Lecture Notes in Mechanical Engineering

Cristina Manchado del Val
Miguel Suffo Pino
Ramón Miralbes Buil
Daniel Moreno Sánchez
Daniel Moreno Nieto *Editors*

Advances in Design Engineering IV

Proceedings of the XXXII INGEGRAF International Conference 21–23 June, Cádiz, Spain

Springer

Cristina Manchado del Val · Miguel Suffo Pino · Ramón Miralbes Buil · Daniel Moreno Sánchez · Daniel Moreno Nieto
Editors

Advances in Design Engineering IV

Proceedings of the XXXII INGEGRAF International Conference 21–23 June, Cádiz, Spain

Springer

Editors
Cristina Manchado del Val
Departamento de Ingeniería Geográfica y Técnicas de Expresión Gráfica
Universidad de Cantabria
Santander, Cantabria, Spain

Ramón Miralbes Buil
Departamento de Ingeniería de Diseño y Fabricación
Universidad de Zaragoza
Zaragoza, Spain

Daniel Moreno Nieto
Departamento de Ingeniería Mecánica y Diseño Industrial
Universidad de Cádiz
Cádiz, Spain

Miguel Suffo Pino
Departamento de Ingeniería Mecánica y Diseño Industrial
Universidad de Cádiz
Cádiz, Spain

Daniel Moreno Sánchez
Departamento de Ingeniería Mecánica y Diseño Industrial
Universidad de Cádiz
Cádiz, Spain

ISSN 2195-4356 ISSN 2195-4364 (electronic)
Lecture Notes in Mechanical Engineering
ISBN 978-3-031-51622-1 ISBN 978-3-031-51623-8 (eBook)
https://doi.org/10.1007/978-3-031-51623-8

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Paper in this product is recyclable.

Contents

Applications of Photogrammetry for the Reproduction and Substitution of Ornamental Elements on the Façade 1
Paula Triviño-Tarradas, José María Pedraza-Tejero, Rafael Enrique Hidalgo-Fernandez, Rafael Ortiz-Cordero, Pilar Carranza-Cañadas, and Diego Francisco García-Molina

Applying Participatory Design to the Creation of New Mini Sculpture Products from the ARTKIT4KIDS Series 11
Oly Carolina Díaz Torres and María Victoria Esgueva López

Assessment of the Hyperbolic Paraboloids of the Church of the Holy Trinity, Caracas Through Architectural Visualization 21
Mariolly Dávila Cordido

Automated Detection of Rust Defects from 3D Point Cloud Data Through Machine Learning 32
Antonio Fernández, Cristina Pernas, Marcos X. Álvarez, and Lucía Díaz-Vilariño

Automated Processes for Preparing a Point Cloud Within the Scan-To-BIM Methodology 44
Riccardo Tavolare, Michele Buldo, and Cesare Verdoscia

Basic Aspects of Digital Interior Design Used in Virtual Reality and Its Adaptation to the Metaverse. Biomimetic CASE 56
Vicente Jover Peris, Silvia Sempere Ripoll, and Santiago Ferrándiz Bou

BIM Information Interchange: Workflow for a Structural Project 67
Cristina Manchado, Pedro Lastra-Gonzalez, Adrián Faulin, Valentín Gomez-Jauregui, and César Otero

Bridge Management System for Historic Infrastructural Heritage 78
Alberto Aglietti, Carlo Biagini, and Andrea Bongini

Cartographic Applications in Terms of Passenger Transport by Road. Application to the Case of Cantabria 90
Raúl Pereda García, Julio Manuel de Luis Ruiz, Ramiro Benito Salas Menocal, and Javier Sedano Cibrián

Comparison of the Precision of Photogrammetry with Respect to Traditional Methods in Anthropology 98
Olmo León-Plaza, Rafael Ortiz-Cordero, Eloy Girela Lopez, Paula Triviño Tarradas, Cristina María Beltran Aroca, and Rafael E. Hidalgo Fernández

Computational Modelling and Performance Analysis of a River Turbine 108
Ángel Mariano Rodríguez Pérez, José Antonio Hernández Torres, César Antonio Rodríguez González, and Julio José Caparrós Mancera

Creation of the Digital Twin of the Cabo de Palos Lighthouse by Reverse Engineering 119
Francesco S. Pomposo, Dolores Ojados González, Héctor Flores Aparicio, Isidro J. Ibarra Berrocal, and Alessandro Naddeo

Design Methodology for Country Road Rehabilitation 130
César Antonio Rodríguez González, Jesús Rodríguez Pardo, Julio José Caparrós Mancera, José Antonio Hernández Torres, and Ángel Mariano Rodríguez Pérez

Design of a Low-Cost Transtibial Prosthesis for Emergency Situations. The Case of the Doula Leprosarium Digital Fabrication Lab 140
María Alonso-García, Ana Pilar Valerga-Puerta, Luis García Barrachina, and Manuel Martínez Torán

Development of Circularity Calculators 150
M. Luisa Martínez Muneta, Borja Torres García, Ruth Carrasco-Gallego, and Marina Arrieta Dillón

Digital Twin for the Regeneration of Disused Public Buildings 160
Saverio D'Auria, Lorenzo Diana, Francesco Polverino, and Pierpaolo D'Agostino

Discrete Variable Conditional 3D Models in Computer Extended Descriptive Geometry (CeDG): Preliminary Study on Cylindrical Polygonal Sheet-Metal Elbow 170
Manuel Prado-Velasco and Laura García-Ruesgas

Do We Know How to Use a Fire Extinguisher? Training Unexperienced Citizens with Virtual Reality 180
Antonio Ruiz Cartiel, Laura Asión-Suñer, César García-Hernández, and Pedro Ubieto-Artur

Extended Reality from BIM Models Applied to Port Facilities 192
Ana Carrera-Monterde, Valentin Gomez-Jauregui, Cristina Manchado, Pedro Lastra-González, and César Otero

From Spherical Photos to Facility Management. Algorithmic Optimization Procedures for Buildings in BIM Approaches 204
Pierpaolo D'Agostino and Giuseppe Antuono

Geometric Characterization of the SOFC Electrodes Microporosity Using Fractal and Multifractal Analysis 214
Marina Díaz-Jiménez, Pablo Pavón-Domínguez, Miguel Castro-García, and Juan Ramón Marín-Rueda

Geometric Modeling and Digital Restitution of a Two-Cylinder Vertical Compound Steam Engine with Speed Control by Henry Muncaster 225
José Ignacio Rojas-Sola and José Francisco Gutiérrez-Antúnez

Geometric Modeling and Digital Restitution of a Single Cylinder Steam Engine of the Grasshopper Beam by Henry Muncaster 236
José Ignacio Rojas-Sola and José Francisco Gutiérrez-Antúnez

Graphical Applications and BIM Software for Parametric Design of Road Pavements 247
Pedro Lastra-González, Valentin Gómez-Jauregui, Cristina Manchado, and César Otero

Integrating Modularity into Industrialization and Prefabrication of Sustainable Residential Housing Solutions 259
Alberto Cerezo Narváez, Eduardo Cárave Reyes, Magdalena Ramírez Peña, and José Sánchez Ramos

Integration of BIM Methodology and AR Technologies for Piping Learning in Buildings 270
Erika Elefante and Pedro Gabriel Vindrola

Inventory Data Definition for Comparative Sustainability Assessment of Three Types of Retail Space Models 280
Aranzazu Fernández-Vázquez, Anna Biedermann, and José Luis Santolaya Sáenz

Methodology for Estimating the Asymmetry of the Antler of the Iberian Deer from Its CAD Characterization 290
Juan Manuel Montalvo-Gil, Diego Francisco García-Molin, José Manuel Valderrama-Zafra, Concepción Azorit-Casas, and Miguel Ángel Rubio-Paramio

Methodology Proposal Using CAD/CAE for the Quantitative Analysis of Contact Forces in Dental Occlusion 301
Mikel Jauregi, Iñaki Garmendia, Mikel Iturrate, Xabier Amezua, Xabier Garikano, Gaizka Erkizia, and Eneko Solaberrieta

Multivariable Visualization Tool of the Performance of Plug-In Hybrid Electric Buses 309
Jose Miguel Aragón-Jurado, Bernabé Dorronsoro, and Patricia Ruiz

NavAR, an App for Training in Cartography and Maritime Navigation Through Augmented Reality 319
Aaron Miguel Acevedo Reverón, Carlos Efrén Mora Luis, and Jorge Martín Gutiérrez

New Efficient and Automatic Approach to Extract Dendrometric Features from Terrestrial LiDAR Point Clouds in Forest Inventories 330
Fernando J. Aguilar, Abderrahim Nemmaoui, Flor Álvarez-Taboada, Francisco A. Rodríguez, and Manuel A. Aguilar

Numerical Analysis of Multispectral Images for Detection of Buried Archaeological Remains 342
Tomás E. Martínez-Chao

Qualitative Study of the Functional Spaces of the Faculty of Health Sciences of Granada 353
Alberto Moreno García, David Hidalgo, Francisco Moreno Vargas, and Jose Manuel Martinez-Linares

Self-Assessment of the Generation of DTM by Means of Models and Computer Simulation of Data Collection in the Field 364
Antonio M. Pérez-Romero, María del Carmen Marín-Buzón, Rubén Martínez-Álvarez, and Manuel J. León-Bonillo

Simulation with CAD in Robotics. Free Software Versus Proprietary Software in University Teaching 375
Patricia Eva Tato-Sánchez-Del-Valle, Adriana Conde-Fernández, and Pablo Vila-Lameiro

The Collection 'General Maps of the City of Cadiz': Use and Conversion of Scales by Military Engineers of the 18th-Century 385
Joaquín Aguilar-Camacho and Gabriel Granado-Castro

The Matagorda Steam Tugboat: Virtual Reconstruction of the Historical Naval Heritage 396
María Gloria Del Río-Cidoncha, Rafael Ortiz-Marín, Alfonso Martínez–Del Río, and Juan Martínez-Palacios

Three-Dimensional Modeling and Neural Networks Applied to Dental Trajectory Simulation 407
José Antonio Oriozabala-Brit, Xabier Amezua-Lasuen, Mikel Iturrate-Mendieta, and Eneko Solaberrieta-Mendez

Traditional Methodology or Photogrammetry. Analysis of Time and Cost Effectiveness for Planimetric Survey in Archaeological Excavations 414
Rafael Ortiz-Cordero, Rafael E. Hidalgo Fernández, and Paula Triviño Tarradas

UAV and Laser Scanner Point Clouds Integration 424
Julio Manuel De Luis-Ruiz, Javier Sedano-Cibrián, Rubén Pérez-Álvarez, Raúl Pereda-García, and Carolina Ruiz-Fernández

Using Reverse Engineering to Assess Precision of Digital Replicas of Dental Arches in Occlusion 435
Xabier Amezua, Mikel Iturrate, Mikel Jauregi, Xabier Garikano, Gaizka Erkizia, and Eneko Solaberrieta

Virtual Reconstruction of a Biplane Model Aircraft Using Selected Materials and Current Technologies 444
Antonio Marroquí, Ramón Pamies, and Dolores Parras-Burgos

Virtual Recovery of Agricultural-Industrial Heritage. A Case Study: The Olive Oil Mill of Gines (Andalusia) 451
Manuel Morato-Moreno and Emilio Ramírez-Juidías

Artificial Intelligence in the Design Workflow. Review of Tools with Special Focus on Additive Manufacturing 468
Daniel Moreno-Sánchez, Daniel Moreno-Nieto, Pedro Burgos-Pintos, and Sergio I. Molina

Bringing Modular Design Closer to Prosumers. A Guide for User-Centered Design 476
Laura Asión-Suñer and Ignacio López-Forniés

Circularity and Sustainability of the Solar Photovoltaic Value Chain in Spain: A Framework 485
Rosa Esteban-Amaro, Ismael Lengua, Sofia Estelles-Miguel, and Eva Burguera-Sierra

Comparative Study Between Mechanical Properties of Silicone Catalyzed by Tin or Platinum and the More Effective Section 494
Javier Martín-Domínguez, Oscar D. de-Cózar-Macías, E. Beatriz Blázquez-Parra, Isidro Ladrón-de-Guevara-López, and Francisco J. Ortiz-Zamora

Construction of a Recycled Plastic Filament Winder for 3D Printing 502
Francisco-de-Paula Luque-del-Castillo, M. Carmen Ladrón-de-Guevara-Muñoz, Óscar D. de-Cózar-Macías, Francisca J. Castillo-Rueda, Jorge Pérez-García, and José-Luis Martínez-Torres

Design and Assembly of a Shielded Enclosure for Industrial Radiology Using Mixlead® Material 514
Juan Francisco Molina and Miguel Suffo

Design and Geometrical Optimization of a New Mountain Bike Frame 529
Daniel Díaz-Perete, Jorge Manuel Mercado-Colmenero, and Miguel Ángel Rubio-Paramio

Design and Production of Parametric Structure Through Grasshopper 539
Elena Cabrera-Revuelta, Fermín Bañón, Daniel Moreno-Nieto, Daniel Moreno-Sánchez, María Alonso-García, and Ana P. Valerga

Design of Mixtures and Manufacture of Self-Compacting Concretes with Recycled Aggregates (Eco-Concretes): Prediction of Compressive Strength Using Machine Learning Models 549
Jesús de Prado-Gil, Rebeca Martínez García, Fernando J. Fraile Fernández, and Covadonga Palencia

Effect of Age and Technology on the Perception of Obsolescence: Case Study of Domestic Vacuum Cleaning Appliances 562
Patricia Camacho-Magriñán, Miguel-Angel Pardo-Vicente, and Pablo Pavón-Domínguez

Emotion Recognition in Product Evaluation: Leveraging Face Tracking Data in Virtual Reality Environments 571
Almudena Palacios-Ibáñez, Manuel Contero, and Jorge D. Camba

Ergonomic Acoustic Guitar Design Using Additive Manufacturing 578
Álvaro Burgos Pintos, Pedro F. Mayuet, María Alonso García, and Lucía Rodriguez-Parada

Experimental Study of the Influence of Strain-Rate on the Mechanical Properties of Cork and Its Agglomerates 588
Samuel Maza Peón, Ramon Miralbes, and Mario Maza Frechin

Generative Design and Analysis of a Bicycle Frame 598
Carlos Vigil-Fernandez, Valentin Gomez-Jauregui, Cristina Manchado, Pedro Lastra-González, and César Otero

Helmet-Integrated Transducer Coil Design for Deep Transcranial Magnetic Stimulation 608
Ana P. Valerga, Jose Antonio Vílchez Membrilla, and Clemente Cobos Sánchez

How to Identify Patient Needs and Preferences Through Service Design Tools in Shared Decision-Making Processes 615
Yeray Sañudo and Jorge Sierra-Pérez

How to Test a Product. The Influence of Different Visualization Techniques in the Evaluation of General Parameters of an Everyday Product 626
María Alonso-García, Almudena Palacios-Ibáñez, Manuel D. Marín-Granados, and Óscar D. de-Cózar-Macías

Innovative Tooling Solutions for Aircraft Assembly: A Case Study on the Development of Reconfigurable and Lightweight Fixtures 635
Ignacio Laraudogoitia, Ibai Ojeda, Mario Renderos, Edurne Iriondo, Maider García de Cortázar, and Franck Girot

Mapping, Evaluation, and Scaling of Innovative Actions in the Healthcare Sector Using Service Design Methodology 645
Carlos Romero-Piqueras, Sara Juste-Lasierra, Ignacio López-Forniés, and Jorge Sierra-Pérez

Methodology for Colour Selection with Semantic Content in Product Design 651
Miguel-Angel Pardo-Vicente, Sergio de la Rosa, María Jesús Ávila-Gutiérrez, Antonio Cordoba Roldan, and Lucía Rodríguez-Parada

Modeling and Simulation of 3D Supports Manufacturing 659
Julio José Caparrós Mancera, José Antonio Hernández Torres, Cesar Antonio Rodríguez Gonzalez, and Ángel Mariano Rodríguez Pérez

Numerical Methodology to Simulate Passive Safety Posts Made of Composite 667
Ramon Miralbes, Francisco Javier Ortun, and David Ranz

Promoting Circular Economy Around Plastic Waste: A New Design of Recycled Plastic Shredder 679
José-M. Tejero-Olalla, M. Carmen Ladrón-de-Guevara-Muñoz, Óscar-D. de-Cózar-Macías, José Macías-García, Laia Miravet-Garret, and Fernando Gómez-Hermosa

University-Company Project for the Active Learning of Graphic Expression Through the Processes of Analysis, Conception, Representation and Manufacture of a Stand 691
María Senderos Laka, Alexander Martín-Garín, Iker Laskurain-Iturbe, and Iñigo Leon Cascante

Additive Manufacturing Technologies: An Actual Overview 700
Michele Calì, Giuseppe Laudani, Giuliana Baiamonte, Alberto Acri, Gianfranco Di Martino, and Salvatore Massimo Oliveri

Advanced Solutions for Flexible Tools for Air-Craft Assembly: Lattice or Reticular Structures 711
Ibai Ojeda, Ignacio Laraudogoitia, Mario Renderos, Edurne Iriondo, Unai Alonso, and Franck Girot

Application of Sustainability Strategies in the Design of an Electric Scooter 722
Enrique Lacasa, Miguel Pena, Jose I. Valero, Aranzazu Fernández, and José L. Santolaya

Comparative Analysis of Environmental Impacts of Fair Trade Organic Coffee Compared to Conventional Coffee Through Life Cycle Assessment 730
Nerea Aguirre, Maider Iturrondobeitia, Ortzi Akizu-Gardoki, Erlantz Lizundia, and Rikardo Minguez

Comparison of Motion Capture Technologies: Accelerometry Versus Kinemetry 739
Aarón Rosales-Pérez, Rodrigo Sánchez-Movellán, Pedro F. Mayuet-Ares, and Francisco Fernández-Zacarías

Design and Manufacture of 3D Bioprinting Optimisation Tools Using Additive Manufacturing Technologies 751
Laura Mendoza-Cerezo, Jesús M. Rodríguez-Rego, Antonio Macías-García, Antuca Callejas-Marín, and Alfonso C. Marcos-Romero

Life Cycle Assessment via Software Tools: Result Analysis in a Bicycle Study 761
Jacid Montoya-Torres, Ortzi Akizu-Gardoki, and Maider Iturrondobeitia

Study of Additives Designed in 3D to Lighten Synthetic Marbles 768
Jesús M. Rodríguez-Rego, Juan P. Carrasco-Amador, Antonio Guerra-Sánchez, Antonio Macías-García, Manuel Alfaro-Domínguez, and Alfonso C. Marcos-Romero

Sustainability of Pumped Hydropower for Short-Term Storage of Wind Farm Electricity 778
Eduardo Martínez-Cámara, Mercedes Sáenz-Baños, Efrén Tarancón-Andrés, David Arancón-Pérez, José Carlos Gomez-Chomón, and Jacinto Santamaría-Peña

Test Tube Manufacturing for Mechanical Tests from Recycled Materials 786
Ángel Mariano Rodríguez Pérez, Julio José Caparrós Mancera, José Antonio Hernández Torres, Aguasanta Miguel Sarmiento, Jose Miguel Dávila Matín, and Beatriz Aranda Louvier

The Effect of Production Parameters on the Surface Roughness of AlSi10Mg Parts Produced by Laser Powder Bed Fusion 794
Omer Furkan Ersoz and Turker Turkoglu

Variation of Mechanical Properties of ULTEM™ 9085 and 1010 Depending on Orientation and Printing Direction 801
Blanca Boado Cuartero, Javier Pérez-Álvarez, and Elena Roibás Millán

Adapting Graphic Expression Subjects to New Professional Contexts. The Case of Bachelor's Degree with Defense Profile 814
Marcos Pueo, Silvia Guillén-Lambea, Jorge Sierra-Pérez, Myriam Cilla, and Mónica Delgado

Adapting Graphic Expression Teaching During the Pandemic: A Turning Point 824
Adriana Conde-Fernández, Patricia Eva Tato-Sánchez-Del-Valle, and Pablo Vila-Lameiro

Adaptive Learning Web Application Applied to Engineering Graphics Teaching 831
Pedro Victor Gabriel Cerna, Antoni Perez-Poch, Francisco Alpiste Penalba, Miguel Brigos, and Jordi Torner Ribé

An Analysis of Academic Outcomes in Graphic Expression Subjects in Engineering by Considering Students' Admission Profiles 842
Mireia Puig-Poch, Elisabeth Quintana, and Jordi Voltas Aguilar

Anamorphosis to Improve Students' Perception of Geometry. Intervention Methodology in Upper Secondary Education 853
Irene Sánchez-Ramos, David Mediavilla-Martín, and María Jesús Casati-Calzada

Creating Didactic Resources Using Additive Manufacturing 862
Magdalena Ramirez-Peña, Jorge Salguero, Juan Manuel Vázquez, Irene Del Sol, and Moises Batista

Design and Fabrication of a Manipulative System to Aid in the Understanding of the Fundamentals of the Direct Dihedral System 869
Xabier Amezua, Gaizka Erkizia, Iñaki Martin, Mikel Jauregi, Angel P. Manso, Eneko Solaberrieta, and Jose Antonio Oriozabala

Development of an Application for the Automated Evaluation of 3D Modelling in Industrial Parts 875
Laura García-Ruesgas, Jaime Areñas-Morales, Francisco Salmerón-Medina, and Cristina Torrecillas

Development of an Augmented Reality Application to Improve Understanding of the Graphic Engineering Fundamentals 885
Xabier Amezua, Ander Tolosa, Mikel Iturrate, Gaizka Erkizia, Mikel Jauregi, Xabier Garikano, and Eneko Solaberrieta

Evaluation of the Emotional Response of New Product Concepts Through the Use of Advanced Sketches 893
Sergio de la Rosa, Miguel-Angel Pardo-Vicente, Pedro F. Mayuet, and Lucía Rodríguez-Parada

Gamification of the Subject Graphical Expression in University Bilingual Degrees 903
Diego-José Guerrero-Miguel, María-Belén Prendes-Gero, Martina-Inmaculada Álvarez-Fernández, and Celestino González-Nicieza

Geometric Dimensioning and Tolerancing Method Based on the Assembly Diagram of a Mechanical Device. Case Study of a V-axis Positioning Device 911
Fernando Brusola, Ignacio Tortajada, Carlos Rubió, Beatriz Defez, Francisco Roca, and Jorge Montalvá

Graphic Expression for 3D modelling: Virtual Reality and Creation 926
David Arancón Pérez, José Carlos Gómez Chomón, Eduardo Martínez Cámara, Efrén Tarancón Andrés, and Jacinto Santamaría Peña

Improving Spatial Rotation Skills Through Video Games. A Pilot Experience in the First Year of Engineering 936
José S. Velázquez, Francisco L. Sáez-Gutiérrez, Rafael García-Ros, Carmelo Gómez, and Francisco Cavas

Introducing Industrial Design Concept to High School Students Through Innovative Graphic Engineering Techniques 943
Jorge Manuel Mercado–Colmenero, Diego Francisco García–Molina, Miguel Ángel Rubio–Paramio, and Cristina Martín–Doñate

New Approach to Learning Construction Concepts Through BIM Methodology 954
Mar Melgarejo-Torralba, Dolores Parras-Burgos, Emilio López-Salmerón, Francisco J. F. Cañavate, and Daniel G. Fernández-Pacheco

New Gazes at the Industrial Design of the Bauhaus from Descriptive Geometry 968
María del Carmen Vílchez-Lara

Project "Acércate a la Ingeniería": Promoting Scientific and Technological Vocation of Secondary Education Students 979
Annabella Narganes-Pineda, Roberto E. Araña-Suárez, Mariana Hernández-Pérez, Paula González-Suárez, Pedro M. Hernández-Castellano, and María Dolores Marrero-Alemán

Study of the Current Situation of Technical Drawing Teaching at Spanish Universities 989
Pablo Pando Cerra, María Belén Prendes Gero, Miguel Muñiz Calvente, and Marta Menéndez Fernández

The ISO-GPS Language, a Proposed Interpretation of ISO 1101: 2017 996
M. Ángeles Esandi Baztan and Antonio Valin Ortega

Author Index 1005

Qualitative Study of the Functional Spaces of the Faculty of Health Sciences of Granada

Alberto Moreno García[1](✉), David Hidalgo[1], Francisco Moreno Vargas[1], and Jose Manuel Martinez-Linares[2]

[1] Departamento de Expresión Gráfica, Universidad de Granada, Granada, Spain
amorenog@correo.ugr.es, dhidalgo@ugr.es
[2] Departamento de Enfermería, Universidad de Granada, Granada, Spain

1 Introduction

Project description. The Faculty of Health Sciences of Granada results from the International Competition (2006–2007). The spatial and programmatic proposal is born from optimizing the urban determinations of the Health Campus, to achieve a university center that houses three degrees (Nursing, Physiotherapy and Occupational Therapy). The maximum open spaces for qualified relationship and transit are proposed, making possible places of exchange between researchers, students and teachers with a surface area of 16,200 m^2.

The architects Marta Pelegrín and Fernando Pérez designed a compact and simple building for the new Faculty of Health Sciences. The concrete facades unfold and generate slight breaks that, like 'shadow lines', propose to attend to the different scales of approach, perception and relationship that the building must maintain with the Campus, with the hospital and the residential neighborhood in transformation (Figs. 1 and 2).

The new faculty presents two entrances at both ends to channel the walk and circulation inside, saving about four meters of difference in topographic level. The classrooms are arranged throughout the building, sequencing double-height spaces, patios and skylights, which enrich transit. On the 0th floor, the theory classrooms are arranged, mainly for the Physiotherapy and Occupational Therapy degrees. On the first floor are the main teaching spaces planned in amphitheater mode, gymnasium and hydrotherapy rooms, as well as administration and deanery spaces, as well as the SUM room and the degree room, also in amphitheater mode, taking advantage of the design that has been executed of the structure. On the second floor you can find reprography, theoretical-practical classrooms, laboratories and the computer room. Finally, on the third and last floor, 130 m long and 19 m wide, is the student delegation, plus theoretical-practical classrooms, the cafeteria and the walkable garden roof, topped by an 8-story 40 × 19 m tower. On the 4th and 5th floor of the tower are the computer rooms, the student delegation and the reading room.

Special care has been taken to qualify these spaces, optimizing the use of natural light, which has already won an international DayLight Spaces award (Austria 2014). On the upper levels are the offices, laboratories, practice rooms equipped with both consumables and sanitary inventoriable material, and a research area. The planning of

C. Manchado del Val et al. (Eds.): INGEGRAF 2023, LNME, pp. 353–363, 2024.
https://doi.org/10.1007/978-3-031-51623-8_34

Fig. 1. PTS Campus

Fig. 2. PTS Campus

the Health Sciences Campus, resulting from an international competition, determined the general volumetry of the faculties, and required a shape for the buildings in a 9-storey tower and a 130 m long and 19 m wide bar. Said project wanted to convert this determinism into one more variable and tighten said parameters to provide the volume capable of as much public space and relationship spaces as possible. Finding places to meet, exchange, relax and walk within the faculty itself was part of the competition proposal.

The space must be one more element of the teaching activity and, therefore, it is necessary to structure and organize it properly. We understand that the environment of the center and the classroom constitutes a very valuable instrument for learning, and for this reason it must be the object of reflection and planning for teachers and students. It includes the architectural characteristics, which should be at the service of the educational project of the center and its didactic models, although the reality is usually the opposite, that is, it is the building that determines the program and the activities, as well as the learning models. The equipment and didactic material are other important characteristics in this topic. Through the good use of these elements, the achievement of the objectives, contents, attitudes, values… Can be facilitated or hindered. That the centers propose (Eliécer 2016) turning it into an educational agent that invites certain actions and conditions a certain type of social interaction [4]. Understood from this perspective,

the space becomes a didactic factor since it helps to define the teaching-learning situation and allows the creation of a stimulating environment for the development of all the abilities of the students, as well as favoring the autonomy and motivation of the teaching team. And teachers. Any space in the faculty is likely to be an educational space and, therefore, it should be organized coherently with respect to the project and program that you want to develop.

It is, therefore, the student space and, more specifically, the learning environment made up of physical, methodological and social aspects that make up the space in which people experience different experiences. Likewise, after reviewing the literature, in a certain way, it can be ensured that the space is an essential educational agent of all curricular planning, since it helps to define the teaching-learning situation and allows the creation of a stimulating environment capable of favoring, for example, the autonomy and motivation of all the people who house it. In the same way, Pozo (2017) contributed that the classroom space should not be something superfluous and merely decorative, Rather, it must be an educational variable that facilitates the achievement of objectives in relation to the implementation of the teaching-learning processes.

Based on everything said so far, the importance of a space and the relationship it can maintain with the teaching-learning process (in the case of educational spaces), it is believed appropriate to carry out an investigation that reflects how people live the educational space to which they have to go daily during their university education stage. To achieve this, a voice is given to those who carry out this action: students and teachers of the Faculty of Health Sciences of the University of Granada (UGR).

Therefore, the research question that arises is: What are the experiences of the faculty and students of the Faculty of Health Sciences of Granada, in relation to the functionality of the building?

2 Methodology

2.1 Study Design

The design of the study carried out is of a qualitative descriptive type, which is the most appropriate as a first approach to this topic of study due to the little existing bibliography on this topic using qualitative research as a research methodology (Fernández 2020).

2.2 Participants and Context

The study was carried out in Granada. The participating people were students and teachers of the Faculty of Health Sciences of the University of Granada, selected by convenience sampling, directly in their work or study environment [7], during the month of March. of 2022. The inclusion criteria for the students were: to be enrolled in this center and to have completed all the courses in this same faculty. On the other hand, for the selection of the teaching staff, it was taken into account that: they would have to have a teaching experience of at least 5 years in this same center. In both cases, non-acceptance to participate in the study will be an exclusion criterion. Interviewing students and teachers separately made it possible to identify the relevant information and triangulate the data.

The contact was made directly at the Health Sciences Campus of the University of Granada, where potential participants were personally approached. Only those who agreed to participate were included in the sample. There was no prior relationship between the researcher and anyone, who could previously know the origin and objectives of the study. Initially, 50 people were contacted, of which 28 did not agree to participate due to lack of time and interest to spend the necessary time conducting the interview. The final sample consisted of 22 people, whose characteristics are included in Tables 1 and 2.

Table 1. Characteristics of the participating people (students and teachers)

Código	Edad	Sexo	Curso	Estudio previos sanitarios	Experiencia laboral sanitaria
ES01	20	Hombre	1º	Si	No
ES02	38	Mujer	1º	Si	Si
ES03	21	Mujer	3º	No	No
ES04	24	Mujer	Master	Si	Si
ES05	20	Mujer	3º	No	No
ES06	22	Hombre	2º	Si	Si
ES07	18	Mujer	1º	No	No
ES08	20	Hombre	1º	Si	Si
ES09	18	Hombre	1º	No	No
ES10	20	Mujer	1º	Si	No
ES11	18	Mujer	1º	No	No
ES12	25	Mujer	Master	Si	Si
ES13	24	Mujer	3º	No	No

2.3 Data Collect

22 semi-structured interviews were carried out to collect the data that lasted between 5 and 20 min. A provisional script of questions was designed to respond to the formulated objectives. This script was piloted with three people to check the clarity and relevance of the questions. The necessary modifications were made and the final script was obtained.

The interviews were carried out in person in March 2022, in the facilities of the Faculty of Health Sciences, in the outdoor garden areas. They were made by the author of this work after receiving training to do so. There was no other person present in them. Participants were offered the chance to view the transcripts of the interviews to check their accuracy. With this number of interviews, the necessary data saturation was achieved [12].

Table 2. Characteristics of the participating people (students and teachers)

Código	Edad	Sexo	Años experiencia docente	Años experiencia docente en esta facultad	Profesor/a del grado de
PR1	30	Mujer	6	5	Enfermería
PR2	64	Mujer	10	7	Enfermería
PR3	46	Mujer	22	5	Terapia ocupacional
PR4	63	Mujer	39	11	Enfermería
PR5	34	Mujer	10	10	Fisioterapia
PR6	43	Hombre	13	13	Enfermería
PR7	33	Mujer	6	5	Enfermería
PR9	39	Mujer	15	8	Fisioterapia

2.4 Analysis of Data

The interviews were audio-recorded and later transcribed verbatim. Field notes were taken, especially regarding non-verbal language, which were incorporated into the data analysis. A thematic analysis of the data obtained was carried out [3]. For this, a series of codes were initially generated that identified the textual quotations of the participating people and that provided the most relevant information to respond to the objectives of the study. These codes were grouped into subthemes, based on their relationship with each other, and these in turn into themes or categories, being the results of this study. Finally, the report was made including some examples taken from the interviews, relating the analysis with the objectives of the research and the existing literature, communicating the results to the participants for their verification. The program used for data analysis was ATLAS.ti version 7 for Windows (Scientific Software Development GmbH,

2.5 Ethical Considerations

The criteria of the Declaration of Helsinki for research with people were followed and permission was obtained from the ethics committee of the UGR with reference number: 2676/CEIH/2022. Participants were provided with an information sheet about the study and they were required to sign an informed consent prior to conducting the interviews. They were free to withdraw from the study at any time without consequences.

The confidentiality of the data and the anonymity of the participants were preserved by replacing their names with an identifying alphanumeric code. These data are kept by the researcher and inaccessible to anyone else, in compliance with Regulation (EU) 2018/1725 of the European Parliament and of the Council, of October 23, 2018, regarding the protection of natural persons with regard to treatment. of personal data by the Union institutions, bodies and agencies, and to the free movement of such data, and repealing Regulation (EC) No. 45/2001 and Decision No. 1247/2002/EC.

2.6 Scientific Rigor

For the scientific rigor of the study, the criteria of Guba and Lincoln [10] have been followed: credibility (the participants had no previous relationship with the researcher, and the final script of interview questions was written taking into account the contributions of the pilot interviews carried out, and the transcript of the interviews was returned to the participants to verify the existence of interpretation errors that could have been made when transcribing), transferability (a detailed description of the context of the participants is provided, attaching a description detail of the methodology followed, as well as the sociodemographic characteristics of the participants).

Dependability (there is congruence between the type of study design-data collection methodology-type of data analysis carried out, and data triangulation was made between the information provided by the two groups of people interviewed), and confirmability (they returned the transcriptions to the people interviewed to confirm the results, literal quotes provided by the participants are provided, the results obtained are compared with the existing literature).

3 Results

In the primary analysis of the interviews, a total of 242 citations grouped into 171 codes were obtained. In a second stage of the coding, the relationship between several codes was established, generating families of codes. Each family refers to a category of the perception of functionality and utility. A total of 19 families were obtained, which in turn were grouped into subtopics (subcategories), and finally into the identified topics (categories). These topics were:

3.1 Functionality of the Theory Classrooms

All the people interviewed have a very similar idea regarding the perception of functionality, which is manifested as the set of characteristics that make something practical and utilitarian.

Within the teaching spaces, a distinction was made between classrooms for theoretical teaching and practical teaching. In the former, ergonomic conditions (temperature, lighting and noise) and technological aspects (good communication with the concierge and adequate technological resources) were highlighted as positive aspects. With regard to ergonomic conditions, it was highlighted how good acoustics, good artificial lighting, and the temperature of the theory classrooms favored concentration.

PR05: "*…the spaces and what is for computers are properly separatedand screens we have a blackboard, projector, teacher's table, chair, that is, everything is quite wide…*´´

S4: "*…the light can be adjusted to be more comfortable and to better see the computer screen.*

However, the negative aspects related to the ergonomics of the theory classes had a greater impact. These were: a bad layout, uncomfortable furniture and the small size of the classrooms.

PR07: "The furniture itself, although what I don't like is that in the end you can't *access to all the students through the fixed bench chairs and you are in themain corridor*

or you are in the next corridor and one remains as narrow and in the end you end up being on one side and the students on another…´´

ES02: "…I see the classrooms with very little space between the student and the part of thewriting. ANDBeing a new campus, the tables are quite uncomfortable and it is difficult to enter because the corridors are narrow.´´

All this makes difficult the concentration that has to be maintained during the theoretical sessions.

IS11:"It makes it difficult because the space is very small, that is, the first rows, ifis that they are closer together and the last one has more space, but it is very complicated because in the end you are trying to serve and the tables own move and you are with the computer taking notes and you you lose concentration because you have to be checking that the table does not move and move space you bump into your partner as you type. Is impossible

It must also be emphasized that due to COVID-19 and to comply with hygienic conditions, both students and teachers agreed that the cold and noise caused by having to keep the windows and doors open further hindered the ergonomics and concentration.

ES11: "In the theory classroom regarding temperature now with the topic COVID *that the windows are open it is true that it complicates the situation a bit because in the end we are on a seventh or fourth floor there is wind, there is noise from the street, you have to have the windows open, so makes it difficult.´´*

Regarding the size and space of the theory classrooms, there was a consensus among students and teachers that it is somewhat small.

PR06: "...the furniture for the students, the single bench, for example, I see them *quite a problem of space, they are small in fact one of the big ones problems that we have especially when evaluating students is that being such small classrooms we require a lot of staff to be able to to watch in the exams and because they agree too close together. Notice that with the issue of COVID, it was not even possible to respect the spaces or the safety distance*!" (Fig. 3)

4 Discussion

The general objective of this study was to explore the experiences of teachers and students derived from the teaching and student activity in the Faculty of Health Sciences of the University of Granada. For this, both the perceptions of students and teachers, collected through personal interviews, were taken into account. With all this, different aspects related to ergonomics were revealed, both in theory and practice classrooms, and how the current COVID-19 pandemic has come to alter all these ergonomic elements.

Regarding the work spaces, the teachers highlighted the dimensions of the offices and their lighting and ventilation conditions, for their part, the students referred to aspects related to the capacity of the study rooms, especially during exam times. Regarding the accessibility of the building, both the adaptability of the classrooms and other elements that facilitate access were highlighted. Finally, in terms of circulation spaces, different aspects related to both equipment and ergonomics were also highlighted.

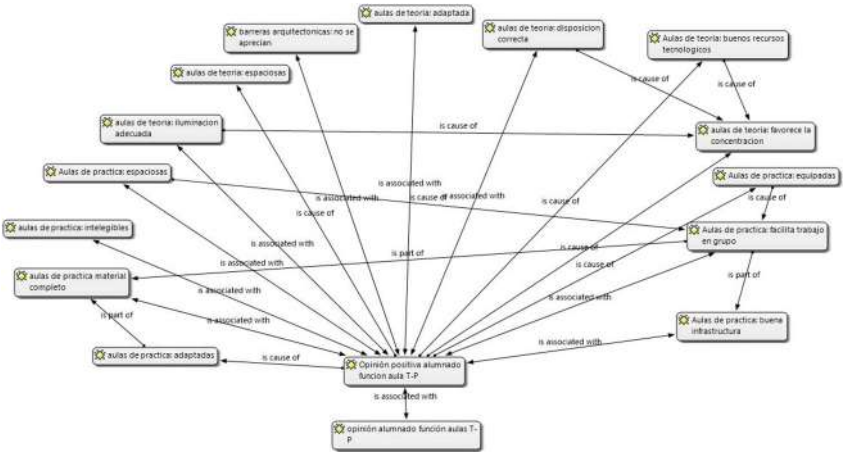

Fig. 3. Network view of the positive opinion of the students about the function of the theory and practical classrooms. *Source* ATLAS.ti.

Regarding the ergonomic conditions of the teaching classrooms, the good conditions of artificial lighting that comes to comply with the opinions of the regulations were revealed.03-UNE-12464.1 (2022) lighting in schools. Regarding the recommended lighting for classrooms according to current regulations, it is considered appropriate that the lighting for classrooms be 300 lux.

In a study carried out by the Ministry of Education (2018), some recommendations are given for the walls that make up the interior environments of educational buildings, regarding their roofs, their surface should be as white as possible, with a reflection factor of 0.75. or 75%, because this way it will reflect the light in a diffuse way, dissipating the darkness. Added to this is the savings in artificial lighting. Wall surfaces located at eye level can cause glare, so pale colors with reflection factors of 50–75% are usually suitable for walls, always in a matte or semi-gloss finish. Floor finishes should be slightly darker in color than the walls and ceilings to avoid glare. The reflection factor of the floors should be between 20 and 25%. 'In the faculty under study, these parameters comply with the regulations.

Different results were found in the study carried out by (Alvarez et al. 2022) at the Public Faculty of the University of Manizales, where the students also highlighted the lack of natural light due to the poor orientation of the classroom. If there was a coincidence in both studies in the fact of excessive noise in the classrooms, as well as in the inadequate temperature inside. However, in the present study from the Faculty of Health Sciences, this was attributable to the hygienic measures that have had to be adopted due to the COVID-19 pandemic.

According to the WHO (World Health Organization) and the International Organization for Standardization (ISO) - 22955:2021 the noise levels in decibels [db(A)] for educational centers should be: classrooms 40 db(A), reading rooms 35 db(A) and common areas 50 db(A). In a study carried out by the magazine of the Faculty of Industrial Engineering, [13] noise tends to interfere in communication with the audience, where

the speech is more important. Speech perception is especially important in classrooms or lecture halls, and in situations where listeners are hard of hearing. For a distance of 1m between the speaker and the listener, the effects generated by background noise levels are known: with 45 dB(A) a relaxing and 100% understandable speech is produced, at 55 dB(A) a speech can be clearly understood, and at 65 dB(A) a speech has to be delivered with more vocal effort to be understood. Once again, in the faculty under study, these parameters comply with the regulations.

Regarding the negative aspects related to the ergonomics of the theory classes, one aspect that was frequently mentioned was the small size of the classrooms, which made it not conducive to concentration. Coinciding with the article Alvarez et al. (2019), the small dimensions of the classroom were also highlighted, which make it impossible to organize the space in different ways. Similarly, the article Gareka (2018), revealed the dissatisfaction on the part of the students with the ergonomic conditions of the theory classrooms for not contributing to favoring concentration during the development of the classes.

The dissatisfaction of the teaching staff and the student body with respect to the practical rooms is also presented, again due to the existing discomfort due to the temperature or noise. Not considering ergonomic measures harms health, causing fatigue and stress, as stated by Felipe et al. (2017), all of which affects the teaching-learning process. On the other hand, as strong points of the practical classrooms, the fact of the ease of working in groups due to the arrangement of the material, among other things, was highlighted. This was something that was also revealed in the article by (Álvarez Díaz et al. 2019), by agreeing on the positive aspects of the mobility of basic classroom resources, such as movable furniture, allowing social interaction. Along with this, the presence of technological resources in the class, such as computers and a projector, are resources that allow interaction with information and communication technologies.

As regards the work spaces, a distinction was made between the offices for the work of the teaching staff and the study rooms as spaces for study. In the first, the ergonomic conditions (space, acoustics and comfort) were highlighted as positive aspects, thus complying with the Spanish technical prevention standard. NTP 503: Acoustic comfort: noise in offices, (Ministry of Labor and Social Affairs 1998) on acoustic comfort mentioned above, as well as anthropometric aspects, such as the existence of adequate furniture. The latter differs from the opinion of the students in the work of Gareka (2018), where the widespread discontent of the study spaces was revealed due to the poor use of spaces.

Lastly, with regard to accessibility to the physical environment, the negative aspects in terms of the presence of architectural barriers predominate, with the discourses in which the existence of said limitations not being mentioned being exceptional. The negative aspects regarding accessibility and capacity within the classrooms were the narrowness of the side aisles, the presence of stairs and the reduced spaces between rows in the theory classrooms. These aspects differ from the article of Alvarez et al. (2019), where an access without difficulty or architectural barriers to the interior of the classroom does stand out.

According to him Technical Document on the Andalusian Accessibility Decree (Andalusian Government 2011) in article 66 in relation to the uses of buildings, the dimensions of vestibules (1.50 m in diameter), the minimum width of corridors

(1.20 m), the slopes of vestibules and corridors (4% and 2% respectively) without the presence of steps. In the faculty under study, these parameters comply with the regulations of article 66 of the Technical Document on the Andalusian Accessibility Decree (Andalusian Government 2011).

5 Conclusions

Regarding the theory classrooms, negative aspects related to ergonomics were highlighted, which do not favor a good concentration, while the practical classrooms did stand out for their ergonomic conditions, facilitating group work due to the arrangement of furniture, among other things. Of the study rooms, the ergonomic conditions (space, acoustics and comfort) and the anthropometric aspects of their furniture were highlighted as positive aspects. To solve the negative aspects in theory classrooms is proposed eliminate the benches of fixed seats and replace them with individual tables, leaving spaces for circulation between them and favoring concentration. For teachers, theory classrooms offer fewer possibilities than practical ones for reasons such as lack of space, excessive number of students or uncomfortable furniture. While the practical classrooms do favor the work environment due to a good arrangement of furniture, good material resources and suitable ergonomic conditions that make possible the good development of said classes.

On the other hand, for the teaching staff, the working conditions in the offices offer an inadequate size, the arrangement of the windows is incorrect and they do not allow them to be opened, which means that it is not the most suitable environment to work. In this case, for the theory classrooms, in addition to what was mentioned above, it is proposed to divide the groups of students so that they are not so large and the teaching can be better taught. Finally, in the case of the offices, the possibility would be proposed that the teachers themselves could open the windows when they deemed it appropriate and would remove the external molding that prevents the entry of light, in addition to individualizing the offices so that they comply with anthropometric measurements. Building more offices in transit areas that are empty without any use.

The hygienic and preventive recommendations imposed by the COVID-19 pandemic both in theory classrooms, practice rooms, and study rooms, generated higher noise levels and low temperatures, that both for the students and for the faculty of the Faculty, generated great inconvenience to work. The hygiene measures by La-Covid do not allow any changes to be made except for the installation of hepa filters that ensure continuous air renewal, thus minimizing the risk of contagion.

References

1. Álvarez K, Márquez J, Franco F (2019) Evaluation of the spatial organization of a classroom from the perspective of a group of university students: a studyof case. Childhood, Educ Learn Mag 5(2):8–13. https://doi.org/10.22370/ieya.2019.5.2.1430
2. Álvarez Vélez- C, Pico-Merchán M, Escobar-Potes M, Jaramillo-Ángel O (2022) University educational spaces: a look from the students. Culture, Educ Soc 13(2):249–266. https://doi.org/10.17981/culteduso c.13.2.2022.14

3. Barragan Lopez (2018) Analysis of the perception of teachers, users of an educational platform through the TPACK, SAMR and TAM3 models in a higher education institution. https://doi.org/10.32870/ap.v10n1.1162
4. Brito J, Vieira V, Duran A (2015) Towards a framework for gamification design on crowdsourcing systems: the GAME approach. In: Proceeding of the 12th international conference on information technology—new generations. IEEE, Las Vegas, NV, pp 445–450. https://doi.org/10.1109/ITNG.2015.78
5. Gareca M (2018) Efficient classrooms for secondary level: what design parameters to follow? Sci, Technol Innov Mag 2018(16–18):9–28
6. Junta de Andalucía (2011) Technical document on the Andalusian accessibility decree. https://www.juntadeandalucia.es/export/drupaljda/Personas_Discapacidad_decreto_Doc_Tec_Acce_Septiembre_2011.pdf
7. Etikan I, Musa SA, Alkassim RS (2016) Comparison of convenience sampling and purpose sampling. Am J Theor Appl Stat 5(1):1–4. https://doi.org/10.11648/j.ajtas.20160501.11
8. Gaitán JE (2016) Information and communication technologies and the performance of secondary school teachers in the educational institution. https://hdl.handle.net/20.500.13053/589
9. Fernandez Almudena (2020) The ethnographic method as knowledge construction: a descriptive analysis of its use and conceptualization in social sciences. https://hdl.handle.net/10630/19608
10. Guba G, Lincoln S (1985) Naturalistic inquiry. Sage Publications, Beverly Hills
11. ISO 22955:2021 en fr Acoustics—Acoustic quality of open office spaces (2021) NTP 503. https://tienda.aenor.com/norma-iso-22955-2021-074237
12. Morse JM (2015) Data were saturated… Qual Health Res 25(5):587–588. https://doi.org/10.1177/1049732315576699
13. Párraga Velásquez R, García Zapata T (2014) Ergonomic design of university classrooms that optimize comfort and reduce student and teacher fatigue. https://dialnet.unirioja.es/descarga/articulo/8635439.pdf
14. Well M (2017) The dissolution of the classroom Map of architectural spaces for a pedagogical territory. [PhD Thesis, University of Seville]. https://doi.org/10.12795/9788447223152