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Laying the Groundwork for Engineering Students to Make Decisions Regarding the Application of Universal Design Principles for Development of Educational Products

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Abstract*— In the context of the training of engineering professionals, the inclusive perspective becomes especially relevant when considering the responsibilities that engineers have in generating products and technological solutions that are accessible and beneficial for everyone. This article presents a guide to facilitate decision-making for the creation of accessible and inclusive educational materials on specific scientific topics in higher education or any educational level. By applying Universal Design and selecting the most suitable technologies, we describe an approach that seeks to attain educational products that are usable by the largest possible number of people, eliminating potential barriers in their learning process. The three-dimensional materials obtained integrate tactile features such as differences in depth and textures, colors and low-cost technology to facilitate interaction and understanding of information, making the educational objects appealing, safe, and accessible to all users. The guide was developed based on research, analysis on the experience of the EduMakers group developing materials on Health Science topics for visually impaired learners. Overall, this work also aims to contribute to the development of transdisciplinary, transversal and multidimensional problem-solving skills in engineering students, professional attributes that are essential to face contemporary challenges.

***Keywords*—educational innovation, inclusive education, higher education, engineering education, universal design**

I. Introduction

The importance of promoting a more inclusive citizenship is reflected in the need to build societies that value diversity and promote equity. Particularly, to support the Sustainable Development Goals of the United Nations ODS4 - Quality education, ODS10 - Reduced inequalities, and ODS16 - Peaceful and inclusive societies [1], it is important to encourage inclusive practices among the emerging professionals of different fields of knowledge to make a positive impact in the reduction of inequalities faced by individuals within marginalized communities. In the context of the training of engineering professionals, this perspective becomes especially relevant when considering the responsibilities that engineers have in generating products and technological solutions that are accessible and beneficial for everyone.

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Training future engineers to make empathetic user-centered decisions considering the perspective and needs of final users -especially when these users are individuals from underserved populations- is a crucial skill that must be cultivated. Nowadays, more companies are making efforts to support inclusion in their workforce; however, the great majority of young people with disabilities face substantial challenges to reach higher education.

Having college students participate in projects oriented to support inclusive education, for example, in the creation of innovative inclusive educational materials, is a step towards achieving inclusive societies [2, 3]. And, to empower engineers in making decisions oriented towards inclusion, it is crucial to incorporate concepts to deepen their knowledge about diversity, accessibility, and inclusion as part of their formation during higher education. Nevertheless, these important concepts are not usually embedded in the traditional engineering curriculum. Thus, it is necessary to provide engineering students with extracurricular spaces where these concepts can be introduced, to shift the way they approach decision making during their design and innovation processes. Most importantly, providing practical experiences that challenge students to think about inclusive solutions will strengthen their ability to apply universal design in creating technologies that have a positive impact on society. Previous experiences have shown that these solutions are generated through the collaboration of multidisciplinary teams that build on the engineer's problem-solving skills in different situations or contexts [2].

Furthermore, the development of such cross-cutting and multidimensional problem-solving skills in engineering students is essential to face professional challenges. Engineers must be upskilled not only with advanced technology skills but also with a variety of professional competencies like adaptability, empathy, teamwork, communication, and active listening [4], those competencies are cultivated through the development of the projects carried out by our students at EduMakers. As previously reported [2, 3, 5], EduMakers is a multidisciplinary extracurricular social service program embedded in a research project that takes place in an innovation makerspace, where students from different disciplines collaborate to generate ideas and educational products for inclusive education.

The work presented here seeks to contribute to the training of engineers to produce inclusive solutions in education, where their skills are most needed. It presents the steps that EduMakers have followed to facilitate decision-making during the creation of accessible and inclusive educational materials on specific science topics in higher education and other education levels. Specifically, the experience focuses on educational materials for science education because STEM careers represent some of the most challenging for people with visual disabilities. Nevertheless, we part from the idea that the needs of vulnerable groups cannot be approached independently or in isolation because it is not about making a special or different design, but an integrative, inclusive, and accessible design for all; one that contemplates the needs of the different groups and integrates them to meet the requirements in spite of diversity [6]. Our objective is to guide engineering students through the decision-making process to design and/or adapt their products using universal design principles, and selecting the most suitable technologies for a wider range of users, such as multisensorial solutions for the inclusion of individuals with sensory disabilities but maintaining an appealing design for all students, creating common learning spaces for everyone and aiming to open opportunities for any youth to access quality and equitable education.

II. METHODS

The link between promoting inclusive citizenship and fortifying the training of engineers lies in the application of Universal Design, a philosophy originated from architecture [7] and now widely applied to create products and environments that are usable by the largest possible number of people [8, 9]. Universally designed artifacts, products and environments must be barrier-free and accessible to all, regardless of age, impairment, gender, or ethnicity [9, 10]. As the idea was adopted for education, the concept has expanded to Universal Design for Learning (UDL), an approach that seeks to eliminate potential barriers in the access to quality education for everyone [10,11,12]. We have previously described the methods we follow as a mix of Design Thinking [13] and User-Centered Design [14], where we take elements of those design methodologies to successfully create accessible and inclusive educational materials complying with the Universal Design for Learning principles [10, 15].

By placing end-users at the center of the design process, accessibility and inclusion become key elements that help transition from functional design to user-centered universal design. The analysis of previous experiences of the engineering and design students participating in the EduMakers project who have created inclusive educational materials for blind and visually impaired (BVI) children and youth [2, 3, 5], allowed to propose a general route to make decisions for designing educational materials that will be accessible and inclusive for all students. These materials targeted BVI students because access to science topics and scientific information is a major challenge for them, as science learning mainly involves visual resources and current available formats are not [16]. The weight on visual resources is gigantic, as the quality of education and motivation for learning achieved by students is becoming increasingly dependent on the quality of the visual aids incorporated in the teaching materials [17, 18]. To level up education for blind students, the materials designed by EduMakers engineers seek to provide visually impaired students with tactile images enhanced with audio information that aims to supply them with the same quality and variety of information as their sighted peers [19, 20].

Through several rounds of iteration and testing with final users applying this general approach, the outcoming products have been constantly improved and refined, and a design guide was generated. To develop the flowchart presented in this paper, a mapping of the processes for obtaining educational materials was performed. This analysis allowed us to systematize the steps that can be followed by anyone who wants to develop inclusive, technology-based universally designed educational products. Then, it is possible to say that the resulting guides are based on a deeper knowledge of how users learn, as well as empirical observations and consequent improvements from users' validation and feedback.

III. RESULTS

A basic decision route, such as the one shown in Fig. 1, starts with the premise that teaching science topics from an inclusive approach is best supported by using physical learning objects as educational resources in the classroom. It is necessary to take into consideration that, if we want them to be suitable for all learners, they have to contain attributes of Universal Design for Learning. Thus, a first step in the direction of any educational innovation should be searching for what is available in the market. When there are commercially available resources that are helpful and informative for the topic to be taught (Fig. 1 route A), the next step is analyzing if those comply with UDL attributes. For example, features related to multisensory information such as tactile, visual and audible information altogether, so they are usable and engaging for the majority of learners. If the materials do comply with UDL (Fig.1 A1), there is no need to design new ones and they can go directly to the classroom. However, what it is usually found is that there are no existing resources to begin with, and they have to be designed and fabricated. In such cases, the steps to follow are on route B (beginning at B1).

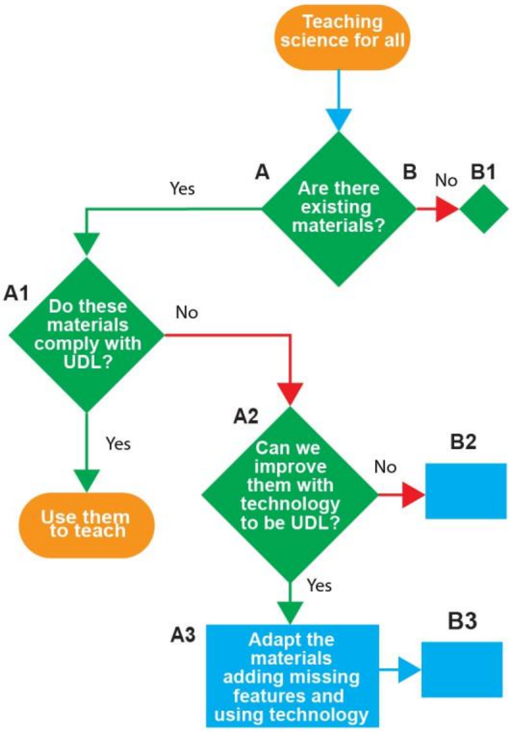

Fig. 1. Decision route map A Use UDL existing educational materials.

When there are materials available in the market, but they do not comply with UDL, the next question is if they can be improved with the integration of technology (Fig. 1 A2). If not, this would mean they cannot be used as a starting point and the steps to follow move to route B (B2). When they can be improved with technology, the next step is to select which type would add the missing features. For this, it is important to consider the characteristics of specific users who face more challenges for accessing the information. The process then continues to the prototyping cycle, where prototypes are created (B3) further validated by users (B4) before their use in the classroom. Improvements to available materials may include:

- Offer autonomy to the user by adding tactile or auditory features that allow the user to perform tasks autonomously or independently, *i.e.*, that do not require assistance.
- User friendly interfaces that allow users to quickly understand the use of the object through simple layouts that facilitate the interaction by suggesting the way of use with the color, shape, size and texture considering the inherent knowledge and experience of the use of similar products.
- Ease of use, where functions, tasks and commands are easy to remember or relearn, simple instructions that do not require prior knowledge for their use and allowing repeating actions as many times as needed.

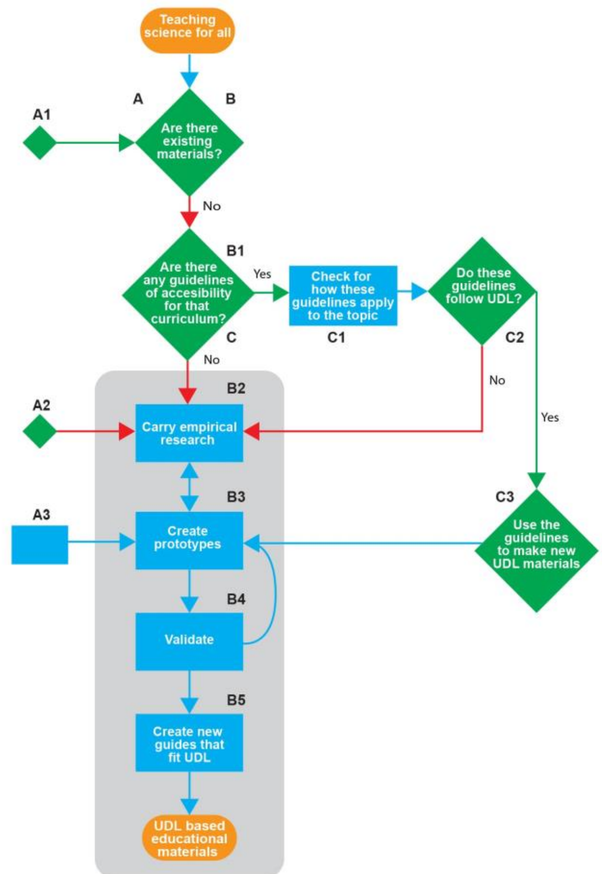

Fig. 2. Decision route map B-C used to make UDL educational materials.

A more laborious, but also most needed path is when there are not learning materials related to the topic in the market, and the process must follow the path shown in Fig. 2 route B. If such is the case, the next question to ask is if there were any established guidelines of accessibility for that curriculum (B1). If there are, we need to be more specific and check how they apply for the topic to be taught (C1) and if they follow UDL (C2), they can be used directly (C3) into the B route to design and create new prototypes (B3) than will further need validation (B4). This suggested path takes place from the understanding that guidelines not necessarily conduct to physical educational objects and is useful to apply them in the creation of prototypes that will then undergo validation. Most often, it is possible to find reports and guidelines; however, they tend to be for specific disabilities and less often are materials based on UDL. Such is the case of most tactile graphics that are widely used by blind and visually impaired students but are not attractive nor engaging for visual learners. When the situation is that there are no guidelines or the guidelines do not consider the perspective of UDL, empirical research is needed to identify successful approaches for teaching using educational objects, to apply those that can be suitable for the topic, test the outcomes and finally obtain novel inclusive educational materials (route B2 to B5).

Research helps find information from different sources and guides the researcher on how to integrate the knowledge from the educational and the technology fields. More importantly, to decide what type of representation to choose so it is accessible and engaging for all students. For instance, it is known that blind students can benefit from the use of tactile features (textures and raised lines) and from the use of various materials to convey information using touch in addition to braille texts, while for low vision students it is important to also use contrasting colors and macro types. However, braille text and simple raised lines may not be engaging for visual learners. The question then would be, how to add those and other engaging characteristics - such as audio descriptions- using technology, as research allows to find what technology has been successfully used for inclusive teaching, but also helps to identify what other widely available technologies can be applied with educational purposes.

Empirical research will also help find how different approaches are implemented to achieve the learning objectives for specific science topics and discern which are amenable for the majority of learners. With the information collected, and the participation of possible users, a list of features that would facilitate learning is compiled and then, a careful design process starts deriving in fabrication of prototypes (B3), which are further validated (B4) and, once several iterative cycles take place, improved inclusive materials can be obtained. From the experience of going through these processes it is possible to propose guides to follow when generating future designs of more innovative inclusive educational materials that fit UDL (B5). In the end, research serves to propose novel ways to incorporate technologies through universal design into the creation of new materials to enhance the experience of all learners.

A. What type of representation to choose?

It is important to highlight that the decision-making process for the selection of the format in which the products will be materialized is fundamental and is linked to the user's needs, the specific science topic, the academic level, and the didactic sequence used to teach. This report refers specifically to science topics, where information is usually presented or communicated in various ways, including text, illustrations and photographs, graphics (for math), formulas, videos and animations, three-dimensional models, and other objects of diverse nature. However, none of the above are accessible for BVI students, except for three-dimensional models; and even those, frequently lack enriched tactile features that allow representation of the information in a form equivalent to the great diversity of visual forms. This means that most of the scientific information might need to be translated to a different form of representation when designing and fabricating educational materials for all learners.

Translating two-dimensional images such as illustrations or photographs from books to 2.5D or 3D objects depends on the needs of the specific subject and how it is usually taught and learned. For simplification, we call 2.5D objects those that are not fully 3D but contain changes of depth and textures to represent the different elements that compose the subject to be represented. The decision on what features to include will depend on the learning objectives of the lesson plans, and thus, those can change not only by the topic, but also by the curriculum relative to the degree in which this is immersed.

For example, in the case of subjects such as Chemistry, theoretical contents are commonly introduced to the students through written formulas that include the use of texts, symbols and diagrams. Because, educational UDL- based materials can be easily represented in 2.5D objects; for instance, a formula contains conventional symbols but didactic UDL-based representations will use differences in height and colors to help identify elements within the formula, while textures could be included to differentiate components.

On the other hand, there are occasions where the amount of information can be enriched with the use of fully three-dimensional models to explain the concepts. This is the case of molecules and atoms, where a three-dimensional representation helps to show the arrangement of the elements, or, for example, biological objects of microscopic size, so they can be represented as they can be found in nature but in larger sizes and with tactile features to identify their components. Then, for topics related to Biology and derived disciplines such as Embryology, Anatomy, Cell Biology and others, the use of 3D representations is highly recommended, but 2.5D objects can also help show different layers of tissues to understand how they are organized inside.

B. What type of technology is best?

With the use of low-cost, easy-to-access technology, new features or functions can be added to objects in a simple way, expanding the range of users who have access to information through the different senses.

So far, in the stage of prototyping it is necessary to part from the features and characteristics that the materials require to support the successful teaching techniques and principles found from the empirical research. With this groundwork, constraints on the scope and functionality of the prototypes are defined before brainstorming. The proposed concepts to develop are oriented to prioritize the following design principles: ease of use, reproducibility, reliability, durability, and clarity. These are influenced by the cost and prototyping time of the project while ensuring the final product is transferable in an open-source spirit. These principles guide the decision-making process to choose the type of technology to base the prototype's functionality.

For instance, the need for auditory information to aid the learning process of BVI students serves as a starting point for engineers to start comparing different components to integrate audio reproduction within the educational material. Adding this valuable feature implies a processing requirement that also serves as a constraint for selecting a cost-effective microcontroller. In addition, audio reproduction requires basic user interface features such as being able to pause, rewind, forward and stop at the users' will. Furthermore, if this functionality is triggered by interaction of the user with elements of the educational material, so additional components such as sensors and switches need to be compared and selected based on their effect on the user experience and their technological requirements.

At the same time, the prototype's casing must be developed with the adequate space and positions of the electronic components. The material of the casing is selected considering the desired durability of the prototype, the manufacturing process and cost, without forgetting it must be easy to clean so it can serve multiple users.

A final consideration is that a cost-efficient selection of affordable technology allows the products to be replicable and reach a wider and diverse population.

To date, the technologies used in EduMakers to provide audible information on the educational materials range from simple systems such as QR codes to more complex systems using RFID readers and tags, and magnetic sensors. EduMakers have also used an existing technology called the Tactile Talking Tablet (TTT) by Touch Graphics (touchgraphics.com), which has been in use for a few years as an assistive technology that aids in associating audible information to various kinds of tactile graphics.

TABLE 1
TECHNOLOGIES USED BY EDUMAKERS TO CREATE INCLUSIVE EDUCATIONAL MATERIALS.

Technologies	Advantages	Disadvantages
QR codes	Easy implementation and no cost for materials.	Requires a mobile device with camera and internet connection.
RFID tags	Reliable and easy access technology. Cost dilutes when a reader is used for many objects.	Design, fabrication and programming requires multiple skills. Each tag needs to be individually programmed.
Hall effect sensors	Reliable, low-cost components. Outputs digital signals.	Design, fabrication and programming requires multiple skills. It might be vulnerable to magnetic fields.
TTT	Blind users can program audio display. Easy to use. No additional cost per object.	Useful for semi-flat objects (2.5D), design can be challenging, equipment availability and cost.

IV. DISCUSSION

The decision map outlined in this paper aims to be a referent specialized in guiding engineers to design UDL-based educational materials but is not the first in its class for general design purposes; there have been previous, successful methodologies proven to be so good that they have cemented an entire discipline such as design. That is the case of Bruno Mundari's Design Methodology [21], which was first published in 1981. Munari outlined a project methodology that can be applied to any problem, regardless of its size, from designing a garden, to creating the latest trending app; he described a series of steps that can be used to develop any design project until its completion. According to Munari, "The design method is nothing more than a series of operations necessary, arranged in a logical order dictated by experience. Its purpose is to achieve maximum results with minimum effort" (idem), which is what we are trying to achieve as well.

Since first published in 1981, Munari´s design methodology has been adapted to current needs and technologies, however, the same fundamental steps have remained as a basic roadmap to guide design students and professional designers all over the world to successfully complete their work. Then, Munari´s method will be briefly discussed next and compared with the one presented in this paper.

In his original proposal, Munari draws a simile between trying to cook a green rice and embarking on a design project of any kind, on each step, he describes the analogy as follows:

TABLE 2
DESIGN STEPS PROPOSED BY MUNARI

Methodology steps	Analogy example
1. Problem	To cook green rice.
2. Problem definition	To cook green rice with spinach for four people.
3. Problem´s components (elements)	Rice, spinach, ham, oil, etc.
4. Data gathering	Is there anyone who has done it before?
5. Data analysis	How did they do it? What can we learn from that?
6. Creativity	How can all the steps above be mixed in the best possible way?
7. Materials and technologies	What kind of rice? What kind of pot? Should we use a low or high flame? Should we do it on the cooker or the microwave oven?
8. Experimentation	Trial and error.
9. Prototypes	Choose a final prototype.
10. Verification	Try it with the final user (Yes, there is enough rice for four people).
11. Final technical drawings	Minimum viable product, or proof of concept, etc.
12. Solution	Green rice for four people nicely plated.

The project outlined in this paper followed some of these same steps but adapted to the mindset of the engineering students collaborating with it, resulting in the guides described above. A major difference is that Munari originally described his methodology as a linear process, while the guides we propose are, on the other hand, working as a map where decisions can be made depending on the original problem, its characteristics, and the tools to reach a final solution; however, most of the original methodology was conserved as it can be seen in Table 3.

A clear difference is the type of process that the present work proposes. More than a linear methodology, the roadmap works depending on if the answer to the question is: "Yes" or "No" after conducting due research, as it is shown in Fig. 1 and Fig. 2; therefore, based on those responses, decisions can be made, and the team can move in the right direction until the result has been reached.

TABLE 3
ADAPTATION OF MUNARI'S DESIGN STEPS

Methodology steps	Analogy example
1. Problem	Teaching science for all by using 3D inclusive materials to help students understand scientific topics.
2. Problem definition	Provide information on a scientific topic.
3. Problem´s components (elements)	Understand the different elements and complexities of each scientific topic.
4. Data gathering	Are there existing materials?
5. Data analysis	Are there any guidelines of accessibility for that curriculum? Do these guidelines follow UDL?
6. Creativity	How can all the steps above be mixed in the best possible way by using the expertise of the team members (most of them engineering students from different areas)?
7. Materials and technologies	Can we use current technologies to create these materials? If there are existing materials, can we improve them by using low-cost technology?
8. Experimentation	Trial and error.
9. Prototypes	Choose a final prototype.
10. Verification	Try it with the final user
11. Final technical drawings	Minimum viable product, or proof of concept, etc.
12. Solution	3D inclusive materials with embedded technology to help students understand science.

Another significant difference with Munari´s methodology is the constant iteration process the roadmap follows while trying different technologies and materials with end users. In contrast, Munari briefly uses iteration as one of the final steps (verification). We are certain that iterations are a key step for improvements plus the iterative cycles of prototyping and validation also informs research, so we did iterations throughout most of the process. This is a main reason for why EduMakers has been generating innovative products, mainly parting from empirical research where design, prototyping and user feedback are highly relevant.

V. CONCLUSIONS

This work is an example of how analysis of universal design processes can generate a systematic roadmap to empower engineering students to become proficient designers so they can produce innovative inclusive educational objects with all desirable characteristics.

A major outcome of these guides is that it lays the groundwork for the creation of three-dimensional materials that integrate tactile features such as textures and height differences to facilitate interaction with the materials and, as final goal, helping users understand the information represented by those objects, while making the objects appealing, safe, and accessible to all users.

With this approach, engineering students can identify the specific barriers that people with disabilities face in education, so they can create and validate their prototype proposals and receive feedback, leading them to design better solutions using available and cost-efficient technologies. This way, the educational materials obtained reduce the gap in education and contribute to meaningful learning, not only for people with disabilities but for all students.

Although the guides presented in this work were made based on the experience of our group developing educational materials on anatomy, biochemistry, and embryology topics for visually impaired people [3, 4], these guides can be applied when designing educational materials for any subject. Helping future professionals learn how to make thoughtful and empathetic design decisions will promote equal opportunities in education and support a more inclusive society. Overall, these guides also aim to contribute to the development of transdisciplinary, transversal, and multidimensional problem-solving skills in engineering students, professional attributes that are essential to face contemporary challenges.

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REFERENCES

[1] United Nations Development Programme. (2023). Sustainable development goals. UNDP. Retrieved from https://www.undp.org/sustainable-development-goals

[2] J. M. Olais-Govea, D. T. Preval, J. R. Aguilar-Mejía and C. G. Reynaga-Peña. (2022). "Developing soft skills in engineering students through the design and production of educational materials for inclusion", in the 2022 International Conference on Inclusive Technologies and Education (CONTIE), Cartago, Costa Rica, pp. 1-6, 2022.

[3] J. R. Aguilar-Mejía, I. M. Santillán-Rosas, J. M. Olais-Govea and C. G. Reynaga-Peña, "Crafting Inclusion: A Dynamic Multidisciplinary Approach to Engineering Education using Makerspaces," 2023 World Engineering Education Forum - Global Engineering Deans Council (WEEF-GEDC), Monterrey, Mexico, 2023, pp. 1-7, doi: 10.1109/WEEF-GEDC59520.2023.10343580.

[4] A. Ghatak, "Talent Acquisition Strategy Has Completely Changed". Dataquest, 39(9), 58–60, 2022.

[5] C.G. Reynaga-Peña, C. Myers, J. M. Fernández-Cárdenas, A. J. Cortés-Capetillo, L. D. Glasserman-Morales and E. Paulos. "Makerspaces for Inclusive Education", in the International Conference on Human-Computer Interaction (HCII): Universal Access in Human-Computer Interaction. Applications and Practice, pp 246–255, 2020.

[6] D. M. García Lizárraga. (2014). Design for disability. Universidad Autónoma Metropolitana.

[7] R. L. Mace, "Universal design in housing. Assistive Technology," 10(1), 21-28, 1998.

[8] A. Gossett, M. Mirza, A. K. Barnds and D. Feidt, "Beyond access: A case study on the intersection between accessibility, sustainability, and

universal design, Disability and Rehabilitation: Assistive Technology," 4:6, 439-450, 2009, doi: 10.3109/17483100903100301

[9] B. Knecht, "Accessibility regulations and a universal design philosophy inspire the design process," Archit Rec 2004;192: 145–150.

[10] D. A. Meyer, D. H. Rose, and D. Gordon. (2014). Universal design for learning: Theory and practice. Wakefield, MA: CAST Professional Publishing.

[11] J. D. Basham, J. Blackorby, and M. T. Marino, "Opportunity in crisis: The role of universal design for learning in educational redesign." Learning Disabilities: A Contemporary Journal, (2020). 18(1), 71-91.

[12] J. M. Mcguire, S. S Scott, and S. F. Shaw, "Universal design and its applications in educational environments." Remedial and special education, 27(3), 166-175, (2006).

[13] T. Brown, "Change by design: How design thinking transforms organizations and inspires innovation," New York, NY: Harper-Collins. R. Cooper, S. Juninger and T. Lockwood, 2009.

[14] IDEO, "The field guide to human-centered design,". Retrieved from http://ideo.org. (2015).

[15] CAST "Universal Design for Learning guidelines version 2.2," [Online]. Available: http://udlguidelines.cast.org. [Accessed: November 2023]

[16] J. C. Koone *et al.*, "Data for all: Tactile graphics that light up with picture-perfect resolution," *Science Advances*, vol. 8, no. 33, p. eabq2640, 2022 doi: 10.1126/sciadv.abq2640.

[17] P. Messaris, "Visual aspects of media literacy," Journal of Communication, 48, 70–80,1998.

[18] V. Ferk, M. Vrtacnik, A. Blejec and A. Gril, "Students' understanding of molecular structure representations," International Journal of Science Education, 25:10, 1227-1245, 2003.

[19] E. Magaña-Cruz, L.F. Garza Vera, J.E. Arévalo Arguijo, A. Treviño Peña, L. Gómez Flores, and C. G. Reynaga-Peña. "Engineering for UDL-based education: translating book images into interactive 3D educational materials for Health Sciences subject," In press 2023 International Conference on Inclusive Technologies and Education (CONTIE).

[20] A. de J Pérez Armendáriz, M. Rodríguez Quintanilla, A. A. Lozano Herrejón, G. E. Oyervides Ramírez, I. M. Santillán-Rosas, and C. G. Reynaga-Peña. "Use of a tactile talking tablet to make inclusive educational resources for health sciences topics based on Universal Design for Learning." In press 2023 International Conference on Inclusive Technologies and Education (CONTIE).

[21]B. Munari, Da cosa nasce cosa. Rome: Laterza, 1981