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Maria Jesus Rosado-Garcia, Maria Jesus Garcia-Garcia & Artur Gonçalves

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# The perception of artistic values within civil engineering. A survey from the Iberian Peninsula

Maria Jesus Rosado-Garcia[1]*, Maria Jesus Garcia-Garcia[1] and Artur Gonçalves[2,3]

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*Corresponding author: Maria Jesus Rosado-Garcia, Department of Forest and Environmental Engineering and Management, Universidad Politécnica de Madrid, Madrid, Spain
E-mail: mariajesus.rosado@upm.es

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Sanjay Kumar Shukla, School of Engineering, Edith Cowan University, Austrila

Additional information is available at the end of the article

**Abstract:** Starting from the hypothesis that, currently, the potential aesthetic and formal values of engineering are not recognized by society, the main objective of this work was to deepen understanding of the perception of engineering work in Spain and Portugal. For this purpose, a structured survey was developed, and the collected data were subjected to descriptive statistics and non-parametric assessment to evaluate differences among groups. A total of 586 participants were considered in this study, of which 80% had difficulties in recognizing contemporary art, 60% continued to associate it with beauty and 75% acknowledged that they do not understand art or are indifferent to it. The age, education, and urban context of the respondents were factors that influenced levels of knowledge and acceptance of civil engineering work as art, with a clear positioning of architecture as the standard-bearer of its aesthetics. When addressing surveyed interpretation of images, frequency of visits to cultural venues favours the perception of contemporary works of art, while most selected civil works were designed by engineers, which shows that aesthetics and design don't have to be assigned to other professionals. The vast majority of the participants agree with the notion that engineering enables trust, while about a third of the participants disagree with the idea that art dominates science in engineering work. Finally, there is a broad perception among participants that engineering works can be elevated to a new form of art.

**Subjects: Civil, Environmental and Geotechnical Engineering; Building and Construction; Art & Visual Culture**

**Keywords: engineering work; work of art; social perception; civil engineering; survey**

## 1. Introduction

Aesthetics and formal values play a small role in many civil engineering projects; those focused primarily on technical aspects such as geotechnics, foundations, or soil mechanics. Nonetheless, a connection between art and aesthetics is evident in the engineering of large civil constructions such as bridges, building covers, stadiums, telecommunication towers, dams, canals, and highways, as well as in single-tall buildings, power stations, and some other specific constructions and, most notably in major landscape interventions. All these engineering works share the trait of being adjusted to the local context, steadily placed on a location, thus evidencing the interrelationship and influence of both the landscape and social attributes.

To understand the possible artistic value of engineering, it is necessary to analyze the relations between architecture and aesthetics. This complementary interaction centers the relationship between architect and engineer in the discussion of the philosophy of design, including creativity (Holgate, 1986).

It was only at the end of the 18th century that engineering and architecture split into separate fields of knowledge/technology, which led to the establishment of rationality and scientific knowledge as central values of civil engineering, and aesthetics as the central value of architecture (Picon, 1988).

As a result, engineering works have struggled to claim independent aesthetic value (Rosado-García & García-García, 2022a). These circumstances call for innovative approaches to the art-engineering interface (Aparicio, 2019). Many engineers are justifiably concerned about the analysis and formal criticism of socially demanded infrastructures, whose ultimate form impacts, positively or negatively, users' perception of the landscape (Cuadernos de Diseño En La Obra Pública, 2009).

If a work of art is defined as a reproduction of a thing, a constructed form, or an experimental expression that can delight, thrill, or move (Tatarkiewicz, 1974), it follows that there should be no limits to what can be considered a work of art, and it must be acknowledged that art should not be reduced to masterpieces (Dewey, 1980). In recent decades, and especially in the context of postmodernity, the definition of the aesthetic has undergone a decisive change, undoing traditional categories and disciplines (Berger, 2002; Shiner, 2001). The impossibility of providing restricted definitions and the importance given to the observer (Bal, 2001; Bryson, 1983) have emphasized the ciject's power to determine what is considered artistic (Bourdieu, 2016). It is widely accepted that modern art system is a recent phenomenon shaped in Europe. For two thousand years, art was utilitarian and what is now pointed to as the death of art is nothing but the end of a certain social institution whose origin dates back to the eighteenth century (Shiner, 2001). Classical criteria such as beauty, narrative and technical skill have recently collapsed, as evidenced by the multitude of recognized works of art that do not follow them. Therefore, it is important to investigate how the criteria of art are determined at a given moment in time (Farago, 1992).

At the end of the twentieth century, aesthetic theories prioritized conceptual definitions, strengthening the idea that a work of art cannot be understood in isolation, according to a set of criteria that determine what is, or is not art. From this time on, the work of art has been placed in its historical, social, and economic context (Graw, 2010). *"The embodiment of ideas, I would say, of meanings, is perhaps all we need as a philosophical theory of what art is"* (Danto, 2013, p. 110). The concept of art as something elevated is still present today; at the same time that it is recognized as something remote from society and belonging to a select few, as it is considered to have a superior quality (Bourdieu, 1996). Given this background, this paper aims to demonstrate, in the context of civil engineering, that the definition of art, and works of art, should cover all types of interventions without discrimination.

It should be pointed out that the simplification around the consideration of what can be a work of art is only the lexicon chosen to bring engineering closer to other perspectives beyond the scientific one. Because nowadays the definition of art itself has been broadened to the point that the question of what is or is not art is certainly sterile (Cristian Camilo et al., 2018). These perspectives also point to the fact that the design of the constructions themselves must go back to the origin (Alexander, 1979). We must recover what Vitruvius pointed out in the 1st century when there was no distinction between architects and engineers: he laid the foundations of what we understand as a work, and he is the first person we can turn to extract criteria for aesthetic judgment for construction. A well-built work must possess three qualities: resistance, utility, and beauty. The three must go together and are inseparable (Perraul, 1761).

Regarding the evaluation of the aesthetics of the landscape, from the 1970s onwards, there has been growing interest in the assessment of the social perception of the landscape (Ittelson, 1973). The evaluation of visual aesthetic quality determines the basic cognitive needs concerning the cijects' physical surroundings, which automatically generates responses of attraction or aesthetic preference (Kaplan & Kaplan, 1989). The perceptual responses caused by visual stimuli can be obtained through the use of psychological theories and research techniques, particularly those which seek reactions to visual and spatial information (Sanoff, 1991).

Since the end of the twentieth century, there has been an interest in re-evaluating the definition of civil engineering, and reformulating its definition beyond the mere resolution of resistance or structural issues, which implies rethinking its relations with other fields, such as the arts or architecture (Black, 1976). The autonomy of art was the artists' response to the domination to which they had been subjected by entrenched power structures for centuries (Rancière, 1998), although at the same time, artworks, and the art industry, emerged as a commodity to which artists folded, with the consequent pursuit of their interests (Adorno, 2015). As a result of intensive commodification, the art market was born, in which artworks were reduced to their economic value and became exchangeable consumer goods, acquiring a mercantile character that the birth of conceptual art opposed (Vallejo Fernández, 2021). The dematerialization, which was a necessary correlate of conceptuality, did not provide an escape from commodification: the possibility of selling a video of a performance exemplifies this.

The aesthetic questions of civil engineering, which are often discussed in general and very subjective terms, in a long tradition institutionalized at civil engineering departments in universities, should be approached in terms of education and philosophy (Neumann & Lyles, 1978). Art, science, and technology are inseparable and cannot be considered isolated fields of human activity, and this inseparability has become increasingly socially important (Robson & Bankoff, 1965). Nonetheless, engineering is still considered distinct from the humanities, limiting the work of engineering to physical objects and granting architects the human interface (Frederick, 2007). This is why studies have emerged which discuss the need and value of interdisciplinary collaboration between architecture students and civil engineering students while investigating the differences and similarities between their aesthetic evaluations and visual preferences with targeted surveys (Garip & Garip, 2012). Likewise, in art today, a social turn is beginning to gain ground, as in the case of participatory art (Bishop, 2012), which emphasizes resistance to any type of homogenization or globalization. This movement also emphasizes that authorship of all kinds is multiple and continually indebted to others. What matters are the ideas, experiences, and possibilities that result from these interactions (Barthes, 1977) The world cannot be known without experience (Mora-Anto, 2020) and engineering emphasizes this. Its ideas are instruments; they have a utility, which allows us to experiment with them to solve problems. Contemporary art, in its openness to society, and wherein the use of intuition allows for different readings of reality, must embrace engineering. Nothing exists independently of the social web of articulations and connections and engineering must aim to intervene to improve utility without destroying the identity of the existing (Nogué, 2015).

Although some studies have investigated the social perception of urban space (Jensen & Birche, 2021) or evaluated selected constructions at the landscape level (Pozo-Antonio et al., 2014), there are no specific studies on society's perception of engineering work.

On the other hand, the approximation of the concepts of engineering and art has been claimed (Tarrés, 1999), since the engineer, as a maker of forms, such as bridges, dams, and buildings, creates a product of sensibility, provoking viewers intellectually in a manner no different from any other art form. However, the conceptualization of engineering work as inherently aesthetic is often limited to theory (Addis, 1994; Billington, 1983) or restricted to the profession itself (Manterola, 2010; Nárdiz, 2021; Romo, 2020). Attempts to frame engineering work as a work of art generally provide an individual analysis of a specific construction, referring to the intrinsic properties of the materials used. A work of art, in a broad sense, should be considered to be any work, including engineering, conceived and designed with creativity, quality, and aesthetic quality, the latter

deduced not from ornamentation, but from fidelity to its structural principles and inherent material characteristics (Cardellach & Calavera Ruiz, 1970). However, in past studies, the relationship between art and engineering has been approached in terms of aesthetics, rather than social perception. Another perspective is necessary to reveal the significance of engineering work (Martínez Calzón, 2013; Miguel Aguiló Alonso, 2013), without reduction to aesthetics (Amau-Amo & Songel-González, 2010); hence the proposal of this research. No one has gone so far as to argue that engineering should also be part of art as a whole, except for a few studies focused on structural engineering (Arenas, 2002; Billington, 1983). This study is based on a problem that has been a focus of increasing attention in the academic literature: the difficulties in the aesthetic appreciation of public works (Aparicio, 2019) and the failure to consider aesthetics as a constitutive value of civil engineering (Fernández Casado, 1976; Fernández Ordóñez, 1990). Attention should also be drawn to other less obvious values of engineering, such as beauty and sensitivity (Martínez Calzón, 2006), and to the creativity and collaboration which characterizes the interface between engineering and architecture (Holgate, 1995; Rice, 1994).

Using a sample from two countries in the Iberian Peninsula, Portugal, and Spain, the general objective of this work is to analyze the social perception of civil engineering in its relationship to visual or aesthetic criteria. This study addresses the societal recognition of art, the specific competencies of civil engineering and its differences with architecture, as well as the perceptions of the surveyed on the aesthetics of construction. Additionally, the question of whether engineering works are close to society and its demands, and more broadly, whether engineering works can be considered works of art, in the sense that they may imply a formal, aesthetic, or narrative concern, are explored.

## 2. Methodology

### *2.1. Survey design*

Across Spain and Portugal, a total of 586 generically representative participants were surveyed, with a confidence level of 95% and a percentage error of 5%. The survey was distributed through social media and the answers were collected through a web platform.

The survey included different sections. The first addressed how the participants recognize art, whether they distinguish civil engineering from architecture, and if they consider engineering works to meet, or fail to meet, their demands. The second section explored the participants' perceptions of the aesthetics and design of works of civil engineering, as well as the interpretation of civil engineering work in relation to art.

This research survey was approved by the Ethics Committee of the Instituto Politécnico de Bragança (Portugal). Participation was anonymous and voluntary. Informed consent for the surveys was requested and participants could withdraw from the survey at any time.

The structured questionnaire was developed in Google forms (Alphabet Inc., California, EE.UU.). The questionnaire consisted of five parts: a). Demography of surveys, b). Knowledge of art, c). Knowledge of civil engineering, d). Perception concerning aesthetics and the design of civil works, and e). Perception of civil works as works of art. The survey was designed by combining Likert scale valuations (1 - Strongly disagree; 2 - Disagree; 3 - Neither agree nor disagree; 4 - Agree; 5 - Strongly agree) and multiple image selection questions.

When using images to determine the surveyed perceptions, attention was given to the similarities in perspective. Most of the images were collected by the authors and exceptions are identified.

In the first phase, three independent reviewers validated the questions, and a preliminary study was conducted with ten surveys from Spain and Portugal. These preliminary steps were carried out

to improve the quality of the questionnaire, although the answers were excluded from the analyzed data.

### *2.2. Survey application*

To calculate the target sample size for this survey, the combined population of 57 million inhabitants between both countries, Portugal, and Spain, was considered, and the minimum size was calculated, estimating a confidence level of 95% and a 5% margin of error. The sample size needed for generic representativeness was 385. Since the population of Spain is around 47 million, compared to 10 million in Portugal, the surveys were sampled in a proportion of at least four to one, from Spain and Portugal, respectively. Access to online platforms should be seen as an access requirement for this research. However, the use of online platforms enabled wider dissemination of the survey. The online survey included two equivalent versions, one in Spanish and the other in Portuguese.

The online survey started on April 20 and was completed on 16 May 2022, using a Google Forms. Dissemination included random distribution by electronic mailing lists and social media platforms, such as WhatsApp, LinkedIn, and Facebook. The sampling process tried to reach random citizens, although Facebook engineering and architecture groups were included to target this specific groups. Once the survey closed, incomplete surveys and serviewees working out of territorial context were excluded and a total number of 586 valid surveys was recorded, 52% over the target sample.

As the sample size exceeded the minimum sample size for representativeness (385 properly completed questionnaires), the generic representativeness of the sample was assured for a margin of error of 4.3% and a level of confidence of 95% (Cochran, 1977) (Table 1).

The data sample shows a slight unbalance in terms of the number of females, while the number of older adults is low, which may be a consequence of the data collection method used in this survey. The survey covered a wide range of groups, in terms of educational level, field of expertise, nationality, household context, etc.

Additional sample description questions included questions regarding travel habits and frequency of visits to museums and galleries, as it was considered that these behaviors could influence the perception of art.

### *2.3. Data analysis*

The data was collected through the Google Forms platform and then compiled and codified in Microsoft Excel. Statistical analysis was performed with the help of the Statistical Package for the Social Sciences (SPSS), v.22, and OpenEpi. Statistical analysis included the use of non-parametric tests to evaluate similarity in the answers. In the case of the answers expressed in the Likert test (scale ordinal or rank data), the Mann-Whitney test was used to assess differences between two distinct groups. The Kruskal-Wallis test was used for the same purpose when evaluating the differences among three or more groups. For both tests, $p < 0.05$ means that the null hypothesis may be excluded, thus suggesting that there are differences in the responses among groups.

Additionally, Pearson's chi-squared test was used to test independence in the selection of images by the different groups. For this test, $p < 0.05$ means that the null hypothesis may be excluded, thus suggesting that there are differences in the selection of images (nominal variables) among different groups (categorial and independent groups). To complement this analysis, Cramér's V was used to measure the strength of association between the selection of images and the different group categories.

**Table 1. Sample description**

| Category | Quantity | Percentage |
|---|---|---|
| Gender | | |
| Male | 243 | 41 |
| Female | 337 | 58 |
| Other | 6 | 1 |
| Age | | |
| Under 18 years | 8 | 1 |
| 18 to 25 years old | 73 | 12 |
| 26 to 45 years | 220 | 38 |
| 46 to 65 years | 256 | 44 |
| Over 65 years | 29 | 5 |
| Training | | |
| No training | 3 | 1 |
| Basic training | 27 | 5 |
| High School or Professional Training | 81 | 14 |
| Diploma/Degree/Bachelor's degree | 194 | 33 |
| Teacher | 194 | 33 |
| Doctorate | 87 | 15 |
| Area | | |
| No training | 74 | 13 |
| Humanities | 86 | 15 |
| Engineer of roads, canals and ports | 92 | 16 |
| Other engineering | 162 | 28 |
| Architecture | 40 | 7 |
| Another focus | 132 | 23 |
| Country | | |
| Spain | 438 | 75 |
| Portugal | 118 | 20 |
| Other | 30 | 5 |
| Home | | |
| Town (<10,000 inhabitants) | 98 | 17 |
| Small city (10,000–200,000 inhabitants) | 203 | 35 |
| Large city (>200,000 inhabitants) | 285 | 49 |

## 3. Results and discussion

### *3.1. Knowledge and perception of those surveyed regarding art*

As a starting point for the study, the survey focused on understanding to what extent society recognizes art, how it decides to name something as art, that is, that decides to include it in this category; and how society values it and feels close to it. In other words, the goal was to understand if the participants were able to identify art and how they determined if it met, or failed to meet, their individual demands. For this purpose, participants were asked to what extent they agreed with different expressions (Figure 1). The results showed that most participants disagreed with the expressions "Art is always beautiful", "Anything can be art" and "I don't understand art", while mixed answers were found regarding "I don't understand art", probably as a result of the

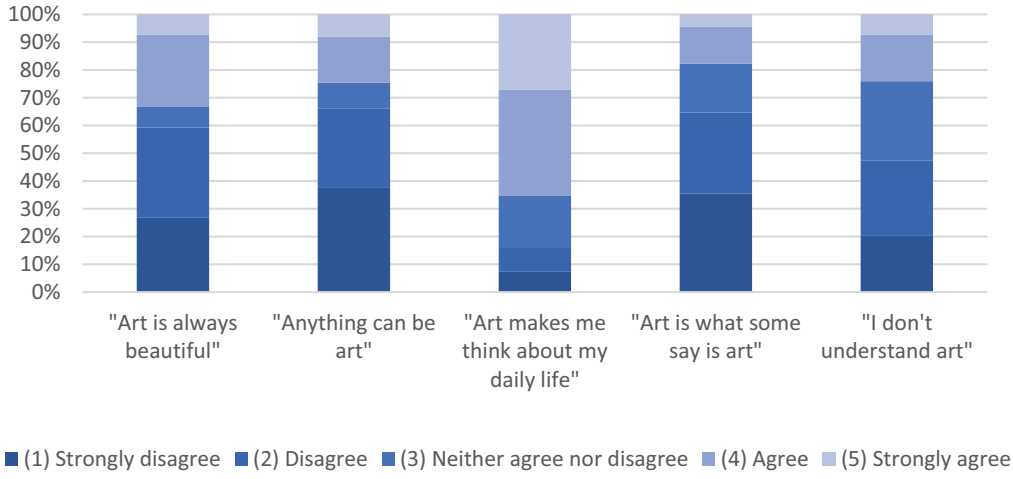


**Figure 1. Level of agreement with the statements regarding the perception of art.**

Horizontal X-axis: questionnaire question. Vertical Y-axis: percentage of responses.

heterogeneity of the surveyed population. Most of those surveyed agreed or strongly agreed with the sentence, "Art makes me think about my daily life".

When applying the Kruskal-Wallis test, some relevant results were found, namely that the participants with higher education mostly disagreed with the idea of not understanding art ($H(5) = 12.02$, $p = .035$). Moreover, the participants with an architecture background tended to disagree with the same statement, expressing a higher level of understanding of art, followed by the participants from a humanities background ($H(5) = 10.901$, $p = .001$). Likewise, the high frequency of traveling abroad ($H(4) = 11.825$, $p = .019$) and visiting cultural venues ($H(4) = 50.47$, $p = 0$) made participants more self-confident about their perception of art. Conversely, Spanish participants ($H(2) = 12.891$, $p = .002$) and those living in small cities ($H(2) = 10.131$, $p = .006$) tended to express a lower level of understanding of art.

When considering the relation between art and its impact on reflection about personal life (question 3), the participants with no education most strongly felt that art had less emotional impact, followed by the participants with education in other fields of engineering (not civil engineering) ($H(5) = 14.358$, $p = .013$). The size of the town of the participants also affected their perception, with participants living in small cities tending to downplay the influence of art on their reflections about daily life ($H(2) = 12.213$, $p = .002$). Participants working in the construction sector tended to record a higher influence of art on reflection on personal life ($U = 34450.5$, $p = 0.005$), to disagree more with the idea of the definition of art by others ($U = 35698.5$, $p = 0.033$), and to have a more positive self-assessment of their knowledge of art ($U = 34922$, $p = 0.012$).

In a second question, the participants were asked to select six out of twelve photographs (Figure 2). Of these pictures, six (1, 4, 6, 8, 10, 12), are considered works of art by critics, are in prestigious art exhibitions or are works by recognized artists. The other pictures are random objects, or works of engineering which are not currently officially recognized as art.

The selection of images by the participants clearly matched, in most answers, the pieces of art presented, namely images 10 and 12. However, the second most voted image was image number 5, which is not a piece of art, but a work of engineering (Figure 3).

Two of the known works of art presented, images 1 and 4, received limited attention from the participants. Tracey Emin's "unmade bed", represented in image 1, one of the most famous images of contemporary art, was the least selected image (84/14.3%) as a work of art of the twelve presented. Similarly, the low selection of Image 4 (163/27.8%), the remains of rubble and concrete from the detention camp for Spanish Republicans in Rivesaltes in 1939, the work of Jean Denant,

**Figure 2. Images depicting possible works of art.**

1

2

3

4

5

6

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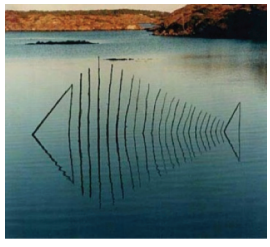
9

10



11

12

shows how contemporary art needs to be interpreted in terms of its context and story, which should be recognized by society. Images 4 and 8 are recently photographed works at the Arco de Madrid exhibition in 2022, but they received limited interest from the participants.

Conversely, images 2, 3 and 5 were selected by most of the participants, even though they do not fit the generic definition of a work of art.

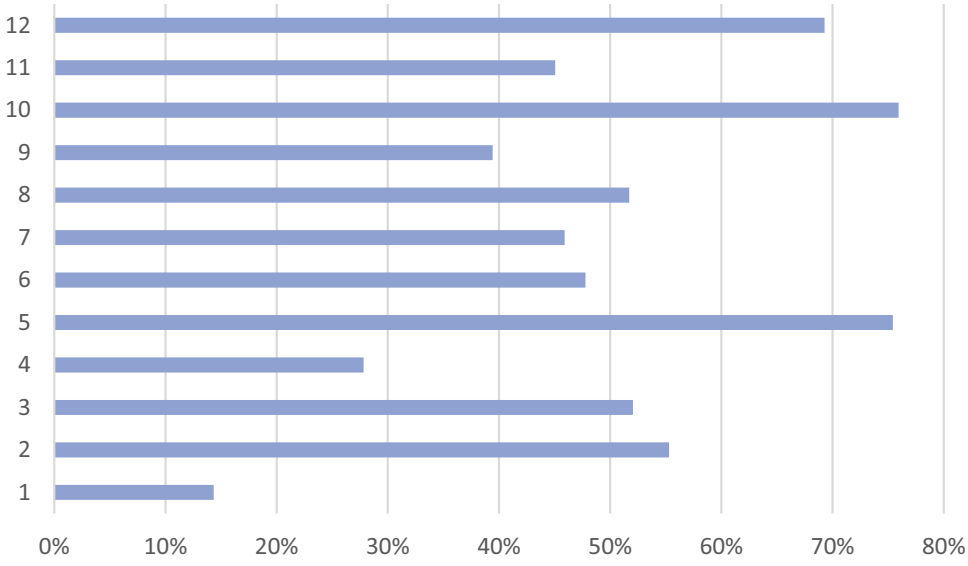



**Figure 3. Results from the selection of the (six of twelve) images that were considered as art.**

Horizontal X-axis: percentage of responses. Vertical Y-axis: image number.

Looking at the differences among the selection in diverse groups, there is a notable interest in image 4 with the older age group ($\chi 2(4) = 19{,}92$, $p = .001$, $V = .181$), although always with most respondents who do not consider it to be a work of art. In the case of image 8, a smaller selection was registered among older age groups ($\chi 2(4) = 15{,}135$, $p = .004$, $V = .161$), with most selections in the groups of 18 to 25 years and 26 to 45 years.

When looking at the differences regarding the level of education of the participants, significant differences were found in images 3 ($\chi 2(5) = 13.196$, $p = .022$, $V = .125$), 9 ($\chi 2(5) = 15.37$, $p = .009$, $V = .162$), and 10 ($\chi 2(5) = 12.305$, $p = .022$, $V = .145$). In images 3 and 9, a greater selection was made by those with lower education, with a wide selection in the first two categories (without education or basic education) and a smaller selection by those with more training. The most educated groups most frequently selected image 10. All these images represent outdoor structures, but images 3 and 9 are landscape engineering works, which should not be considered works of art, according to standard definitions.

It should be noted that a bridge (Figure 4) was the image (442/75.4%) most recognized as a work of art, although it was not considered as such in the initial hypothesis. This assessment of the Tortosa bridge by the participants reflects how engineering work can be categorized as a work of art; it is a powerful indication that engineering works which express a formal vigor can be categorized as aesthetic forms by society. In this study, the art-engineering binomial is proposed the axis to reveal the aesthetic value of engineering work and its relation to theoretical problems

**Figure 4. The Tortosa Bridge over the river Ebro, by Julio Martínez Calzón.**

Source: www.ideam.es.

introduced by, among other circumstances, the birth of aesthetics as a discipline and the historical struggle for the autonomy of art. It is based on the conception of the art object as a symbolic asset, which allows engineering work to gain significance since, in the sense of the non-material and transferable, the engineering work would be thereby raised above even conceptual art. The issue with contemporary art, which is characterized by concepts such as market, autonomy and idealization, is that the engineering works may not be considered art merely on account of not being salable, given the centrality of money in the field of contemporary art. On the other hand, the move of contemporary art away from aesthetic reductionism, and towards meaning and possibility "to be", makes the chances of including engineering works as close as possible to art. This indicates the significant value of the engineering work (Miguel Aguiló Alonso, 2013).

To understand the answers given by the participants, it should be made clear that engineering work is determined by a combination of different factors, such as the resistance of materials, the gravitational field, and the definition of structures that meet the concept of "tensegrity", in a sufficiently remarkable spatial dimension to gain a very high possibility of being judged in aesthetic terms. This process takes place because the human mind captures such values from "immediate indirect intellectual intuition" (López-Quintás, 2003) and thereby immediately grants the intrinsic qualities of engineering aesthetic value. The existence of engineering work in the landscape and its patrimonial value should not be underestimated; their material and visual force make it possible to claim a narrative that may then become a central element in the interpretation of the place (Crespo & Rosado-García, 2021; Miguel Aguiló Alonso, 2013). In other words, if the possibilities of relating engineering works to the territory are multiple, so are the narratives which they may bring. Therefore, the ability of civil engineering to become central to a broader narrative is a decisive factor in its approach to art.

Nonetheless, according to the results of the survey, art is still mostly associated with beauty, in the traditional or conventional sense (Han, 2015), as found in objects such as 2 2 (324/55.3%), a recognized work of art. However, when looking at the participants' backgrounds, there was a noticeably lower rate of selection by architects relative to the other professions. Although biological beauty does not require more education, and in fact, that may negatively affect their intuitive judgments, the role of art, despite its increasing spiritualization, should not be to deny these biological or organic roots but to provide satisfactory expression for both our bodily and intellectual dimensions (Dewey, 1980).

These answers reflect the difficulties found when trying to find a common value for art and engineering. The answer may lay in the fact that even contemporary art could hardly be placed in that category in previous centuries, as art from previous periods is now recognized by society, which feels a natural affinity to it and finds it easily recognizable even in terms of current standards of beauty. The discrepancy between some contemporary and established art is sufficiently noticeable to present a challenge to incorporating engineering into art, if art is defined in established terms. Conceptual art, for example, as an intellectual endeavor, reaching beyond objective beauty, falls closer to engineering since aesthetic value is not necessarily its main objective. This is not to deny the objective beauty of constructions, because today if people who are the actual users of some buildings and urban spaces judge them to be ugly, then a massive realignment is called for (Lavdas & Salingaros, 2022). The technical constraints of engineering, as well as the dependence on materials, have led to the tyranny of structural forms, which, for example, have led to repetition and monotony. Monotony is not rewarding, details are relevant and society wants beauty because it makes people feel happy (Sagmeister & Walsh, 2018), even more than the cleanliness or safety of the living space (World Happiness Report 2020, 2020). Engineers sometimes forget that the functionality-beauty dichotomy means nothing more than the inability to satisfy what people want: functionality and beauty (Fernández Ordóñez, 1990), and no one should be forced to choose between the two (Arenas, 1990). Society wants beauty, and it seems indisputable to say that they demand it because it simply makes us happy, since the beginning of time.

On the other hand, the frequency of visiting museums or art exhibitions had a significant impact on the interpretation of images 1 ($\chi 2(4) = 13.236$, $p = .010$, $V = .150$), 2 ($\chi 2(4) = 15.387$, $p = .004$, $V = .1162$), 4 ($\chi 2(4) = 11.058$, $p = .026$, $V = .137$), and 5 ($\chi 2(4) = 10.215$, $p = .037$, $V = .132$). The selection of image 1, the work "unmade bed" by Tracey Emin, grew with an increase in the reported number of visits to museums and exhibitions, although the selection of this image was a minority for all groups, as has been noted above. Comparable results were found for image 4, also an established work of art, where the trend is for a greater selection with an increase in the level of visits to cultural venues such as museums and galleries.

Conversely, in the case of image 2, the trend is reversed, and from non-visit to regular visits to museums and exhibitions, there is a decrease in the selection of this image, which represents elaborately presented food on a plate. Image 5, a bridge, was one of the most selected representations and was proportionally selected more by those with a lower frequency of visits to artistic venues.

These results reflect how the frequency of visits to cultural venues favors the perception of contemporary works of art.

### *3.2. Participants' knowledge and perception of civil engineering*

This section tries to address whether society recognizes civil engineering, values it, and feels that engineering responds to their demands. One question focused on the recognition of the difference between technology and engineering. From the available images (Figure 5), five were selected, with reference to whether an engineer has participated. An engineer participated in the design shown in images 13,14,15,19,22.

Before looking at the results (Figure 6), it is important to clarify the difference in the concepts discussed in this study. Technology is understood in transactional terms (Perrow & Davy, 2008), as the material means used to achieve a certain end. In modern terms, technology implies devices and mechanisms but also includes relationships between them combined in a system, in its functional configuration (Rip & Kemp, 1998). Contemporary engineering tends to be placed closer to science and technology than to art. Today, there is no clear distinction between engineers and scientists due to the strong bond between technology and science, but in any case, engineering tends to be placed on the side of science, thus downplaying its intrinsic links to human activity (Rosado-García & García-García, 2022b). Engineering is a synthesis of science, art, and human relations to solve mechanical and natural problems, but also sociological ones (King, 1981). It should be emphasized here that engineering should not be confused with science or technology. It uses scientific knowledge, but science is dedicated to uncovering laws that have always existed, being part of the natural world, while engineering produces objects and forms that have never existed (Billington, 1983).

In this section, the inhabitants of the towns were less able to distinguish between engineering and technology ($H(2) = 7.026$, $p = .03$), which may be due to a lower level of education or access to knowledge and/or technology, which suggests the need to promote a smart territory (Vegara, 2009). It is worth noting that participants over 65 ($H(4) = 10.371$, $p = .035$) are most likely to consider that engineering and technology are the same, relative to the rest of the population. Nonetheless, there is a clear consensus over this basic distinction (393/522–75.3%).

The bridge represented in image 15 (583/99.5%) was most recognized as an engineering work followed by a wind power plant in image 19 (516/88%), while about a third of the participants did not select the sculpture, shown in image 14 (397/67.7%), that was designed by a multidisciplinary team of artists which included engineers. The low selection rate for image 14 suggests that although a large modern sculpture needs engineering to exist, given the demands of structural design, this necessity is not fully recognized by society. In this sense, it might seem that engineering is reduced to a mere enabling tool, given its primarily technical contents. However, it should be

**Figure 5. Images presented in the question, "which of this images you consider the work of an engineer?".**

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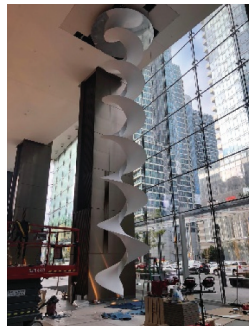

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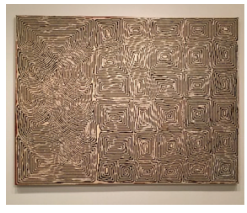

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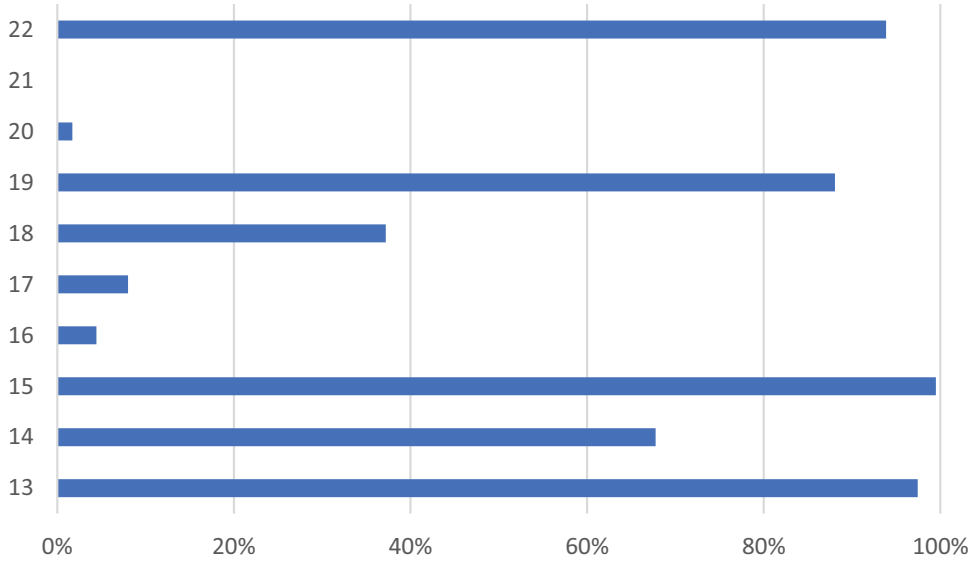



**Figure 6. Results from the selection of five images from ten presented representing projects in which an engineer was involved.**

Horizontal X-axis: percentage of responses. Vertical Y-axis: image number.

emphasized here how the vision of engineering connects science and art. It requires not only the application of technical processes, based on science but also the intuition of the engineer, as can be seen by the symbiosis evident in this modern sculpture. Based on the above, it could be argued that modern sculpture is engineering; engineers provide the support or a skeleton for the form, not only in a material sense but also in intellectual perception as well as sensitivity. Light and space are added to the work's materiality, without the need for ornaments of color or texture, and lays within the domain of gravitational forces transcending the concept of purely volumetric form. The engineering is an example of the dominance of resistant landscapes, although it has been pigeonholed into structural typologies, of conventional materials, beyond the free forms of sculpture (Figure 7).

Another section of the questionnaire explored the value of engineering work; for example, the trust generated when crossing a bridge. It was designed to determine if more names of architects than engineers are known and if the respondents believe that architects design aesthetically significant bridges. The results (Figure 8) indicate that the vast majority of the participants agree with the notion that engineering enables trust, while typically knowing more architects than engineers. Regarding the role of architects, results are strongly split between different groups.

**Figure 7. Ekpyrotic String VI (Mariko Mori) in New York.**

Source: https://ar2v.com/proyectos/portfolio-category/obras-arte/.

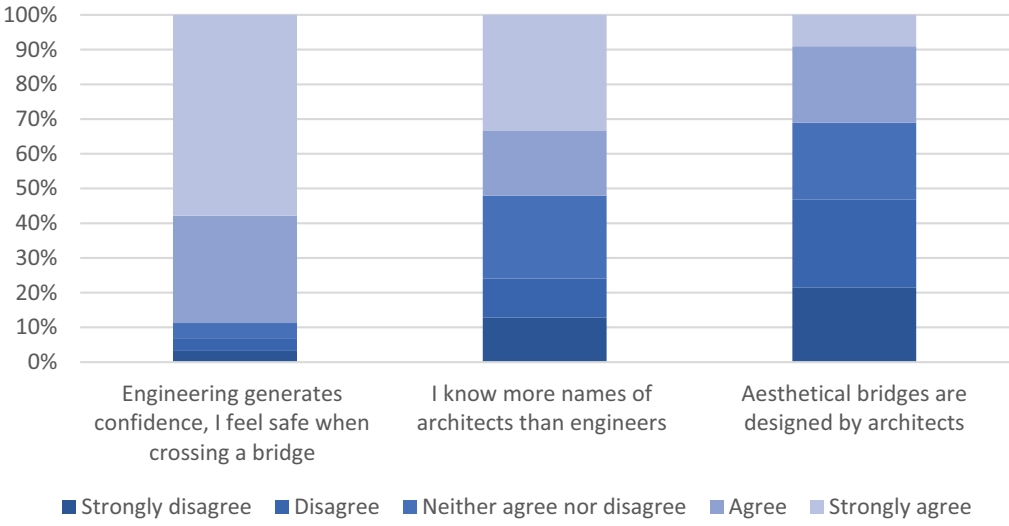



**Figure 8. Level of agreement with the statements on the value given to engineering work.**

Horizontal X-axis: questionnaire question. Vertical Y-axis: percentage of responses.

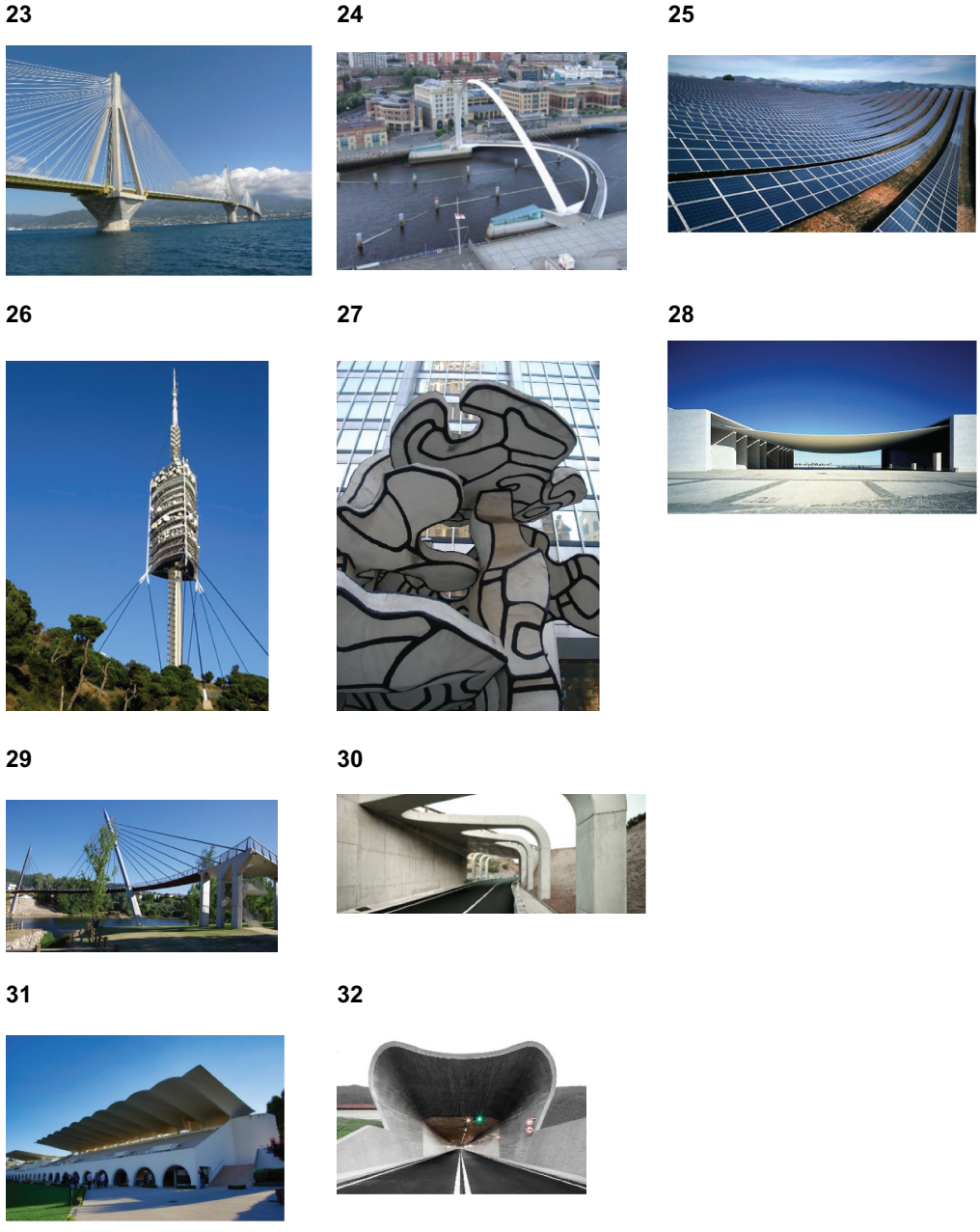
Looking at the responses by the different subgroups, Spaniards have more confidence in the safety of engineering work ($H(2) = 19.080$, $p = .000$) and know more names of architects than engineers ($H(2) = 8.539$, $p = .014$), when compared to the other nationality. Participants with a background in civil engineering feel the most confidence regarding the safety of their work ($H(5) = 12.901$, $p = .024$). The participants not involved in construction ($U = 29460$, $p = .000$), the youngest ($H(4) = 14.517$, $p = .006$), and those living in rural areas ($H(2) = 17.839$, $p = 0$) have a stronger sense that aesthetically valuable bridges are designed by architects, although the more they travel abroad ($H(4) = 9.994$, $p = .005$) or the more educated they are, the higher their disagreement ($H(5) = 20.479$, $p = .001$) with this concept, except architects themselves, who thought that the design of an aesthetic bridge requires their participation, taking a position noticeably different from that of civil engineers ($H(5) = 66.319$, $p = 0$).

Looking at the list of works (Figure 9), participants were asked to select five they believed were designed by architects. The objective was to ascertain if the participants were able to accurately determine who is responsible for design in the twenty-first century. An architect is responsible for the design of the following works: 23, 24, 26, 28, 32, while the rest were the outcome of a shared design or the work of other professionals. The analysis of the results of this section also sheds light on the relationship between aesthetics and the design of civil engineering works.

The results show that there is no clear consensus on the selection of images (Figure 10), indicating that the involvement of different professionals is not clearly identifiable based on the image alone.

Looking at subgroup differences, and particularly regarding image 28, the National Pavilion of Expo '98 in Portugal by the architect Álvaro Siza, there is a significant increase in the selection when moving from the youngest to the older respondents, followed by a decrease among those over 65 years of age ($\chi 2(4) = 20.460$, $p < .000$, $V = .187$). In the case of image 30, a pergola-type design that solves the very skewed intersection of two routes, a wider selection is recorded in the case of those over 65 years of age ($\chi 2(4) = 14.251$, $p = .007$, $V = .156$), although it is worth noting that this image was selected by the majority of those surveyed and identified as an engineering work designed by an architect. This shows how engineering works that break with the forms characteristic of specific structural typologies and explore contemporary designs, generate an association with the work of other professionals.

**Figure 9. Images of construction works presented for the selection of those considered to be designed by an architect.**




Notably, there is a wide disparity in the selection of images according to the level of education of the respondents. Such differences are especially significant in the case of image 23 ($\chi 2(5) = 59.936$, $p = .000$, $V = .320$), a bridge whose design was attributed to an architect; and images 24 ($\chi 2(5) = 16{,}368$, $p = .006$, $V = .167$), 25 ($\chi 2(5) = 21{,}117$, $p = .001$, $V = .190$), 27 ($\chi 2(5) = 31{,}319$, $p = .000$, $V = .231$) and 32 ($\chi 2(5) = 12{,}573$, $p = .028$, $V = .146$). Image 23 was much more likely to be selected by respondents with basic education when compared to the other levels of education, and the lowest selection of this image corresponds to those surveyed with a master's level education. In the case of image 24, a pedestrian walkway also designed by an architect, the selection was rare among respondents without formal education when compared to the other categories, the image being most widely selected among respondents with a master's degree. Image 25 represents a field of solar panels of purely engineer-led design. This image was widely selected by the respondents without formal education, which contrasts with its low selection among the other

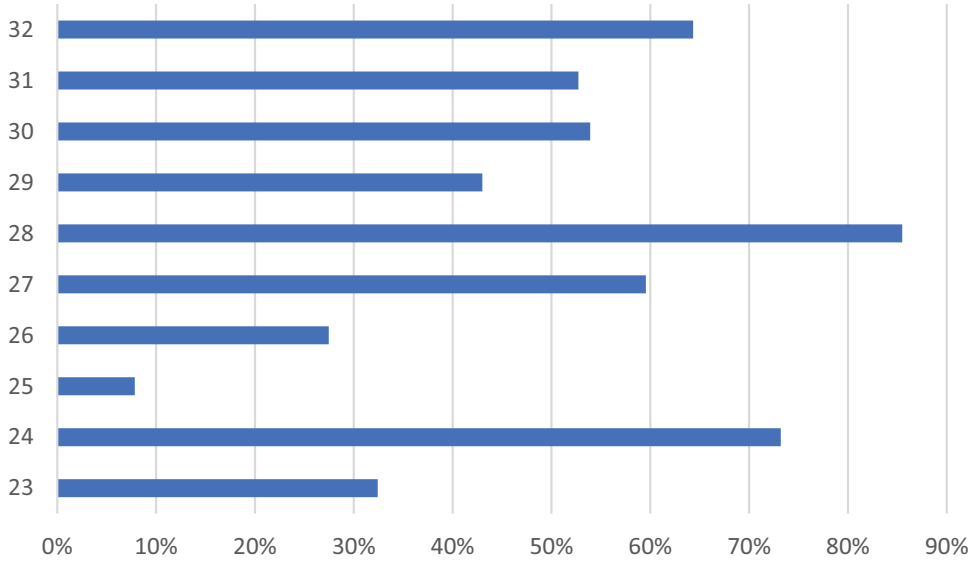



**Figure 10. Selection of five images from ten presented of construction works considered to be designed by an architect.**

Horizontal X-axis: percentage of responses. Vertical Y-axis: image number.

subgroups, highlighting how significantly education influences perception. Similarly, participants from smaller settlements were most likely to select image 25 ($\chi 2(2) = 13{,}202$, $p = .001$, $V = .150$), suggesting that the level of urbanization influenced the selections.

Image 26, which represents the Torre de Collserola by the architect Norman Foster and the engineer Julio Martínez Calzón, was selected as a purely architectural design by all the respondents without formal education, in clear contrast with the lower selection rate among the other groups. As for image 27, a sculpture by the Japanese artist Mariko Mori in which AR2V Engineering carried out the structural analysis, a greater selection was registered in those surveyed with a higher level of education, with a majority selection among participants educated to master's level. This corroborates how design is associated with architecture. Likewise, the frequency in attendance of cultural venues determines some significant differences for this image ($\chi 2(4) = 22{,}735$, $p = .000$, $V = .197$), with an increase in the selection among those surveyed with the highest frequency of visits, with the exception of those who visit weekly. Additionally, there is a clear increase in the selection of this image among respondents living in larger settlements ($\chi 2(2) = 19.711$, $p = .000$, $V = .183$). As for image 21, a painting made by Australian aborigines, all the respondents without formal education selected this image, in contrast to the other categories. Finally, regarding an architectural design such as the building in image 22, there is a clear increase in the level of selection with the increase in the respondents' educational attainment.

The multiple differences among subgroups emphasize the importance of education in determining how respondents approach the landscape and particularly to the knowledge of what has already been built, for which a new education is required. It is widely acknowledged that contemporary society is facing, to a greater or lesser extent, the challenges of a new world that is developing rapidly. Often, existing education fails to provide an adequate framework for understanding these changes. Education must adapt and deepen students' knowledge of the interrelation between the technical disciplines and art, providing an overarching interdisciplinary narrative, avoiding overcategorization, and promoting relevant concepts to clarify the relationship between engineering and the built environment.

Regarding the differences depending on the professional sector, in the case of image 26, a broader selection was recorded among the groups most directly associated with the construction sector, such as civil engineers and architects. On the other hand, the image 27, a smaller selection was registered among respondents without training, which corroborates the aforementioned

results, and was selected almost unanimously by civil engineers. Image 28 was chosen by a large majority of those surveyed, although the proportion was higher in the case of architects, which may reflect pre-existing knowledge in the profession.

It is worth noting how two properly artistic works, in which an architect had not participated, were frequently selected. Regarding Image 30, there was a contrast between the selection among professionals associated with construction and the others (not related to the construction sector), the latter being the ones that most selected this image as an architectural design, while in the first group, the level of selection was low. Moreover, among participants living in smaller residential contexts, a greater selection of this image was recorded. Finally, regarding image 31, there was a much lower selection in the case of civil engineers compared to the other professionals and in particular with the architects, among whom the selection of this image indicates a strong preference.

These results suggest a need to go beyond the group interests of each profession and focus on delivering cultural values, values of purity and technical quality that can be translated into constructions of the highest cleanliness, expressiveness, and harmony, values that should be common to the architect and the engineer. In this sense, would it not be possible to re-integrate both academic disciplines into a single profession, characterized by professionals who, enriched by all kinds of cultural and scientific values, would have a more comprehensive vision of reality and could contribute decisively to the construction of a more complete and harmonious landscape? (Arenas, 1999). It is hoped that the answer to this question can generate a change in perspective regarding the aesthetic qualities of construction works.

### *3.3. Perception on the relation between aesthetics and design of civil engineering work*

Another question explored aesthetics in engineering work. From a list of pedestrian walkways (Figure 11), participants were asked to select the four images that they liked the most. An architect or an artist was responsible for the design of the following works: 34, 37, 38, 39. An engineer designed the following works: 33, 35, 36, 40. Works 34, 36 and 39 were selected as the most aesthetic bridges by critics (Made for Walking: The World's Most Aesthetic Footbridges, 2017).

The results show that there is no generic differentiation between the works of architects/artists and engineers (Figure 12). In fact, the two most selected images, 33 and 40, represent works designed by engineers. Conversely, the least known work, image 39, was developed by an architect.

When looking at the answers by the sample groups, the results show that age determined multiple significant differences in participants' selections images: 33 ($\chi 2(4) = 14.808$, $p = .005$, $V = .159$), 34 ($\chi 2(4) = 12.545$, $p = .014$, $V = .149$), 36 ($\chi 2(4) = 12.743$, $p = .013$, $V = .1147$), 37 ($\chi 2(4) = 19.698$, $p = .001$, $V = .183$), and 38 ($\chi 2(4) = 11.070$, $p = .026$, $V = .137$). In the case of image 33, increasing selection corresponded to increasing age, except for the group of 26 to 45 years. Image 34 was favored by the youngest group of respondents, with a reduction in preference as age increased. Similarly, in another work in which a design artist has participated, namely image 37, there was a tendency for the selection to decrease with an increase in age. Overall, this image was selected by 82% of those surveyed.

Regarding the level of education, there were not many differences in the responses. However, when looking at the professional sector, a number of differences were found to be significant for images 33 ($\chi 2(5) = 17.516$, $p = .004$, $V = .173$), 34 ($\chi 2(5) = 19.227$, $p = .002$, $V = .181$), 35 ($\chi 2(5) = 24.744$, $p = .000$, $V = .205$), 37 ($\chi 2(5) = 20.911$, $p = .001$, $V = .189$), 38 ($\chi 2(5) = 13.412$, $p = .020$, $V = .151$) and 40 ($\chi 2(5) = 18.955$, $p = .002$, $V = .180$). Image 33, a work designed by engineer Javier Manterola, was preferred by a majority in all groups, although the highest selection was recorded among those educated in Civil Engineering and Humanities, with a lower selection by those who studied Architecture. Conversely, image 34, a pedestrian bridge designed by the architect Michele

**Figure 11. Images of pedestrian walkways presented for the selection of those preferred by the participants.**


De Lucchi, was chosen by civil engineers the least, while it achieved a selection rate close to 50% in the other categories.

Differences among group responses may be explained by the fact that engineers tend to avoid over-decoration and oversizing, which would conflict with the ethical principles of engineers, due to the subsequently added costs, often associated with free forms. Engineering has historically been linked to the tyranny of structural typologies, which has undoubtedly led to the simplification of engineering works. However, some theories have tried to overcome these self-imposed limitations with concepts such as significant form (Martínez Calzón, 2008) or structural truth (Billington, 1983), which advocated avoiding over-decoration and mastering techniques to reveal formal essences and transcend the tyranny of traditional typologies. A previous example and a reference was provided by Torroja (Torroja, 2010), who, by following his intuition, greatly liberated forms even without technology. On the other hand, in the field of engineering, geometric relevance is unquestionably significant, with few existing examples of approaches to freer forms, which may explain the selections made by civil engineers.

Engineers cannot transfer the aesthetic problem to architects. Moving away from the domain, from the deep meaning of buildings, not only destroys the environment but can make people sick and contribute to the hatred of technology (Schlaich, 1991). This is because we do not like standardization, buildings like boxes next to each other (Figure 13), and motorway overpasses

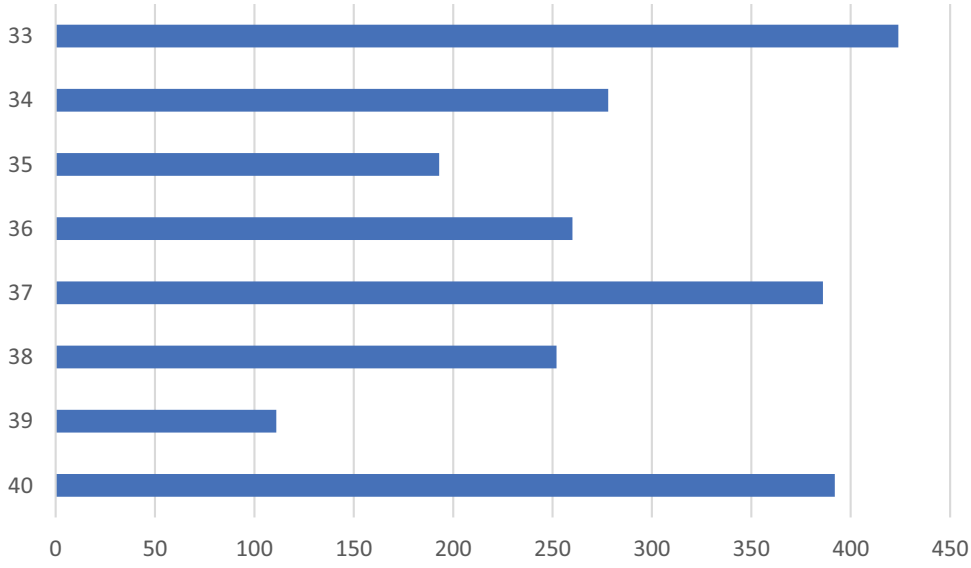



**Figure 12. Frequency in the selection of four images from eight presented of pedestrian walkways, indicating participants' preferences.**

Horizontal X-axis: number of responses. Vertical Y-axis: image number.

**Figure 13. City of Tokyo, Japan. An example of how the building-bridge complex, in its chromatic monotony and solutions, subverts the premise of satisfying what people want: functionality and beauty.**

one behind the other. Our brain reacts measurably to what surrounds us making us more or less happy (Sagmeister & Walsh, 2018). Increasing evidence from investigations suggests how the built environment affects our well-being; the neuroscience of architecture is well-positioned to study the biology of architectural beauty to improve human experience and well-being by optimizing built structures that surround us for much of our lives (Coburn et al., 2017).

Our earliest tools were cut symmetrically in the manner of perhaps a drop of water, a pattern of nature becoming part of our biology because it helped our ancestors to survive. Like fractal patterns, the symmetry in nature so common in nature is extremely familiar to our brains and humans seem to have developed the concept today it goes further, developing an instinct for beauty that nevertheless has a common denominator according to several research studies (Bies et al., 2016; Spehar et al., 2016): the choice of works that have been planned for example according to fractal patterns. Nowadays we do not have to survive nature, we have left the natural world and created our own, we have been expanding and forming a reality of our own making, that society often associates with a lack of beauty. The beauty of engineering is obligatory because it is a social value.

The different approaches to design are clear from the engineer-designed structure shown in image 35, which was most selected by the participants close to the sector of civil engineering, with values close to 50%, in contrast with the other groups. In terms of characteristics, this construction

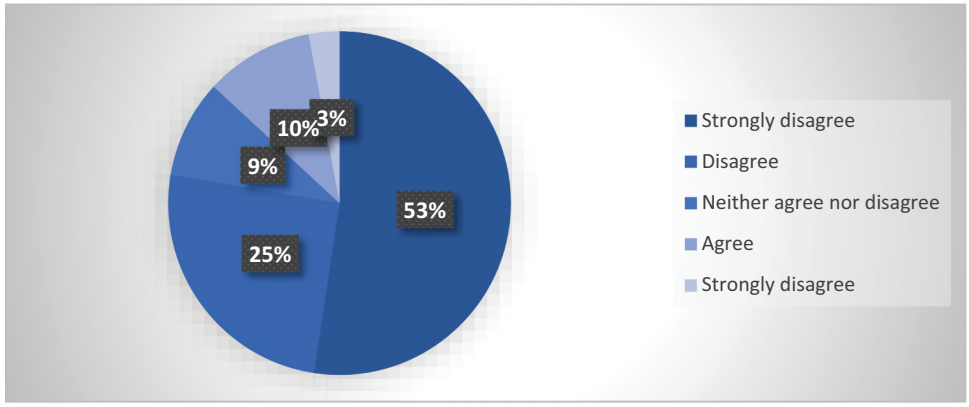



**Figure 14. Level of agreement with the expression "engineers are not expected to have creativity, since that is the role of architects".**

contrasts the walkway designed by an artist represented in image 37, selected by a few civil engineers, in contrast to other professional groups. It is, therefore, crucial that the potential of the twenty-first century is not hidden under adornments, and that art direction is not excessively dominated by contemporary artists or architects; scientists and engineers have their own vision, but they lack the conviction to follow it [20].

Another example in which the intellectuality of the engineer is linked to knowledge level is image 38, a walkway that was not designed by an engineer. This image received more attention from the participants without formal education, in contrast with the other categories. Finally, for image 40, a work by the engineer Javier Manterola, although most participants from all the groups selected this image (over 60%), the selection among engineers was the highest (82%).

The results demonstrate that there is no unique preference for designs created by architects, artists, or engineers, demonstrating the fragility of the line which divides the disciplines, and suggesting that collaboration is the most fruitful path. It is important to recognize that the finished object does not emerge from a sealed box, such that the artist or the architect delivers an idea or a design that is then simply materialized in the engineering phase. Nonetheless, prioritizing multidisciplinary teams requires collaborative decision-making, which is also influenced by aesthetic questions.

In a more direct approach, a survey question asked if the participants agreed with the idea that engineers are not expected to have creativity since that is the role of architects (Figure 14). This limited view of the role of engineers was rejected by more than two-thirds of the participants. Nonetheless, this opinion was less acceptable for participants who were not directly related to the construction sector ($U = 35110$, $p = 0.011$), along with the youngest age group ($H(4) = 13.773$, $p = .008$), the population with less education, and the architects ($H(5) = 27.555$, $p = 0$). The answers to this question had major similarities with a previous one regarding the design of an aesthetically valuable bridge.

### *3.4. Perception of civil constructions as works of art*

Bearing in mind that the main objective of this work is to analyze the social perception of civil engineering works in relation to art, in another section of the survey, another series of questions were posed: *Do you have the same experience looking at a bridge as looking at a painting? Does engineering takes good care of design and aesthetics? Is there creativity in engineering works? Is there art that is not collectable?* Respondents were asked to express their level of agreement using the Likert scale ranging from less to more.

The results show (Figure 15) that most of the participants agree with the notion that engineering takes care of design and aesthetics, uses creativity and that art may exist beyond collections. As for the experience provided by a bridge in comparison to a painting, opinions were quite diverse.

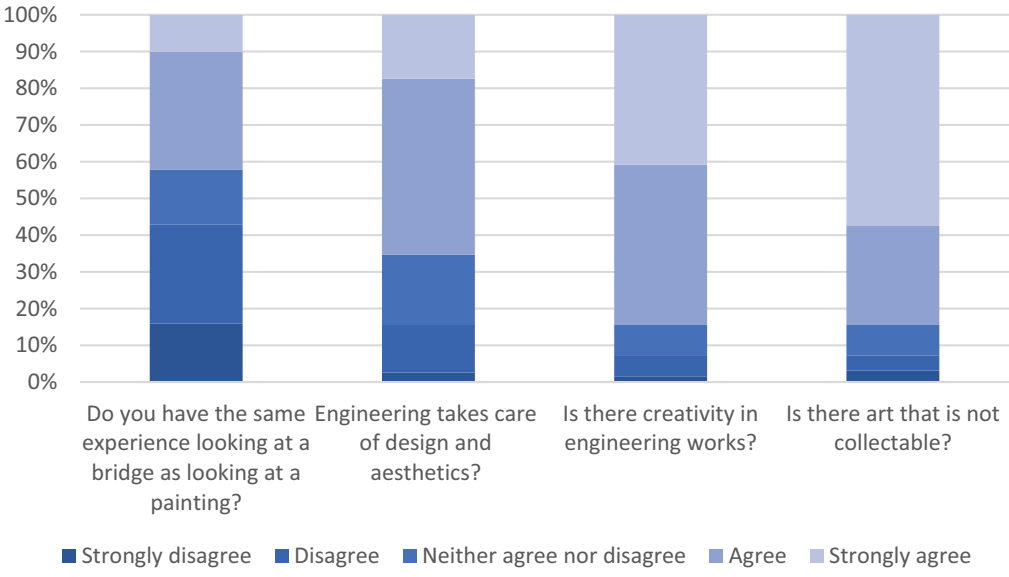



**Figure 15. Level of agreement with the statements on civil construction as a work of art.**

Horizontal X-axis: questionnaire question. Vertical Y-axis: percentage of responses.

Engineering work can be considered a work of art because people should have the same experience contemplating a bridge as a painting, especially those trained in the humanities, perhaps because of their particular awareness that art is a product of experience (Dewey, 1980). In other words, the work of engineering can be considered an artistic work as it is related to creativity, formal concern, and aesthetics, and can even be equated with artifacts traditionally considered works of art, such as paintings. This is especially true for those with a humanistic background, perhaps because of a less normative and restricted conception of the artistic. Accordingly, it should be noted that architects ($H(5) = 16.674$, $p = .046$) agreed least with the aforementioned similarity, and civil engineers and participants with education within the fields of humanities agreed the most with the equivalence between an engineering work and a work of art ($H(5) = 55.905$, $p = 0$). Additionally, this convergence is more recognized by women ($H(5) = 7.697$, $p = .021$). As mentioned above, the view of engineering works as art, in terms of the experience when looking at a bridge ($H(2) = 8.449$, $p = .015$), creativity ($H(2) = 21.288$, $p = .000$), or because there is the art that is not collectible ($H(2) = 11.407$, $p = .003$) was not as acceptable for participants from smaller settlements as it was for those living in larger cities. Conversely, these same assumptions are highly acceptable among those who attend artistic and cultural venues and equally so for those educated in the humanities. Additionally, civil engineers themselves agree that engineering works take account of design and aesthetics ($H(5) = 14.402$, $p = .013$), and as a result, of creativity ($H(5) = 22.442$, $p = .000$). Respondents from Portugal demonstrated a lower agreement with the statement that engineering work is a work of art, as shown by the significant differences in all the questions; in terms of experience looking at engineering work ($H(2) = 14.402$, $p = .013$), creativity in engineering work ($H(2) = 9.032$, $p = 0.011$), and art not being only collectible work ($H(2) = 41.137$, $p = .000$).

We must emphasize the need to make the aesthetic language of the engineering work about the experience more accessible to all actors in the sense of transversality. Newly developed theories in neuroscience, for example, have allowed us to improve and deepen our knowledge of human experience in the built environment; so interdisciplinary studies investigating developing and emerging concepts must be established (Karakas & Yildiz, 2020). That is to say, to open its aesthetic critique to not only professionals or small communities but to legitimize the collective's judgment to enrich the experience concept. It is necessary people are better educated about the importance and value of engineering in daily life, not just ensuring safety but also giving aesthetic experience and pleasure, closely related to beauty (Brielmann & Pelli, 2019), to ordinary people.

Considering yet another visual element, the participants were asked to express their level of agreement with the consideration that a particular bridge could be understood as a work of art (Figure 16).

The results are consistent with those of previous questions and show that around three-quarters of the participants agree with the notion that this particularly noteworthy bridge should be considered a work of art (Figure 17). Beyond this consensus, civil engineers, and architects, followed by those with a background in the humanities, most strongly advocated for the recognition of the bridge as art, with a lower recognition registered among the other groups. Participants found higher agreement among the more educated ($H(5) = 55.9$, $p = .0$), those who traveled more ($H(4) = 9.788$, $p = .041$) and those lived in large cities ($H(2) = 12.918$, $p = 0$).

Trying to understand the potential role of civil engineering, participants were also asked to express if they felt that this professional activity should be considered closer to a form of art than it is to a form of science (Figure 18).

Results show that about a third of the participants disagree with the idea that art dominates science in engineering work. When looking at the answers among the different groups, civil engineers felt that engineering is much more about art than science, in contrast to the views of architects' ($H(5) = 18.582$, $p = .002$).

Comparing the participants' perception of two works of art, a bridge and a sculpture (Figure 19), as elicited by a question asking about their aesthetic similarity, the results show that the cultural level

**Figure 16. Golden Gate Bridge (San Francisco, USA), used as a reference for the question: Is this bridge a work of art?**

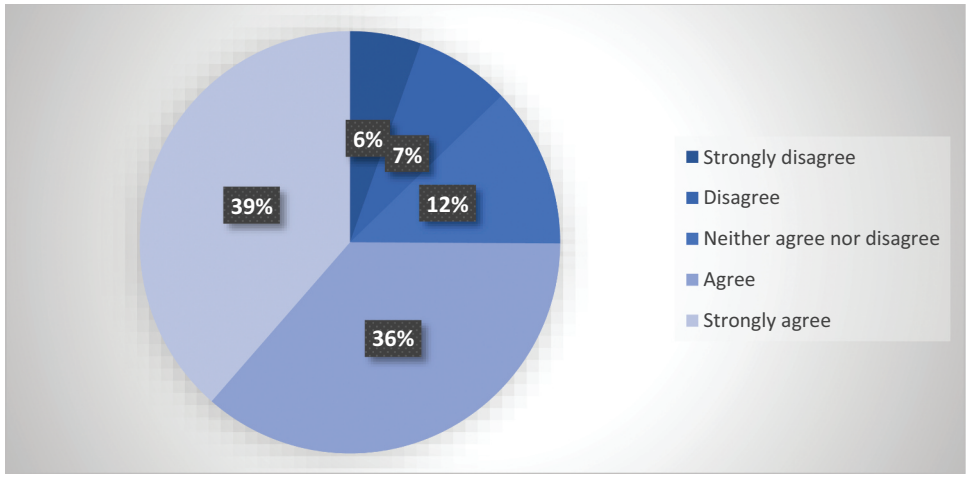



**Figure 17. Level of agreement with the question: "Is this bridge a work of art?".**

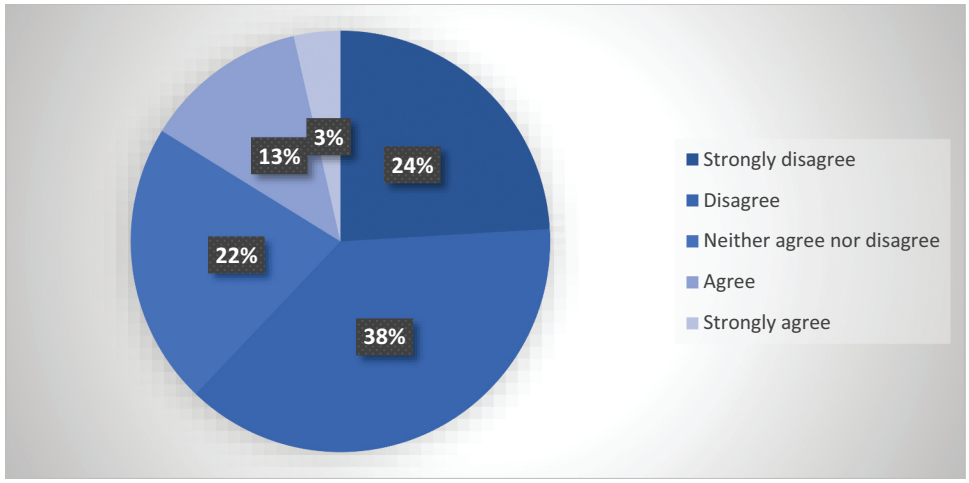



**Figure 18. Level of agreement with the question: "Engineering is more about art than it is about science".**

**Figure 19. Images used to test the equivalence between two works of art, a bridge (Left - Diablo Bridge by Julio Marínez-Calzón) and a sculpture (Right – Monument to Tolerance by Eduardo Chillida "Monumento a la tolerancia"**

Source: http://laesculturaenelsxxyxxi.blogspot.com/).

associated with regular attendance of artistic venues ($H(4) = 10.348$, $p = .035$) meant an increase in considering both works aesthetically similar, thereby approximating engineering to art. Likewise, participants from small settlements expressed more disagreement ($H(2) = 6.219$, $p = 0.045$), thus suggesting that distance from cultural events and access to cultural venues may have influenced participants' answers.

Finally, participants were asked to express their agreement with the notion that, since architecture and cinema are considered arts, engineering should also be considered an art. The results show (Figure 20) that there is a broad consensus among the participants regarding the notion that engineering works should be considered art.

Considering the differences among the groups, the analysis of the results shows that the field of education of the participants influenced the results ($H(5) = 18.390$, $p = .002$), as the participants from humanities tended to agree more with this selection, followed by the engineers, while architects were less favorable to this new form of art. Nonetheless, there is a predominant agreement in all categories. Similarly, female participants ($H(2) = 7.280$, $p = .026$), and Spanish ($H(2) = 6.898$, $p = .032$) also tended to agree more with the mentioned notion, without compromising the general consensus among participants.

These results show that regardless of the different perspectives regarding art in construction works, and regarding the professional roles behind the development of artistic elements in such works, there is a broad perception among participants that engineering works can be elevated to a new form of art. This definitive result indicates that the combined effort of those engaged in materializing engineering works

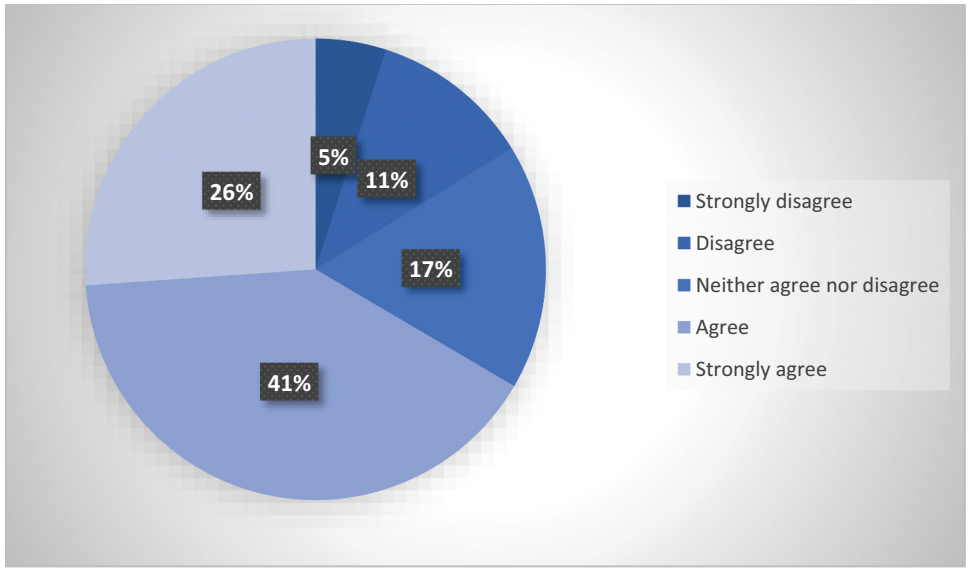



**Figure 20. Level of agreement with the expression "Nowadays, architecture or cinema are considered art. Engineering works should belong to the same group of arts.".**

has already achieved some level of artistic recognition in society, thus reinforcing the notion that engineering work, as a form of art, should be valued in contemporary societies.

The wide range of professional activities within the construction sector emphasizes the need for the New European Bauhaus initiative (European Commission, 2020; Rosado-García et al., 2021), which fosters interdisciplinarity and emphasizes the relational nature and sustainability of construction, architecture, and civil engineering. Contemporary architecture is a field of creativity and aesthetics, while engineering is understood to exist at the interface of technology and science. However, according to those surveyed, engineering is not only a science but rather an expression of the necessary synthesis of art and technology. This supports defining the germ of the rebirth of modern consciousness as interdisciplinarity (Panofsky, 1972).

## 4. Conclusions

This research is one of the first to address the perception of society towards civil engineering in relation to what is considered art, and more so, to address the countries of Spain and Portugal. In this geographical context, participants were exposed to art and to art-related content throughout their lives, such as through formal education, under context-specific circumstances, etc. Therefore, the results from this study should be understood in terms of this limited geographical and cultural context. Despite the size of the sample and its focus on two culturally and historically similar European countries, the results can be used to support certain hypotheses for reflection on the consideration of civil engineering that will have to be validated, qualified, or contested by studies that address other regions.

It should be noted that talking about what is or is not a work of art is only the way to address other more important aspects of engineering, since, as has been explained, in contemporary art, the very definition of art has been expanding beyond traditional aesthetic factors and considerations to the point where everything is considered as art.

As a summary and in response to the hypotheses and objectives raised in the study, the results suggest that society struggles to recognize contemporary art, which continues to be associated with a traditional concept of beauty. Additionally, many recognize their general lack of aesthetic understanding. Art is valued as far as it is considered an intellectual stimulant and receives a more positive evaluation from participants with a higher cultural and educational level, who travel more and live in larger cities. Regarding whether society knows what art is and whether it feels an affinity for it, three out of four respondents found it easier to contemplate a work of engineering than a work of art.

Particularly noteworthy is how architects and those trained in the humanities believed they understood more about art, compared to other professionals, such as civil engineers. Likewise, the Spanish participants expressed a lower understanding of art when compared with the Portuguese.

Most of the participants in this study recognized what civil engineering is and were able to distinguish it from technology. Moreover, they valued it and felt that civil constructions were typically safe and important for their daily lives. However, the role of Civil Engineer is still seen as narrow by many participants, who thought that aesthetically impressive bridges were designed by architects. This opinion was particularly popular among architects, the less educated or those who lived in smaller settlements. The bridge is the work of civil engineering that the participants most emphatically recognized as a work of art, even over some conventional works of art included in the survey. Conversely, the recognition of the participation of engineers in works of art, such as in the construction of large sculptures, is low. Most Spanish participants trust engineering and consider that it meets their demands, but its recognition as a work of art is more common for those with higher cultural levels and even more emphatically for those who live in larger cities.

Regarding differences in education, there is a difference regarding the role of civil engineering and its constructions in the art environment, with a clear positioning of architecture as the standard-bearer of aesthetics. Engineering works can be considered works of art for those with a higher cultural level, and those who live in cities as opposed to rural areas. The foregoing suggests that it is extremely important to make the work of engineers familiar to the population and begin serious consideration of educational improvements from the perspective of humanities rather than the exclusively scientific.

In terms of the perception of the participants regarding the aesthetics and design of civil works, the most frequently selected works were designed by engineers, which suggests that aesthetics and design do not require the intervention of other professionals. Conversely, creativity in engineering is not widely recognized by architects, or by the youngest participants, who emphasized the importance of the contribution of architects.

These results suggest that there is a need for a change in the traditional narrative regarding engineering, particularly when it comes to the young population, and to promote this change to the wider society. Likewise, engineering should be able to provide its own aesthetics, expanding, and complementing, the role of artists or architects; scientists and engineers are aware of this, but they lack the conviction to pursue it. These conclusions are reached after considering the relationships between engineers, artists, and architects, as well as the theory of aesthetics, which together allow the mathematical limitations of engineering to be overcome.

The results of this study support the notion that art, science, and technology are inseparable and cannot be considered isolated areas of human activity. Professional subdivisions that may have been convenient historically, struggle to respond adequately to contemporary demands. Engineers must educate themselves in humanistic principles beyond aesthetics since civil constructions must be considered from all angles to bring them in line with human sensibility. Engineers, architects, and artists should receive uniform humanistic education, since society demands complete professionals, beyond specialization, renewing the Renaissance vision, with extensive knowledge of human factors emphasized, in addition to the requisite technical ones.

It should be noted that not all works of engineering are identically valid in the contemporary context of art, nor equally classifiable as art, but instead should be understood from a contextually sensitive perspective. Many of them have a particularly strong role in ensuring safety. Many great works of engineering, such as the Golden Gate Bridge in San Francisco (USA), belong in this category. Beyond the German sense of caring, found in the German word for construction, emphasized in Heidegger's work, it is a broader sense of protection that such works provide, demonstrating successful manipulation of the landscape to create a new sense of place, which must be deepened and should be the object of a further investigation.

Some engineering works go beyond art because they demonstrate dominance and human superiority over nature's own forms of power and domination. Therefore, in such cases, beauty *per se* should not be excessively prioritized. It is difficult to determine how beautiful a floodgate can be, for example, and this difficulty suggests that further conceptual work in future studies is desirable.

In terms of the renewal of language and its interface with society, a turning point is approaching, where contemporary art, with its different interpretations of the world and different readings of reality, can be examined from the perspective of engineering.

All creation follows a common approach, be it traditional aesthetic forms, such as photography, sculpture, and painting, or works of architecture or engineering. All of them have in common the spectator, with his/her personal lived experience and complex and reactive emotions. At first, there is a most common and universal language, which is visual, and which cannot be considered independently. The starting language for engineering can and should be technology, delivered through the mastery of its environment, from which it is possible to move into new territories. Art, science, and technology are, without a doubt, highly objective disciplines, with little room for the subjective, but once their first and, possibly, the primordial goal has been reached, they can rise above those achievements and search for meta-technical aspects such as: aesthetic and sometimes, why not? Transcendental.

To elevate civil engineering works beyond their traditional settings, it is paramount to guarantee an interdisciplinary, experimental, and participatory education in architecture, engineering, art, design, and humanities. Moreover, the language employed in this educational setting should be accessible, reaching, in its interdisciplinary, all relevant, while remaining to criticism, not only from professionals or small communities, legitimizing a collective judgment that enriches the concept of engineering. These results suggest that clarity, harmony, and functional integrity are the standards recognized by engineering and should become the criteria for all construction. Engineering should produce its own aesthetic, and which can be reflected on a social level, as well as being recognized internally.

The primary motivation of this study is to generate debate in research work in engineering and thereby foreground the voice of engineers. So, it is intended to move beyond the merely technical aspects of engineering, providing the discipline with a broader conceptual remit, just as other disciplines, such as architecture have done. Future work should aim to further affirm that aesthetics is a constitutive part of the functionality of engineering works, insofar as they are valued by society. It is also crucial to demonstrate the change in the perception of the cultural value of engineering works, given their aesthetic qualities, both as individual monuments and as a part of the landscape, ensuring they are considered cultural artifacts.

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**Author details**
Maria Jesus Rosado-Garcia[1]
E-mail: mariajesus.rosado@upm.es
ORCID ID: http://orcid.org/0000-0003-3524-6011
Maria Jesus Garcia-Garcia[1]
ORCID ID: http://orcid.org/0000-0002-1213-6963
Artur Gonçalves[2,3]
ORCID ID: http://orcid.org/0000-0002-4825-6692
[1] Department of Forest and Environmental Engineering and Management, Universidad Politécnica de Madrid, Madrid, Spain.
[2] Centro de Investigação de Montanha (CIMO), Instituto Politecnico de Braganca Escola Superior Agraria, Bragança, Portugal.
[3] Laboratório Associado Para a Sustentabilidade E Tecnologia Em Regiões de Montanha (SusTec), Instituto Politecnico de Braganca Escola Superior Agraria, Bragança, Portugal.

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