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Integrating Art and Engineering: What do faculty think?

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Integrating engineering and art: What do faculty perceive?

Abstract

STEAM Education is a framework for the disciplinary integration between science, technology, engineering, arts, and mathematics. In practice, it is possible to consider this integrative framework as cross-disciplinary, multidisciplinary, interdisciplinary, or transdisciplinary dependent upon the educational objectives. On the one hand, schools may consider that STEAM education leads to students' innovative thinking and contributing to society's workforce development goals. On the other hand, STEAM education can be focused on creativity, self-expression, and empathy, which can lead to self-realization and fulfillment. Currently, K-12 settings are the primary users of this framework, shaping the curricular activities, exploring new ways to integrate these five disciplines, and researching the content, pedagogy, and assessment related to this field. However, at undergraduate or graduate levels, this framework has been little explored. This research seeks to understand faculty members' perception as a factor that may prevent the extensive use of STEAM education by undergraduate and graduate engineering education levels. In that sense, this pilot study focused on exploring how two of the STEAM areas, engineering and art, faculty members from a Large Midwestern University perceive engineering, art, and their integration. This study used Moscovici's and Abric's Social Representation theory, looking for the core and peripheric attitudes and information that faculty participants have regarding the integration of engineering and arts. In total, seven faculty members, three from the College of Engineering and four from the College of Liberal Arts, were interviewed as a way to "enter into the other person's perspective"[1, p. 426], making visible the components of their social representation in the form of feelings, intentions, memories, meanings, or ideas. Data were analyzed using thematic analysis and discussed from the perspective of the social representations.

Introduction

According to the Every Student Succeeds Act (ESSA), section 4107 3-c-vi, STEAM education is one of the "activities to support well-rounded educational opportunities." Also, these activities integrate "other academic subjects, including the arts, into STEM subject programs to increase participation in STEM subjects, improve the attainment of skills related to STEM subjects, and promote well-rounded education" [2]. ESSA focuses on creating K-12 activities, programs, and opportunities that integrate arts to motivate secondary students in pursuing a STEM field occupation to foster innovation and economic development through these future professionals. Later, in 2018, the Federal Government amended the Perkins Act, expanding ESSA's scope to postsecondary students (college and university) to improve the recruitment, preparation, retention, and training of STEM professionals, including art-related strategies, focused on "the academic knowledge and technical and employability skills" [3].

This scope has brought the opportunity to explore meaningful ways to teach STEM areas. In K-12 settings, Science, Technology, Engineering, Art, and Mathematics (STEAM) education has been the framework that teachers and researchers use to talk about the pedagogical praxis and research related to this integration [4]. According to Perignat and Katz-Buonincontro [5], STEAM education has four levels of integration (Cross-disciplinary, Multidisciplinary, Interdisciplinary, and Transdisciplinary), depending on the intention of the practitioners and researchers and the conception of the "A" in STEAM. However, this framework seems not been extensively used or researched in postsecondary engineering settings with some notable exemptions, such as the study done by Sochacka, Guyotte, and Walther [6]. One possible explanation of this lack of information could be related to the perception about the integration of engineering and art by the faculty members of each field, the integration practices have not been documented, or they conceive or created another framework that guides this integration. To the Committee on Integrating Higher Education in the Arts, Humanities, Sciences, Engineering, and Medicine [7], different approaches to the integration “can lead to different levels of integration" (p.173). This statement suggests that it is essential to understand how the integration is conceived to identify possible future paths in the curricular design and implementation.

At the higher education level, faculty members are an essential stakeholder to adopt innovative pedagogical frameworks. In that sense, their perceptions and prior experiences could frame the potential future initiatives that foster a more integrated education. In that order of ideas, a study that involves understanding faculty members from the five STEAM areas would be an essential start for holistic education. As a pilot for a more extensive research that will include the other fields, this study explored the faculty members' perceptions about engineering, art, and their integration in a Large Midwestern University through the lenses of social cognition. For that, this research sought to learn in practice the scope of the Social Representations Theory as a framework to understand the common sense that a small group of people has about a topic, without generalizing, and as an alternative to analyzing qualitative data.

Social Representations

In social psychology, groups construct systems of values, ideas, metaphors, beliefs, and practices to understand the world, establish social order, orient participants, and enable communication inside and outside them [8]. These systems, also called Social Representations (SR), constitute the symbols of common sense [9] and are embodied in the form of attitudes and information, creating a field of representation that a specific group shares about a social object. This object could be material (things and beings) or immaterial (ideas, thoughts, concepts, etc.), meaning that the SR also involves the external and internal realities. According to Moscovici [9], in SR, *attitudes* are the actions and intentions to action that are manifested concerning a common topic. They are usually represented in the form of values, emotions, and behavioral reactions. *Information* is the level of knowledge that a group has about the social object. The *field of representation* is the model constructed socially about a punctual element of the social object. This framework has been helpful to research the representations about the health and disease, external debt, values transmitted by the massive media, women's role in society, feminism, moral conduct, the conception of body, or the students' body seen by their teachers, among others [10].

Nevertheless, the three elements of the SR are organized in a structure that changes through time because of periods of crisis related to the individual and group reflection, dialogue between groups, and different life experiences. For Abric [11], this structure has a stable core and a flexible periphery. The *core* is compact and creates a rigid and complex field of representation that gives a group a consolidated understanding of a phenomenon through the previously constructed values, emotions, and reactions. One example could be the non-negotiable values that a population has towards a difficult topic, such as abortion. On the other hand, the *periphery* is the interaction space where the SR of one group communicates with the SR of another group about the same object. Going back to the previous example, the periphery would the group of flexible attitudes and information that help the group to concrete, regulate, or defend the non-negotiable values from values of a different group. In that sense, this periphery is flexible, simple, and detailed to help the SR interact with others. To Abric, SR and Social Perceptions (SP) are used interchangeably to represent the same concept, being a term usually used by different institutions to construct scientific and technological policies based on the public perception of a country.

Due to the high applicability of this theory in the construction of common sense, not a generalization, around a specific object, the SR will be used in the following study to understand how faculty members of two different colleges structure their perception about engineering and art.

Methodology

This exploratory qualitative study tries to understand how engineering and art faculty members perceive engineering, art, and their integration in a large Midwestern University. One-on-one interviews were conducted with art and engineering faculty members, following a semi-structured interview approach, which has a primary goal to uncover and interpret the meanings people constructed to "make sense of their lives and their worlds" [12].

Participants and data collection

After the IRB approval, purposeful sampling was done with the advice of an expert researcher. As part of the process, faculty members from the Colleges of Engineering and Liberal Arts were contacted to explore their willingness to participate in the research. For Engineering faculty members, it was decided to reach one from each of the four branches of engineering disciplines (chemical engineering, mechanical engineering, electrical and computer engineering, and civil engineering) who have an appointment in two or more departments or exclusively in interdisciplinary fields. There were contacted fifteen engineering professors by email invitation, and three of them responded to the call from the areas of chemical engineering, electrical and computer engineering, and civil engineering. After two additional rounds of invitations to mechanical engineering professors, none of them responded. The expert researcher also suggested contacting a group of faculty members known for their work in different art disciplines for art-related professors. Four of nine professors answered the call from art education, dance, interior design, and theater technical direction. Table 1 summarizes the participants' characteristics.

Table 1. Participants characteristics

Participant	College	Concentration
Prof. B.-E	College of Engineering	Professor of Chemical Engineering and Professor of Chemistry, by courtesy. Emphasis on polymer science and polymer chemistry and biophysics.
Prof. G.-E	College of Engineering	Professor of Electrical and Computer Engineering. Emphasis on computational electromagnetism.
Prof. N.-E	College of Engineering	Professor of Civil Engineering. Environmental Engineering, Civil Engineering, and Chemistry. Emphasis on sustainability.
Prof. D.-LA	College of Liberal Arts	Professor of Technical Direction. Professor of Practice. Emphasis on theater technical direction.

Prof. J.-LA	College of Liberal Arts	Professor of Dance. Emphasis on contact dance improvisation.
Prof. S.-LA	College of Liberal Arts	Professor of Art and Design. Professor of Art Education.
Prof. Y.-LA	College of Liberal Arts	Professor of Interior Design.

Data collection consisted of semi-structured interviews, which helped to understand better the context where the answers came from and tailor "follow-up questions within and across interviews" [10, p. 154] according to the participants' response. The questions were structured according to one element of the correspondence analysis of SR related to selecting a series of words-stimuli that allude to the social object to be researched [10]. In that sense, *art*, *engineering*, and *integration between art and engineering* were selected as the words-stimuli to design the interview. Each interview was scheduled according to the participants' time, following the health recommendations for researching during the COVID-19 pandemic. In that sense, all the interviews were made and recorded with their authorization via Zoom. The interviews followed, but were not restricted to, the subsequent questions: How do you define engineering? How do you define art? What similarities and differences do you see between engineering and the arts? How do you conceive their integration? Other questions emerged during the interview, deepening and clarifying some topics. Approximately every interview lasted 30 minutes which were transcribed manually, including filler words and the segments that introduced and closed the conversations.

Data analysis

This research focuses on exploring engineering and art faculty members' perception of engineering, arts, and their integration as a pilot to understand why the STEAM education framework is not commonly used in university settings. To analyze the data, the correspondence analysis asks for establishing the similarity between the diverse semantic fields [10] that each participant constructed during the interview as part of their answers. These similarities could help to represent the findings and the overlap or independence grade between the results depending on the clumping graphic zone graphically. In that sense, the data collected was analyzed following Abric’s structure (core and periphery), assuming the core as the clumping zone where the similarities between the responses overlap and the periphery as a space where there is less grade overlapping. To identify the similarities, a typological analysis was done [14], identifying the typologies *engineering perception*, *art perception*, and *engineering and art integration perception* to analyze the information obtained from interviews. As this kind of analysis proposes, after the topologies' identification, data were read, searching and highlighting the information related to each of these typologies. A summary per participant was then written, recording each entry by typology on a big piece of paper which was cut into fragments for searching "patterns, relationships, or themes within typologies" (p. 153).

The fragments were pasted on three paper sheets, two for the perceptions of art and engineering and another for the integration's perception, and, later, the entries were coded according to the themes identified. It was decided to search for similarities in the entries seeking the themes where apply the proposed theoretical framework by structuring the core and peripheral perceptions. In that sense, it was considered that the most mentioned similarities between participants' perceptions were the core of each typology, and those entries mentioned less as the periphery. This step allowed finding the relationships within the patterns, writing those patterns as a one-sentence generalization, and selecting the data that support the inferences. Tables 2 and 3 summarize the coding process, showing the typology, themes, and examples that support them for the core and periphery of perception.

Table 2. Perceptions' core for the integration of art and engineering according to the participants

Typology	Theme	Example
Perception of Art	Art "delivers" a message.	"art is an expression of ideas, feelings, questions, responses to the human conditions" (Prof. S.-LA)
	Art is a personal experience.	"I think that you can explore being a human, being doctor, but we (artists) explore ways of being human in sort of more felt, felt ways, and using an internal guide of what we are valuing that is not always something that is valued by all society" (Prof. J.-LA)

	Art is knowledge in practice.	"it's in some form of media, whatever media that may be, is trying to bring, I guess, distill the essence of human experiences into a song or a dress or into painting or something like that. But to still capture what humanity is feeling, and put it into something that will last in some media for a long time" (Prof. B.-E)
Perception of Engineering	Engineering solves problems	"It depends on if you want to think more broadly, in terms of an engineer, if you want to think more their traditional disciplines, but, you know, that's kind of in the eye of the beholder. To me, it is anything and everything kind of counts as long as you're adopting that problem-solving mentality with nor necessarily a hypothesis-based approach, but some rigorous- based approach towards problem-solving" (Prof. B.-E)
	Engineering is a doctrine.	"el estudiante también esta siendo adoctrinado a la ingeniería, entonces el estudiante tiene que aprender el lenguaje de los ingenieros" [the student is also been indoctrinated to Engineering, so the student should learn engineers' language] (Prof. G.-E)*
	There are many ways to be an engineer.	"anyone could potentially do engineering. There's no difference between practicing in the engineering activity or an engineering exercise and being a credentialed engineer. So, that part is clear. I mean, we have professional societies, and we have degrees, and we have credentials, and we can get a license, but the actual applying of scientific principles to solve problems and improve society, anyone can do that, a child can do that" (Prof. N.-E)
	Engineering education: More than "intellectual" skills	"It's probably only about 20%, the deep technical knowledge, and the rest is kind of being able to make it happen" (Prof. B.-E)
Perception of the integration	What for?	"higher-order skills, I think, is one of those areas of connectivity because successful engineer and successful artists have to employ critical thinking, they have to identify problems or re-identify problems and questions, they have to be open-minded to solutions, they have to consider possibilities" (Prof. S.-LA)

	How to do it?	"integration of arts and engineering is in this thing called design" (Prof. Y.-LA)
	Limitations and difficulties	"when you have established programs, are established thoughts and methods, and they start blending, then there's usually some resistance in losing that identity" (Prof. Y.-LA)

*Note: I asked Prof. G.-E to interview him in Spanish if he desired. In that sense, each fragment used for this research is in the original language followed by my translation.

Table 3. Perceptions' periphery for the integration of art and engineering according to the participants

Typology	Theme	Example
Perception of Art	Artists are the only ones who do arts.	"From a purely practical standpoint, it makes a lot of sense to consider us [technical directors] to think about our work as less about being the artist who's determining what the set looks like" (Prof. D.-LA)
	Art as handcraft	"Arte no es que solo yo tengo un sentimiento y lo trato de sacar, también tiene una parte de que yo he trabajado en eso, porque viene de artesanal, como los artesanos que son las personas que aprenden una vocación y lo hacen muy bien, y después del tiempo pues se va sistematizando, y el artesano desaparece" [Art is not that only I have a feeling and I try to get it out, it also has a part of the fact that I have worked on it, because it comes from artisanal, like artisans who are people who learn a vocation and do it very well, and after time it is systematized, and the craftsman disappears] (Prof. G.-E)
Perception of Engineering	Engineering as art	"como práctica, yo creo que la ingeniería también es un arte, en el sentido que cuando estamos creando todos estos productos o estamos tratando de crear soluciones, estos son productos de arte en el que nosotros, como artistas, estamos tratando de crear algo que hace cierto objetivo y, con nuestros componentes, estamos creando estas cosas de arte que cran lo que nosotros queremos mostrar al mundo […] Como práctica, yo creo que la ingeniería es un arte " [As a

		practice, I believe that engineering is also an art, in the sense that when we are creating all these products or we are trying to create solutions, these are art products in which we, as artists, are trying to create something that does certain objective and, with our components, we are creating these art things that create what we want to show the world […] As a practice, I believe that engineering is an art] (Prof. G.-E)
	Engineering as disciplines	"I also recognize that there are engineers who work on the atom and many scales. Engineers might work out processes for manufacturing, they might build manufacturing equipment, or they might build products, and other things" (Prof. Y.-LA)

Note: Prof. G.-E asked that I interviewed him in Spanish. In that sense, each fragment used for this research is in the original language followed by my translation.

Findings

Three typologies organize this research's results: *Perception of art, perception of engineering*, and *perception of the integration*. The first two typologies focus on the conception of art and engineering, respectively, and the last typology presents the attitudes, information, beliefs, and values that professors expressed about the integration.

Core

For *the perception of art*, I obtained three core themes representing the patterns found during the analysis: *Art "delivers" a message*, *art is a personal experience*, and art is knowledge in practice. In general, the seven participants agreed that art's goal is to communicate and express ideas, feelings, and questions. From the data, Prof. S.-LA's answer about art conception captures the essence of what the other participants stated. To him, art captures and explores the human experience in purely practical ways to "record events historically; represent a culture, time, or place, and provide a physical record of human interactions, problems they deal with, questions or concerns they have not found answers to, and for those with multiple answers, and puzzles they are trying to unravel." In that sense, for them, *art is a personal experience* where artists, in the words of Prof. J.-LA, "explore ways of being human in sort of more felt, felt ways, and using an internal guide of what we [artists] are valuing that is not always something that is valued by all society." At the same time, this idea of exploration recognizes the use of various media and materials for delivering the messages they are going to communicate. Finally, the participants considered *art as knowledge in practice*. As Prof. B.-E stated, "art distill[s] the essence of human experiences into a song, a dress, painting, or something like that. However, to still capture what humanity is feeling, and put it into something that will last in some media for a long time".

For the *perception of engineering*, four themes emerged: *Engineering solves problems*, *Engineering is a doctrine*, *There are many ways to be an engineer*, and *Engineering education: More than "intellectual" skills*. The first theme refers to how participants conceived engineering's goal. In general, they considered that engineering consists of adopting a problem-solving mentality based on hypothesis and rigor. Also, the final objective of engineering relies on "crear situaciones que nos ayudan, como humanos, a enfrentar a la naturaleza o a poder mejorar como especie o nuestra vida" [create situations that help us, as humans, to face nature or to improve as a species or our lives] (Prof. G.-E), building products and understanding how they work (Prof. D.-LA) and constructing physical and technological interphases between humans and the world (Prof. J.-LA), using the right materials (Prof. Y.-LA). Engineering is transmitted as a doctrine related to specific knowledge in science and technology (Prof. S.-LA) through a language that allows effective communication within engineering disciplines and constructing a professional identity (Prof. G.-E). According to Prof. N.-E, this doctrine results from engineering societies and institutional structures that push for "credential needs to do certain work or approve certain work," shaping engineering culture.

The acquisition of engineering knowledge impacts engineering identity and shapes the definition of an engineer. According to the definition of engineering mentioned above, the participants considered that an engineer is a person who can solve problems using scientific and technological knowledge.

However, this definition applies to any other activity, not just engineering. For example, Prof. N.-E manifested that anyone can be engineering because for him:

> there's no difference between practicing in the engineering activity or an engineering exercise and be[ing] a credentialed engineer. I mean, we have professional societies, and we have degrees, and we have credentials, and we can get a license, but the actual applying of scientific principles to solve problems and improve society, anyone can do that, a child can do that.

Following this idea, Prof. J.-LA linked this potential that anyone has to something she called *primary energy and focus*ed on engineering, which is related to how people prioritize what they are thinking about engineering and how they respond to it. To Prof. B.-E, this response to the conception of engineering is related to a public perception of engineering, which according to him, an engineer is a person who wears a squared shirt, belt, pants, white t-shirt, and have pens in the shirt's pocket.

Another approach to defining the engineer is to focus on the kind of knowledge they use. Prof. B.-E proposed two categories: Classic-technical and non-classic. Classic-technical engineers are those who support their practice on mathematical models and theory-based. Non-classic engineers are those who are also interested in size and shape. This perspective is similar to what Prof. D.-LA considered as engineering, making a distinction between theory-based and practice-based engineering:

> There's a lot of tradition and strong feelings about where the boundaries of engineering are, right? So, I don't often claim that 'We do engineering at Theater,' on campus because we're not part of the College of Engineering, and I don't want to get in any of the turf battles about that but, in practice, sure, there's a problem that needs to be solved.

To Prof. N.-E, this distinction is related to the engineering *ego*, alluding that engineers "don't miss the opportunity to claim or insinuate 'I'm an engineer; therefore, I'm smarter or, I'm an engineer, and my ideas are more important.'"

Nevertheless, technical, size, or shape knowledge are not the only essential skills for engineers. In the theme *Engineering education: More than "intellectual" skills*, there were collected the different competencies that engineers could have besides the "intellectual" ones. Within them, critical thinking was the most mentioned by the professors, as a strategy to identify new ways to solve theoretical and mathematical problems (Prof. G.-E) or engineering problems (Prof. B.-E), regarding the impacts of those solutions on society (Prof. S.-LA) or environment (Prof. J.-LA). Also, emotional intelligence was another skill that participants considered necessary for engineers. To Prof. B.-E, this skill consists of learning "read[ing] the room, making sure that everyone in the room is heard "… "not always being the loudest room in the room," and understanding the different perspectives that can shape a team. On his side, Prof. N.-E also considered that engineering involves an affective domain that is constrained during the college stage: "We [professors] tell them first of all, when they are delivering a design or a design alternative to a client, they don't get to use their opinions because that's not appropriate […] it is not healthy to ignore your feelings", something that is related to communication skills, and the recognition of different styles and languages in engineering and other disciplines (Prof. B.-E). Finally, participants considered empathy an essential skill to reach clients' and engineers' desires involved in the problem's solution.

The core emergent themes for the typology *perception of the integration* were *What for? How to do?,* and *Limitations and difficulties*. According to the participants' answers, the integration between art and engineering follows a different approach depending on where it happens. On the one hand, the integration could be a process where engineering supports the artistic practice, solving the problems that art can have in a theater production (Prof. D.-LA) or creating new materials and means (Prof. B.-E; Prof. G.-E). On the other hand, art support engineering in the development of new abilities such as body awareness and empathy (Prof. J.-LA), communication skills (Prof. B.-E), feeling expression and self-awareness of engineering practice (Prof. N.-E), and creativity, motivation, and critical thinking (Prof. S.-LA). The participants also considered design as the place to develop that integration, being a difficult concept to define since it is a noun (object and discipline) and a verb that requires some skills related to solving problems (Prof. Y.-LA). Although I did not ask for a formal definition during the interviews, participants mentioned it as something the engineer does as part of the intersection between art and engineering.

About *how to do* this integration in educational settings, the participants presented a myriad of possibilities. From a practical perspective, Prof. D.-LA considered that entertainment engineering and theater technical direction are disciplinary options for formal integration. However, Prof. Y.-LA suggested that industrial design (product) and interior design (environments) are *per se* disciplines that have integrated art and engineering for a long time, without recognition of this labor, but from a less theoretical approach and a conception of art related to the idea of aesthetics and the human science (anthropology). From an education perspective, Prof. S.-LA proposed implementing the STEAM education framework at university and practitioner levels to foster integration. This proposal was supported by Prof. D.-LA, who offered Project-Based Learning (PBL) as the pedagogical strategy for integration inside the classroom. Prof. J.-LA also considered creating workshops to foster body awareness to improve the design based on the Universal Design (UD) framework. Prof. N.-E recommended specific assignments where the students can express their feelings towards engineering practice through artistic production, mainly poetry. Finally, Prof. B.-E and Prof. G.-E offered the creation of specific projects where engineering supports artistic creation and production.

Despite these possibilities, participants were concerned about the *limitations and difficulties* the integration between art and engineering would have. In a broader perspective, the main problem observed was the controversy of design represented on each field's resistance to lose their identities for one design-based with the excuse that the integration is already done without blurring the lines. For Prof. J.-LA, this resistance is due to art and engineering have different agendas. Engineering focuses on making things work, while design, as a representation of art, ruins the functionality proposed by engineering because of aesthetics. Different disciplines represent art and engineering; however, these different perspectives can contribute to talking about the same thing. From the educational perspective, the limitations and difficulties depending on the level where the integration is sought. At the institutional level, Prof. S.-LA considered that the College of Engineering would not be open to the idea of adding art to the classes (dance, music, or visual arts), which require advocacy and more information to confirm his perspective. Also, this Professor suggested that the implementation of STEAM education at the university stage has the risk of becoming art as the "maiden" of engineering, bastardizing and disrespecting it. At the classroom level, the participants agreed that engineers and engineering students have different predispositions and interests, which do not allow integration (Prof. Y.-LA), impacting the learning goals achievement. Besides, the learning process is individual, not everyone is open to integrate art in engineering or not everyone has questioned before the current world (Prof. J.-LA). Finally, time is a significant restriction in the college stage since professors have an amount of specific engineering-related content and values to teach that sometimes cannot be delivered entirely.

Periphery

For this study, the peripherical themes emerged as those entries which were less common patterns in participants' answers. In that sense, I found two themes for *the perception of art*: *Art is only for the artists* and *art as handcraft*. For the first one, Prof. D.-LA considered art to be only for the artist, creating a clear boundary between art and engineering, primarily with technical theatre direction. For him, "from a purely practical standpoint, it makes a lot of sense to consider us [technical directors] to think about our work as less about being the artist who's determining what the set looks like." In that sense, engineering is a specific discipline that supports performance arts, no more than that. This conception contrasts with the one proposed by Prof. G.-E In the beginning, he made one definition of art, considering it as the result of artisanal work:

> "arte no es que solo yo tengo un sentimiento y lo trato de sacar, también tiene una parte de que yo he trabajado en eso, porque viene de artesanal, como los artesanos que son las personas que aprenden una vocación y lo hacen muy bien, y después del tiempo pues se va sistematizando, y el artesano desaparece" [art is not that only I have a feeling and I try to get it out, it also has a part of the fact that I have worked on it, because it comes from artisanal, like artisans who are people who learn a vocation and do it very well, and after time it is systematized, and the craftsman disappears]

At the same time, this conception of art is linked with the emergent theme, Engineering as art, which is part of the typology *perception of engineering*. In this theme, Prof. G.-E continued framing art as handcraft; however, he extrapolated this definition to the field of engineering:

> "como práctica, yo creo que la ingeniería también es un arte, en el sentido que cuando estamos creando todos estos productos o estamos tratando de crear soluciones, estos son productos de arte en el que nosotros, como artistas, estamos tratando de crear algo que hace cierto objetivo y, con nuestros componentes, estamos creando estas cosas de arte que crean lo que nosotros queremos mostrar al mundo […] Como práctica, yo creo que la ingeniería es un arte " [as a practice, I believe that engineering is also an art, in the sense that when we are creating all these products or we are trying to create solutions, these are art products in which we, as artists, are trying to create something that does certain objective and, with our components, we are creating these art-things that create what we want to show to the world […] As a practice, I believe that engineering is an art].

Finally, the theme *Engineering as disciplines* states that engineering is divided by disciplines, a claim that could be obvious but which only Prof. Y.-LA mentioned, "I also recognize that there are engineers who work on atom and many scales. Engineers might work out processes for manufacturing, they might build manufacturing equipment, or they might build products and other things". Figures 1, 2, and 3 summarizes the core and periphery themes mentioned above for each perception.

Figure 1. Art perception's core and periphery

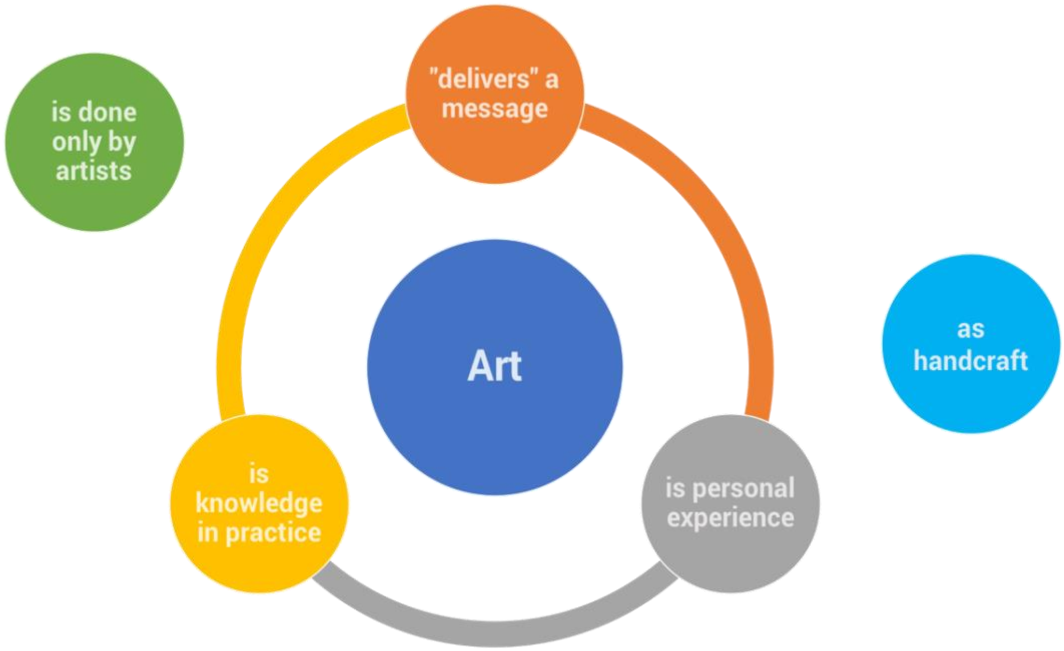


Figure 2. Engineering perception's core and periphery

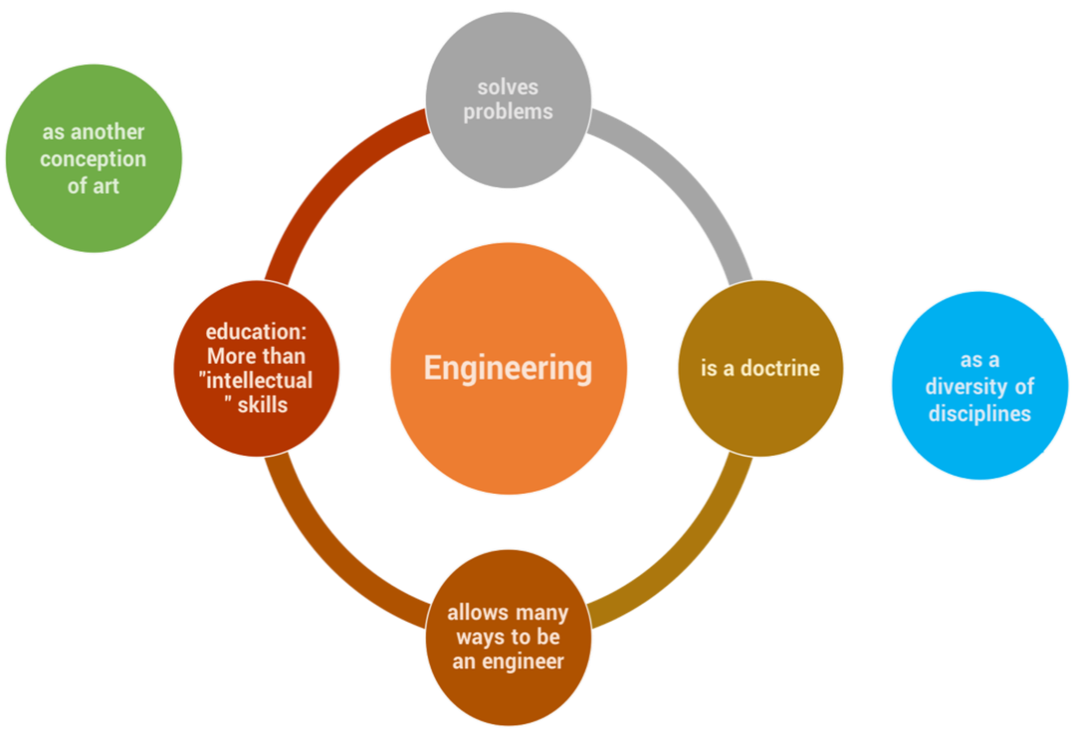
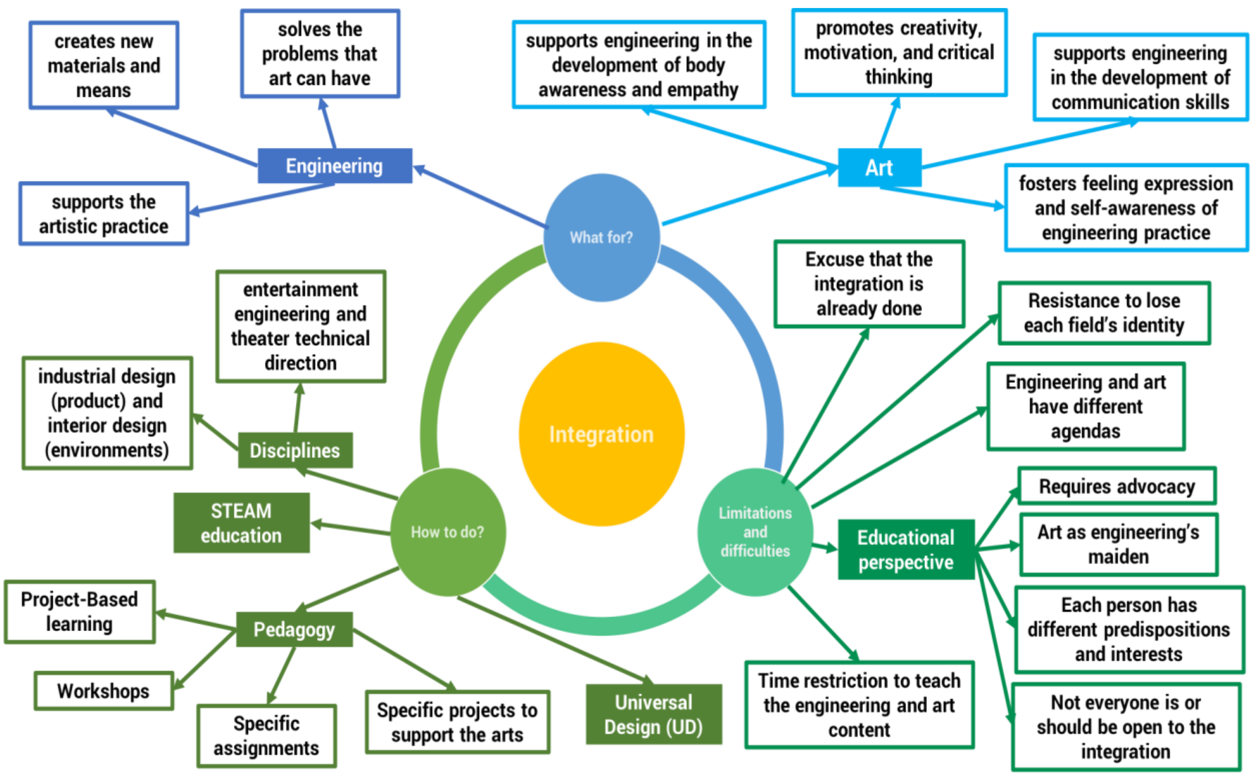


Figure 3. Integration perception's core and periphery



Discussion

This study attempts to understand why the STEAM education framework has not been extensively appropriated or used extensively by undergraduate and graduate engineering education levels. For that, I started exploring the perceptions of art and engineering faculty members from a Large Midwestern University about engineering, art, and their integration as a pilot for a more extensive research that seeks to understand the perception of all the STEAM areas. It was possible to identify that the similarities in the perception of art found in this research follow the three categories of art stated by Perignat and Katz-Buonincontro [5]: Arts Education based on disciplines—mainly visual and performing arts—, Arts as non-STEM disciplines—such as anthropology and design—, and "Art/Arts as a synonym for project-based learning, problem-based learning, technology-based learning, or making" (p. 38). From another perspective, one of the participants compared engineering with art since engineering is a problem-based discipline as art. This perception is consistent with one of the conceptions of liberal art as practical arts based on intellectual activities, such as design and architecture [15].

In general, despite the participants' experiences in art and their diverse definitions, all of them showed positive attitudes towards this area. The participants considered that art is a way to capture and explore the human experience, as stated by Dewey [16], valuing it as an inherent and essential part of humanity as doers (artists) or consumers (spectators) that help to understand, critique, and question the world. On the other hand, the participants related engineering to the idea of problem-solving, applying science and math, and making things (creation of artifacts and technology). These results are similar to the outcomes found by Pawley [17] in her research with engineering faculty members and engineering, where engineering is considered as a corpus of knowledge and competencies that involves the four cognitive processes proposed by Lande and Leifer (design thinking, engineering thinking, production thinking, and future thinking) [18].

As it is possible to observe, these results are consistent with narratives that could be conceived as typical for engineering and art. However, in the case of their integration, there exist different ways to understand this idea. For example, the results have some links with STEAM education practices used in K-12 settings, where, as Liao [19] considers, art is usually oversimplified as the means to motivate and support the engineering education, avoiding the competencies, abilities, and other learnings that students potentially can obtain and construct from it. In that sense, engineering faculty members tend to have a utilitarian perspective of art that has the risk of bastardizing it to a "more relevant" goal related to the STEM areas. In other words, there is an implicit hierarchization of the fields, being art the one ranked at the bottom of the list in comparison to the others, independently the three of the four levels of integration they proposed during the interviews (cross, multi, or interdisciplinary). From this, it is possible to infer that the cause of this kind of perception is a lack of artistic knowledge and practice of engineering faculty members. However, it requires more in-depth research related to the genesis of this perception to support this statement.

By contrast, from the perspective of art education, Karpati [20] suggested that it is possible to have a linguistic integration of the arts (liberal and servile arts/arts, crafts, and architecture), using the word *design* as an intellectual process that links them. In that order of ideas, the findings of this research suggest that the linguistic integration can be extended to an integration of art and engineering, where design is a transverse practice to both fields, resulting from the conception of art as a language with its own signs, principles, and symbols

Conclusions

As a pilot study to understand the causes of the lack of use of the STEAM education framework in higher education, this research collected data related to the conceptions of art and engineering and the perceptions of its integration from the perspective of faculty members from the Colleges of Engineering and Liberal Arts at a Large Midwestern University. Using the Social Representations approach as a way to explore similarities in the participants' perception, it is possible to conclude the following. First, the results suggest that the SR of art and engineering have consistent cores, as the most common themes mentioned by the participants. For art, this core is related to a personal experience and knowledge in practice that delivers a message. For engineering, the core is associated with a doctrine with a set of skills to solve problems, allowing different ways to be an engineer. In the case of their peripheries, they came the less mentioned themes, specifically from engineering faculty. Second, although it was possible to group the data into themes, the integration did not have a consistent core. The responses were different between the participants; thus, it was not possible to obtain a clear structure. However, the two presented integration perspectives presented in the discussion propose different levels, which invites to link the integration with art education knowledge to consider art in equal conditions than engineering, not only its support to teach engineering content or competencies. Third, the responses suggest positive attitudes concerning engineering, art, and their integration.

On the other hand, this research could find clues that propose different ways to integrate art and engineering at college stages. However, it was possible to identify some limitations, such as the need to indagate more about some aspects that were slightly clear during this research. First, it was not evident during the interviews the conception of artist and the characteristics that frame this kind of person, the definition of design, the definitions of talent and art education, in-classroom activities related to the integration between art and engineering, or potential activities integrating the five STEAM areas. Second, this study could not identify the influence of the faculty's previous artistic or engineering experience on the presented perceptions. In that sense, it is recommended to research in-depth the faculty experiences and how they shape their perception about the integration. Third, we recognize there would exist different graphical representations, depending on the users' interpretations, being a restriction to present the data. Finally, we recognize the Social Representations as a worthy frame to analyze future studies related to understanding the common sense (similarities) of specific populations. However, this study only focused on a synchronic and overall description of the perception rather than a diachronic and detailed perspective of the representation, which could put aside some rich and essential information to understand the phenomenon.

References

[1] M. Q. Patton, *Qualitative research and evaluation methods*, 4 th. Sage Publications, 2015.

[2] 114 U.S.C., *Every Student Success Act*. 2015.

[3] 116 U.S.C., *Perkins V Act*. 2019.

[4] J. E. Martinez, *The search for method in STEAM education*. Palgrave Macmillan, 2017.

[5] E. Perignat and J. Katz-Buonincontro, "STEAM in practice and research: An integrative literature review," *Think. Ski. Creat.*, vol. 31, pp. 31–43, Mar. 2019.

[6] N. W. Sochacka *et al.*, "Learning Together: A collaborative autoethnographic exploration of STEAM (STEM + the arts) education.," *J. Eng. Educ.*, vol. 105, no. 1, pp. 15–42, Jan. 2016.

[7] National Academies of Sciences, Engineering, and Medicine, *The Integration of the humanities*

and arts with sciences, engineering, and medicine in higher education: Branches from the same tree. Washington D.C.: The National Academies Press, 2018.

[8] T. Teo, Ed., *Encyclopedia of critical psychology*, Springer R. 2014.

[9] S. Moscovici, *El psicoanálisis, su imagen y su público [Psychoanalysis: Its image and its public]*. 1979.

[10] M. Mora, "La teoría de las representaciones sociales de Serge Moscovici," *Athenea Digit.*, no. 2, pp. 1–25, 2002.

[11] J. Abric, *Prácticas sociales y representaciones [Social practices and representations]*, Ediciones. 2001.

[12] S. B. Merriam and E. J. Tisdell, *Qualitative research. A guide to design and implementation*, 4th ed. Jossey-Bass, 2016.

[13] S. M. Ravitch and N. Carl, Mittenfelner, *Qualitative research. Bridging the conceptual, theoretical, and methodological*. SAGE Publications, Inc., 2016.

[14] J. A. Hatch, "Analyzing qualitative data," in *Doing qualitative research in education settings*, State University of New York Press, 2002, pp. 147–210.

[15] D. Novitz, *The boundaries of art: A philosophical inquiry into the place of art in everyday life*, vol. 52, no. 2. Cybereditions, 2001.

[16] J. Dewey, *Art as experience*, 23rd ed. New York: Wideview/Perigee Book, 1934.

[17] A. L. Pawley, "Universalized narratives: Patterns in how faculty members define 'engineering,'" *J. Eng. Educ.*, vol. 98, no. 4, pp. 309–319, 2009.

[18] M. Lande and L. Leifer, "Incubating engineers, hatching design thinkers: Mechanical engineering students learning design through ambidextrous ways of thinking," in *American Society for Engineering Education*, 2010.

[19] C. Liao, "From interdisciplinary to transdisciplinary: An arts-integrated approach to STEAM education," *Art Educ.*, vol. 69, no. 6, pp. 44–49, Nov. 2016.

[20] A. Karpati, "Art, arts, or culture: An educational dilemma from an Hungarian perspective," *Stud.*

Art Educ., vol. 26, no. 1, p. 14, 1984.