

Article

Student Competitions as a Learning Method with a Sustainable Focus in Higher Education: The University of Seville “Aura Projects” in the “Solar Decathlon 2019”

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Abstract: In recent times, teaching in higher education has undergone a significant transformation. Current advances and innovative proposals in educational science research are centred around a transdisciplinary approach, the so-called integrated curriculum and the incorporation of the transversal concept of sustainability. In summary, the so-called learning processes through problem-solving. The Solar Decathlon Competition is the most prestigious international university student competition for sustainable habitat. The aim of this article is to show how the *Aura Strategy*, developed by the University of Seville Solar Decathlon Team to participate in the Solar Decathlon 2019 Latin America and Europe competitions, is aligned with the aforementioned proposals. Among the results, the generation of a transforming teaching network of the departmental structures in the University of Seville is to be highlighted. These transformations in teaching lead students to new, broader and more holistic approaches to study, as well as new capabilities and skills. The question of interdisciplinarity requires new tools and research lines to achieve successful implementation in higher education, and the participation in the Solar Decathlon Competition is one of them.

Keywords: education; transdisciplinarity; innovation; competition; habitat; social sustainability; learning environments

1. Introduction

In recent times, teaching in higher education has undergone a significant transformation, in which current advances and the most innovative proposals in educational science research are focused on a transdisciplinary approach [1–4]. One of the longest-standing trends in educational innovation, and that which has given the best results in terms of learning, is the group of proposals known as the integrated curriculum [5,6]. This commitment to transversality implies dealing with problems from the perspective of different disciplines. In the majority of cases, issues cannot be resolved by a single subject, such as History, Structures, Construction, Urban Planning or Projects [7]. To break away from the traditional organisation of teaching based on the master classes of a single discipline, a move towards a more integrated vision is proposed. This should correspond to the logic of the disciplines and follow other logics which are more closely linked to the usefulness of what is being taught and the needs of the world we inhabit. Like any other, this type of change in the organisation of content has a direct impact on the classroom and, consequently, on the associated methodological strategies [8]. Nevertheless, further to the transdisciplinarity of the integrated curriculum, other methods such

as enquiry-based learning have recently been gaining prominence in the different fields of higher education [9–11].

Alongside this demand for a change of focus in teaching is the need to incorporate the concept of sustainability across strategies and teaching content, and hence, it has been highlighted by various higher education institutions [12]. With increasing pressure on resources and the UN estimate that 80% of citizens will be living in cities in the 21st century, it is necessary now, more than ever, to focus on the re-use of urban, architectonic, heritage and construction resources [13,14]. This forecast shifts a real problem both to the university classroom and, more specifically, to teaching in architecture. However, the complexity involved in introducing environmental sensibility from a theoretical, conceptual, methodological and critical perspective in the academic context of higher education requires a new set of teaching tools [15]. This is due to the fact that problem-solving from a sustainable perspective implies the collaboration of different disciplines that consider social, economic, cultural and environmental issues [16]. This leads to the conclusion that the previously mentioned processes are the most appropriate for initiating this transformation in teaching.

This change of focus in teaching allows the use of the Solar Decathlon Competition (SDC) as a truly transformative tool in higher education. This competition, which was originally sponsored by the U.S. Department of Energy, is the most prestigious international student competition for sustainable habitat. In this competition, students must design, build and put into operation a prototype housing cell, which is evaluated during the competition process from 10 tests linked to design or energy efficiency, among others. In the case of the University of Seville (hereinafter, US), the rigid departmental structure that composes it hinders the approach to sustainability in a holistic and transversal way in the classrooms of the School of Architecture. Therefore, participation in the Solar Decathlon Latin America and Caribbean 2019 competition (hereinafter SDLAC'19) and in the Solar Decathlon Europe 2019 competition (hereinafter, SDEU'19) gave the opportunity to implement issues such as integrated curriculum and learning processes through problem-solving.

In this respect, the aim of this article is to show that, in this context, the *Aura Strategy*, which arose from the University of Seville Solar Decathlon Team (hereinafter, ESD-US) in 2019, transcends its status as a learning tool in different subjects within the US Fundamentals of Architecture Degree [17] and generates research areas in higher education, thus changing the paradigm in this area of education. The aim of the *Aura Strategy* was to develop Aura 3.0 and 3.1 projects (hereinafter, Projects 3.0-3.1) to participate in the SDLAC'19 and in the SDEU'19 through a teaching and research methodology with the concept of sustainability at its heart. Additionally, the *Aura Strategy* was based on the 17 sustainable development goals (SDGs) and, in particular, on Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable [18]. This encouraged the students to work in line with current international premises and raised their awareness of the challenges that architecture faces in the near future [19].

To achieve the above-mentioned objective, this article begins with a section which reflects on methods of enquiry-based learning and the integrated curriculum and identifies the lines of research which were to be included in the development of the *Aura Strategy*. Next, a chapter is developed explaining the methodology used in the case study, which is based on the choice of the SDC as the new teaching strategy. The approach taken to this competition led to the creation of the *Aura Strategy*, defined by the design of a teaching network and the implementation of a teaching innovation methodology that resulted in Projects 3.0-3.1. The experience gained by the students throughout the prototype development stage, the blend of theoretical and practical classes, the number of students involved, the variety of teaching staff who participated in the process and the number of centres that provided the initiative with institutional support are just a few of the examples which demonstrate that the *Aura Strategy* is a benchmark for the promotion of innovations to improve higher education teaching.

2. Sustainability as a Learning Methodology in Higher Education

As far as higher education teaching is concerned, a number of international bodies insist on the need for teaching proposals to respond to current needs more satisfactorily [20]. At the same time, the most innovative proposals in the field of educational science research concur with the latest advances and results in such ground-breaking areas as neuroscience. This means that teaching proposals that have been successful at other levels of the education system are increasingly being taken into consideration in higher education [21].

One of the longest-standing trends in educational innovation, and the most successful in terms of learning, is the group of proposals jointly known as the integrated curriculum [5,8]. This term refers to the group of trends which are primarily based on addressing the division of content in academic disciplines in order to better respond to learning needs. Ultimately, these trends aim to break away from the traditional organisation of content in favour of a more integrated vision that focuses on the logic of the disciplines and follows other logics which are more closely linked to the usefulness of what is being taught and the needs of the world we inhabit [22,23]. These types of changes in the organization of content have a direct effect on classroom work and, ultimately, on the associated methodological strategies, such as the disappearance of the master class and the student's active involvement in the development of the lesson [23,24].

Despite the recent boom in these types of didactical endeavours within the field of teaching, they do all in fact take inspiration from a tradition which dates back to the Enlightenment. This tradition has experienced different manifestations throughout history, with particular developments occurring during the 20th century. Significant contributions were made in the last century by Dewey, Decroly and especially Kilpatrick, who already speaks of a "project method" [25–27]. Authors such as Stenhouse or Bruner can also be cited; they delved further into the idea of the integrated curriculum, although from different perspectives and with distinct nuances [28,29]. More recently, these proposals have been brought to fruition in different tendencies, such as interdisciplinarity, transversality or globalisation. Besides being centred on the classic disciplines of academic study, all these tendencies facilitate the insertion of the concept of sustainability thanks to the incorporation of teaching staff from other departments and disciplines. They also consolidate in the student new capabilities and skills which, previously, he or she would not have been used to using, such as responding more adequately to society's needs and problems [16,30].

In the case of teaching in the discipline of architecture, the current issue which differentiates theoretical from practical classes is of particular interest. These concepts make it difficult to implement the previously mentioned strategies. The Bauhaus of last century was the first to change the rules of the discipline by posing the combination of theoretical education and practical methodology through workshops, the prototyping of ideas, the design of processes and a concern for the social aspect of design [31–33]. In this sense, the *Aura Strategy* revived the Bauhaus tradition and the innovation of new teaching methodologies, placing trust in a blend of disciplines. This strategy came into being with the vocation to include ideas such as the integrated curriculum, transdisciplinarity, transversality and enquiry-based learning in a teaching strategy whose aim was not only to be used by the ESD-US when participating in the different editions of the Solar Decathlon Competition but also to be transferred to other subjects within the study programme, in the Fundamentals of Architecture Degree and other US undergraduate or post graduate programmes.

3. Methodology

This study combines the method proposed by the research team where an integration of different departments and subjects is sought with the work methodology defined by the rules of the competition. The stages of the methodology are as follows:

1. The Solar Decathlon sustainable architecture competition was selected as a tool and strategy to break the rigid departmental structure of the US, while generating a methodology for teaching innovation.
2. For the presentation to the competition, the *Aura Strategy* was proposed, based on two lines of action:
 - a. The constitution of a network of teachers between departments, subjects and centres in the US that offer varying support to the process of the genesis of Projects 3.0-3.1.
 - b. The construction of a teaching methodology based on problem-solving and included in the subjects of the Fundamentals of Architecture Degree, where through responding to the different phases or training cycles (project, financing, definition of systems, prefabrication, transport, assembly, monitoring and disassembly) learning environments are generated with a holistic approach to conceptual, procedural and attitudinal content.
3. Evaluation of the learning environments generated from the results obtained in the competition.
4. Conclusions. Advantages and disadvantages that became evident after the experience of participation in the competition.

The development of the project and construction of a prototype for the SDC reproduced all the stages of design and construction of a real architectural device. During this process, most of the skills required for the professional practice of architecture are put into practice. Active participation throughout this process became a tool for learning through projects.

4. Case Study

4.1. The Solar Decathlon Competition

The Solar Decathlon Competition has been held since 2002, when it was initiated by the United States Department of Energy and is now the most prestigious collegiate competition related to sustainable habitat throughout the world. Since 2010, 18 editions of the competition have taken place in other regions of the world, such as Europe, Asia, Africa, the Middle East and Latin America. In the European version, the competition stems from a line of research whose original purpose was to find model dwellings which reduce the environmental impact in line with the European Union H2020 Framework Programme. Universities from around the world take part in the competition, in collaboration with institutions and private companies, with the aim of designing, constructing and managing a prototype of a self-sufficient dwelling unit powered by renewable energy. However, the construction of the final prototype is not the only aim of the competition. During the teaching and research process, participants work on ten contests—hence the name decathlon. These are: Architecture, Energy Efficiency, Engineering and Construction, Comfort, Marketing and Communication, Electrical Energy Balance, House Functioning, Innovation, Urban Design and Affordability and Sustainability [34]. Student participation in the design and construction process allows them to gain experience, not only in the field of architecture, but also tackle the design and conceptual process from an integrated and holistic perspective.

The main objective comes to fruition in the final two-week phase of the competition, when the different prototypes, now open to the public, are monitored and evaluated in situ at the organisation's designated site. Nevertheless, from a pedagogical and teaching perspective, the most significant part is the process of learning through resolving a social and urban project from which the embodiment of sustainable habitat is derived and subsequently tested with scientific and humanistic parameters.

It should be mentioned that among the various international Solar Decathlon Competitions, in the first Latin American edition (SDLAC 2015), the main premise differed from that of the previous versions of the worldwide collegiate competition, which had focused teams on the pursuit of an eco-efficient prototype [35]. On this occasion, the focus was instead on sustainability in very specific conditions

of environment, position and location: a tropical climate and the problem of social housing and urban growth.

The University of Seville's first participation in this teaching and research initiative dates back to 2010 as a pilot study for the Higher Technical School of Architecture (ETSA). In 2012, the university competed again with the "Patio 2.12" project in collaboration with other Andalusian universities [36–38]. The Aura Project began in 2015 when a transversal team composed of ETSA and members of the University of Santiago de Cali in Colombia presented a proposal for the first Latin American edition of the competition (SDLAC 2015) [39]. In this edition, the Aura Prototype, as well as being awarded third prize in the main SDLAC 2015, received first prize in the "Communication and Social Relevance" and the "Conditions of Comfort" contests. It also received a Special Mention in the "Architecture" contest and third prize in both "Innovation" and "Engineering and Construction". Months later, the Aura prototype exceeded the boundaries of the competition to be awarded the National Research prize in the XIII Spanish Biennial of Architecture and Urban Design [40]. In the Europe 2012 and Latin America 2015 editions, ETSA obtained first place in the "Communication, Marketing and Social Conscience" contest, which highlights the concern for the transfer of knowledge and the social element. They were also awarded the second prize in Innovation in both editions (Figure 1).



Figure 1. Timeline of the editions of the Solar Decathlon Competitions in which the US has participated. Source: SD Team.

4.2. The Aura Strategy in The Latin American and Caribbean 2019 and Europe 2019 Editions of The Solar Decathlon Competition

Despite the fact that the Aura Project was established in 2015 (through participation in the SDLAC15), it was not until the participation in the European and Latin American 2019 editions of the competition that the Aura Project evolved into the *Aura Strategy*. This reformulation came about through the realisation that in order to approach Projects 3.0 and 3.1 in a holistic, integrated and sustainable manner, it would be necessary to draw from different disciplines. This need to come into contact with different disciplines had a dual effect: on the one hand, forming part of the subjects of the Fundamentals of Architecture Degree and coming into contact with different members of the US teaching staff that enriched the prototype's conceptual development and construction process and, on the other hand, generating a new teaching methodology in line with the most innovative proposals arising from research in educational sciences.

The aim of this section is to reflect on the conceptual process which guided the *Aura Strategy* and, consequently, the development of Projects 3.0 and 3.1 for participation in the previously mentioned competitions. This reflection will be addressed from two perspectives: on the one hand, from the formation of the teaching network integrated by centres of the US and, on the other, from the prototype design project itself (Projects 3.0 and 3.1) with its corresponding teaching and research methodology carried out in the heart of the ETSA Fundamentals of Architecture Degree. Additionally, this section aims to demonstrate that the *Aura Strategy* is a truly innovative teaching and research tool committed to the changes higher education demands.

4.2.1. Teaching Network

The prototype design for the SDLAC 2019 and SDEU 2019 editions was addressed holistically with the aim of eliminating barriers between disciplines, faculties and schools in the University of Seville. As a result, the participation in the competition was undertaken by the University of Seville rather than ETASAS, which foments participation by the whole university community irrespective of disciplines. This is one step on the way to interdisciplinarity, and in the case of ETASAS, an initial reflection on the integrated curriculum from a sustainable perspective.

In the current climate of science and research, the concept of sustainability is broad enough for the definition of strategies in the prototype to include the greatest number of disciplines possible, stretching from technology to heritage via landscape, territory and city, without forgetting health, comfort, security and psychological stability [14]. This led the University of Seville's governing body to call on all faculty and school heads and deans to form a completely interdisciplinary team. In 2017, the team underwent substantial transformation and became ESD-US. As a result of this call, members of the Mathematics, Physics, Medicine, Educational Sciences, Communication, Psychology, Economics and Business Studies, Fine Art, Biology faculties, the Office of Cooperation and Development and the Schools of Civil Engineering and Information Technology collaborated on the prototype design. Support was also given by foreign universities, such as the Universidad Técnica Federico Santa María de Chile, the Universidad Católica de Chile, University College London (United Kingdom) and the Universidad de Monterrey de México, as well as public entities such as The Andalusian Energy Agency, the Official College of Architects of Seville and the local council. These make up 8% of the total participation.

Within the US, the variety of profiles shows great diversity. Forty-eight percent of participants were degree students, while 24% were teaching staff. It is also worth mentioning that 2% of participants were members of the administrative staff, Erasmus and postgraduate students, and a total of 23% of heads and vice-deans also signed up to the initiative. Finally, the professional category refers to those institutions outside the US (Figure 2). These figures highlight the breadth and range of the teaching network. Another issue is the data related to the different types of participation involved in both editions of the competitions, where there is a direct relationship between decathletes and undergraduate, postgraduate and Erasmus students, and between faculty members and teaching staff, which were the main roles in the process. The administrative staff were considered collaborators for their supporting role in dissemination from the library and the FabLab. The assistants were the professors from foreign universities. The institutional sponsor was composed of members of the governing body, the management team and external professional institutions (Figure 3).

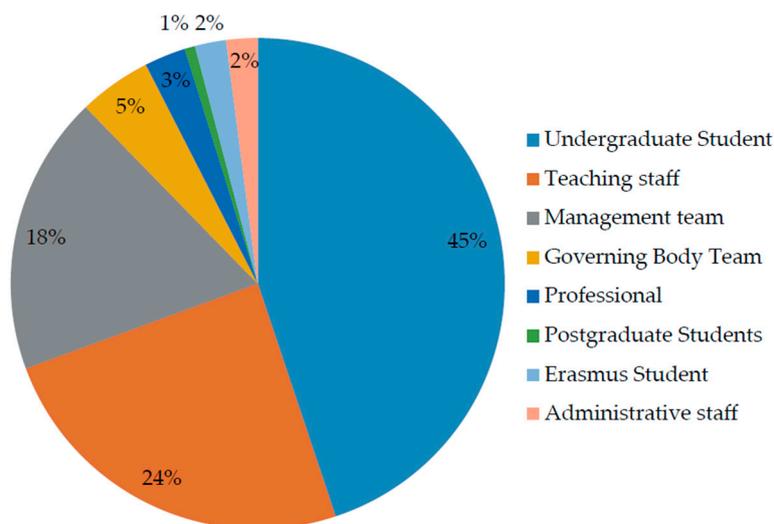


Figure 2. Profiles of participants in the Solar Decathlon Latin America and Caribbean 2019 competition (SDLAC 2019) and the Solar Decathlon Europe 2019 competition (SDEU 2019). Source: SD team.

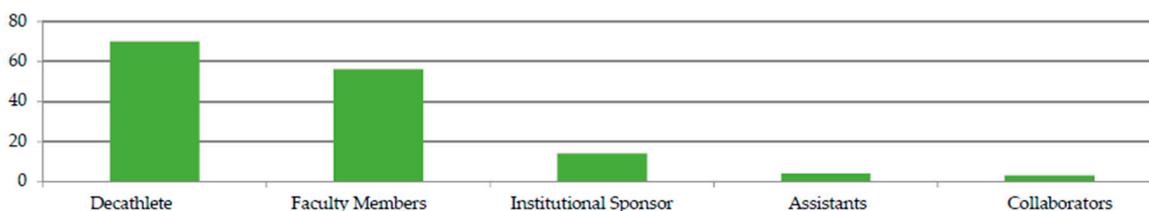


Figure 3. Numbers and roles of participants in SDLAC 2019 and SDEU 2019. Source: SD team.

Even though participation in this edition of the competition was under the name of the US, as can be seen in Figure 4, almost half of the participants—including students, teaching staff and management team—were from ETSA, the driving force and coordinator of the initiative via the Office of the Vice-Dean of Sustainable Habitat. It has also been considered of relevance to note the implication in one way or another in the competition of 19 centres. These supported the initiative, either institutionally or through direct implication in the prototype or another of the ten contests.

As well as the implication of different faculties and centres, this attempt to give a holistic and integrated focus both to the design proposal and the teaching methodology itself has led to other results. The ESD-US has been able to determine that this teaching network (Figure 5) is the basis on which to start working on a teaching matrix that covers all of the University of Seville’s centres interested in participating in future editions of the competition. It also leads to collaborations between different subjects with the aim of implementing transdisciplinary, transversal and sustainable teaching in the US. In this case, the Office of the Vice-Dean of Sustainable Habitat has benefited from this institutional thread at a lesser extent by implementing it in subjects in the Fundamentals of Architecture Degree via Projects 3.0 and 3.1.

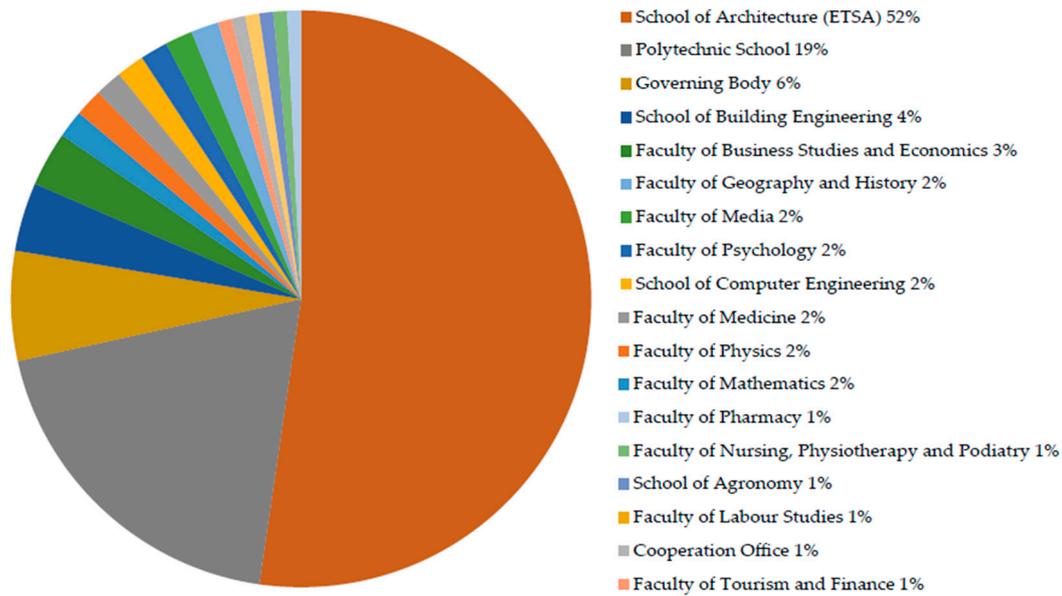


Figure 4. Faculties and Schools Participating in the SDLAC 2019 and SDEU 2019. Source: SD team.

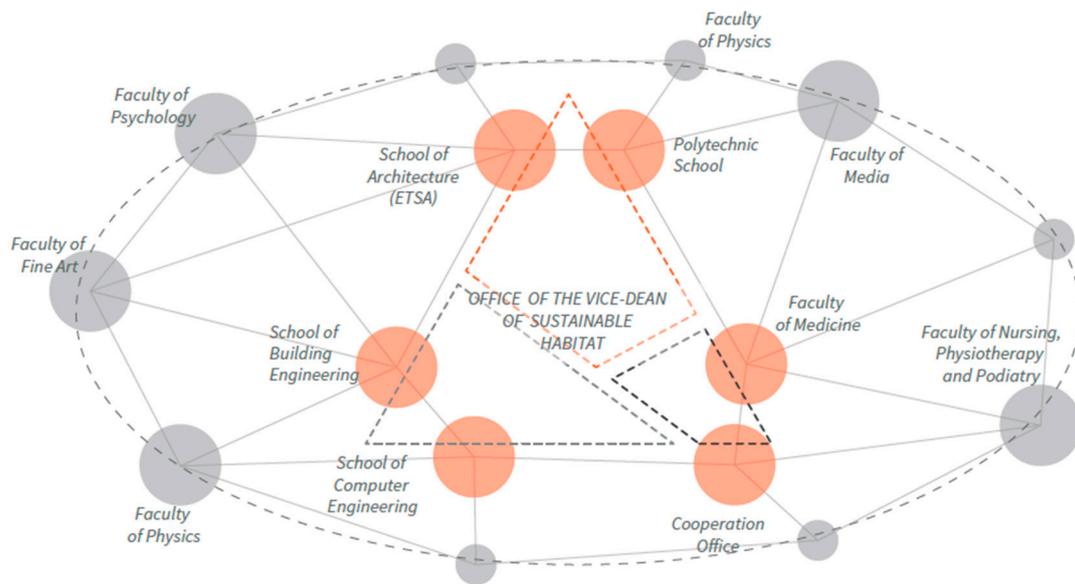


Figure 5. Teaching network. Source: SD team.

4.2.2. Innovation in Teaching Methodology in the Fundamentals of the Architecture Degree: Project 3.0 and 3.1 Prototype Design

As has previously been mentioned, what is truly ground-breaking about the participation of ESD-US in the SDLAC 2019 and SDEU 2019 competitions is the methodology employed to achieve the final design of the prototypes. Greater importance was placed on the process over the final result of the prototype construction. In this learning method, interdisciplinarity, a blend of practical and theory-based classes and an integrated curriculum spearheaded the prototype idea and design development process that was developed by Fundamentals of Architecture students.

The *Aura Strategy* was proposed as a learning tool through the resolution of these two projects. Architecture students actively participated over two years in the complete process of materialising a built artefact as a rehearsal of a professional exercise of the architect understood from the point of view of sustainable construction. The process began with the elaboration of an initial conceptual proposal, which was progressively developed through the collaborative work of students supported

by teachers from different areas of knowledge, culminating in the prefabrication, transport, assembly, testing, exhibition and dismantling of the previously projected housing prototype pavilion. This real experience, carried out from beginning to end, gave rise to the incorporation of not only conceptual contents but, above all, procedural and attitudinal ones that would not have been possible in other learning environments.

This process covered all the phases of the exercise of Architecture as a training activity involving all the competences that students must acquire to complete the Fundamentals of Architecture Degree at the US. The learning results can be verified through the results obtained in the International University Competition Solar Decathlon.

Below, the process of work derived from the contests which define the teaching methodology is described.

Stage 1: Inception

The aims of this stage were to put together the team, look for business and institutional support among others and develop the project's initial proposal (Figure 6). Before the beginning of the 2017/2018 academic year, the basic group of the Solar Decathlon Team of the University of Seville (ESD-US) was formed, made up of a small group of professors and students from the ETSA, which developed the required progress of the projects for the registration in the two competitions: SDELAC'19 and SDEU'19. Both projects were selected to participate in the competitions that would take place in the second half of 2019. The size of the projects and the scope of the issues to be addressed until their completion made it appropriate to build a team that would incorporate a broad range of teacher and student profiles.



Figure 6. Students developing both proposals. Source: SD team.

In this initial phase, during the first months of the year 2018, the ESD-US was aware of the need to implement a transdisciplinary approach in order to solve the problem it was faced with. It was decided that the issue should be transferred to other subject areas within the degree course which may be interested in participating in the design process during 2018/2019. The aim was to build a large and diverse team with the capacity to develop creative, innovative and effective proposals in the field of sustainability. In fact, a teaching matrix was generated by the EDS-US with a hundred and forty-one first, second, third, fourth and fifth-year undergraduate students and three postgraduate students providing a variety of expertise for the prototype design and city proposal through their project work (Table 1). The energy and sustainability module was purposely designed to channel these different collaborations and coordinate the process. It was students of this subject who initiated the

development of the strategic pillars and conceptual schemes, which were then built on by other areas involved in the process. The implication of various teachers in the process led to a teaching support network where the integrated curriculum on which the teaching matrix lies was backed not only by the previously mentioned subjects (defined as the environmental itinerary) and additional studies but also by libraries; laboratories; the Fablab; the E.P.S. workshops; companies based on knowledge and the teaching staff's research groups (HUM 965, RNM 159, HUM 666, TEP 130 and TEP 206), who all play a role in the research and design of the prototypes. A diagram with all the university agents that made up the "curriculum integration" is shown in Figure 7.

Table 1. Scope of the Aura Strategy in different subjects within the Fundamentals of Architecture Degree at the University of Seville.

Subjects	Year of Study	Type	Academic Year	Number of Credits	Degree Course	Number of Students
Projects 10	5th	Compulsory	2017/2018	6	Fundamentals of architecture	23
Environmental Construction and Sustainable Technology	5th	Optional	2017/2018	6	Fundamentals of architecture	5
History, Theory and Architectural Composition 3 (HTCA3)	4th	Compulsory	2017/2018	6	Fundamentals of architecture	15
Project 1	1st	Foundation	2018/2019	6	Fundamentals of architecture	10
Workshop 3	3rd	Compulsory	2018/2019	6	Fundamentals of architecture	4
Energy and Sustainability	5th	Optional	2018/2019	6	Fundamentals of architecture	24
Environmental Construction and Sustainable Technology	5th	Optional	2018/2019	6	Fundamentals of architecture	20
Facilities and Systems for the Design of Efficient and Intelligent Buildings	5th	Optional	2018/2019	6	Fundamentals of architecture	20
Construction 6	5th	Compulsory	2018/2019	6	Fundamentals of architecture	4
Additional studies	Year of study	Type	Academic year	Number of credits	Degree course	Number of students
End of Degree project (TFG)	5th	Compulsory	2018/2019	6	Fundamentals of architecture	5
End of Course Project (PFC)	1st	Compulsory	2018/2019	30	Master in Architecture	5
Master's Project (TFM)	1st	Compulsory	2018/2019	9	Master in the City and Sustainable architecture	6
Total						141

The proposal's overall strategy was based on the 17 SDGs of the 2030 agenda and the 169 goals set out by the United Nations in 2015 [41]. A review of these documents led to the 17 SDGs being grouped into 7 strategies according to the location (Cali and Hungary): environment, water consumption, economy, mobility, society, quality of life and common development. These strategies were also aligned to the 10 contests of the Solar Decathlon Competition 2019 [42]. The use of the SDGs as a starting point was both innovative and in line with international urban development policies. The innovation lies within the inclusive vision of city development taking issues such as climate change, cultural identity, reduction of poverty, drinking water and sewerage, natural resources and decent living conditions into account. Considering these SDGs as research strategies implied the transformation of a series of abstract ideals into real actions for a city. The conceptual strategy was therefore doubled. On the one hand, it was the response to a competition whose principal aim is to revitalise housing stock while taking issues such as local resources and neighbourhood impact into consideration. On the other hand, to also combine these requirements with the 17 SDGs to improve the community's quality of life and welfare. During the project process, the team also aspired to take local opinion into account in

line with the concepts set out in the New Urban Agenda at the Habitat III International Conference, where governability was the key theme. The process of understanding and accepting the SDGs is not restricted merely to the competition period but is transmitted to the students who will go on to become the designers of the cities of the future. At this stage of the process, the History, Theory and Architectural Composition (HTCA3) subject, Energy and Sustainability subject and the Undergraduate and Master's projects have taken centre stage in the generation of information and debates regarding the previously mentioned conceptual issues (Figure 7).

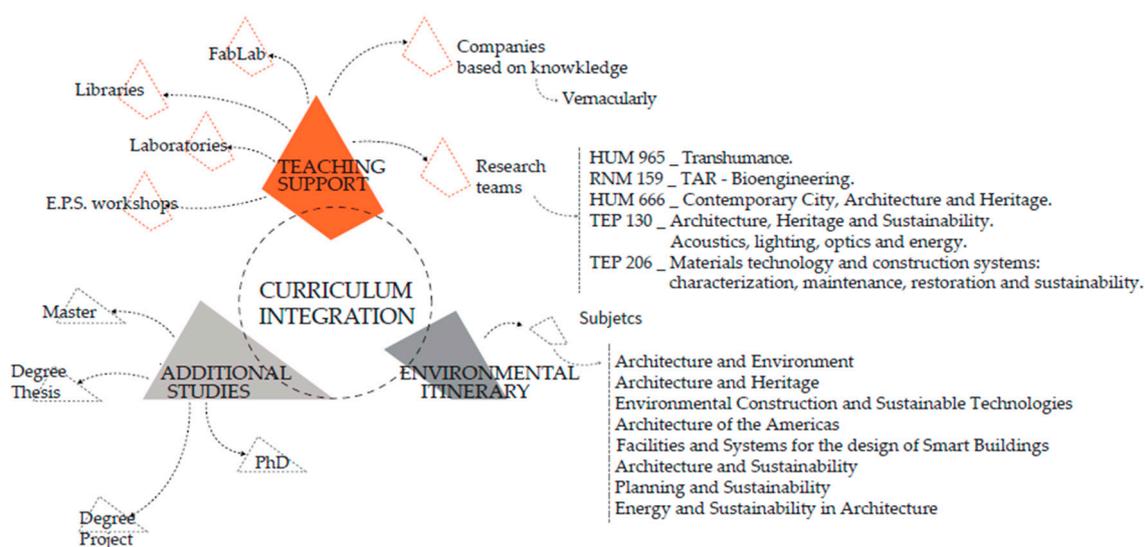


Figure 7. Teaching matrix within the Architecture Degree. Source: SD team.

Stage 2: Development of Design and Construction Documents

Once participation in the final round of both competitions was confirmed (after having been selected from among participating universities from around the world), contact was made with Hungary and Colombia to study both locations and begin the corresponding planimetry for the design and execution of the prototypes. These would be carried out following the strategic lines established in Seville. Through the *Aura Strategy*, the prototype models would draw from the same initial idea: addressing obsolete social housing units through urban rehabilitation strategies rather than increasing building stock with the creation of a new dwelling. Other aims of this stage were the development of the model, audio-visual and media material, the website and the continued quest for financial support. A timeline which includes deadlines and deliverables was set out for all the necessary documentation to be presented (Figures 8–10).

Work was begun on both prototype designs by students in Projects 1 and 10, Facilities and Systems for the Design of Efficient and Intelligent Buildings, Workshop 3 and Environmental Construction and Sustainable Technology under the guidance of their respective teachers. The process was similar to that undertaken in Architecture workshops where knowledge and problem-solving is transdisciplinary and focused on a blend of theory-based and practical classes. Work sessions were also organised in conjunction with other subject areas to gather relevant data for the prototype design. The design proposal took shape with continual review of the working processes, along with the generation of structural plans and calculations, conditioning calculations, construction development and electrical and PV calculations. The preliminary energy analysis, preliminary analysis on market viability and business and fundraising planning were also carried out during this stage.



Figure 8. Planimetry for Aura 3.0 (for SDLAC19) urban rehabilitation strategies. Source: SD Team.

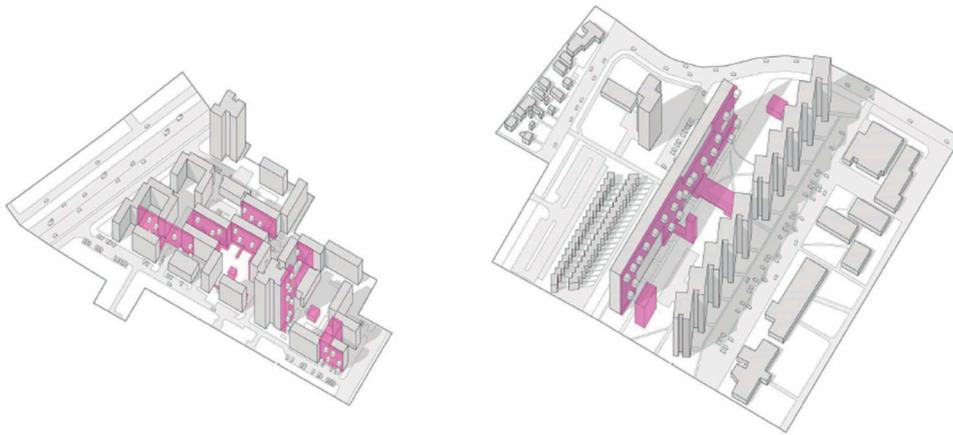


Figure 9. Volumetry for Aura 3.1 (for SDEU19). Source: SD team.



Figure 10. Volumetry for Aura 3.0 (for SDLAC19) and Aura 3.1 (for SDEU19) prototypes. Source: SD team.

Stage 3: Material Development

The aim of this stage was to carry out the necessary work to ensure construction of the prototypes for both competitions. Various parts of these were analogous as the *Aura Strategy* promoted a similar formal (although not constructional due to the different settings and geoclimatic conditions of each) character in both. To do this, an on-site operation plan was drawn up, the final design specifications established and the pre-competition construction tests carried out. In the case of SDEU19, the different pieces which comprise the Pavilion/prototype were put together (as a 1:1 scale model) in the University of Seville and later moved and re-assembled in Hungary. In the case of the Latin American competition,

at the time of writing this article, the final phase of the competition had not yet begun; the pre-assembly of the various parts of the prototype in Colombia by the previously displaced students was planned, and then moved to the competition site (Figure 11).



Figure 11. Aura 3.1 prototype (for SDEU19) being built in the ETSA Sports Centre and loaded onto transport. Source: SD team.

Stage 4: Competition

The main actions in this phase are the defence, intervention and setting up of the pavilion/prototype, as well as its continual evaluation during this final phase of the competition. In this period, all of the team's previously planned strategies were carried out so as to transmit the project in the most efficient way to the various judges participating in the seven subjectively evaluated tests. During this stage, the prototype's functions were adjusted in order to obtain optimal results in the other 10 tests (now objectively evaluated through precise measurements). It is worth noting in this section that, at SDEU19, the ESDUS was awarded first prize in two of the three measured or scientific tests: Comfort Conditions and House Functioning (Figures 12 and 13).

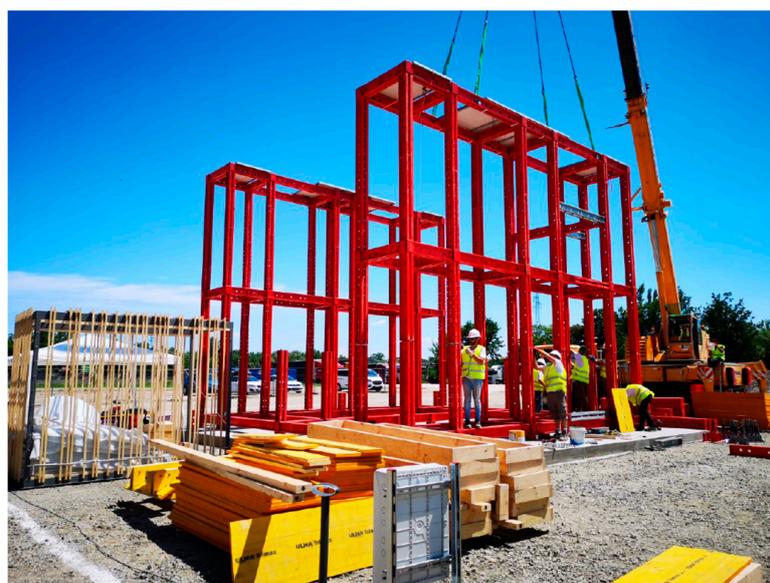


Figure 12. Assembling process of the Aura 3.1 Prototype (for the SDEU19) on the Szentendre Solar Competition site, Budapest, Hungary. Source: SD Team.



Figure 13. Aura 3.1 Prototype (for the SDEU19) on the Szentendre Solar Competition site, Budapest, Hungary. Source: SD Team.

Stage 5: Disassembly

Once the competition has finished, there is a long prototype exhibition period during which the results are analysed and all the documentation relating to the process is prepared. After this period, the Pavilion is dismantled and the parts that can be reused in other competitions transported back to the place of origin. The majority of the prototype is left in the competition country where it will be given a “second operational life” on another site and with a new architectonic configuration. This will also permit future monitoring and study.

5. Results and Discussion

The real added value of this methodological process is the creation of holistic and varied learning environments, in that it provides the possibility for such learning to take place from all possible perspectives. For this purpose, experience is fundamental when it comes to solving the real problems that arise in the course of the project. The acquisition of knowledge, as Kim proposes, is feedback when it comes to thinking about how to do something (know-how) and the ability to articulate a conceptual understanding through experience (know-why) [43].

The use of the ABP method [44] implies a radical break with traditional university teaching and incorporates methodological tools, based on experience, capable of facilitating the absorption of the objectives of future architects within the new structure of the European Higher Education Area (EHEA) [45]. It should not be forgotten that this qualification of future architects is enabling as such, and therefore, it must be active in generating curiosities, reflective and eminently practical. This research is aligned with the precepts of several authors who argue that personal work and tutoring should be encouraged to the detriment of theoretical lectures, in which the role of the university student is generally more passive [46].

The SDC, structured as an ABP, has been a strategic opportunity for learning, not only of conceptual contents but also of procedural and attitudinal contents [47] based on the material execution of the prototype, which, on the other hand, is vital in the qualification of the architect. There are several authors who defend the importance of these and their necessary integration in university

education [48]. The *Aura Strategy* has generated the following learning environments [49], which, as Piqué and Forés classify, are the set of interrelated elements that constitute a system that favours learning. These multiple scenarios are necessary for the handling of transdisciplinary concepts such as sustainability and energy efficiency:

- Innovative learning environments. Through participation in the SDC, students are required to incorporate innovation as a tool of creation as set out in the structure of the competition. Indeed, one of the tests they face is "Innovation and Engineering". In order to do so, they must learn to incorporate nonconventional construction and energy efficiency technologies into the design process, which will bring uniqueness to the prototype presented to the competition.
- Collaborative learning environments among students. One of the fundamental values of this teaching experience is the need to generate an organisational learning model that manages human resources with the participation of more than fifty students and twenty teachers from different centres and disciplines. A system of planning, control and information transmission is needed to facilitate the communication of actions and of the documentation generated, eliminating concepts acquired in noncollective work, such as individual defensive routines, the centralisation of decisions [50] and the concept of authorship.
- Research learning environments. This research is aligned with the trend that advocates that learning, understood as the increase of a person's capacity to carry out effective actions, is based on two aspects that feedback each other. The process itself becomes an experimental laboratory that allows the channelling and acquisition of concepts through the manufacture and execution of real tasks that have been previously projected. In this way, and in a transversal way, students must find the balance between the projected design, its functionality and aesthetics and the tools, materials, means and economy they have at their disposal to carry it out.
- ICT learning environment. The nature of the competition urges participants to operate in an environment that implements all possible tools, both in terms of design and information management. In this way, 3D design programs, BIM environments, energy behaviour simulation programs, programs for construction life cycle analysis and waste management and various online applications and platforms for managing the communication section were used.
- Networking learning environments for teachers. The teaching network that has been created for the incorporation of different disciplines into this collective experience has been explained in previous sections. This network, sometimes virtual and sometimes face-to-face, serves as a model for the students themselves to generate collaborative work dynamics and enhance group work strategies. The participation of teachers from different disciplines, the combination of theoretical and practical classes and the mixture of students from different courses, subjects and ages has ensured the transdisciplinarity and transversality of the process, as opposed to the line traditionally drawn by the study plans of the Fundamentals of Architecture Degree [17].
- Assessment learning environments. The SDC, in addition to the design, construction, transport and assembly phases in which the know-how processes are concentrated, has an implicit evaluation phase. In this phase, the organisation establishes a classification among the participants in the ten categories in which they compete and awards the consequent prizes. In this evaluation phase, the ESD-US won two first prizes and a third prize. This evaluation implies, besides recognition for the students, an opportunity for criticism and later reflection on the nature of the experience. In addition, the TFM and TFG works carried out from processes related to the competition in different disciplines can also be considered as evaluation indicators.

From the results obtained, and aside from the fact that both projects were borne out of the vocation to align with an integrated curriculum strategy, the information gathered proves that the methodology generated has the requirements to advance learning methods through problem-solving—in this case, applied to environmental, urban, cultural and social innovation.

6. Conclusions

The *Aura Strategy* became a real learning tool through the resolution of the projects. For two years, architecture students actively participated in a complete process of materializing an idea, as a test of the practice of the architecture profession, from the point of view of sustainable construction. This real and transversal experience has allowed the generation of different learning environments, gradually incorporating conceptual, procedural and attitudinal content.

The validity of the process versus the mere finality of the competitive proposal, the wealth of the complex situations to be encountered along the way and even the two-way learning between teachers and students make this type of international event an excellent teaching tool. Furthermore, it is stimulating for students to come into contact with the most up-to-date conceptions being developed in other universities and have the possibility to exchange ideas, concepts, concerns and materialisations. Fortunately, in recent years, interesting student-centred higher education competitions have arisen at the international level around the world. Some of these competitions, like the one mentioned in this article, provide an exceptional framework for the exchange of information and an efficient forum for the transfer of knowledge and idealisations generated in academia. They are also considered extremely useful for students' future professional careers.

One of the most revealing conclusions was the importance that participation had for those involved—students and teachers alike—not only in the formal conceptualisation and construction of the prototype itself but also in the initial search for financing, the publicising of the project outside the academic world, the agreements (and disagreements) had within the ESD, the learning in the digital production workshops and monitoring sessions and, above all, in the handling of the management mechanisms of such a unique project in a location so far from the habitual university environment; in other words—outside of their comfort zone. However, in order to make further progress in improving the process, in the next research, there will also be opportunity to study the project impacts and learning, as perceived by the students. All of the above highlights that, in these cases of project-based entries in innovative competitions in higher education, learning depends to a much greater extent on the consideration and development of the process as opposed to the final result, which consolidates the idea of making the process the means to an end. This initiative should serve as the starting point to gradually facilitate a change in focus of university teaching methodology. This should not only adapt itself to the reality of the profession but also align itself, in the same way that other authorities do, to the requirements set out by international bodies such as Agenda 2030 and the 17 SDGs.

With regards to the teaching network, it is important to note the relevance of the decision to compete in these editions as the US, which has led to a connection between different university faculties, departments and subjects. The effort made by the ESD to connect with different centres and faculties within the US with the aim of creating a teaching matrix comprised of teachers and researchers willing to work together in favour of sustainability reveals that the *Aura Strategy*, aside from its role as a competitor in the SDLAC and SDEU competitions, is a good example of how to gradually introduce concepts such as the integrated curriculum, transdisciplinarity and enquiry-based learning into higher education.

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team. To do so, all of the teaching staff who, to a lesser or greater extent included some of the themes related to the Aura Projects in their undergraduate or master's subjects, would need to be mentioned. Finally, it would also be unfair to name all of the decathletes who participated in the process insofar as their presence altered depending on the needs and requirements of the two competitions. Nevertheless, it should be noted that the final responsibility for leading the students fell to the Team Leader of the U.S.S.D. Team.

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