

UNIVERSITY AND TECHNICAL EDUCATION IN THE CERAMIC SECTOR

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ABSTRACT

The present paper presents an analysis of the technicians who take part in the decision-taking process, from the design of the material to its installation, in order to determine the university training that each receives, focusing particularly on architects and technical architects.

Possible avenues of further education are highlighted, for in-depth training and specialisation in ceramic tilings, whether within university education or as postgraduate training.

An evaluation is also made of ceramics in architecture, with a view to determining the reasons prevent greater use of ceramic tilings.

1. INTRODUCTION

Among the actors in building construction who take part in the ceramic tile specification and installation process we have found users, builders and promoters, construction company technicians and building directors; technical architects and architects, technicians from the ceramic materials and adhesives manufacturing companies, and even experts acting as outside advisers.

The numerous actors that take part in the ceramic tile selection and installation process, together with the fact that consumer goods are often involved, lead to a great variability in the decision-taking procedure with multiple casuistries when it comes to deciding on the materials and the installation techniques to be used.

However, as a common factor in all the actions in which there is a technical project, and independently of whom has ultimately taken the decision in selecting the material and tile installation system, the only 'legally' responsible persons are the architect and technical architect, known as the so-called Facultative Management of the building work.

In view of this situation the present paper analyses the regulated university training that technical architects and architects receive in the field of ceramic tiles.

This analysis also sets out the rest of the knowledge that the future technicians must acquire and to which, therefore, they will also have to devote study time in detriment to that which could have been spent on ceramic tiles.

The possibilities are analysed, furthermore, of non-regulated training, which enables specialisation in ceramic tilings, as well as the interest that these materials arouse in architects and technical architects.

For this reason we shall first analyse the different functions performed by technical personnel that take part in the tile installation process, to centre subsequently on the training that the Facultative Management of the building work receives and analyse whether this is sufficient or not.

2. THE TECHNICIANS IN THE CERAMIC SECTOR

In the tile manufacturing and installation process we find technicians with different backgrounds, depending on the phase involved.

2.1. CERAMIC PRODUCT DESIGN AND MANUFACTURE

Both in the design and formulation of new materials and in their manufacturing control, the main technicians are Chemical Engineers, Industrial Engineers, Chemistry graduates, or simply technicians trained in the company by cumulative experience.

In this sense it may be noted that Universitat Jaume I (UJI) offers a series of degrees potentially destined for the ceramic sector. The last graduation figures were as follows.

Industrial engineering	46
Chemical engineering	35
Technical engineering of industrial design	62
Chemistry	45

According to ITC these degree studies, first in Chemistry and later in Chemical Engineering with Ceramic Technology orientation, which started in the 93/94 course, have a professional placement rate in the ceramic sector of about 80%.

ITC also indicates that the specialty of Ceramic Tiling Design delivered at the School of Arts and Crafts, is accompanied by a labour placement rate in the ceramic sector exceeding 85%.

All these technicians receive training focused on their future activities in the ceramic sector, which will be completed by their professional experience and the in-company training they receive.

2.2. PRODUCT RESEARCH AND CONTROL

This segment is covered by the Institutes, Institutions and Laboratories for materials (such as ITC, IPC, ALICER and the Ceramic Laboratory Sebastián Carpi), which are devoted to control of the raw materials and the resulting products, as well as undertaking R&D projects for the creation of new products, or the improvement of present manufacturing processes.

This field is also covered by the degrees mentioned previously together with some other engineering or with technical architects, with the singularity that these technicians generally complete their academic training with the labour experience acquired in the course of their professional career.

2.3. CONSULTING IN TILE INSTALLATION

Some manufacturers, concerned about the promotion of ceramic products and their new applications, offer consultancy services for their clients in regard to the design of non-conventional applications and for the installation of traditional tilings, thus assuring correct selection of the materials and their appropriate installation, adding value to the product and, therefore, laying the groundwork for better market prospects in the future.

This new sector gives rise to the training of technical sales staff, charged with sales and consulting in ceramic products.

In this field the actors involved must obviously be well-acquainted with ceramic products and tile installation techniques, in addition to having good social skills that enable them to sell products. For this reason their selection is more complex than the foregoing; in this case the most appropriate degrees are those that provide knowledge of the manufacturing processes and of tile installation systems, and this knowledge is generally acquired with professional experience in the sector.

Thus we can find any number of the degrees mentioned above together with all those that enable acquiring construction knowledge.

Note in this sense that in the case of architects and technical architects, despite having sufficient knowledge, given the sector's current expansion, this is not an attractive professional option for the recent graduate.

2.4. TILE SPECIFICATION AND INSTALLATION

The persons responsible for the tiling specification in building construction are the architects, who draw up the projects. However, a distinction may be made between public architecture and residential architecture, since in the latter, tiling is a finish that is often part of the customisation of each dwelling, which is why the decisions regarding the type of material are usually taken by the end-users themselves.

On the other hand, in relation to the tile installation systems, and especially bonding materials, given the lack of knowledge regarding these materials or, in some cases, the little importance attached to this, the decisions are delegated in the tile fixers.

Furthermore, in the installation of these tiles, as apparently traditional materials are involved, technical architects and architects delegate or trust in the good practice of the tile fixer.

Thus, contrary to what happens in the institutes or research centres where the technicians face problems of progressively greater difficulty, as they rise to higher levels of responsibility, in the case of the specifications and management of building work, technicians may be faced with complex tiling situations, regarding which they have hardly any previous experience, but for which they are ultimately responsible.

For this reason we shall focus on these technicians, because they have the final responsibility for the tilings, and may need knowledge or a capacity for resolving ceramic tilings, without this being their special field of knowledge, and in many cases not even the main one.

3. THE TRAINING OF THE TECHNICIANS



Of all of these we shall focus on the training of the technicians responsible for the specification and the installation of the tiles, since in the other cases the training matches the professional needs; however, in this case the specific training in ceramic tiles is just part of the knowledge that the technician progressively acquires in his university training of a general character.

3.1. THE TRAINING OF THE ARCHITECT

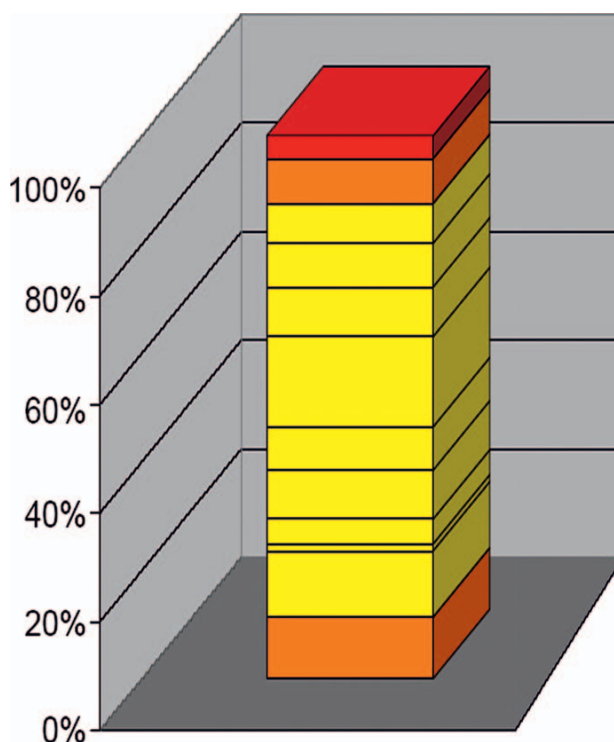
Architects can conduct their professional activity in various specialties, such as building construction, town planning, evaluations, expert reports, public administration, restoration, etc. For this reason, as it is the sole qualifying degree for the various professional specialties, the degree trains generalists, whose education is designed to enable the future technician to carry out the tasks involved in the various specialties.

The architect, whose usual professional practice brings him into contact with ceramics by virtue of his professional attributions, is the technical drafter of the project and director of the building work and, therefore, responsible for the specification of the materials and their installation systems.

His university studies in architecture at present time include about 420 credits (1 credit is equivalent to 10 hours' teaching for the student), in which all the subjects must be delivered that are subsequently going to provide him with the minimum knowledge in order to practice professionally in the various specialties.

If we analyse the curriculum of the Technical School for Architecture in Valencia we find the following structure:

SUBJECT	CREDITS	%	
Building materials	11	3%	
Construction	35,5	8%	
Basic sciences	31	7%	
Graphic expression	34,5	8%	
Structures	34	8%	
Projects	71	17%	
Architectural composition	39	9%	
Town planning and legal architecture	38,5	9%	
Conditioning and services	19,5	5%	
Building work Economics and Organisation	5,5	1%	
Optional	52	12%	
Free choice	48,5	12%	
TOTAL	420	100%	



Of the entire teaching load, only 3% goes to building materials, of which ceramics is a small part.

In the field of construction something similar occurs: in the 8% of the teaching devoted to construction, ceramic tiles must share time with the rest of the coverings, envelopes, carpentries, structures...

Thus, we can estimate that the time available for the study of ceramic materials is insufficient for in-depth study, which is why the approach of the study and learning system must be based on knowledge of the fundamentals of each subject, making this knowledge extrapolable to new materials and new problems that may be posed in the future.

In order to be able to go deeper into certain subjects, the present curricula establish some optional and free choice subjects in the degree at the university, which enable the students to extend their knowledge in some of the subjects already dealt with, or to acquire new knowledge in non-treated subjects of a generic slant.

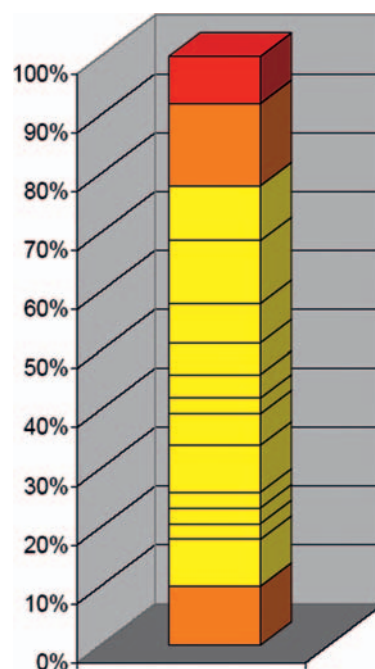
3.2. THE TRAINING OF THE TECHNICAL ARCHITECT

Technical architects, according to their legally recognised professional attributions and in actual professional practice, can usually conduct their professional activity as facultative management and building directors, or as technicians of some building materials manufacturing company, and their functions may include the quality control of the building work, labour safety and health, organisation of the building work, its economic control, or work as experts. This all requires generalist training, which encompasses the different fields that technical architects could potentially enter in the course of their professional life.

Thus, their university studies at the present time at most reaches 250 credits, in which all the subjects must be delivered that are subsequently going to be required in professional practice.

If we analyse the Technical Architecture curriculum at Universitat Jaume I we find the following structure:

SUBJECT	CREDITS	%	
Building materials	18	8%	
Construction and history	31,5	14%	
Basic sciences	21	9%	
Graphic expression	24	11%	
Structures	15	7%	
Installations	12	5%	
Computer science and English	9	4%	
Equipment	6	3%	
Economics and legal aspects	12	5%	
Organisation and cost estimates	18	8%	
Safety and health	6	3%	
Projects	6	3%	
Practices placement	6	3%	
Optional	18	8%	
Free choice	22,5	10%	
TOTAL	225	100%	



The number of credits for building materials is similar to that in the architecture degree, although in this case, materials are studied which in architecture are studied in the subject of construction.

The 18 credits for building materials, 180 hours of teaching, in which all the building materials must be dealt with, are distributed approximately in the following way:

THEME BLOCK	CREDITS	%
BUILDING MATERIALS I		
Introduction	0,5	3%
Properties	2,0	11%
Natural stones	1,5	8%
Ceramics and glass	1,5	8%
Binders	2,0	11%
Conglomerates	1,5	8%
BUILDING MATERIALS II		
Concrete	3,2	18%
Metallic materials	2,3	13%
Organic materials	2,3	13%
Synthetic materials	1,2	7%

If we analysed the teaching load devoted to ceramic tile installations in the construction subjects, we would find a similar situation.

For any technician responsible for control of ceramic tilings, the education content of 1.5 credits (15 hours) may be insufficient; however, the competition with other materials involves a series of conditioning factors that prevents a more complete training of the technical architects.

Just as occurred in the case of architecture, the student interested in going deeper into a given subject will have to resort to the optional or free choice subjects, provided the offer exists at the centre.

3.3. THE TRAINING OF ENGINEERS

In the case of the engineers we find a similar situation, although minimised as a result of a greater specialisation, although this does not lead to a specific attribution of competences.

However in the reality of professional practice, specialisation takes place in different fields of work, which is why each technician has the possibility of focusing on and going further in a particular field of professional practice.

At Universitat Jaume I of Castellón the following degrees are currently delivered, whose professional placement could be in design, manufacturing and consulting for the installation of the ceramic tilings:

- Industrial Engineering
- Chemical engineering

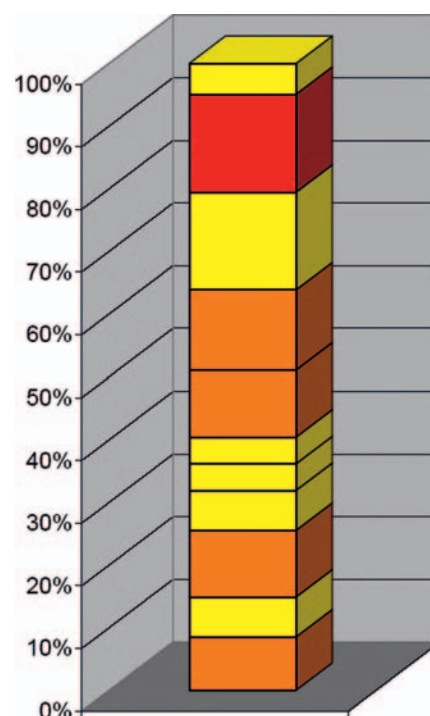
- Technical Engineering in Industrial Design
- Chemistry

Similarly, at the Polytechnic University of Valencia, the University of Valencia, or other universities similar degrees are delivered whose graduates can conduct their professional activity in the ceramic sector, in the field of design and manufacturing and, with complementary training, as advisers in tile installation.

As a singular case at the Polytechnic University of Valencia, a major is delivered called Materials Engineering, one of whose subjects deals with ceramic materials.

If we analyse its curriculum we find the following contents:

SUBJECT	CREDITS	%	
End-of-course project	7	5%	
Area: Ceramic materials	22	16%	
Area: Building materials	22	16%	
Technology and Materials Applications	18	13%	
Free Choice	15	11%	
Projects	6	4%	
Economics and organisation of Industrial Processes	6	4%	
Mechanical Behaviour of Materials	9	6%	
Structure of Materials	15	11%	
Electronic, Thermal and Optical Behaviour	9	6%	
Chemical fundamentals and materials science	12	9%	
TOTAL	141		



This major is taken by many graduates of other degree courses, as well as undergraduates, majors in other courses and, often, technical architects or technical engineers.

In this case, 16% of the teaching load centres on raw materials, manufacturing processes, design of materials, tests and behaviour in service of ceramic materials.

A further 44% of the teaching is in subjects relating to the design and use of building materials.

This training produces technicians with a previous training of a general character, who specialise in the knowledge of materials and particularly in ceramic materials, analysing both manufacturing processes and ceramics use.

This is therefore a particularly interesting degree for technical architects or architects who wish to specialise in ceramic tilings, producing technicians that are able to analyse the ceramic material as well as its installation.

3.4. SPECIALISATION IN TRAINING

As already remarked previously, in the case of both the architect and the technical architect, and in some cases in engineering degrees as well, we are faced with generalist training that deals with the different modalities of professional practice, which is why it is not possible to go into great depth in particular subjects of some of the disciplines.

To supplement this lack of specialisation we can resort to different strategies:

- By offering free choice subjects, specialising in ceramic tilings, in which the interested students can extend their training, with the advantage that students from different degrees could take these subjects, so that the same subject could complement the knowledge of various technicians who are going to have different tasks in design, specification, tile installation and control of ceramic tiling.
- By conducting outside educational activities, such as seminars, conferences, talks... designed to extend the knowledge of students in certain fields.
- To foster postgraduate training by means of technical symposia, courses and even Masters that enable creation of a body of experts at different levels, who can act in the different decision-taking stages in design, specification, sale, installation and control of ceramic tilings.

In this sense it is possible to highlight the initiatives of ASCER in the creation of Ceramic Chairs and Classrooms in several Spanish universities, which allow students from technical architecture and architecture to approach the materials of the ceramic sector.

In addition, the professional colleges in their mission to train and inform their members organise courses and technical seminars in which, with the collaboration of experts who may or may not be linked to the manufacturers, dissemination takes place of the new knowledge on materials, tile installation techniques and new applications.

3.5. THE PERMANENCE OF THE KNOWLEDGE

Another of the aspects to be dealt with in this training process of the technicians involved in the sector is the permanence of the acquired knowledge.

It seems obvious that those technicians whose professional activity centres on ceramic tilings will remember the knowledge acquired throughout their training, with a constant feedback as a result of new experiences, researches or applications.

However in those cases in which the professional activity is plural, covering several fields with their respective professional attributions could lead to forgetting the knowledge acquired in the formative phases, as a result of not needing to use this, and no feedback occurring.

In the university training of technicians, certain minimum levels of knowledge are set which students must meet in order to earn a degree; however if we conducted the same tests of level on graduates after a number of years, a considerable reduction in their knowledge would be noticed as a result of the lack of use of this knowledge.

Thus, professional activity acts as a refiner of the knowledge acquired in the training phase, completing the knowledge that is needed and suppressing the unnecessary knowledge.

4. EVALUATION OF CERAMICS IN ARCHITECTURE

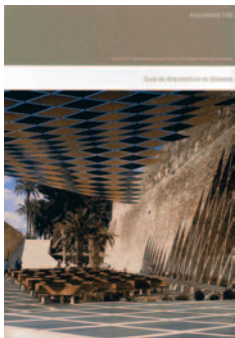
Beyond knowledge of the material and tile installation techniques, we could analyse the interest aroused, which in a certain way will lead to a greater or lesser knowledge of the material.

The interest aroused among technical architects and architects from an overall standpoint could be considered scarce, since ceramic tilings account for just a small part of the group of materials and constructive systems involved in a building work.

In order to be able to analyse this interest we shall try to establish some objective and subjective values, which indicate the repercussion of ceramics in the field of architecture or building construction.

4.1. DISSEMINATION OF CERAMIC TILES IN ARCHITECTURE.

We shall measure this first value by the presence of advertisements and articles or works with ceramic tiles present in architecture and technical architecture journals.

PRESENCE OF CERAMICS IN ARCHITECTURE PUBLICATIONS		
Last 10 issues of the journal <i>Arquitectos</i> of the High Council for Colleges of Architects in Spain		
	Advertisements by ceramic tile companies	26
	Advertisements by ceramic brick manufacturers	38
	Advertisements by lightweight ceramic block manufacturers	4
	Articles on ceramic tilings	0
	Buildings with ceramic tilings	0
Last 10 issues of the journal <i>Cercha</i> of the High Council for Colleges of Building Supervisors and Technical Architects in Spain		
	Advertisements by ceramic tile companies	11
	Advertisements by ceramic brick manufacturers	36
	Advertisements by lightweight ceramic block manufacturers	4
	Articles on ceramic tilings	15
	Buildings with ceramic tilings	2

After this preliminary quantification of these two publications which all technical architects and architects receive at their offices, it may be noted that the number of advertisements is comparable to those of other ceramic materials. However if we analyse their design, we will find that many these advertisements could pass unnoticed by those who are not market insiders in ceramic tiles, and therefore unfamiliar with the brands and patents.

As far as popularising articles of the qualities of ceramic tiles are concerned, these may be more or less frequent depending on the journal, but they are usually small.

Much less usual is the publication of buildings with ceramic tilings; only the Spanish Pavilion at the universal Exposition in Japan by Alexander Zaera, and the Auditorium of Tenerife by Santiago Calatrava have featured in the issues reviewed of these two journals.

4.2. ECONOMIC REPERCUSSION OF THE TILINGS

Another parameter to be considered in estimating the importance of these materials in the construction process might be the economic repercussion that ceramic tilings involve in the whole building work budget.

We have analysed this influence by calculating the economic repercussion of the ceramic tilings in the budget for the material execution of a building with 24 dwellings between party walls with intermediate qualities, for different levels of application of ceramic tilings:

ECONOMIC IMPORTANCE	% REPERCUSSION
With ceramic claddings and tiling in bathrooms and kitchens	approx. 8 %
With ceramic claddings and all ceramic flooring	approx. 10%
With ceramic claddings, all ceramic flooring and facade with direct adhered ceramics.	approx. 15%
With ceramic claddings, all ceramic flooring and ventilated ceramic facade with mechanical anchorings.	approx. 19%
Repercussion on the structure	approx. 17%
Repercussion on the installations	approx. 22%
Repercussion of all the tilings without considering the facade	approx. 18%

From these approximate values we can infer that in conventional constructions in which ceramic tilings are not used on facades, their economic repercussion is less than 10% of the budget for the work execution, whereas the structure or the installations have a greater cost, which is why greater importance is generally attached to these.

For the special cases of facades with ceramic claddings, these costs are observed to increase in such a way that they become important items to be analysed and controlled during the execution of the work.

4.3. LEGAL LIABILITY

The last factor to be analysed is the liability and risks that tiling failure entails.

LEGAL IMPORTANCE	
Obligatory nature of damage liability insurance	Structure only
External control of the work	Structure only
Responsibility for construction defects	10 years
Risk in case of flooring failure	Functional ruin
Risk in case of facade cladding failure	Danger for pedestrians
Slip risk	Danger in use

Note in this sense that although the responsibilities deriving from the failure of a ceramic tiling can be serious and have important economic repercussions, it is not paid any special attention as it does not jeopardise the general stability of the building, and is not subject to the compulsory external controls or insurance that assure coverage of the damage caused.

4.4. OVERALL EVALUATION

The foregoing can all entail a certain lack of interest for an apparently traditional material, without knowing the new products and installation techniques.

Furthermore, if we analyse ceramics from the three requirements that **Vitruvius** states architecture should fulfil: **firmitas**, **utilitas** and **venustas**, we find that the first two are amply met by the technical performance of ceramics, whereas beauty as a subjective matter is harder to measure, and in this sense we may recall some of the expressions that architects use when talking about the materials employed in their projects:

- Natural, noble materials...
- Authentic materials
- Appealing materials
- Homogenously heterogeneous materials
- Massive materials
- Sustainable, ecological, recyclable materials...
- ...

Before these and many other terms used to describe the materials that form the works of architecture present in the architecture journals we could ask ourselves whether ceramic tilings respond to the Vitruvian requirement of beauty.

5. CONCLUSIONS

By way of conclusions of the foregoing reflections on the training of the technicians involved in the different phases of the ceramic sector, it may be noted:

- That the technicians receive a generalist university education to enable them to practise professionally in various fields.
- There are different degree and postgraduate offers for specialisation in the various professional fields.
- The professional colleges together with the associations and public institutions, together with certain manufacturers carry out dissemination work regarding new materials and promoting their adequate installation for the benefit of the sector.

Over and above the present situation, for the promotion of ceramic tiles, a series of measures are needed to improve the situation:

- Specific training should be fostered, which can take place within university education by means of the optional or free choice subjects, or in later phases by means of courses or symposia organised by Universities, Professional Colleges, Institutions or Associations.
- It would be interesting to have a postgraduate training, in order to create a body of experts in ceramic tilings that could act as engineering offices or specialised consultants to advise other technicians, independent from the technical departments of the ceramic or adhesives companies.
- For the promotion of ceramic tilings it is essential for the ceramic industry and the technicians (specifications writers and persons responsible for the execution) to work more closely together, in order to facilitate knowledge of the material and its possibilities, either through the university or the professional colleges.
- The ceramic industry should go from selling materials to selling systems.
- The dissemination of new materials and novel applications should be done by using publications of wide dissemination among technical architects and architects.

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