanding nature is another" (Munari 2008, 158). The better we understand what we aim to communicate and the audience we are designing for, the greater the impact the resulting projects will have.

The key is to transform such initiatives into our daily practice, rather than treating them as isolated events driven by individual groups of enthusiasts. Through exposure to these topics within the curriculum, visual communication design students (illustrators, graphic designers, photographers) should be given the opportunity to realize that by developing creative solutions they can enhance any project, making it suitable for the entire population within the broader society.

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OUR VIEW ON THE COLLABORATION BETWEEN BLIND AND PARTIALLY SIGHTED PEOPLE AND DESIGNERS AND WHAT WE CAN ACHIEVE TOGETHER

Tomaž Wraber

Keywords

testimony, accessibility, experience, examples, vision loss, accessible design

Abstract

In this paper, Tomaž Wraber shares his personal and engaging experience of visual impairment and blindness and systematically demonstrates the importance of accessible design through his experience of serving on a number of national and international bodies. His story begins with the early discovery of his low vision and with his parents, who allowed him to be educated in the mainstream system. This gave him a broad cultural and intellectual base that helped him to cope with his sight loss later in life. He points out that rehabilitation is crucial for people with sight loss, but also attaches equal importance to the role of society in ensuring accessibility. The author looks in detail at various aspects of accessibility, from architectural adaptations to the design of digital content, and is critical of the lack of inclusive design. He pays particular attention to the design of visual communication, signs, and typography, pointing out that designers should also take visually impaired users into account when designing. Using a number of examples (tactile communication in space and on products, adapted keyboards, and audio-descriptions), the paper shows how thoughtful design can improve the lives of people who are blind or visually impaired. The author concludes with the idea that designing accessible environments is not just a technical issue, but a reflection of society's empathy and willingness to include all people equally in public life.

PERSONAL STORY

Deviating from conventional norms of academic articles, I want to begin my contribution with a particularly personal touch. Shortly after my birth, my mother, a defectologist, observed that as a baby I did not respond to her presence in the room, but only to the sound of her voice. Naturally, my mother immediately suspected something was very amiss. Shortly after I turned one, an ophthalmologist examined me, discovering that my vision was less than 50 per cent. Due to severe myopia, I was prescribed glasses with a dioptre of approximately minus five before I was even two years old. At that time, I was supposedly one of the youngest people in Ljubljana wearing glasses. Back then, children were not individually assessed and placed, but were categorized either for mainstream or special education schools. As my mother was a teacher at a special education school, she was not only a member of the categorization commission, but served as its head for an extended period. Her significant contribution involved the introduction of a process for re-assessing, re-evaluating and re-categorizing children assigned to special education schools just before they commenced their education. Through her observations, she discovered that some of these children could overcome years of developmental delays within a short period, as brief as half a year or less, and demonstrated the necessary abilities to be enrolled in mainstream schools. I am unaware and do not recall whether I was assessed by such a commission, but I do know that the 'school system' decided to enrol me at the Institute for Blind Youth on Langusova Street in Ljubljana. In response, my mother, a defectologist, my father, a biologist and internationally renowned scientist, and his grammar school classmate and close friend, esteemed psychologist Prof. Dr Anton Trstenjak, formed an *ad hoc* commission specifically for my case, which is today known as the Commission for the Placement of Children with Special Needs. The specifics of my evaluation process are unknown to me, but after the assessment and a thorough deliberation, the commission arrived at an unambiguous conclusion: my parents were to enrol me in a mainstream primary school.

At that time, terms like 'integration' and 'inclusion' had not even been dreamed up, let alone was the school system prepared for such an 'oddity'. Only decades later, did I realize how much my parents had really risked and what I truly gained by receiving my education in a mainstream school. This insight came when I was a member of the governing board of the Union of the Blind and Partially Sighted of Slovenia (UBPSS), where I was responsible for education, rehabilitation, and matters concerning children with special needs. I came to understand that, in many ways, the Institute for Blind and Visually Impaired Youth focused on teaching its students 'how to be blind' rather than equipping them with the skills to lead their everyday lives as normally as possible. I became aware of the immense favour my self-appointed 'commission' had granted me. Looking back, I recalled a series of struggles and doubts my parents had endured, which I, as a snot-nosed carefree child, was blissfully unaware of and which they had chosen to keep from me.

Not wanting to lag behind my older brothers and sister, I enrolled in the classical class of Prežihov Voranc school after completing the fourth grade of primary school in Spodnja Šiška, and then continued my education at the former classical grammar school on Šubičeva Street in Ljubljana. Throughout those eight years, from the second half of primary school to the end of grammar school, I was fortunate to be surrounded by an incredibly stimulating environment, filled with incredibly positive challenges on a daily basis, thanks to the diverse array of classmates. Needless to say, we did not avoid any of the adolescent foolishness, but we also pushed each other to absorb as much knowledge as possible about a wide range of subjects, especially about literature in all its forms, music, fine arts, film, theatre, and all that Ljubljana had to offer. Contrary to popular belief today, cultural opportunities in Ljubljana were far from scarce during my youth. We visited almost all the theatre performances, exhibitions, and concerts, and we watched most of the films that were new in cinemas. We never ran out of time for cultural events, and even for us, tickets were not too expensive back then. Alone or with the scouts, we roamed the hills and the Slovenian countryside. Vinyl records of classical music were too expensive that we could borrow from each other, but the situation was different when it came to fine art. The Italian publisher Rizzoli was publishing a large collection titled *I Classici dell'arte Rizzoli – Opera completa*, which featured the complete body of works by some of the most important painters in the history of art.[1] These books were probably cheap for Italians (1000 lire each), but for us they were relatively expensive. Therefore, we co-ordinated our purchases to avoid duplicates presenting the same artist. In the end, our combined collection included about a hundred books with the works of the most important painters in art history. We would lend each other books and then engage in discussions on the individual artists and their works. I soon built an almost complete art collection in my mental library, and over the following decades, when I visited the majority of the world's most important galleries and museums, I rarely encountered a prominent work of art that I had not already formed a vivid impression of before seeing the original for the first time. Among these, I was most impressed by the original of El Greco's *The Burial of the Count of Orgaz* in a Toledo church. Its grandeur left a profound impression on me that few other works of art have ever matched. As our exploration of visual art was complemented with the study of general history, music, literature, films, and a few foreign languages, all of which we absorbed so effortlessly during our secondary school years, we built an extensive mental library of ideas, images, concepts, and connections, granting us unhindered access to all the diverse realms of human culture.

During the end of my adolescence, and even a bit beyond, my dioptre rapidly increased, and by the time I was around 20 years old, I wore glasses with a prescription of minus 20. The lenses were so heavy that my nose had blisters and so thick that they left abrasions on my cheeks. My eyesight slightly deteriorated every winter,

1 Each large-format book contained at least about 50 full-page colour reproductions of the painter's most significant works, along with black-and-white reproductions of their other pieces in the final section. Basic information about all the works was also added.

improving to some extent during spring. Despite this, I could read, go to the cinema, even drive a car … Until one spring, when my vision did not improve, nor did it get better the following year, and, what is more, every winter it worsened more than the previous. What followed was the onset of a severe and rapid crisis, during which my vision deteriorated daily, and shortly after turning 30, the ophthalmologist estimated that I had only 1.8 per cent of vision in my better eye. Any residual vision below 30 per cent is defined as partial-sightedness, while any residual vision below five per cent as blindness. This categorization is also in line with the International Classification of Functioning (ICF).

> I am sure you are already wondering why I am bothering you, my readers, with this story.

Firstly, because it is important to know that not all blindness is the same, nor is partial sightedness. The reason for this may not necessarily stem from the five distinct categories used to classify the conditions of individuals according to the *Definition of Blindness and Partial Sightedness of the Republic of Slovenia*. This classification is very important in practice. The cause and the modality in which someone lost (or was progressively losing) their sight and the length of the deterioration process, as well as the age at which vision loss occurred or began, are elements which significantly influence how the individual will navigate everyday life. In addition, personality and other individual traits can also be the underlying factors determining whether someone faced by partial or total sight loss either becomes truly incapable of confronting the challenges of everyday life when or is able to function in life as if nothing special has changed, even in the case of total blindness, seemingly overcoming almost every difficulty.

Today, I am aware of the extraordinary privilege of being sent to a mainstream school by my parents, where I encountered outstanding individuals who—much like my home environment—held a deep appreciation for art, science, culture, education …

I am grateful for having retained a significant part of my sight long enough to read most of the world's most important works of literature, become acquainted with the majority of works by the world's most renowned classical composers, engage with a significant portion of creations by the world's most important dramatists, and explore the art of almost all of the world's most prominent visual artists. There are likely few individuals with such a robust spiritual foundation and a vast library of concepts from which to draw the immeasurable spiritual riches accumulated over millennia of human civilization, as I have been extremely fortunate to do.

And again, you might ask, why the need for this explanation? Within the UBPSS I founded the Blind and Visually Impaired Intellectuals group and served as its chairperson for several terms. The group's primary objective was to meet the exceptional demands for knowledge and, in particular, culture among its members who harboured such desires. Visits to museums and galleries were one of the frequent forms of our activity. The exhibition of Leonardo da Vinci's technical inventions at the National Museum of Slovenia was enriched with reproductions of his masterpieces to offer a more comprehensive insight into his genius. After an excellent guided tour with detailed verbal descriptions of the exhibits, the guide led us to the last room and said: "And here is Leonardo's famous Mona Lisa!" One of the older members, an educated and knowledgeable man who became blind as a child during the war, surprised us by asking: "What type of painting is that? Is it a nude, a portrait, a full-figure painting or something else?" This question made it strikingly apparent how significantly the perception of images differs—not only of paintings, sculptures, and artworks but also of the real world—depending on whether one is blind from birth, has lost their sight as a child, or became visually impaired as an adult. The Mona Lisa, an undeniably recognizable icon for a sighted person, held no reference for him until the guide provided him a very detailed and truly illustrative description of the face, the posture of the hands, the visible part of the sitter's figure, the sfumato background in which the landscape behind the figure is lost, and, naturally, the enigmatic smile. I have not the slightest idea what mental image this gentleman formed in his imagination or how he interpreted the famous enigmatic smile in the portrait. However, after the guide's vivid description, he was evidently content and undoubtedly enriched by a concept that had previously been unknown to him.

This instance serves as compelling evidence that it is possible to make visual art accessible to the blind and partially sighted, presenting it in a way that enables them to form their own interpretations and probably also experiences of the artwork. It is irrelevant that we do not know what this mental image is really like. Do we truly know what form a visual artwork takes in the mind of a sighted person? Did they truly perceive, recognize, and comprehend the elements of the painting in the same way as someone else with equally good eyesight? The vision of one sighted person differs from that of another and, even more so, the image constructed by brain based on the optical signals received from the eye. Trust me, I have plenty of experience with how relative the sense of sight is, and how people with perfect vision can perceive, for example, the same work of art in completely distinct ways, to the point of noticing and recognizing very different elements in the same piece.

BLINDNESS AND PARTIAL SIGHTEDNESS

The percentage of blind people with total vision loss unable to even perceive light (amaurosis) is relatively low. Most individuals classified as blind according to the definition of blindness and partial sightedness retain at least minimal residual vision, and many even have residual vision that can be very useful (under the right conditions). It is widely accepted among the professionals in the field that for every person who is blind (by definition) there are at least ten people who are partially sighted. However, the general public remains unaware of this fact as blindness and partial sightedness carry a strong social stigma, compelling the majority of people with severe visual impairments to frequently conceal their condition even to those around them (whether it is partial sightedness, let alone blindness). This decision subjects them to a range of daily challenges. In my four decades of engagement in this field, I have witnessed and experienced much, but public attitudes towards blindness and partial sightedness in Slovenia have not significantly improved (much like in other parts of the world). Many still conceal their partial sightedness, which, to be honest, is considerably easier to hide than total blindness. And you will not believe this: I am familiar with a case from Slovenia where a family kept their blind son hidden at home until he was 42 years old, fearing that he would bring them shame.

This does not mean that there have not been considerable improvements in many respects, or that the current circumstances are the same as they were a hundred years ago. While enormous progress has been achieved, there is still room for further improvement.

After partial or total loss of sight, the most pressing need for an individual is rehabilitation. Rehabilitation has to be comprehensive; to reintegrate into daily life, a person needs to learn and develop such a vast range of practical abilities and acquire so many new social skills related to various situations that the majority would be unable to achieve these goals without assistance. But before all else, they need psychological support to come to terms with their new condition (which is not easy, I assure you) to the point that they view life as worth living and find the strength to try to stand on their own feet once again. This requires a considerable effort on the part of the rehabilitation team, which requires an interdisciplinary organization; however, it is the individual themselves who bears the greatest burden of effort in the rehabilitation process. The rehabilitation can be successful only if the rehabilitee (i.e. the person who is yet to be rehabilitated) is willing to invest the effort—which can sometimes be immense—to acquire the necessary skills to become a rehabilitant (i.e. the person who has been rehabilitated). Nevertheless, this represents just a part of the efforts involved.

The second, equally important aspect referred to as 'accessibility' is the responsibility of a society striving for welfare and inclusivity.

MY VIEW ON ACCESSIBILITY

Many people associate accessibility only with lowered pavement kerbs or ramps, sometimes accompanying staircases. While high kerbs, steps, and similar features do pose barriers to wheelchair users, they are far from being the only elements that hinder accessibility. Due to my personal experience, my perspective on accessibility is very clear.

Above all, I view accessibility as the possibility for everyone to have physical access to all private and public areas in both buildings and outdoor spaces. Physical access is a prerequisite for enabling any other forms of access and fostering inclusion in all the social processes that occur within these spaces—whether temporary or permanent—as part of everyday social life. I am not referring to various social events (though not excluding them), but rather to all the fundamental processes in which we, as members of society, engage on a daily and permanent basis. What often goes unnoticed is that many of these fundamental processes remain inaccessible to a significant portion of society. This is particularly true for the blind and partially sighted, but also the deaf and hard of hearing, as we experience the greatest level of discrimination when it comes to inclusion in this aspect of social life. Finally, accessibility also encompasses equal possibilities of access to all the information that, in modern society, is essential to receive education; acquire training for various jobs and professions; acquire training for performing essential daily tasks; make everyday or vital decisions; or simply navigate urban environments.

All of this, and probably more, constitutes accessibility, and I believe that design is closely linked to it or can sometimes even be a prerequisite for ensuring equal access.

THE BROAD FIELD OF DESIGN AND USER EXPERIENCE

I would like to share some of my thoughts on design in different areas, providing examples for clarification.

Design can be a very broad concept. For millennia, we have transformed untouched nature by designing our dwellings through interventions in the landscape, creating urban environments that enable planning. We (re)design nature to facilitate our activities and establish equal relations with other people, plan and design a range of everyday objects, and design communal buildings that house various human endeavours, such as educational, economic, scientific, cultural, and more. For these purposes, we design spaces, objects, and relationships essential for seamlessly performing countless human activities, ensuring they bring benefit to humanity. We design and plan groups perceived as optimal to carry out various processes, as well as the skills deemed essential to achieve the desired outcomes. It may be slightly confusing to some readers that I am equating planning and design; I do so not only because the term 'design' can encompass both concepts, but also because I believe these two ideas share the same origins in the distant history of civilization. I will not speculate on which came first: planning or design. Many experts, far more qualified than myself, have likely explored this question. If design planning indeed pre-dates design, I believe that human civilization made a significant leap forward when design extended its influence to planning for the first time, regardless of the underlying cause.

I am also convinced that design should be an indispensable component of the purely technical aspects of any creation. Considering the denotation, I assume that already the ancient architects viewed load-bearing elements as a 'necessary evil' in contrast to non-load-bearing elements, and yet both types received equal attention in their design (think of the ancient columns). This attention should be sustained even in some contemporary, purely technical planning. Initially, this might seem unnecessary, as the technical aspect remains largely hidden. I am referring to the suboptimal accessibility of most websites, which incorporate both visual and technical design. A limited number of websites support Slovene speech synthesis, and even on those that do, blind users often have to wade through a mountain of clutter before accessing the desired text.

As millions of people use Microsoft computer programs, this software has established a somewhat monopolistic presence. The desire to stay connected compels those of us who are blind and partially sighted to use these programs as well. However, their usage is not accessible to us because they were not planned and designed with the needs of blind and partially sighted users in mind. We have to purchase additional software that allows us to work with Windows. Personally, I use ZoomText, which costs almost EUR 1000. Annual updates cost me approximately EUR 100, and after five or six years, I have to repurchase the base software as well as updates for the following four years. But that is only the financial side of the problem. The other, perhaps even more frustrating aspect is that Windows software is developed by one company, while the programs that render them accessible to blind and partially sighted users are created by several other companies. As a result, despite the rapid progress of information and communication technologies (ICT), compatibility issues between the two essential types of software are a persistent problem for us. We encounter these issues daily when working on a computer, sometimes multiple times a day. For instance, conflicts between Windows and ZoomText (or other adaptive software) commands often lead to computer freezes or failure to execute the command. While I have complete confidence that an expert computer engineer confronted with such a situation would be able to ingeniously resolve these issues, we often find ourselves in predicaments, leaving us unsure of how to proceed. This occurs because software designers overlook the needs of those who are blind or have low vision.

Similar challenges are experienced by those of us who, due to blindness, can use a personal computer only with the assistance of the Slovenian speech synthesizer *Govorec* ('Narrator') and its add-on, *eBralec* ('eReader'). One of the authors of Govorec explained to me that Windows is like a castle with five hundred rooms, and that the programmers (planners, designers) who developed Govorec can only access about a hundred of these rooms. This limitation allows for only partial adaptation and leads to unexpected bugs, which can hinder or even prevent smooth operation. While it is worth noting that these issues are becoming less frequent, speech synthesis can still come to a sudden halt during reading. Occasionally, the software 'takes a few minutes off' before resuming its function, and in some instances the computer simply freezes, requiring a force quit and reboot. This can result, for instance, in the loss of a significant part of a just written text or a number of other problems.

Word offers features intended to make work easier or possible for people from 'vulnerable groups' as individuals with disabilities are sometimes referred to. I have tried to use these features myself and I have found it impossible to work with them. What is more, I do not know any blind or partially sighted person who can confidently say that these tools are sufficient for their computer work. This makes me wonder why Microsoft did not hire the same developers who created ZoomText, for example, to integrate it into Windows, which would enable seamless functioning and performing simultaneous updates with the operating system. Is this ignorance or profiteering at the expense of disadvantaged groups?

This situation is similar to the practice, only recently changed, of first constructing high staircases and then adding ramps (at substantial additional costs) to enable various groups to overcome the height difference. However, this approach completely overlooks the fact that stairs (whether leading up or down) in most cases also pose a serious mobility barrier for the majority of blind and partially sighted people.

Although modern legislation (including Slovenian) has contributed to a significant reduction of architectural barriers compared to just a few decades ago, it has by no means eliminated them entirely. For this reason, even in architecture, which is undoubtedly one of the most important areas of human design (involving public and private spaces), issues persist, despite architects having generally shown an inclination towards designing spaces accessible to all groups. In Slovenia, one of the first to systematically address architectonic accessibility, was the architect Marija Vovk, but her work has been largely overlooked. I found particularly informative my discussions on accessibility in architectural design with Prof. Stanko Kristl. I could listen for hours to his calm and particularly quiet explanations about designing fluid spaces in buildings that seamlessly flow into each other, serving their various purposes without creating barriers for anyone, regardless of their condition. He also provided observations regarding efficient transportation of patients in emergencies to places where medical teams can help them survive. What I do not know is whether he put these valuable observations and insights in writing.

In contrast to architecture, industrial design tends to be less noticeable, despite its constant presence in our mundane and complex daily tasks. Poor industrial design is probably not just visually unappealing to the sighted but can also create challenges for people with disabilities, who may find it very difficult or even impossible to perform a certain task.

Many still remember Iskra's black Bakelite telephones, which were first replaced in the 1970s—a period marked by significant development in Slovenian design—by the ATA 20 and ATA 60 models. These new telephones, made of lightweight, multicoloured plastic, featured rounded sides, gently softening their angularity. They were a real hit, both at home and around the world. But towards the end of the 1970s, Iskra introduced an even greater achievement, the ETA series, which offered several telephone models.[2] I was most impressed by the ETA 85, which, instead of a rotary dial, had a 12-key keyboard, on which

2 I have seen ATA and ETA series telephones in museums in the US, Amsterdam, and elsewhere, so it is unsurprising that fakes of these two series were being produced all over the world.

I instantly learned to type accurately. I also found the aesthetics of the model to be superb, with the handset fused with the telephone base as if it were its integral part. Since the headset was always black and the body was typically red or yellow, I could always locate the headset easily, as I still had some residual vision at that time. I was surprised, however, when one of our top designers responded to my compliment by commenting that the handset should be fully exposed, preferably as in the telephones from the interwar period where it was mounted on a high fork. The headset was separated in a way that made it nearly impossible to miss with a sweep of the hand. It took me some time to grasp the correctness of this assessment. The keyboard, which eliminated the need to painstakingly count the holes on the rotary dial with a finger (to find the right number), was undoubtedly a significant improvement, but the headpiece fused with the base actually proved to be a disadvantage in terms of accessibility.

One major problem that sighted people may not even notice is the inconsistency between numeric keypads. The layout of numbers on computers is, in fact, inverted compared to phones, with the exception of zero, which is located at the bottom in both cases. In other devices with physical or tactile keyboards (such as ATMs and credit card terminals), the number arrangement may follow either that of a computer keyboard or mirror the layout of a telephone keypad. This inconsistency is a source of significant and unnecessary confusion, in particular for blind and partially sighted people, and cannot be justified on either economic or design grounds. Even sighted people have complained to me about this issue. Despite years of drawing attention to this situation, there has been no interest in addressing it seriously and working towards a uniform and universally binding layout for all numeric keypads in the world. Imagine if the hands on some clocks ran in the current direction while on others in the opposite direction! Or if municipalities had the power to independently decree whether traffic runs on the right- or left-hand side of the road.

It is also worth mentioning that tactile keypads without audio feedback are becoming an increasing problem. A decade ago, I successfully convinced the Slovenian expert committee to vote at the EU level against adopting new standards for control panels in lifts. Our position prevailed, preventing the EU from introducing into its legislation tactile control panels for lifts without audio support. What is more natural for a blind person than to slide their fingers along the wall of a lift until they feel the control panel? If the physical keys lack markings, a blind person can still attempt to find the key corresponding to the desired floor by counting. On the other hand, if they touch a tactile keypad the lift might take them to a completely unfamiliar floor. How can a blind person handle such a situation?

A visit to the toilets in the European Parliament in Brussels was a particular experience. When I wanted to wash my hands, I carefully felt the entire water tap, including the spout and the sink, as well as its immediate and less immediate surroundings and even the wall behind it, searching for a lever or buttons to turn on the water. There weren't any. Then I searched all around the tap for a sensor that would detect my hand's proximity and automatically open the water. Nothing! I used my shoe to check if there might be a pedal under the sink counter that would activate the water flow, but again, there was nothing! I repeated the process a few times, my nervousness growing. As I still had not left the toilets, a partially sighted colleague, who had seemingly guessed the reason for my delay, came in and said: "Tomaž, you turn on the water by twisting the very top of the tap," saving me from this situation. At the end of a very long spout there was a tiny piece that could be turned in either direction to control the flow of cold or warm water. This little component could not be distinguished from the spout as there was no discernible visual contrast or dilatation that could be seen let alone perceived by touch, neither was there a texture that was different to touch. In other words, even for the normally sighted it was probably insufficiently identifiable. The designer, carried away by the desire to achieve the perfection of form, failed to consider other aspects.

In the past, the design guru Jacques Séguéla caused a real cultural scandal in France. In an advertising campaign for an old-fashioned upholstered armchair (Vaterstuhl), in which you can easily fall asleep, your arms draping over the armrests as your head remains supported by two side headrests, preventing any wobbling, he chose the slogan: "Merde au design!"[3] His aim was not to denigrate design outright but rather to emphasize that design has sense especially when it also serves a practical purpose. What actually sparked a revolution was the use of the word 'shit' in advertising, which caused countless controversies. Due to the polemics, the chair became known to virtually every person in France. The effect, probably multifaceted, was achieved.

VISUAL COMMUNICATION DESIGN AND THE CONCRETE CHALLENGE

The terms 'graphic design' and 'visual communication' have a wide range of meanings. Reading, which is one of the most complex functions the brain performs, is among the initial and most significant challenges that individuals face when experiencing progressive vision loss. However, by using an appropriate font this problem can be reduced for an extended period. Dr John Gill, who for many years headed the RNIB's[4] Scientific Research Unit, and his colleagues developed the Tiresias family of fonts, which are specially adapted for the blind with residual vision and partially sighted. As it has not yet been widely adopted, the European Blind Union (EBU) recommends the use of Arial or Verdana, in bold and sizes 12 or 14. It is crucial that the text is in an upright and sans serif font (italics and serifs are to be avoided as they significantly hinder the recognition of characters). Moreover, the text has to be reproduced on a matt (never glossy) background with maximum contrast. Nonetheless,

3 The sense of the slogan can be translated as: "Screw the design!"

4 RNIB – Royal National Institute of the Blind People is not a scientific institute, but the largest organization for blind and partially sighted people in the UK and one of the most important in the world.

through serious commitment and by incorporating user testing, designers can likely provide a better solution.[5]

In addition to signs, many symbols assist us in navigating both outdoors and in buildings, but their design is frequently neglected, making them challenging for the blind and partially sighted to notice and even harder to read—an issue that affects a growing population of older people as well. One such symbol, which I believe is best adapted to the environment and its purpose, is the Slovene inventor Alojz Knafelc's trail blaze invented more than a hundred years old. Its simplicity and colour contrast, tailored to its surroundings, make it an almost unmistakable guide, even along intricate mountain or forest paths. I am almost certain that more people get lost in public buildings than in the mountains. Is it really impossible for a designer to create something similar to the Knafelc trail blaze that would be comparable in function but adapted to the conditions of urban space?

Although the design of corporate identities, logos, and various other symbols has become a real science, it appears to me that no designer or design team has considered the possibility of incorporating tactile elements into, for example, a logo, making it as easily recognizable as the Mercedes star. Would this really be a too daunting task for the myriad of Slovenian studios?

A few years ago, I was surprised when some members of our Union proposed that we should work towards a uniform toilet label as well as separate labels for men's and women's toilets. As bizarre as it may sound, this proposal stems from the numerous experiences of blind and partially sighted people, who have wandered around bars without assistance, struggling to find their way and ultimately make the correct choice between two separate toilet spaces.

5 Some projects in this area actually already exist: for the Braille Institute of America, Studio Applied Design Works from New York designed the Atkinson Hyperlegible font, which is freely available on the Google Font platform. For more information on legibility in typography, see the article by Černe Oven in this publication (ed. note).

What I described above usually involves a reduction of all non-essential elements, purification, and simplification; conversely, illustration (regardless of its nature and purpose) allows for much more artistic freedom. The minimalism of logos, for example, gives more scope for spatial and tactile representations than illustration. Most would throw in the towel simply stating: "That's impossible!" Aleš Sedmak proved otherwise by proposing his idea that inspired a group of students and, subsequently, professors from various art academies abroad, realizing the impossible: a publication with tactile illustrations of birds, which was followed by two publications featuring insects and marine organisms. I cannot confirm if he was the first in the world, but he must have been among the pioneers in this field and more importantly: his experiment succeeded! And then there was a second attempt, followed by a third attempt, and it can be concluded with certainty that each one of them represents a significant improvement from the previous. Experience with issues always led to new and better solutions. I am both hopeful and confident that this project and its vision will endure, which instils optimism for even greater achievements.

A few years ago, I became friends with Dr Joel Snyder from the USA, who is one of the leading experts in audio description, i.e. the process of providing descriptive narration for films, theatre performances, gallery and museum exhibits, cultural monuments, etc.[6] I invited him to deliver a presentation on the fundamentals of audio description for Slovenian national television. The event was aimed at a broad professional audience and took place over the course of an afternoon. Later, I persuaded him to come to Ljubljana for a whole week, during which he conducted basic training for audio description providers. An increasing number of Slovenian films and TV shows are now equipped with it this type of audio narration. What if, in collaboration with Dr Snyder, we also attempted to offer audio descriptions for the

6 Films pose the greatest challenge, as the description of the shot and its action has to be very accurate and inserted into the very short pauses between dialogue, allowing blind and partially sighted people to follow the action of the film.

blind to accompany works of design and other visual pieces (in addition to providing tactile copies, descriptions in Braille, and enlarged print)?

I have already mentioned the encounter with the Mona Lisa. All sighted people or those who had retained their vision for a sufficient number of years have a mental collection of artistic icons (the Venus of Willendorf, the Pyramids of Giza, the Acropolis of Athens, the Venus de Milo, Michelangelo's David, the Eiffel Tower, Munch's The Scream, Guernica, etc. to name just a few that immediately come to mind). This mental repository accompanies us throughout our lives, providing the basis for making connections, evaluations, and metaphors. But, as I have mentioned before, in this regard, I consider myself immensely fortunate in life! Why not try to make these cornerstones and treasures of human culture more accessible to those who have been blind since birth? And also: why not extend this approach to artworks that are not immediately recognizable or instantly memorable? Moreover: why not expand it to encompass as much as possible of the artistic wealth created by painters and sculptors over more than two millennia? Nevertheless, in all these scenarios, it is crucial to always consider and respect the unique starting point of each individual.

All this is yet to be realized, and although it may seem impossible, the results of Aleš Sedmak's efforts prove that it is worth making an attempt. Nothing is impossible.

In an attempt to synthesize these somewhat unsystematic reflections, I can derive a few insights.

Design holds a significant, albeit sometimes unnoticeable, presence across a vast array of human activities, such that its contributions often remain overlooked. It is likely that much of this has already been widely explored and clarified within the professional field and potentially even systematically categorized. Even though design is present in our everyday life, from mundane tasks to the heights of human culture, we lack familiarity with this systematization and therefore fail to appreciate or recognize contributions that are a result of good design. In general, we only become aware of design when faced with frustrations as in the case of a spoon that is uncomfortable to hold or makes ladling soup a challenge; a frequently used object with an irritating handle; an environment that complicates our search for something essential; an object we deem aesthetically unappealing, etc. In other words, we are quick to notice shortcomings but have difficulty identifying good solutions. If theoretical reflections on design (in the broadest sense of the word) were more present in the public consciousness, a sensitivity to a more accurate distinction between good and bad design would develop as well. In addition, systematic categorization makes the problems in this area of human creativity clearer. Once the problems have a name, we usually realize that they have already been solved, at least partly, or the solution no longer seems distant. Theoretical research contributes not only systematics and order (not in a negative sense) but also connections, which can generate new and higher value and often pave the way for designers to develop better solutions.

What conclusions can be drawn about design that enhances accessibility, promoting the highest degree of inclusive equality of blind and partially sighted individuals in private, professional, and public life? The situation in Slovenia is not optimal, yet it could be considerably worse. Traffic lights are increasingly equipped with acoustic signals, and the Tactile Floor Guidance System is becoming more prevalent on the pavements of Slovenian cities and towns. It is true that the Tactile Floor Guidance System is not always implemented according to standards and professional norms, and it is also a fact that bars and restaurants often obstruct these guided pathways by placing tables on them, but it is equally important to recognize that many blind and partially sighted individuals still lack adequate knowledge about the straightforward rules of the Tactile Floor Guidance System, which is designed for easier and safer navigation. However, it is here and its presence continues to expand.

The biggest issue might lie in the fact that, in practice, we as a society are hardly aware of the importance of 'creating a society for all'. Consequently, the initiative is driven almost exclusively by empathetic individuals or, more concerningly, those who may have a financial stake in it, which unfortunately, is not uncommon.

The only long-term approach could be offered by increased theoretical research targeted at detecting and identifying the challenges that blind and partially sighted people encounter across various aspects of life in order to inform solutions, which can be achieved through design and planning. This would also improve the quality of life for the large population of elderly people in Slovenia, which is in rapid growth and is typically affected by vision problems.

→ RESEARCH OF SECONDARY SOURCES
→ PRELIMINARY SELECTION OF SUITABLE ORGANISMS
→ RESEARCH OF DESIGN FOR THE BLIND AND PARTIALLY SIGHTED PEOPLE

1. RESEARCH BEFORE THE INTERNATIONAL SUMMER SCHOOL

THEORY

LECTURES
→ Marine organisms
→ Scientific illustration
→ Assistive technologies
→ Cognitive aspects of inclusive illustration
→ Perception of the blind and partially sighted people
→ Translating visual elements into tactile graphics
→ Inclusive design and empathy

FIELD TRIPS
→ Piran Aquarium of the Science Centre of the University of Primorska
→ Marine Biology Station of the National Institute of Biology

EXPERIENTIAL LEARNING WITH A TYPHLOPEDAGOGUE
→ Visual impairment workshop with active participation and hands-on experience

2. INTERNATIONAL SUMMER SCHOOL

PRACTICE

OBSERVATION IN THE FIELD

VISUALIZATION
→ Sketching (analogue, digital)
→ Study drawing (learning about the anatomy and life of marine organisms)
→ Habitat illustration (marine organisms in their habitat)
→ Scientific illustration (illustration of a typical representative of the selected species)
→ Stylization and reduction of illustration (conversion to black and white illustration)
→ Graphic technique (linocut prints in black and without colour)

OBSERVATION AND VALIDATION OF THE RESULTING MATERIAL

MAKING RECOMMENDATIONS ON DESIGN AND ILLUSTRATION FOR THE BLIND AND PARTIALLY SIGHTED PEOPLE
→ Collecting secondary material
→ Observing and recording insights gained from practice

3. BUILDING ON THE FIRST PHASE

PREPARATION OF ILLUSTRATIONS FOR ANALOGUE AND DIGITAL PRINTS
→ Corrections of the subjects' anatomical elements
→ Adjustments to line drawings in black and white in line with recommendations
→ Unification of all motifs
→ Printing in linocut on an alternative printing press
→ Preparation of the model in modelling software (from line drawing to surfaces, correction, rounding of edges)
→ Adjustments to the model according to the chosen 3D printer
→ Enlargement of the organism detail: model preparation in the modelling software (emphasis on realism)
→ 3D printing of all tactile models

→ Designing test methods
→ Checking the adequacy of methods with experts
→ Planning in-depth interviews with selected target groups
→ Questionnaire for professional staff and other stakeholders
→ Expert guided tours of exhibitions
→ Implementation of the testing

4. TESTING THE FIRST PHASE

→ Preparing materials for the exhibition
→ Exhibition design
→ Setting up the exhibition

→ Drafting final recommendations for illustration and design for the blind and partially sighted people
→ Planning and preparation of a scientific monograph
→ Preparation of a service design project for a toolkit for stand-alone 3D printing of materials

5. ITERATIONS OF RESULTS

→ Preparation of final versions of materials

THEORY

PRACTICE

THE FINAL RESULT

6. DIDACTIC MATERIALS ON MARINE ORGANISMS FOR THE BLIND AND PARTIALLY SIGHTED PEOPLE

TESTING AND PROPOSED IMPROVEMENTS TO THE TACTILE ILLUSTRATION SYSTEM

TESTING

For potential iterations of the models, we organized two guided tours with the possibility of conducting interviews and testing in the context of the exhibitions: one with deafblind adults in collaboration with the Center of Illustration, and the Deafblind Association of Slovenia DLAN (1 October 2024) and with blind and partially sighted children in cooperation with the Centre IRIS – Centre for Education, Rehabilitation, Inclusion and Counselling for the Blind and Partially Sighted (3 October 2024).

The insights we have gained from this are very valuable, as they allow us to improve and iterate the content. Due to the heterogeneity of the groups, the low number of participants with whom we managed to organize guided tours in the limited time available, as well as the age and characteristic differences of the participants, it is impossible to draw definitive (statistical) conclusions. Nevertheless, the guided interviews, observing the participants and interacting with them were one of the most interesting experiences of the project. If we had the option of involving additional groups, we would probably opt for more in-depth interviews and a longer time span next time.

We were able to observe how blind and partially sighted users go about touching the objects, whether our scale is appropriate, and how the users go from the details to the large illustrations and vice versa. The advantage of having direct contact with the target group also lies in being able to have a discussion. The direct questions we posed gave us a starting point to consider what information we might have forgotten to include, have not highlighted enough, or have not stressed enough in the guided tour scenario itself.

Identifying Animals

Through a structured questionnaire, we gained numerous interesting insights.[1] Mostly, participants were able to identify all parts

1 Notes of the questionnaire test, blind and partially sighted people from the Centre IRIS, Thursday, 3 October 2024. The participants were primary school children.

of the animals by touch (or residual vision), but in some cases, crucially, the sound recording also helped them to do so. For individual animals (e.g. seahorses), some had difficulty in pinpointing the fin under the abdomen. For all respondents, the 3D prints helped them to get a better idea of the organisms. The amount of new information gained depended on their background knowledge, which was as varied as their age, and the statements also reflected their level of enthusiasm for the subject of marine organisms in general.

They had more difficulties identifying completely unfamiliar animals (e.g. green chiton). For this organism, one of the participants did not recognize the difference between the thicker and thinner line, which he attributed to the complexity of the organism. Elsewhere (e.g. cuttlefish), they expressed the opinion that the division into planes and lines in the illustration was very good for orientation, although other participants (from observation) had difficulty in identifying the number of tentacles and eyes in this organism. Interestingly, when asked when they found objects (e.g. animals) most comprehensible, between the options a) 2-dimensional reliefs, b) 3-dimensional magnifications of details and c) models in space, most participants chose the models in space (e.g. objects or dioramas in museums).[2] This was also confirmed by some of the adult participants.[3]

Subtitles, Letters and Braille

The partially sighted participants were satisfied with the size of the letters, which did not cause them any problems with reading. The braille was also appropriately sized and positioned.[4]

2 IRIS testing.

3 Direct insights, testing on 1 October 2024, deafblind adults from the DLAN Association. Adult participants.

4 IRIS testing.

Animal Details

When the detail of the shore crab was discussed, some people expressed their excitement over the experience, as they had never felt the armour of the crab before and that made it much easier to imagine the animal. They could also identify where the detail belonged on the animal.[5]

Material and Touch

When asked about the material, participants reacted positively, finding it pleasant to the touch. Despite our concerns, they were not bothered by the plastic material (which is not natural), and some were even impressed by it. Participants who touched the illustrations (some were partially sighted and spent more time observing) stated that the illustrations were pleasant to the touch. The amount of convexity on the illustration was correct for optimum tactility.[6]

Audio Content

Regarding the informative audio content (animal descriptions), there was a consensus that the recordings are very easy to understand and have the right amount of information. They were perceived as an excellent source to get information in the quickest and most efficient way. They also found it useful that they could listen to the recording several times.[7] The ambient sounds of the sea were also positively received, the participants did not find them distracting and wished there had been more.

In any case, the above shows that the 3D prints have been received with enthusiasm and participants have stated that they are better than previous editions of illustrations with embossing.[8] This was also the opinion of a deafblind person (deaf since birth,

5 IRIS testing.

6 IRIS testing.

7 We also had some technical problems with the audio content, where the recording was not loud enough in the crowded environment. IRIS testing.

8 Direct insights, testing on 1 October 2024, deafblind adults from the DLAN Association. Adult participants.

blind since childhood): the convex embossing is clearer than the linocut matrix, but his attention was particularly drawn to the 3D-printed relief, which he said immediately upon touching was the best because it was smooth, solid (stable) and clearer.[9]

PROPOSED IMPROVEMENTS AND CONTINUATION OF THE PROJECT

During the design and after testing, we identified certain shortcomings of the system, which we list here as a springboard for considering possible improvements. One of the necessary improvements relates to the perceptual distinction between the blind and the partially sighted. Already with the very first participants, we saw that all the convex surfaces on the illustrations and captions (including the braille) should be augmented by adding colour contrast on the tactile illustrations—black lines on a white background—in order to optimize the experience for partially sighted users.[10] The vast majority of people with visual impairment are not blind, they have impaired vision. If the colours in an illustration are contrasting enough, people with low vision can distinguish them and use a combination of visual and tactile stimuli to identify the image.

This also applies to the details of organisms: they can be painted in the colours and patterns found on the actual organism. The detail tries to represent a part of the organism as realistically as possible. It is true that this process is more technically demanding and time-consuming.

The presentation of the illustrations could also be improved by adding a scale to them to give the user a sense of size. Information on the size of a typical specimen of the animal representative is important. The current solution is to mention the size in the description of the organism, but it would be even better if the system could convey this information graphically. The most correct option is of course to present the animal in its actual size, but as this is

9 Direct insights, testing on 1 October 2024, deafblind adults from the DLAN Association. Adult participants.

10 Direct insights, testing on 1 October 2024, deafblind adults from the DLAN Association. Adult participants.

often not feasible, another element could be added to the system to show the size of the animal.

The current system also does not include information on which part of the organism is presented with the detail. Given the specific purpose of the system, it is useful to consider how its individual elements (the species name in braille, the simplified illustration, the detail and the accompanying text) are put together to form a whole. The design we chose for this project worked well for a gallery exhibition, but perhaps for other purposes (if the system is used as a teaching tool in schools, etc.) other layouts might make more sense. Consideration should also be given to facilitating the storage of illustrations when the system is not in use.

The next observation relates to the integration of colour. The final challenge is the tactile representation of an organism's colours. Patterns can be represented quite easily with relief, which can be misleading – relief can mean colour patterns or actual shapes. Such ambiguity should be avoided in scientific illustration. It is very difficult to communicate colours – for people who have been blind since birth, they are also very difficult to imagine, or they perceive them in a different way. A possible solution is to use materials with different thermal conductivities – thermal conductors (e.g. metal) represent cold colours, while insulators (e.g. wood or plastic) represent warm colours. This has its drawbacks, such as the complexity of production, the loss of clarity of the message due to the additional component of sensing heat when touching, and the fact that the full spectrum of visible light still cannot be represented in this way.

In the process, we have also learned a lot about the importance of preparation for testing. One improvement here could be to test the audio recordings in the room where the testing will take place, taking into account the ambient noise that will be generated by the crowds.

It will also be necessary to focus on detailed instructions for making and printing the models as the project progresses. This part could probably be carried out in an interdisciplinary way, either as part of the study process or as part of a future international summer school with suitable partners.

BRIEF RECOMMENDATIONS FOR DESIGNING (TACTILE) ILLUSTRATIONS FOR PEOPLE WITH VISUAL IMPAIRMENTS

These recommendations are based on the experience gained from the Kaverljag workshops[1] and are compiled from years of experience of professionals working with blind and partially sighted people,[2] secondary sources, and research projects.

Blind and partially sighted people are an extremely heterogeneous group of readers. Each reader has their own experience, perception (and potentially additional special needs), and knowledge of the depicted topic, so it is impossible to provide an equally effective reading experience for everyone at the same time. The recommendations are guidelines on how to achieve the best possible result, but this should always be verified with the target audience through testing and iteration according to the context of each project.

In particular, you have to bear in mind that these recommendations focus on didactic material with popular science content for children (12+) and adults, with a focus on illustration, whereby only the most essential elements of the broader field of design are covered.

Editorial notes:

In this text, we refer to the user as "reader". In the context of this publication, the word "reading" covers all ways of identifying and perceiving content (listening to audio descriptions, touching, smelling). Blind and partially sighted people can use different media and a variety of aids and tools to access the desired content. Although the recommendations refer to tactile illustrations, they can also apply to reading contexts outside the medium of books (reading for orientation in space, reading for the use of aids, and other types of media and contexts).

In this document, the word "illustration" is used to describe any image, picture, graphic, or graphic sign, regardless of style, technique, or semantic message. The recommendations are intended for the use of tactile illustration in publications as well as for individual tactile illustrations in the context of exhibitions and didactic materials. The recommendations are aimed at clear and effective reading

1 We would like to thank Aleš Sedmak, Zdravko Papič (1953–2013), Ljubomir Daničič (Inter-Municipal Association of the Blind and Partially Sighted Koper), Hana Jesih, and Ajda Petrič for sharing their insights and experiences.

2 We would also like to thank Prof. Mateja Maljevac, PhD, and Prof. Aksinja Kermauner, PhD, for permission to include their findings in this monograph and for reviewing the material and advising us during the process of drafting these recommendations. One of the sources was a lecture by Prof. Mateja Maljevac entitled *Perception of People with Visual Impairments*, given at the International Summer School in Pliskovica on 23 July 2024.

of tactile illustrations in publications that address closed thematic clusters and are predominantly intended for education[3]. The recommendations do not address the spatial components that affect the safety and optimal movement of blind and partially sighted people in space, as this is outside the scope of the project.[4]

GENERAL FINDINGS

- Insights that apply to different types of illustration and different uses of typography, or to graphic or information design in general, mostly also act as a basis for design for the blind and partially sighted (e.g.: if you are communicating scientific facts, use scientific illustration concepts; when illustrating children's fiction, use fiction illustration).
- Not every illustration made in relief is a tactile illustration.
- The recommendations apply to the blind and partially sighted (exceptions and adaptations are provided in the examples).
- The content must be methodologically and didactically adapted to the target group of blind and partially sighted people for whom it is intended.
- The most effective illustrations are those that combine visual and tactile images (e.g. if embossing is used which has convex elements, these parts are additionally printed in a contrasting colour to improve the visual experience for the partially sighted).
- Text can be added to the illustration (especially in the context of publications), consisting of text in braille and text in a contrasting colour (to the background)[5].
- When designing, we need to take into account that people with visual impairments need more time to take in the content by touch than sighted people.
- For tactile content, it is important to remember that all elements (e.g. illustrations) should always be convex (like braille), not concave, for easier perception by touch.

3 For example, a book that focuses on a specific topic (e.g. geography, biology, marine organisms, etc.) and can be used to complement didactic activities.
4 For more examples of the relevance of accessible information, see also Wraber, p. 222.
5 More on colour below.

PRECISION AND CLARITY

- → Tactile illustration should be as clean as possible, but not to the detriment of the content it communicates.
- → The amount of secondary information is reduced for clarity.
- → Decorative elements are not included in the illustration (unless they are an essential or communicative part of the illustration).
- → If illustrations are produced in a series, consistency of visual language is also important (e.g. how details are unified).
- → Illustration is generalized and abstracted. Objects are typed and depicted with pictograms/signs, which increases recognition and understanding.
- → The presented object must not contain perspective.
- → The object is always facing upwards (e.g. the depicted animal's head is on the top).
- → The left and right sides of the subject—to facilitate the perception of the blind—are shown symmetrically.

ILLUSTRATION FORMATS

- → The size of the illustration must be equal to (and no larger than) two adult hands placed on the surface (i.e. no larger than A4 horizontal).
- → If designing for children, the size of the format should be adapted accordingly.
- → When depicting real objects, try to keep natural proportions where possible and reasonable.
- → Where this is not possible (e.g. because life-size objects are larger), apply a clearly indicated scale.

SIZE OF ELEMENTS WITHIN THE ILLUSTRATION: LINES AND AREAS

- → The standardized braille dot is the basis for the sizes of the individual elements (lines, dots) in the illustrations. (Figure 1)
- → Since braille is the basis, the thickness of the thinnest line is limited by the thickness of the standard dot (Marburg Medium 1.3–1.6 mm, Marburg Large 1.5–1.8 mm).
- → When determining the minimum distance between the lines, the spacing between the braille dots is taken into account (the horizontal distance between the braille dots is 2.5–2.7 mm).
- → We try (as far as possible) to keep the thickness of the lines uniform in the illustrations, as varying the thickness often impedes perception (this does not apply to the highlighting of elements, see below).
- → All lines belonging to a shape are therefore of the same thickness.

HIGHLIGHTED ELEMENTS IN THE ILLUSTRATION

- The outer lines of the subject (contours) are thicker for improved visibility and clarity, and are used to emphasize the difference between the subject and the background.
- Surfaces can be marked with specific textures instead of colour coding (coding identical surfaces with a uniform texture).

PAGE LAYOUT AND TYPOGRAPHY

- It is important to unify the illustration (e.g. an animal illustration is preferably depicted life-size in a square frame, the enlarged version is shown in a round frame).
- There should be at least 10 mm of space between the frame and the motif.
- The object shall be positioned centrally in the frame.
- The spacing shall be consistent on all sides.
- All other information included must also be uniform: page numbering system (e.g. page number in print top right, page number in braille bottom right), additional symbols, etc., so as not to confuse the reader.
- If the illustration contains a textual description, the description and the corresponding illustration should be on the same page. If this is not possible, they should at least be clearly linked.
- Keep in mind that braille requires much more space than the letters of the Latin alphabet.
- If Latin script is used, medium bold/heavy monoline fonts without serifs (sans serifs) should be used and should not be in italics. We do not use underlining. Capital letters (majuscules) should only be used for headings.[6] Letters must not have contrasts.
- The appropriate font sizes for the blind and partially sighted are considered to be between 16 and 20 points[7], with Verdana and Arial in bold being the most commonly used fonts.[8] Other monoline fonts without serifs, which are not tapered and have a large x-height, are also suitable. Letters can be positioned with slightly increased letter spacing.

6 EBU clear print guidelines https://www.euroblind.org/sites/default/files/media/ebu-media/Guidelines-for-producing-clear-print.pdf (17 December 2024).

7 For more information on legibility, see also the paper by Černe Oven, p. XX.

8 In addition to Helvetica, these two are recommended by the European Blind Union. See: EBU clear print guidelines https://www.euroblind.org/sites/default/files/media/ebu-media/Guidelines-for-producing-clear-print.pdf (17 December 2024).

COLOURS

→ To improve the functionality of the illustration and to assist the visually impaired, a contrasting colour (e.g. black on a white background) should also be printed on the relief of the tactile illustration.
→ If a combination of black and white is not used, use the highest light contrast (yellow – dark blue; yellow – black).
→ When colour coding realistic information (e.g. geographical relief), we need to be consistent in the use of colour (e.g. dark colour is always expressed with a higher relief, light with a lower one, or depending on the system, which is clearly explained in the corresponding legend for ease of understanding).
→ Complementary colours (e.g. red – green, yellow – purple) may only be used if there is sufficient tonal contrast between them, otherwise they are inappropriate. They are better avoided as they are also inappropriate for certain types of colour blindness. For people with colour vision impairments, colours can be replaced by hatching.

HEIGHT OF EMBOSSING

→ The illustration must have tactile functionality.
→ The height of the relief must correspond to the height of the braille (the height of the braille dot is proportional to the diameter, between 0.5 and 0.8 mm), but may be higher. (Table 1)

COVER OF A BOOK OR OBJECT

→ As with other design projects, the cover of a publication for the blind and partially sighted—as well as all other products—must semantically communicate the content.
→ It must enable the object to be recognizable and highly memorable (e.g. by including the illustration, the title in so-called enlarged print (font size!) and in braille).
→ For tactile books for children, it is preferable for motoric reasons that the covers of the book are either made of a different type of paper or are larger in format than the inner pages.
→ As in all design projects, it is important to keep in mind the sustainability aspects of the production of objects and to make decisions based on synergistic didactic effects.

MATERIAL

→ If possible, the material should resemble the real materials of the depicted objects or at least retain some essential characteristics (cold materials – cold colours).
→ If the technology does not allow a choice of material, it is more important that the illustrations are functional in terms of message than to abandon the technology because of an unrealistic link between the illustration and the material (e.g. use of 3D printing).
→ Cardboard, various structured papers, plastics, or any other material are welcome in tactile experiences to arouse interest and offer variety (especially for younger readers).
→ Base the choice on the age of the reader and the content you are communicating.
→ For reading materials, always use matte paper, not glossy paper.
→ The material should be of a suitable thickness to avoid the content bleeding through to the other side of the page.
→ For publications, keep in mind that the shape of the braille print requires a higher paper weight for a good quality print, and the paper must be wood-free and long-fibred.

SAFETY

→ The materials and production technique must be safe to touch and handle (e.g. book, framed illustration, model, etc.), paying particular attention to details (edges, sharpness) to avoid damage to the reader's finger pads.

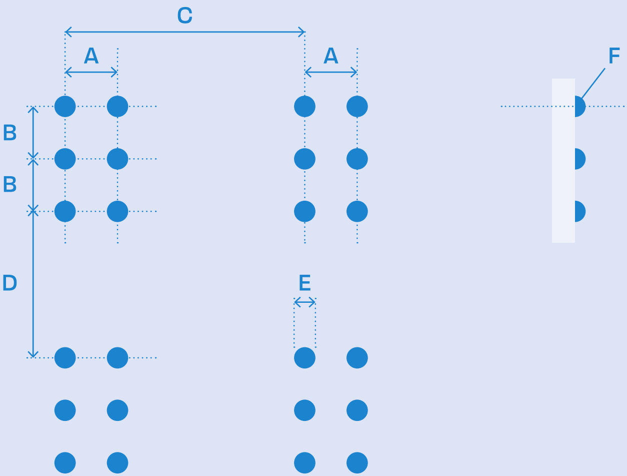

Figure 1: *Example of the Size of Braille Writing* (Gregorc et al., 2016, 8)

	Marburg Medium	**Marburg Large**
A – horizontal distance between braille dots within a braille cell (from the centre of the first braille dot to the centre of the second braille dot)	2.5 mm	2.7 mm
B – vertical distance between braille dots within a braille cell (from the centre of the first braille dot to the centre of the second braille dot)	2.5 mm	2.7 mm
C – distance between braille cells (from the centre of the first dot in the first braille cell to the centre of the first dot in the second braille cell)	6.0 mm	6.6 mm
D – distances between lines (from the centre of the first dot of the first braille cell in the first line to the centre of the first dot of the first braille cell in the second line)	10.0 mm	10.8 mm
E – diameter of a braille dot	1.3–1.6 mm	1.5–1.8 mm
F – height of a braille dot	proportional to the diameter of the braille dot, from 0.5 to 0.8 mm	

Table 1: *Description of Braille Standards* (Gregorc et al., 2016, 8)

Zoja Čepin and **(Leon) Rojk Štupar** – one is a graduate industrial designer, the other a graduate biologist. Both have been volunteering with the Scout Association of Slovenia (Zveza tabornikov Slovenije) for many years, where they started to work more closely together, all the while unaware that, as youngsters, they attended the same pre-school art workshops in their hometown Celje. Together, they started creating activities for children, but soon their Boy Scout projects expanded into more artistic areas – painting the club, a long tradition of innovative Christmas cards, decorative pins for handkerchiefs, and more. In recent years, their collaboration has expanded beyond the Boy Scouts.

Professionally, Zoja is particularly interested in inclusive design, and as part of her diploma thesis she designed a system for creating tactile adaptations of artworks for people with visual impairments. She is fascinated by the colour orange (especially there around #E56717) and postcards.

Rojk is starting to update the identification key for dragonfly larvae, the topic of his Master's thesis. More than kiwi green (#8EE53F), he is fascinated by the kiwi bird *(Apteryx sp.)*, films, and the ellipsis …

Dr Petra Černe Oven is a designer, lecturer, and author of research in typography, information design, and design theory and history. As a freelance designer, she has won prestigious awards at home and abroad, and completed her PhD at the Department of Typography and Graphic Communication at the University of Reading (UK), where she also did post-doctoral research. She is a curator of exhibitions, initiator of conferences, lectures, and workshops, and co-founder of the Brumen Foundation and the Institute for Design. She is the representative for Slovenia at the Association Typographique Internationale (ATypI), the world typography organization. Together with Barbara Predan, she edits Collection 42 in the Pekinpah Association, the only collection in Slovenia dealing with design theory. She is a member of national and international design juries (European Design Awards, Art Directors Club NY) and numerous editorial boards of international academic journals and conference organizing committees. Černe Oven is a visiting professor at the Politecnico di Milano (IT), and at the UL AFAD she is a lecturer in the Department of Visual Communication Design and Chair of Theoretical Sciences. Since 2024 she has been a member of the research team in the Visual Literacy research programme at UL AFAD.

Dr Lech Kolasiński is an interdisciplinary artist and designer. He completed his PhD at the Faculty of Industrial Design of the Academy of Fine Arts in Krakow under the supervision of Prof. Czesława Frejlich. He conducts research in the field of universal design, architecture of tactile information, and tactile feedback. He deals with educational adaptations and typhlographic interpretations of works of art for the needs of people with visual disabilities and painting. In 2021, he received the Award of the Minister of Higher Education and Science for implementation work for the Comprehensive Typhlographic Solution for the Botanical Garden of the Jagiellonian University in Krakow. He is the author of individual exhibitions, among others in Krakow, Ljubljana, Maribor, and Lecce and a participant in numerous group exhibitions in Poland and abroad. Since 2014, he has been working at the Faculty of Art of the KEN University (Uniwersytet Komisji Edukacji Narodowej) in Krakow.

Dr Mateja Maljevac is an Assistant Professor at the Faculty of Education at the University of Primorska. She also works as an itinerant teacher at the Centre IRIS – Centre for Education, Rehabilitation, Inclusion and Counselling for the Blind and Partially Sighted, Ljubljana. Her research interests are in the field of special needs and inclusive education, with a focus on people with visual impairment. She has been the President of the TIFLO Section of Slovenia for two terms and a member of the main committee of the Association of Special and Rehabilitation Educators of Slovenia, and in her third term she is its Vice President. She is actively involved with the National Education Institute Slovenia in the field of special needs, on the organizing committees of conferences and in international projects, for which she was awarded the Quality Apple in 2023 as a member of the Erasmus+ project team of the *Deafblindness project*.

Igor Miljavec - With decades of experience working with blind and visually impaired individuals and over 15 years of experience in accessibility, Igor Miljavec has gained a deep understanding of their needs and challenges. He is committed to creating a space that will be friendly to everyone, often using his knowledge and skills as a coach. In addition to presiding over the Intermunicipal Association of the Blind and Visually Impaired Nova Gorica, Igor is a member of the working group for improving digital accessibility in Slovenia, member and leader of the working group for accessibility of information and communications of the National Council of Disability Organizations of Slovenia, a member of the working group for the active inclusion of the disabled in the labour market in the Involved World project, member of the NGO Council of the Northern Primorska region, and the chairman of the Council for the Disabled of the Municipality Nova Gorica. In the years 2019–2024, he was a member of the Council of the Government of the Republic of Slovenia for the promotion of the development of volunteerism, voluntary organizations, and NGOs, and from 2017–2023, he was the vice-president of the Association of the Blind and Visually Impaired of Slovenia.

Marija Nabernik - Her areas of expertise are scientific illustration, illustration, and graphic design. She showcases her work in national and international selections, creates for clients, and participates in public competitions. She is involved in the creation, research, and teaching of scientific illustration in the framework of various artistic research projects in the field of visual literacy. She is a juror for calls for proposals and competitions and actively participates in expert committees in the field of illustration. In 2006, while studying at the Academy of Fine Arts and Design (UL AFAD), she went on a study exchange to the Academy of Arts, Architecture and Design in Prague, where she studied illustration and graphic design. She graduated in 2007 and received her MA in 2012 from UL AFAD. Between 2009 and 2015, she was self-employed in culture as a graphic designer and illustrator. In 2011, she attained the title of lecturer for higher education. In 2013, she specialized in teaching media production. Between 2008 and 2015, she was a lecturer at the Institute and Academy of Multimedia in Ljubljana. In 2013, she started cooperation with UL AFAD and in 2015, she was habilitated in the field of visual communication design and took over the management of the Illustration course. In 2023, she improved and shared her skills on exchange at the Italian Accademia di belle arte di Bari at the Department of Graphic Arts. Since 2021, she has been actively involved in the management of UL AFAD as Vice-Dean for Academic Affairs.

Tim Prezelj has a degree in microbiology and a Master's degree in molecular and functional biology, while also studying cognitive science. During his studies, he gained additional knowledge abroad, mainly in Germany, Austria, and Italy. He is currently employed as a junior researcher at the Research Centre of the Slovenian Academy of Sciences and Arts and is active as a teaching assistant at the Faculty of Education, University of Ljubljana, where he teaches and has introduced topics in the field of sex education. At the UL AFAD, he collaborates with the Department of Theoretical Studies and contributes to the study of illustration. His research focuses on the theory and history of the intersections between art and science, theoretical biology, sex education, and the biology of gender. He is committed to a closer integration of the natural sciences and the humanities, with a particular focus on interdisciplinary fields such as neuro- and psycho-aesthetics. He obtained his Master's by researching the impact of laboratory biology on the development of European visual arts, and regularly publishes on transdisciplinary themes linking art theory and science in national and international publications.

Aleš Sedmak (born 1952 in Postojna) is active as an academic painter, graphic artist, illustrator, designer, teacher, mentor, and organizer of educational workshops and events. He is a graduate of UL AFAD. During his studies, he was one of the founders of the SDG workshop (Section for Design and Graphics) and the head of the art activities at the student cultural association Forum. He has been self-employed in culture for most of his professional life. He helped establish the Insula Gallery in Izola (1987) and acted as a programme advisor for the Fine Arts Gymnasium in Koper. From 1983 to 1987, he was the President of the Association of Slovenian Coastal Artists, and from 2011 to 2021, he was the President of the Slovenian Association of Fine Arts Societies. For 16 years, he was the head of the Kaverljag project, the only manifestation of its kind with international participation of professors and students. His studio in the small Istrian village above the Dragonja Valley is remembered as a venue for unique educational camps focusing on current issues, especially ecology, the usability of products, and the integration and synergy of fine arts and various scientific disciplines. Sedmak has had numerous solo and group exhibitions at home and abroad. He has participated in many international art colonies, has given numerous lectures, and is constantly fighting for the rights of the self-employed in culture, especially fine artists, and trying to improve their legal, social, and working conditions.

Tomaž Wraber (born in 1950) studied directing at the Academy of Theatre, Radio, Film and Television in Ljubljana, worked as a contract director at Marketing TV Slovenia, and later took a job as an editor. Due to his sight loss and a diagnosis of blindness, he had to stop working as a director. But he did not accept disability retirement; instead he initiated a process of vocational rehabilitation and was granted the right to adapt his workplace, where he worked successfully for the next 30 years. With considerable effort, he managed to keep up with his sighted colleagues. Occasionally, he also directed some short videos. He retired in 2012.

After losing his sight, he began to be actively involved as a member of the Union of the Blind and Partially Sighted of Slovenia (UBPSS), and served as its President from 2009 to 2017. He used his personal experience to actively improve the conditions for blind and partially sighted people. Among his most important achievements are the legalization of the right to aid and service for the blind, insured by another person, and the partially sighted, and the legalization of the right to the Comprehensive Rehabilitation of the Blind and Partially Sighted (CRBPS). He led the expert group that developed the CRBPS programme, which is now implemented at the Eye Hospital, University Medical Centre Ljubljana. He managed to secure almost €3.2 million in EU funding for the renovation of the Library for the Blind and Partially Sighted.

He has also been very active in the European and World Blind Union (EBU and WBU) and was involved in the negotiations with the World Intellectual Property Organization (WIPO) that led to the Marrakesh Treaty. As a member of the International Society for Low Vision Research and Rehabilitation (ISLRR), he prepared the first Slovenian lecture for the Vision conference.

Although retired, he is still actively working to improve the conditions for the blind and partially sighted in Slovenia and abroad.

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TWO EXCERPTS FROM REVIEWS

This scientific monograph highlights the importance of accessible design for the blind and partially sighted. Despite the dominance of visual culture or ocularcentrism, the authors prove that it is possible to design beyond the visual.

The book builds on the long-standing efforts of the international Kaverljag workshops, which since 1998 have brought together students of art, biology, and design to create tactile content for the blind. In 2024, the workshops were revived with the Marine Organisms for the Blind and Partially Sighted project, focusing on the development of 3D-printed tactile illustrations. The process from scientific illustration to a tangible model is described in detail in the monograph, with particular emphasis on methods that ensure accessibility and accuracy. The articles also shed light on the broader context of scientific illustration as a pedagogical tool, its adaptation for visually impaired users, and the impact of design on social inclusion. The monograph thus goes beyond theory and brings concrete solutions, which are still rare in Slovenia. It is intended not only for professionals and students in the fields covered, but also for all others who work with the blind and partially sighted.

Due to the interdisciplinary nature of the project, which was the central theme of this book, the editor decided to keep the original terminology used by the authors. […] This gives the reader an authentic experience and insight into the different approaches, while ensuring the best possible flow of information. The diverse terminology reflects the broad scope of the interdisciplinary debate and contributes to a comprehensive understanding of the subject.

Aksinja Kermauner, PhD

The monograph presents key scientific findings related to the development of tactile illustrations and relevant accompanying text and audio for the blind and partially sighted. It highlights the importance of interdisciplinary collaboration between designers, scientists, and educators to develop visualizations that are accessible to all users, including vulnerable groups. One of the main findings is the importance of adapting learning content for people with visual impairments, in particular the development of tactile illustrations as a tool to engage blind and partially sighted people in the learning and research process.

The monograph also draws attention to the need to use modern technologies (such as 3D printing) that enable the creation of tactile models specifically tailored to the needs of users. This makes scientific and artistic content for blind and partially sighted people more accessible and promotes their inclusion in the social and educational process.

An important contribution is the exploration of the cognitive aspects of the perception and use of tactile illustrations, where it is evident that such adaptations facilitate the understanding of scientific and natural science concepts for the visually impaired.

The monograph offers important insights into how design and technology can serve as bridges to a more inclusive and equal society.

Raša Urbas, PhD

ILLUSTRATING THE INVISIBLE: TOWARDS AN INCLUSIVE SOCIETY FOR BLIND AND PARTIALLY SIGHTED

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The scientific monograph is the result of the research programme P5-0452, Visual Literacy at the University of Ljubljana, Academy of Fine Arts and Design, co-financed by the Slovenian Research and Innovation Agency (ARIS); the Development Pillar for Funding (DPF) in the Field of Arts: Student Projects for Sustainable Development: B.II.3 (Development and Strengthening of Cooperation in Transnational Inter-Institutional Learning Communities); and Promoting the Inclusion of Non-Traditional/Privileged Groups in Higher Education (S.C.1.3) ; and co-financed by the Institutional pillar of funding at the Academy of Fine Arts and Design of the University of Ljubljana.

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The monograph "Illustrating the Invisible: Design for an Inclusive Society" marks a new and extremely important step in the integration of scientific and artistic research within the framework of the Visual Literacy research programme, which is run and implemented at the Academy of Fine Arts and Design, University of Ljubljana. It focuses on design in an interdisciplinary consortium as a field that not only connects, but also sees and hears all stakeholders in the process with subtlety and a high degree of empathy. In other words, this study and research project reaffirms the thought of designer Victor Papanek, who argued that if we want to codesign an inclusive society, we must first of all see all those who are most often overlooked and then intentionally design for them. In fact, by designing for them, we are actually designing for everyone.

The detailed research results presented in this publication show a remarkable level of insight, commitment, and an incredible desire to explore and to create new knowledge and potentially shape a new approach in the largely overlooked field of visualization for people with visual impairments. What's more, the project clearly demonstrates that visualization is just as important for people with visual impairments as it is for the rest of us sighted people. An additional contribution of this monograph is that, besides having participated in two texts, blind and partially sighted people have also actively participated in the development, testing and evaluation of the resulting works. In other words, we are witnessing the most beautiful interplay between science and art, and science and design. This interplay is a prerequisite for understanding the world, anticipating different needs and being able to work together with a purpose and desire to solve problems.

Assoc. Prof. Barbara Predan, PhD,
Vice Dean for Research and Development, UL AFAD