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STEAM Architecture—A STEAM Project for Pre-University Studies to Connect the Curricula with Architectural Concepts

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Abstract: This article presents STEAM Architecture, a STEAM project for all educational levels, from pre-school to high school, a project that links the learning of subjects with architectural concepts, thus trying to generate meaningful learning in students. The project is the result of an ERASMUS+ project (DART4City (2020-1-ES01-KA227-SCH-095545) Empowering Arts and creativity for the cities of tomorrow) in which a methodology was developed to extract STEAM projects from European curricula. This methodology has two variants: "forward" and "backward". The "forward" variant analyzes the curriculum and found the areas of opportunity with more connections among the contents while the "backward" methodology proposes a specific theme to look for the connections. The "backward" variant allows finding a topic that may be of social interest. This is the variant we use in this article. We explore the "backward" methodology in order to find an area of opportunity in society, in particular related to architecture. A questionnaire is distributed to different sectors of people in society to find out whether the learning of different architectural concepts at pre-university levels is interesting. The results of these tests show the potential of a STEAM project related to architecture. The design of the STEAM architecture project shows how the subdivision is carried out from an educational point of view, and also from an architectural point of view. Both worlds agree on dividing space into micro-, meso- and macro-space depending on the scale of what is being treated. For this reason, the STEAM architecture project is subdivided into Room, House, Neighbourhood and City for each educational level: pre-school, primary school and high school (which is 4 years of secondary school (ESO) and the last 2 years of high school). At the end of the article, we show the different workshops that were held in order to analyze the goodness of the proposal.

Keywords: curriculum; project-based learning; STEM; STEAM; opportunity area; architecture

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1. Introduction

STEAM learning is an educational model that pursues the integration and development of scientific–technical and artistic subjects in a single interdisciplinary framework [1]. The acronym emerged in 2008 when Yakman, trying to promote interdisciplinarity, introduced the A of "arts" in another existing acronym that collected the acronym in English of the disciplines of science (S), technology (T), engineering (E) and mathematics (M). In the development of the STEAM theory, the role of each of the disciplines in learning is established in a very specific way, defining STEAM learning as the learning of "Science and Technology interpreted through Engineering and Art based on the language of Mathematics" [1,2]. However, this differentiation between discursive, interpretative and linguistic disciplines can close off possibilities for research between them and prevent a deeper understanding of how each discipline works with the others [3]. In this project, STEAM learning is conceptualized from a mutual instrumental and pedagogical approach (Quadrant 4 of

[3]), in which the disciplines are conceptualized equally, avoiding placing one above the other and promoting their simultaneous use. This conception explicitly recognizes the equal conditions and contributions of each of the STEAM disciplines, integrating them to increase interest and learning potential and promote their deeper learning [3]. In addition, it allows to overcome the historically rigid constructions of the priority and hierarchy of the educational disciplines of Western educational systems to achieve a more holistic and effective education. Along these lines, in [4], the authors indicate that including art in STEM projects, that is, moving from STEM to STEAM, is a way to promote interdisciplinarity and the capacity for technical, artistic and scientific understanding in students.

1.1. STEAM Methodology: Interdisciplinarity, Meaningful Learning and Active Methodologies

The need to train new generations with sufficient scientific and technological skills makes education systems face the challenge of redefining their education models. This challenge involves introducing new methodologies, educational tools and multidisciplinary teaching activities. Based on this need, STEM (science, technology, engineering and mathematics) learning is developed, whose implementation is causing doubts about how to integrate the four disciplines. In this context, STEAM learning has emerged including Art as an integrating agent, which generates much more interdisciplinary, creative and innovative learning situations. STEAM learning, as a methodological model, promotes and improves the study of scientific–technical and artistic disciplines in a single comprehensive and interdisciplinary framework [5], enhances knowledge and meaningful learning [6] and moreover, through active methodologies, promotes critical, creative, reflective and logical thinking and the development of cognitive processes [7].

1.1.1. Interdisciplinarity

The separation of disciplines in traditional teaching hinders the preparation of students to face the challenges of an interconnected and constantly evolving world [8]. The STEAM methodology breaks conventional disciplinary barriers by proposing a synergistic integration of knowledge and integrating the scientific and artistic subjects of the curriculum. In this way, the author of [1] defines STEAM as the learning of "Science and Technology, interpreted through Engineering and Art, based on the language of Mathematics" and places it in her pyramid in the place of integral learning, between the multidisciplinary learning of STEM and the holistic approach that considers learning as a "whole" in which the contents are secondary. The integration of disciplines in the STEAM model, in addition to breaking with the limitations imposed by the compartmentalization of knowledge, fosters in students a more complete and contextualized understanding of the contents and develops diverse skills that prepare them to address future challenges with a comprehensive perspective [8]. This interdisciplinary character of the STEAM methodology allows to respond to the challenges of the real problems of everyday life within a globalized and changing society, using various approaches [9], such as the holistic approach that promotes an inclusive education, the functional literacy approach, which aims to train individuals to adapt to a changing environment, or the constructivist approach, which considers students as drivers of their own learning.

1.1.2. Meaningful Learning

In [10], the author states, in his theory of meaningful learning, that the student's learning depends on the previous cognitive structure, understood as the set of concepts and ideas that they have in a certain field of knowledge, which is related to new information. That is, from previous knowledge, new knowledge is acquired that can be used in explanations, arguments and solutions to new problem situations.

Meaningful learning is related to the functionality of learning, that is, the knowledge acquired must allow its use in future life situations, and this use allows to determine the level of understanding of the acquired learning [11]. In this way, learning is meaningful and functional if it answers questions such as the following: What is the purpose of what I learned?, How can I apply what I learned in specific life situations?, What can I learn from what I learned so far? How can I apply what I learned to keep learning?.

For learning to be meaningful, it requires coherent and organized knowledge to be learned, a substantial relationship between the knowledge to be acquired and prior knowledge and motivation on the part of the student [10]. The STEAM methodology meets these conditions, since with its use, a positive response is observed in students who focus their interest on work and what they learn, and furthermore, problems derived from the subject itself are reduced, the diversity of interests and origins of students is addressed, results are improved and the role of the teacher as a counsellor is favoured [12].

In addition the teacher, when scheduling STEM projects, must take into account the student's prior knowledge, provide activities that arouse the student's interest and allow them to express their opinion, exchange ideas and debate, supervise the process and act as a guide, and also choose and propose situations developed in the student's daily life.

1.1.3. Active Methodologies

The origin of active methodologies lies in the methods proposed by the New School movement at the end of the 19th century to train citizens to become more active in, critical of and committed to society. These approaches are based on the activity, interests and needs of students. Today, active methodologies also represent a reaction against traditional model in which the teacher assumes an active role as a transmitter of knowledge and the student a passive role as a simple receiver of knowledge. In this way, active methodologies are the "methods, techniques and strategies used by the teacher to transform the teaching process into activities that encourage active student participation and lead to learning" [13]. The STEAM educational model promotes the use of active methodologies, in which the student becomes the protagonist of the teaching–learning process and is able to build their own knowledge. Active methodologies such as project-based learning, problem-based learning, collaborative learning or the flipped classroom are effective tools to motivate students, generate meaningful learning and to train critical, creative people prepared to face current and future challenges and able to work in a team, communicate, discuss, evaluate, etc. Project-based learning is the active methodology inherent in STEAM projects as it aims to build a final product from an initial challenge. The development of the project, which constitutes the final product, is carried out in four phases: presentation of the challenge, implementation of the project, presentation of the product and final reflection and evaluation. In the development of the final product, new challenges or problems arise, and they require problem-based learning, in which students, while solving the problems, inductively build new knowledge. The problem-based learning process begins with the recognition and identification of the problem, continues with the discussion of possible hypotheses and the choice and justification of solutions and ends with the presentation of the solution obtained. Both methodologies use collaborative learning; work is carried out in small groups in which students with different skills and levels share situations and address common goals. In collaborative learning, students are responsible for their own learning and that of their peers so that they reach their goals if, and only if, the peers also achieve theirs. STEAM projects frequently use the flipped classroom method in which students learn the contents at home, usually from online tutorials, and then carry out activities and tasks in class guided by the teacher. In a flipped classroom, the learning process, although greater student involvement is required, is adapted better to the student's pace, providing deeper and more meaningful learning. Other active methodologies that can be used in STEAM projects are competency-based learning, contract-based learning, gamification, design-based learning or case study. The implementation of active methodologies in STEAM projects implies a new organizational structure of the classroom, a different way of managing time and assessment systems, and a change in the teacher's role and training, which represent a challenge for the teachers.

1.2. Society and Its Relationship with Buildings and Cities

Our city, our neighbourhood, our house, the space where we live, are part of our life in an intrinsic way from the moment we are born. Sometimes we enjoy these spaces and sometimes we suffer because of them. Sometimes we choose to be in these spaces and sometimes they are imposed on us, but we always adapt to them to a greater or lesser extent. We are human insofar as we relate to others, and the place where we do so is not inconsequential. We inhabit and share our time with family and friends in our home, and we also make our space more personal. We work and interact with colleagues or clients in offices, shops, factories or studios. Children and youngsters learn in schools, play, participate in sports and have fun in parks, hiking, trekking and climbing in forests and mountains. We visit the doctor at health centres and hospitals. We socialize with the rest of people in the streets, squares and leisure areas. In short, we live in the city, urban spaces and buildings (architecture) as they have been given to us, without considering their reasons or use. We usually leave that work to the architects. And yet, we criticize or praise this work without understanding or knowing, out of instinct or pleasure or out of the mere feeling of "I like it–I don't like it".

Cities are undoubtedly witnesses to the development of people: they safeguard traditions, weave customs, build everyday life and incubate ideas. These facts, isolated or related, contribute to the formation and sedimentation of cultures. That is where the importance of urban centres lies; far from being static, they play a decisive role in the construction of a civilization. Cities have a formative responsibility. They must not only "house" but "train" citizens. Similarly, society must not only "live" the city but also enjoy it, for which we must take care of it and develop it, favouring its growth, evolution and development.

But these cares are not learned by intuition. There are concepts and techniques that should not be available exclusively to professionals, hence the importance and responsibility, at the same time, of the teaching of architecture since it is part of our life, personally, socially and economically, because much of our economy is invested in the purchase, rental and maintenance of housing. We look for the right place, for proximity to others or to work, for quality and services. And we try to turn our house into our home, seeking the well-being of those who live in it for the simple fact of feeling good and being happy.

It is true that, insofar as a city is composed of its inhabitants, the responsibility for its transformation lies with them. But this requires proper training. All our proposals would be better argued if we had been educated for it. Despite being part of our environment, until now, we have not been trained enough to take care of, update or propose solutions for our own cities and buildings, or, which is the same, for our lives.

In our society, even buildings have a label for use (recently mandatory for rent or sale). We are obliged to understand and collaborate with the system, and the sooner we start, the more natural it will be for us to develop it. Faced with the situation of the lack of knowledge of space, culture and technology, for architectural environment and energy sustainability, we have the need to educate young people on the basic concepts of architecture, urbanism and energy efficiency in the foundations of education.

Architecture in Pre-University Studies

No discipline is developed out of thin air, and the vast majority of them need the insights provided by STEAM learning. Architecture is a clear example of this. In a building, science and mathematics are intertwined with technology and engineering to be able to build functional buildings whose beauty is given by the artistic part. This implies that, with a little creativity, architecture itself could easily be integrated into any curriculum [14].

In [15], authors highlight that not only would it be relatively easy to link the different STEAM subjects with architecture, but it would also be something necessary for society since there is no social awareness and respect for historical buildings in both cities and rural environments. Therefore, in [15], authors assert that education from an early age is one of the most important ways to protect the cultural landscape and maintain sustainable development.

In [16], authors use different workshops for children aged 8–12 years with the intention of raising awareness about their built environment and architectural culture. Also, in [17], extracurricular activities are carried out for primary and secondary school students that aim to inform children about their architectural heritage and historical environment.

In [18], it is stated that the quality of human life depends, to a large extent, on the quality of our built environment and that this cannot be directed only by architects; it is the product of everyone—citizens, professionals, companies, legislators… working together. Therefore, the future quality of our lives depends on the next generations and they must be provided with the knowledge and tools to make wise decisions that take into account their impact on the cultural, social, economic and political well-being of the environment in which they live [18].

1.3. Previous Works

Since [1,2] proposed the STEAM methodology, a large number of publications and application proposals have appeared in the literature; see, for example, [19]. However, the main drawback faced by teachers who want to implement this type of methodologies in the classroom is that they have to integrate them with the curriculum, which is a handicap often insurmountable since the curricula are not adapted to implement this type of methodologies. The contributions of STEAM projects are usually carried out in extracurricular activities outside of regulated teaching.

In 2020, the project ERASMUS+ (DART4City (2020-1-ES01-KA227-SCH-095545) Empowering Arts and creativity for the cities of tomorrow) was launched with the aim of developing a methodology to implement STEAM projects, connected with curricula in order to replace conventional teaching. The proposed methodology was published in [20]; it analyzes, among others, the curricula of Spain, Italy, Cyprus, France, Finland and Germany.

The methodology proposed in [20] allows selecting the area of opportunity or thematic area belonging to a STEAM discipline that meets the necessary conditions to be the main theme of a STEAM learning project in two ways: "forward" and "backward". In the first variant, "forward", an analysis of the curriculum is carried out for a given course or level and the areas of opportunity are selected among the thematic areas which have more connections with the rest of the thematic areas; in this way, STEAM projects developed from these areas of opportunity contain a large number of thematic areas and cover an important part of the curriculum. The second variant, "backward", is carried out from a specific topic that is considered interesting for developing a STEAM project; subsequently, the connections of the selected topic with the thematic areas obtained from the analysis of the curriculum are sought. That is, both methodologies have a common stage in which the curriculum is classified into STEAM thematic areas and, from there, in the "forward" methodology, the connections between the thematic areas are sought in order to find the areas of opportunity with more connections, while in the "backward" methodology, the project theme is selected first and then the thematic areas related to the theme are sought.

The "forward" and "backward" variants proposed in [20] provide two interesting approaches for the development of STEAM projects. On the one hand, the "forward" methodology allows designing STEAM projects from an area of opportunity, which guarantees a large number of connections with thematic areas and maximizes the result of the project from the curricular point of view. This type of methodology is more aimed at governments and administrations that want to promote STEAM projects in schools, since with a low number of STEAM projects a wide range of knowledge could be covered. On the other hand, the "backward" methodology starts from an idea, concept or need detected in society and, from this idea, the connection with the curriculum is sought.

In [20], the STEAM Cocina project is proposed as an example of the "backward" methodology in which the kitchen, a daily element commonly used by society, is the concept used to connect with secondary school subjects, Mathematics, Art, Physics and

Chemistry, Biology, Design, etc. The STEAM Cocina project not only makes it possible to teach high school subjects in a more integrated and enjoyable way, but also indirectly enhances students' culinary skills.

1.4. Research Objective

On the one hand, the methodology proposed in [20] using the "forward" and "backward" variants to develop STEAM projects develops tasks that, on the one hand, allow the student to acquire the knowledge of the subjects and generate significant learning linked to the needs of society.

On the other hand, the literature shows the importance of introducing concepts of architecture at an early age. In [15], it is highlighted that this approach is necessary for society since there is no social awareness and respect for historical buildings both in cities and in rural environments. In [18], it is determined that the future quality of our lives depends on the next generations and they must be provided with the knowledge and tools to make wise decisions that take into account their repercussions for the cultural, social, economic and political well-being of the environment in which they live.

In [15], the author emphasizes that it is relatively easy to link the different STEAM subjects with architecture, since in the creation of a building, science and mathematics are intertwined with technology and engineering to build functional buildings whose beauty is given by the artistic part. This implies that, with a little creativity, architecture itself could easily be integrated into any curriculum [14]. This idea fits perfectly with the "backward" methodology proposed in our previous works—see [20]—to develop STEAM projects based on architecture.

This article proposes the STEAM Architecture project developed with the "backward" methodology, where a complete educational program from pre-primary to high school is proposed. The STEAM Architecture project has a twofold objective. On the one hand, it seeks to unify the contents studied in other related subjects, and on the other hand train future citizens to understand, care for and improve the cities and buildings that are part of our lives.

The possibility of teaching certain social needs in pre-university studies generating significant learning while training students in curricular content opens up a wide range of possibilities that must be detected and measured in advance.

This article presents a contribution to research and innovation within the field of educational sciences in two aspects:

1. *The use of a current and incipient methodology, the "backward" methodology of curricular analysis, in the design of STEAM projects.* In this case, the "backward" method used in [20] allows the STEAM project to be integrated into the curricula by unifying the contents distributed in other subjects. This innovative, incipient and current method is a variant of the "backward" methodology that aims at integrating curricular content into STEAM projects.
2. *The use of concepts on architecture to promote creativity and sustainability in children and adolescents.* The project connects different architectural concepts with the curricular contents of various stages of the educational system (from primary school to high school), and therefore the sizes of the space as didactic variables (micro-, meso- and macro-space) are connected with the types of space defined in urban design. In this way, the project understands architecture as a series of constant original creations that arises from the creativity of their designers, which is one of the fundamental competences developed by the project. In the project, students develop and encourage their creativity by experimenting, improvising and taking risks without being afraid of making mistakes [21].

In a first part of the work, an analysis of the knowledge possessed by people on architecture is carried out. With all the information obtained from the different studies (surveys, interviews and working groups), we can see the lack of knowledge that citizens have about various areas related to architecture which do not allow them to understand, care for and improve the cities and buildings that are part of our lives. The results show the need to include architecture in the curriculum, not only in workshops or extracurricular activities as shown in the literature—see [16,17]—but also as an additional subject that allows to connect with the rest of the contents that are being taught at that time in other subjects.

The second part of the work aims to define how the STEAM Architecture project was developed. This aims to train children in the fundamental aspects of architecture, which helps the development of people and cities from the base of society and their commitment to the environment and energy saving by unifying the contents studied in other related subjects such as Social Sciences, Geography and History, Visual Plastic Education, Introduction to Building and Civil Work, History of Art and Civilizations, etc. This program will be complemented with the incorporation of complementary concepts that offer cohesion to the problems dispersed in multiple disciplines and all of them can be integrated into a single STEAM project. The third part of the work shows the workshops developed to validate the STEAM projects proposed for each educational level. Discussion, conclusions and future works are shown at the end of the article.

1.5. Study of the Knowledge of Architecture in Citizenship

In [15], authors highlight that education is one of the most important ways to protect the cultural landscape and maintain sustainable development. In [18], it is stated that the achievement of the quality of human life depends to a large extent on the quality of our built environment and that this cannot be directed only by architects; it is the product of everyone: citizens, professionals, companies, legislators, etc., working together. Therefore, the future quality of our lives depends on the next generations that must be equipped with the knowledge and tools to make wise decisions [18]. This study aims to explore the current knowledge about architecture that citizens have. The questionnaire used is divided into two blocks:

- *Block A—Importance of architecture:* the opinion about the importance of architecture for daily life, for society or in a personal way is questioned.
- *Block B—Knowledge about architecture, urbanism and energy efficiency:* a series of questions are raised about architectural culture, urbanism, construction, facilities, energy rehabilitation and graphic representation.

1.5.1. Study Sample

In this study, data and opinions are obtained from the population groups directly or indirectly involved in the proposed approach: students of secondary school and the last two years of high school, students of technical careers such as architecture or engineering, teachers of secondary education and the last two years of high school education, architects or professionals related to architecture. The total number of the responses analyzed is 619, from which 51% of the respondents are women and 49% are men. In Table 1, we show the distribution by years, while in Table 2, the levels of education are shown, where 31% of the students are architecture students. The distribution by professions is shown in Table 3.

Table 1. Study sample. Distribution by ages.

Age	Percentage
<12	12.11%
16–18	14.29%
19–25	14.70%
26–35	15.83%
36–45	19.20%
46–55	14.54%
56–65	5.65%
>66	3.68%

Table 2. Study sample. Distribution by level of studies.

Level of Studies	Percentage
Doctors	10%
Master's degree	14%
Graduates	33%
Last two years of high school	15%
Secondary school	14%
Primary school	13%
Vocational training	1%

Table 3. Study sample. Distribution by professions.

Profesions	Percentage
Architects	25%
Architects who practice as a teacher	6%
Teachers	28%
Professions related to architecture	1%
Other professions	39%

1.5.2. Questionnaire

The questionnaire used was evaluated as a likert test rated as follows: 1 = Strongly Disagree; 2 = Disagree; 3 = Neither agree nor disagree; 4 = Agree; 5 = Strongly Agree. Block B was evaluated with Yes, No or partial responses. The tests obtained a Cronbach's Alpha of 0.93. The questions asked can be seen in Tables 4 and 5.

Table 4. Statements provided for Block A.

ID	Statement
1	Architecture is important in my daily life.
2	Architecture is important for the society in which we live, since we live, work and socialize in architectural spaces.
3	Society has enough knowledge about architecture to understand, care for and improve the cities and buildings in which we live.
4	Society should be more involved in the design, development and maintenance of cities and their buildings.
5	It would be positive to receive further training on architecture, urbanism and energy efficiency to improve the cultural level of the population on these issues, promote coexistence in cities and sensitize society to the proper use of buildings.
6	It seems appropriate to incorporate modules and/or subjects on architecture, urbanism and energy efficiency in secondary education (ESO) and last two years of high school.
7	I think it would be positive to train young people with the theoretical knowledge, values and skills that are developed with the study of architecture, urbanism and energy efficiency.
8	I believe that the study of architecture can improve some aspects of our daily lives, such as reading a plan well before buying a house or knowing how to interpret the evacuation route of a building.
9	I think that the artistic competence is conveniently worked on in the different subjects of ESO and last two years of high school.
10	Comment on some situation in your life related to architecture.

Table 5. BLOCK B—Knowledge of architecture, urbanism and energy efficiency.

ID	Question
11	Can you find 5 emblematic buildings in your city?
12	Can you find 5 relevant Spanish architects?
13	Would you know how to classify buildings according to their different functions and uses?
14	Can you describe the different types of cities according to their morphology?
15	Do you know the distribution networks of facilities of a building?
16	Could you identify the main elements that make up a façade wall?
17	Can you explain what energy rehabilitation is?
18	Would you know how to read an architectural plan?
19	Would you know how to use 2D and 3D graphical representation systems (dihedral, axonometric and conical), scales and dimensions to graphically express a project?
20	Name the relevant buildings or urban spaces you have visited in the last year.

1.5.3. Responses and Discussion of Results Obtained

The answers obtained can be seen in Table 6.

Table 6. Citizen's questionnaire responses, Likert-type questions.

Question	SD	D	N	A	SA
1	14	31	95	217	262
2	3	12	24	184	396
3	206	289	77	30	17
4	4	3	26	242	344
5	1	9	35	235	339
6	7	8	68	225	311
7	4	10	53	246	337
8	3	6	34	258	318
9	185	233	155	31	15

In Question 10, only 133 people answered from the 619 respondents, which is 21%, completing a total of 150 different answers related to architecture; see Table 7:

Table 7. Citizen's questionnaire responses to Question 10.

Percentage	Answer
19%	Their profession or being or having been a student.
13%	The rent or purchase of a home or premises.
6%	Works, renovations or improvements in housing.
6%	The interest they show in the distribution and use of spaces in their work or housing, or for their love of designing nearby spaces.
5%	Their interest in knowing buildings and spaces in general, and in particular from their cities.
3%	Their tourist trips.
9%	Their interest in the renovation, design, and redevelopment of the spaces of their city, as well as architecture as a hobby, design, decoration magazines, etc.
7%	Show their concern for accessibility and architectural barriers.
7%	Are interested in energy efficiency and saving as well as ecological issues.
5%	Point to soundproofing, thermal and acoustic insulation, safety, lighting or occupational hazards as important issues.
3%	Related to architects.
8%	Consider that architecture surrounds our lives, work, leisure, home, etc.
9%	Various considerations.

The answers obtained in Block B can be seen in Table 8.

Table 8. Citizens's questionnaire responses, Block B.

Question	YES	NO
11	456	60
12	280	188
13	296	188
14	234	265
15	266	295
16	225	316
17	250	223
18	258	199
19	226	284

As for Question 20, only 189 people answered out of the 619 respondents, which is 31%, completing a total of 678 different responses (an average of 3.6 per person); see Table 9.

Table 9. Citizen's questionnaire responses to Question 20.

Percentage	Answer
1.21%	Museums or art galleries.
2.14%	Religious spaces or centres.
3.90%	Palaces, castles, fortresses, and fortifications, towers or castles.
4.90%	Office complexes or towers, including corporate or institutional headquarters.
5.80%	Theatres, auditoriums, cultural centres, foundations, universities and other cultural spaces.
6.80%	Squares, parks, gardens, fountains and other open spaces of the cities.
7.30%	Unique hotels and homes.
8.30%	Stations, airports and other transportation buildings.
9.20%	Business buildings or shopping malls.
10.10%	Buildings or sports centres.
11.10%	Other unique buildings, including libraries, markets, slaughterhouses, bridges.
12.13%	Cities and historic centres or other general mentions to architectural ensembles.

1.5.4. Discussion and Conclusion of the Results Obtained

With regard to Block A of questions, we can conclude that 94% of respondents consider architecture to be important for society and their daily lives. Less than 3% of them do not consider it important. According to the opinion of 80% of respondents, society does not have enough knowledge of architecture to understand, care for and improve the cities and buildings in which we live. Up to 95% of respondents believe that society should be more involved in the design, development and maintenance of cities and their buildings. Only 1% believe that greater involvement is not necessary. A total of 90% of respondents consider it positive to train young people with the theoretical knowledge, values and skills that are developed with the study of architecture, urbanism and energy efficiency in order to improve the cultural level of the population on these issues, promote coexistence in cities and raise awareness in society of the proper use of buildings. Further, 93% consider the study of architecture able to improve some aspects of our daily life, such as reading a plan well before buying a house or knowing how to interpret the evacuation route of a building. Almost 87% of the answers show that it is appropriate to incorporate modules and/or subjects on architecture, urbanism and energy efficiency in ESO and the last two years of high school.

With regard to Block B of questions, we can conclude that a large majority of respondents, almost 74%, can name five emblematic buildings of their city, and less than 10% of them do not know any names. Only 45% of respondents claim to be able to name five relevant Spanish architects, and 24% can name only some of them. Only 48% of those who responded to the survey claim to be able to classify buildings according to their functions or uses, more than 30% of those not even partially able to. Apart from architects and architecture students, the rest of repondents only managed to make this classification (24%, and 32%) only partially.Almost 43% do not distinguish the different types of citis according to their morphology and 38% cannot even partially do so. However, if we leave out architects and students of architecture, it would only be 10% of repondents knowing how to make this distinction, and more than 62% who would not. A total of 37% of respondents say they know the distribution networks of buildings facilities, and only 17% of them know partially. If we leave out architects and architecture students, only 10% claim to know the distribution networks. Further, 51% of respondents do not know how to break down the elements of a facade wall compared to 36% who know how to do it. If we leave out architects and architecture students, then only 8% know how to list the main elements of the facades. In conclusion, we can see how society perceives the need to train citizens in the design, development and maintenance of cities and buildings, which makes it an area of opportunity for the development of STEAM projects at pre-university levels.

2. STEAM Architecture

The aim of the STEAM Architecture project is to train students in architectural concepts and link STEAM subjects with them. The perception that children/students have about what surrounds them is a decisive handicap when designing the learning process at each level. In [22], the author discusses the size of the space to learn geometry. The size of the space is a didactic variable in the sense that the size taken influences the associated mental constructions and the manipulative activities carried out in class. In [22], three values are defined, and these are

- The micro-space, which corresponds to the world of small, manipulable objects by using the hands on the table, objects of visible size up to half the height of the handler.
- The meso-space, which corresponds to a size of objects between the upper limit of micro-space up to 50 or 100 times the height of the handler.
- The macro-space, which corresponds to larger spaces, beyond the meso-space.

In architecture, in urban design, those types of spaces with similar sizes are also defined; see [23]. These are

- Macro-spatial urban design, which studies the entire city and its scope, including water in urban areas, the link between hills and cities, the road network in the city region and the link between the urban traffic network and urban morphology, the city limits, the city skyline.
- The urban design of the meso-space, which includes residential blocks, commercial centres, administrative centres, industrial blocks, urban parks.
- The urban design of micro-space, which includes architecture, the link between architecture and the natural environment, the link between architecture and space, and street infrastructures.

Based on the different sizes of space that can be assumed in each educational level and the spatial division of urban design, the following levels of architectural abstraction are defined for each educational level, see Figure 1:

- Pre-school: The room.
- Primary school: The house.
- Secondary school: The neighbourhood.
- High school: The city.

Figure 1. Levels of architectural abstraction depending on educational level.

Design of STEAM Architecture

Without losing generality, this article uses the methodology published in our previous works [20], as well as the analysis of the Spanish curriculum for primary and secondary school published in [24,25] to design the STEAM Architecture project. Tables 10 and 11 show the opportunity areas obtained in [24,25] that are part of the STEAM Architecture project for each level. Figure 2 shows the doughnut charts generated for each educational level.

Table 10. STEAM Architecture. "The house". Primary school.

Procedural	Conceptual	
	Opportunity	Non-Opportunity
S1. Introduction to the scientific method	S5. Ecosystems S6. Sustainability	S3. Health and illness S7. Weather and climate S11. Economic and human activity
T1. Use of the ICTs	T3. Electrical machines and appliances	T4. The calculator
	E1. Matter and materials E4. Measurement: units, measurements and machines E7. Geometric plotting	E2. Electricity and magnetism E3. Scales, maps and representations E6. The monetary system E9. Waves: light and sound
A4. Interest in artistic manifestations	A1. Image: elements, value and functions A5. Plastic and audiovisual composition	A2. Advertising, social function and elaboration
M1. Math problem solving M3. Operations with natural numbers and mental calculation	M5. Proportionality and percentages M7. Flat figures: elements, perimeters and areas	M2. Natural numbers M4. Fractions and decimals M6. Angles and sexagesimal system M8. Geometric objects

Table 11. STEAM Architecture. "The neighbourhood". Secondary school.

Procedural	Conceptual	
	Opportunity	Non-Opportunity
S1. The scientific methodology	S3. History and evolution of the Earth S6. Living beings S7. Sustainability and pollution	S5. The human body
T1. Hardware and software	T8. Electronics and robotics T8. Electronics and robotics T9. Electrical machines and circuits	T3. ICT in research and technological projects T4. Office automation
E8. Drawings and representation systems	E1. Materials E7. Energy	E3. Matter E4. Chemistry E5. Chemical reactions E6. Forces and work
A2. Elements of the graphic work A3. Strategies and graphic resources	A6. Advertising A8. Graphic design	
M1. Numbers M2. Troubleshooting	M4. Proportionality and percentages	M5. Plane geometry M6. Geometry of space

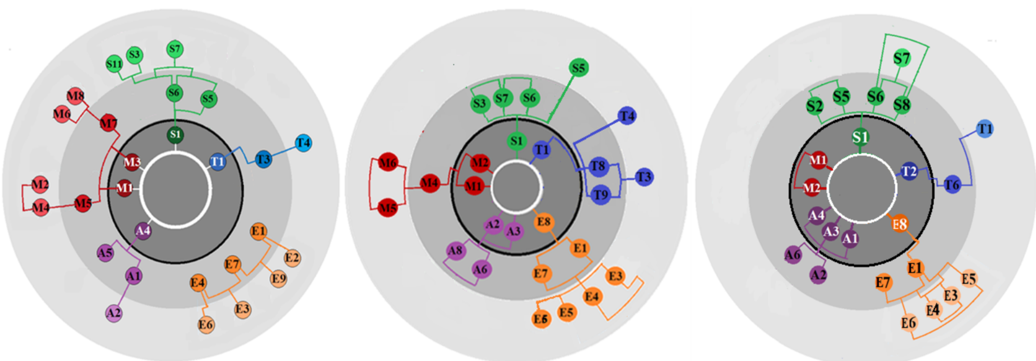

Figure 2. Generated diagrams.

3. Implementation of Pilot Projects—Results Obtained

This section presents the three workshops implemented to validate the STEAM Architecture project, the segmentation by levels and how it is perceived on the levels of house, neighbourhood and city. At the end of the workshop, students must answer the questions in Table 12.

Table 12. Questions asked.

ID	Question
1	Did you find this workshop interesting?
2	Did you know the concepts worked during the workshop?
3	Did you find the contents suitable for your level of knowledge?
4	Would you like to hold other workshops on architecture, urbanism and energy efficiency?
5	Would you like to have an annual subject on architecture, urbanism and energy efficiency?
6	And quarterly?
7	Did you find the structure of the workshop adequate (dynamic explanation with slides, review of fundamental ideas, explanation of the activity, division of tasks, teamwork with supervision and doubts to the teacher, exchange of ideas)?
8	Do you think that these workshops on architecture, urbanism and energy efficiency can also train you as a person, valuing the built environment?
9	Do you think it would be positive if society had more knowledge about architecture, urbanism and energy efficiency, to care for, value and propose improvements of the built environment?
10	Workshop global score:

3.1. My House, My Building

The workshop is carried out with four groups of students from the second year of primary school (aged 7–8 yeras), with a total of 86 students, grouped in pairs for the exhibition part and each one in their class, with the cooperation of the tutors for the workshop part.

3.1.1. Presentation

There is a small presentation on architecture with questions to students such as the following: What is an architect? What is his/her job? Do you know any architect? What is architecture? Is there architecture in your building? What about in this school? There is a dialogue with students about their answers, specifying and guiding some comments. The session is supported by a PowerPoint presentation with the following contents.

Perception of the space in a close distance, houses, buildings, urbanization, neighbours, etc. Explanation about the type of housing, parts of a house, parts of a building, etc. Dynamical aspect with questions related to the students' homes and buildings with the contribution of the students trying to learn new content starting from that they already know. We can see the following:

- Houses on the outside: chalets, flats, semi-detached houses, etc. (each student must identify their own type of house).
- Parts of a house: kitchen, living room, bathrooms, rooms, garage, etc. (they must describe their houses).
- Parts of a building: garage, facilities, lift, doorway, stairs, doorman's room, hallways, etc. (students comment on what they identify).
- Types of buildings they know: houses, schools, shopping malls, churches, offices, hospitals, sports centres, etc. (students name them).
- There are photos of parts of the house, houses and "beautiful" buildings, as an example of what has been said.

3.1.2. Workshop

Students are asked to build a house by using a shoe box or something similar, distributing its interior according to the parts of the house studied. The boxes can be stacked as a way to simulate buildings, containers of several homes. Steps to follow:

- Draw a house or an invented one in 2D (according to ability, usually in the plan, etc.), on paper, which will serve as a plan for the one they make in 3D. Individual work task.
- Assemble a house in 3D, individually or in groups, with shoe boxes as containers and making interior partitions and furniture with other cardboards and materials. Windows, decks, stairs, etc.
- Assemble the buildings by stacking the houses.

Figure 3 shows the results of the workshop.

Figure 3. Results obtained in primary school. House abstraction level.

3.1.3. Questionnaire Responses in Primary School: House Abstraction Level

The answers to the questionnaire are those shown in Table 13.

Table 13. Workshop, my house. Likert-type questions.

Question	SD	D	N	A	SA
1			8	25	53
2			14	15	57
3				18	68
4				26	60
5			12	53	21
6			6	21	59
7			15	51	20
8			16	44	26
9			14	47	25
10			7	16	63

3.2. My Neighbourhood

The workshop is carried out with three groups of students in the fourth year of primary school (aged 9–10 years), with a total of 82 students, grouped in an empty classroom used for exhibition and organized by groups in the same classroom, with the cooperation of the tutors for carrying out the workshop.

3.2.1. Presentation

There is a small presentation on architecture with questions to students, such as the following: What is an architect? What is his/her job? Do you know any architect? What is architecture? Is there architecture in your building? and what about in this school? Is the design of a neighbourhood considered architecture? Can the design of a city be also considered architecture? There is a dialogue with students about their answers, specifying and guiding some comments. The session is supported by a PowerPoint presentation, with the following contents: Perception of space at medium distance, around

500–1000 m: the student's houses, buildings, urbanization, neighbourhood. Explanation about the functioning of the neighbourhoods within the cities and elements that compose them (building, infrastructures, roads, green areas, etc.), making an analysis about the different equipment, uses and distribution of the buildings in a dynamic way, with directed questions about what students perceive in their daily life, their neighbourhoods and their city (Madrid), trying to learn new content starting with what they already know. We can see the following:

- Types of buildings in the neighbourhoods: houses, schools, shopping centres, churches, offices, hospitals, sports centres, gyms, (they must name these), bakery, fruit shop, etc.
- Also empty spaces: streets, parks, building courtyards, car parks, transport, etc.
- How are they organized? How many of each type?

3.2.2. Workshop

Students are proposed to create a single neighbourhood, dividing it into three zones (groups), each of them with captains who negotiate the respective equipment, responsible for parks, roads and housing. Paper is spread on the floor, from side to side of the class (about 6–8 m × 1 m), and the zones of each team are marked. Once organized, the students must:

- Draw on paper the organization of the neighbourhood, tracing the streets, leaving space between them for different type of equipment and green spaces.
- Build with boxes and all kinds of recycling material, the buildings assigned to each group, explaining their morphology, their characteristics, dimensions, etc.
- Place the buildings and symbolize the flat spaces.

Figure 4 shows the results of the workshop.

Figure 4. Results obtained in the workshop. Neighborhood abstraction level.

3.2.3. Questionnaire Responses in Secondary School: Neighborhood Abstraction Level

The answers to the questionnaire are those shown in Table 14.

Table 14. Workshop, my neighbourhood. Likert-type questions.

Question	SD	D	N	A	SA
1			4	10	68
2			25	43	14
3				9	73
4				7	75
5			6	9	67
6				6	76
7			3	10	69
8			5	55	20
9			3	15	64
10			12	16	54

3.3. My City

The workshop is carried out with three groups of students in first and second years of secondary school (aged 12–14 years), with a total of 78 students, grouped in a classroom where the exhibition is held and organized by groups each in their class, with the cooperation of the tutors for carrying out the workshop.

3.3.1. Presentation

There is a small presentation on architecture with questions to students, such as the following: What is an architect? What is his/her job? Do you know any architect? What is architecture? Is there architecture in your building? What about in this school? Is the design of a neighbourhood considered architecture? What about a city? There is a dialogue with students about their answers, specifying and guiding some comments. The session is supported by a PowerPoint presentation, with the following contents:

Perception of long-distance space, such as 1000–10,000 m, in their city. There is an explanation about the functioning of the neighbourhoods within the cities and the typologies of the cities (irregular, radio-centric, orthogonal, and linear), making an analysis about the different morphologies, function and distribution of the buildings and roads in each of them, dynamically, with directed questions about what students perceive in their daily life, their neighbourhoods and their city (Madrid), trying to learn new content starting from what they already know. We can see the following:

- Elements that organize the city: streets, buildings, green spaces, parks, transport, etc.
- Typologies of city and examples of each: irregular (Córdoba, Toledo, Granada), radiocentric (Paris, Moscow, Vitoria, Canberra), orthogonal (plan Cerdá: Barcelona, Montevideo, Athens, Alicante, La Carolina), linear city (Arturo Soria, Madrid).
- City view at street level and bird's eye view (in plan).
- Evolution, characteristics, functioning of each typology.

3.3.2. Workshop

Students are asked, gathered in groups of 5–6, to make a scale model between approximately 1:1000 and 1:500 of a representative part of a city, with recycling materials in the second year and bath sponges and hand soaps in both years, trimmed depending on the scale and selected shapes of each building, and to mount it on A3–A2-sized forex or cardboards. Taking as an example the types of cities presented, each group is assigned a typology to be built of the four analyzed. The steps to follow are as follow :

1. Draw on the support of the model or on paper the distribution of the main road, the free spaces, and the location of the buildings according to the type of city assigned.
2. Trim (sponges and soap) and assemble (with recycling material) the buildings with their different shapes, colours and sizes, according to their function.
3. Place and distribute the buildings created to configure the designed city.

Figure 5 shows the results of the workshop.

Figure 5. Results obtained from "my city" workshop.

3.3.3. Questionnaire Responses in High School: City Abstraction Level

The answers to the questionnaire are those shown in Table 15.

Table 15. Workshop "my city", Likert-type questions.

Question	SD	D	N	A	SA
1				14	64
2			13	45	20
3			9	15	54
4			7	14	57
5			16	24	38
6			9	21	48
7			7	10	61
8			8	15	55
9			9	12	57
10			7	10	61

4. Discussion

This article proposes the STEAM project, STEAM Architecture, as a STEAM project connected to the curriculum by using the "backward" methodology. This variant of the methodology allows us to search the areas of opportunity/interest in society that allow us to carry out STEAM projects with a significant important learning aspect.

In the first part of the article, we present the results of the questionnaires distributed to respondents that show that architecture is an area of opportunity that can improve our society. The second part shows the large number of connections that architecture could have with the thematic areas of the curriculum at any educational level, which would allow creating a multilevel STEAM project in which the ability to perceive the environment on the part of the student conditions the architecture that connects with the contents.

The subdivision of space in urban design into micro-, meso-, macro-space coincides with the didactic division of the teaching of geometry, and that is why we divide it into room, house, neighbourhood and city for the different levels of pre-school, primary, secondary and the last two years of high school. The main contribution of this article is the information shown in Section 2. Through architecture, most of the knowledge taught in different subjects could be connected at different educational levels. What is shown in Section 2 is specific to the Spanish curriculum but easily extendable to any curriculum as demonstrated in our previous works. The massive implementation of these methodologies in schools is a great handicap since it depends not only on the teachers but also on the management team of the schools. What is shown in Section 3 is just a small sample of how this approach could be implemented.

The different workshops carried out show that the division as well as the reception of the workshops by the students is correct.

The actual implementation of what is proposed in this article entails an intervention at all educational levels. In this article, several workshops that were held are described. They were held to assess the acceptance that this type of subject could have among students, as well as whether the levels of abstraction—my house, my neighbourhood, my city—are appropriate to the level. The results of the questionnaires show that the level is correct and that there is a high level of acceptance of the workshop.

5. Conclusions

This article proposes the STEAM Architecture project as an application of the STEAM project extraction methodology proposed in our previous work [20]. The application of the ”backward” variant allows exploring niches in society of areas of opportunity that allow building STEAM projects considered of social interest. In this article, architecture was explored as an area of opportunity to train the future inhabitants of cities in concepts that will allow them to become better citizens while learning the contents of different educational levels.

The workshops show the goodness of the proposal. Our future work will be focused on looking for new niches in society to carry out STEAM projects.

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