Innovation and Ecodesign in Ceramic Industry

An Overview of Knowledge Needs in Portugal, Spain and Greece

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The InEDIC project (2009-2011) is an EU Life Long Learning – Leonardo da Vinci funded project, which aims at developing training materials and ecodesign tools to support the integration of environmental considerations in the design of ceramic products, thus contributing to the innovation and competitiveness of this longstanding industry in Portugal, Spain and Greece.

Ecodesign is a concept that receives considerable attention from environmental specialists in all participating countries but specifically in the case of the ceramics sector partners report that there is a lack of know how and training materials to support the systematic integration of environmental considerations in the development and design of ceramic products during the whole life cycle. To support this presupposition by concrete evidence, the InEDIC project included a situational analysis to identify existing materials on the subject and the needs experienced by companies and by vocational education and training institutions. The results will be used to inform the development of the innovative InEDIC ICT-based training materials and tools, ensuring high quality, relevance and appropriateness. The identification of offers was based on data and information collection and analysis, including previous projects carried out by the partnership and other available sources and training courses from reference institutions. The analysis of needs was carried out by interviews with ceramic com-

panies, business associations and VET organizations as well as meetings with experts and other relevant organizations or initiatives in the ceramic area.

The paper presents the main results of the review and gap analysis in the three countries, as well as the main findings for the next steps of the project: the development of the InEDIC Ecodesign Manual and databases of materials and technologies which support ceramic product developers in the detailed design of innovative, more eco-efficient ceramic products.

Introduction

The Integrated Product Policy of the European Union makes products and services key elements in implementing actions for achieving Sustainable Development. In the design and development of products and services, the prevention of environmental impacts throughout their life cycle is maximized while innovation and new business opportunities are encouraged and potential cost savings arise.

The main objective of the "Innovation and Ecodesign in the Ceramic Industry (InEDIC)" project is to develop high quality training materials and tools on ecodesign for the ceramic sector, in order to supply designers, trainers and other professionals with the skills to apply this sustainability strategy and practice in companies and to disseminate this know-how in the vocational education and training (VET) system. This project is a follow up of a previous Leonardo Project, "Transfer of Knowledge in the Field of Ecodesign" (contract CZ/04/B/F/PP-168002), upon which the InEDIC project will build by updating the training materials and, in particular, by adapting them to the ceramic sector.

The project started in October 2009 with a situational analysis aiming at analysing the present situation regarding ecodesign in the partner countries' ceramic industry in order to identify existing training materials for the ceramic process and the needs of know-how experienced by companies and of VET institutions (Celades et al., 2010). The situational analysis will be used as a tool for the development of InEDIC training materials, ensuring high quality, relevance and appropriateness, as well as providing a source of information on the state of the art in ecodesign in ceramics, which will be made available to a wide spectrum of stakeholders through dissemination activities.

Overview of the ceramic sector in Portugal, Spain and Greece

Portugal

According to the most recent, unpublished data from the Portuguese Association of Ceramic Industry, in February 2010 there were in Portugal 605 ceramic companies, 401 of which were active. These figures show a decline of the sector when compared to the official data as of 2007 presented in table 2.1.

Table 1 – The Portuguese ceramic industry: facts and figures per subsector (2007)
Source: APICER, 2009

Subsector	No. of companies	Annual turnover (€)	No. of workers	Brief market and economic descripiton

Structural ceramics (bricks and roof tiles) NACE[0] 2332	147	205 Mio.	3500	Market: mostly Iberian, transportation costs are a barrier to exports. Competitors: Spanish companies and succedaneum products Domestic market tends to decrease
Ceramic wall and floor tiles NACE 2331	76	370 Mio.	4685	Turnover is concentrated in few companies Market: mostly external Strong competition, mainly from Italy and Spain
Sanitary ware NACE 2342	22	278 Mio.	3186	58% of sales to exports (Europe, Angola. Cape Verde, United Arab Emirates)
Table and ornamental ware (porcelain, earthenware and fine stoneware) NACE 2341	405	318 Mio.	10955	58% of turnover to exports The subsector includes a small number of large companies and a very large number of workshops producing handicraft In 2006 Portugal was the main producer and exporter of earthenware
Special ceramics (electric isolators, refractory products and others to various industries such as military, automotive, Aerospatiale, biomedical and electronics) NACE 2343 and 232	50	44 Mio.	664	Most products are exported Low internal competition, due to the products' specialization
TOTAL (2007)	700	1215 Mio.	22990	-

Despite of the difficulties the ceramic industry is facing due to the economic crisis and the prices-based competition from producers outside Europe, the sector has been steadily showing an increase in the quality and capacity of the development of new products, supported by the adoption of the most recent production techniques and the accumulated know-how throughout the years.

Spain

The Spanish ceramic industry is characterized by the versatility of the forms and colours of its products; the industry has always implemented innovation strategies, since the sector stands out for its industrial investment and dynamism.

Table 2 – The Spanish ceramic industry: facts and figures per subsector

Subsector	No. of companies	Annual turnover (€)	No. of workers	Brief market and economic description
Structural ceramics (bricks and roof tiles) NACE[0] 2332 Year: 2009	280	Not available	9300	Production: 10000 tonnes Typology: family companies scattered throughout the country. Production is intended for regional or national consumption, due to transport costs. In general, mining operations are located in the areas near the factories, since the low cost of the raw materials does not allow their transportation to be cost-effective.
Ceramic wall and floor tiles NACE 2331 Year: 2009	Ca. 185	2591 Mio.	17700	Production: 324.4 Mio. Spain is the leading European ceramic tile producer and has the highest global per capita tile consumption Last few years: gradual decline in the number of tile manufacturers due to mergers or acquisitions and some shut-downs.
Sanitary ware	Not available	Not available	Not available	Spain has traditionally been one of the main

[0] NACE Code is a pan-European classification system which groups organisations according to their business activities

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NACE 2342				sanitary ware producers, but since 1999 production has declined. The industry is healthy due to the growing importance of the bathroom in the home has increased customer interest in new designs. New trends in the bathroom sector, focusing on greater wellness and care of the room, have led manufacturers to offer customers a comprehensive range of products for the bathroom.
Table and ornamental ware (porcelain, earthenware and fine stoneware) NACE 2341 Year: not specified	Not available (tableware) 190 (ornamental ware)	34 Mio. (tableware)	7600 (tableware)	Tableware: Spain ranks third in sales behind Germany and France. Recent years have witnessed a dramatic reduction in the number of companies. Ornamental ware: 190 small companies located in Valencia region and Andalusia. Fierce competition of production from Asia, particularly China, has led to a significant deterioration in the prospects of this industry
Special ceramics (refractory products) NACE 2320 Year: 2009	33	Not available	1402	-
Ceramic frits NACE 203021 Year: 2009	Ca. 20	794 Mio.	3278	Production: 0.9 Mio. tonnes (60% of European production) The performance of the frits sector closely follows the success of the ceramic sector as a whole, and if the latter declines, then the frits sector that supplies it, will also suffer. Export sales represent more than the 60% of the production. Main export countries are: Italy, Egypt, Portugal, Morocco, Germany, France, Poland and Russia.

Greece

In Greece the InEDIC project focuses on small workshops producing handicraft or art pieces, due to the fact that mass production of tiles and ceramics in Greece is not of special interest since, from the 70's and 80's, many industrial ceramics units have closed down and today almost 80% of total ceramics and clay production comes from small, family based workshops.

Handicraft has always been the tradition in Greece. The respect for ceramic art is inherited from generation to generation, preserving the values of tradition. In Greece there are numerous, mainly family based, workshops which maintain a high level of craftsmanship and participate in domestic and international exhibitions.

We may divide today's ceramists into three categories:

- Traditional ceramists who mainly manufacture houseware items.
- Modern ceramists, who mainly produce decorative items. The products are practical ones, as we might call them, pottery items (such as dishware, bowls, vases, jugs, ashtrays, candlesticks, mirrors with ceramic frames, tables with ceramic surfaces, wall decorations, hangers, lights, pottery items for social events – such as weddings, christenings -, souvenirs or gifts for events, meetings and congresses, table mats and coasters, piggybanks or toys, decorative items for hotels or restaurants, imitations inspired by primitive or Byzantine techniques, etc.)
- Art ceramists: There are many workshops which have more of an artistic character and which deal with products of free expression, creation and aesthetics touching topics of sculpture or a combination of other materials with ceramics – as it is the case of the various installations – or other ceramic items, such as dolls, masks or copies of various objects (tools, shoes (!), houses, tables etc.) These ceramists make unique works and they promote them in personal exhibitions

Ecodesign in the ceramic sector

The manufacture of ceramic products takes place in different types of kilns, with a wide range of raw materials and in numerous shapes, sizes and colours. The general process of manufacturing ceramic products, however, is rather uniform, besides the fact that for the manufacture of wall and floor tiles, household ceramics, sanitary ware and technical ceramics often a multiple stage firing process is used. The key environmental aspects of ceramics production are (European Commission, 2007):

- Air emissions: particulate matter, soot and gaseous emissions (carbon oxides, nitrogen oxides, sulphur oxides, inorganic fluorine and chlorine compounds, organic compounds and heavy metals);
- Process waste water, which mainly contains mineral components and other inorganic materials, small quantities of numerous organic materials as well as heavy metals;
- Process losses/waste, mainly consisting of different kinds of sludge, broken ware, used plaster moulds, used sorption agents, dust, ashes and packaging waste;
- Energy consumption/CO2 emissions: all sectors of the ceramic industry are energy intensive, as a key part of the process involves drying followed by firing (800-2000ºC). Today natural gas and fuel oil EL are mainly used for firing, while heavy fuel oil, liquefied natural gas, biogas/biomass, electricity and solid fuels (e.g. coal, petroleum coke) can also play a role as energy sources for burners.

The ceramic industry has, for many years, performed important technological and managerial improvements to tackle these environmental aspects of the manufacturing phase. In the other life cycle stages, the greatest environmental impacts usually occur during the withdrawal of the product after its useful life. This environmental impact is significant due to the large amount of solid waste accumulated in demolitions due to the large number of construction elements that are removed, with virtually no recycling or reuse because separation from other materials is very complicated.

It is possible to find many ceramic products with innovations that can be classified according to ecodesign strategies; below, some examples from Spain and Portugal are presented. One should keep in mind, however, that the environmental benefits of those innovations were not studied, as they didn't result from a systematic ecodesign method and therefore environmental trade-offs may occur. It is also observed that typically only one strategy or environmental component is observed: again the integrated approach of ecodesign, covering the whole life cycle of the product system was not studied or at least not communicated by the companies. Nevertheless these examples illustrate the potential of ecodesign in an industry which has traditionally focused its environmental efforts in the manufacturing processes. Whether or not this potential is recognised by companies and other players in the ceramic arena was a matter for research and will be presented in the next sections of this paper.

Table 3 – Examples of ecodesign in the ceramic industry

Ecodesign strategy	Activity or solution	Examples
Selection of low impact materials	Incorporation of waste	Some tile manufacturing companies recycle pre-consumer waste, reaching up to 90% recycled material by weight while retaining the strength and versatility. There are also examples of house ware and tile producers that manufacture items using the sludge from the wastewater treatment plant.
Reduction of the material use	Reduction in products' thickness	Wall and floor tiles companies have researched into raw materials to achieve a reduction in tile thickness (in some cases from 12 mm to 4 mm).
Selection of environmentally sound production techniques	Reducing kiln firing operations	The ceramic industry has invested significantly in more eco-efficient production techniques. Designers can also influence the environmental performance of the manufacturing processes e.g. by designing products whose production requires less firing steps or lower temperatures.
Optimizing packaging and distribution	Reduction of packaging	Companies have been engaged in reducing the amount of cardboard, shrink plastic and glue, and eliminating strips in packaging.
	Eliminating distribution activities	A recent trend is called picking, a new form of direct sales orders from the end consumer to the manufacturer, thus reducing the transport impacts.

Reduction of the environmental impact during the use phase	High efficiency construction elements	New bricks with high thermal, mechanical and acoustic performances have been developed. In this case it is not the product itself that is improved, but the energy performance of the building, a matter of high concern in the field of sustainability.
Optimizing the end- of-life systems	New method of installation and dismantling	Raised Technical Floor is a method of installation of floor tiles that reduces building waste and facilitates waste separation. This floor is a construction system installed on a metallic substructure at a certain height above the substrate allowing the incorporation of radiant heating systems under the flooring.
New concepts	Integration of functions	Ceramic wall and roof tiles that incorporate a thin photovoltaic film are intended to have a high aesthetic quality and technical performance contributing to a new building architecture type, based on eco-design concepts.

Methodology

In order to confront training needs and offers in the field of ecodesign in ceramics and thus inform the development of the InEDIC training materials, the research followed a combination of questionnaires, experts interviews and a review of information sources such as literature references, data bases of ceramic materials and technologies and others which are relevant for ecodesign in ceramics.

Three semi-structured questionnaires were developed targeting ceramic companies, VET institutions and business associations and included the following information:

- Companies: the company's profile, its environmental strategy, implemented management systems and other certifications, the design strategy, the experience with ecodesign and the needs of know-how in ecodesign the company identified.
- VET institutions: the institution's profile, how design and ecodesign are approached in its training and education offers and the needs in know-how on ecodesign related to the ceramic sector.
- Business associations: the association's profile, its experience with design and ecodesign approaches, including requests from associates, and the needs of know-how in ecodesign the business association considers important for its associates.

The questionnaires were replied by phone or during face-to-face interviews; the partners had therefore the opportunity to clarify any concept that the respondents would not be familiar with, thus reducing the potential bias due to misunderstandings related to the somewhat hermetic terminology used by ecodesign practitioners.

The results of the questionnaires were analyzed using current practices of simple statistics: descriptive analysis, frequencies, averages and simple cross-tabulations to identify trends and examine possible associations between one variable and another.

Confronting the information available and the training offers on ecodesign in ceramics and the needs identified in the survey allowed for a gap analysis and the establishment of a number of conclusions that inform the development of the InEDIC training materials and tools – the next stage of the project– , ensuring its high relevance and appropriateness.

Results and discussion

Review of information sources on ecodesign in ceramics

A thorough review of literature references in the field of ecodesign and, specifically, in the field of design in ceramics was undertaken. This encompassed books, manuals, papers and information included in specific websites. Over 50 references were identified and analysed and the main conclusion is that although a wealth amount of ecodesign materials are available, most of them are not specific for ceramics; and the sector-specific references found often relate to environmental management of the production processes, to specific ceramic tech-

niques or specific environmental topics such as energy management. No reference on the proposed subject of the InEDIC project was found, so there is clearly a gap to be filled in by the project.

Another issue of interest to the project was to identify existing ceramic materials databases displaying technical, environmental and economic information to support designers choices. The conclusion was that there countless databases and webpages containing lists of "sustainable" materials and products; in some cases they have been rigorously selected on the basis of criteria such as ecolabeling award or life cycle assessment or are published within environmental product declarations; however databases whose selection criteria is not clear have been found. Another finding was that it is much more common to find environmental information about finished products than about raw materials.

Similarly, eco-efficient technologies databases were surveyed. In this case the existence of the Reference Document on Best Available Techniques in the Ceramic Manufacturing Industry provides a very valuable and systemised information; however, those techniques that can be influenced by the design and development team are not particularly explored in this document. Other sources in the field of cleaner production have a similar approach: the description of the technologies and managerial measures do not entail a "design perspective".

Training needs and offers identified in Portugal, Spain and Greece

In Portugal the questionnaires were replied by 31 ceramic manufacturers from four subsectors (table and ornamental ware – 11; bricks and roof tiles – 10; wall and floor tiles – 8; sanitary ware – 2), three VET institutions (one Vocational Training Centre, one Polytechnic Institute and one University) and the national business association APICER.

In Spain, 21 ceramic companies from five subsectors (table and ornamental ware – 1; bricks and roof tiles – 1; wall and floor tiles producers – 10; sanitary ware – 4 and special ceramics – 7), 17 VET institutions (mostly Universities) and 6 business associations replied to the questionnaires.

In Greece the questionnaires were handed out to eight ceramic workshops and all were returned. Most of them are family based enterprises (SME's) and all are located in Central Greece, in the broader area of Magnesia Prefecture.

Spain and Portugal have a much more industrialized ceramic sector than Greece, where companies are very small and the production capacity is much lower. This conditioned the sample for the interviews and the focus of the study and therefore the findings regarding the ecodesign training needs of Spain and Portugal are very different from those of Greece. In the former, training offers are wider and most of them are encouraged by the government, through public education in Universities, VET or other institutions; however, in Greece there is a lack of state schools and diplomas, and total absence of pottery classes in school and professional training, since this knowledge is inherited from generation to generation.

The common points found in the gap analysis of Portugal and Spain are shown below, followed by the conclusions from the gap analysis of Greece, due to the different situation:

- All the surveyed entities and organizations seem to ***know the meaning of ecodesign and the majority defend its importance in the reduction of environment impacts of the product during its life cycle***.
- Nevertheless, companies' environmental efforts ***focus on company manufacturing processes and not on life cycle; the 'ecodesign culture' has just started in the ceramic sector***, in which companies have begun to declare their interest and will probably keep on presenting more specific needs and demands in the future.
- ***Although it is still in a very early stage, the ecodesign strategy is considered to be an important competitiveness factor for the ceramic sector***. Enterprises are already asking their associations for more information about eco-efficient materials and techniques.
- It was observed that most companies have the freedom to change their products, have in-house design and development, and employ designers, so that ***designers and product developers (including free lancers that are subcontracted by ceramic companies) are an appropriate target group within the industry*** for the project results. This was confirmed by the business associations, which were consulted on ecodesign by designers and ***environmental experts***. The latter, in the sense that they interact with designers, especially when environment is a design criterion, are to be considered as well.
- Although ecodesign is, at least to some degree, taught in the framework of design, ceramic technology or environmental management courses, all surveyed institutions detected ***training needs*** in subjects such as:

  - Tools for assessing the environmental impacts of ceramic products in the product life cycle
  - Ecodesign strategies for ceramic products
  - Communication tools for ecodesigned products
  - Creativity techniques
  - Environmental information on materials and technologies used in ceramic products

- Although criteria are defined for the EU Ecolabel for hard flooring, and there are product category rules for environmental product declarations of ceramic products (roofing tiles, clay construction products, building products, clay products, etc.), few ceramic companies use these communication tools, although the interest in increasing. ***Given their importance and direct relation to ecodesign, InEDIC should address ecolabels and environmental product declarations in the training materials.***
- The building-related subsectors are very important in view of the Ecodesign of Energy-related Products Directive of the European Union [REF]. ***In the environmental evaluation of products and as part of proposed ecodesign strategies, InEDIC should encompass the role of ceramic products in the sustainability profile of buildings.***
- A fair percentage of the companies have a certified quality and/or environmental management system in place; half of those that stated their motivations to perform ecodesign indicated "standard requirements". The conclusion is that the ***training materials should include the relationship between ecodesign and quality/environmental management systems.***

The main conclusions regarding Greece of the Greek gap analysis are as follows:

- Pottery and ceramics in Greece are based on small and medium-sized workshops. However, all of them are, on the one hand, ***forced to adjust to the global changes towards sustainability*** and, on the other, are ***interested in making products that incorporate the ideas of sustainability*** in general and ***protection of the environment***.
- Since production and supply costs are very important factors, ***a balance needs to be found between development*** (through ecodesign and sustainability) and ***production costs***. As long as this fine balance is attainable, almost ***all are willing to adjust and incorporate ecodesign/sustainability methods and rationales.***
- Vocational Training Centres are desperate to ***attract young people*** through incentives such as the INEDIC project or other new ideas.
- All modern Ceramists are interested in ***adjusting to the new reality of ecodesign,*** not only in order ***to promote their businesses,*** but also to ***protect the environment*** and to ***become competitive***.

Conclusions

The study clearly indicated that there is a lack of systemized, easy to use and state-of-the art based training materials and tools to be applied by companies and design practitioners that want to address environmental concerns in the design and development of ceramic products, while responding to the needs of more demanding markets and striving for innovation. The next stages of the InEDIC project are to develop and test such materials through pilot training and demonstration projects in the three partner countries, given that ceramic companies and workshops belong to the consortium as test partners.

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Maria Helena Arroz Costa Correia is the Technical Director of CENCAL – Vocational Training Centre for the Ceramic Industry since 1985, has the Degree of Industrial Chemical Engineering, Instituto Superior Técnico and a Post-graduation in Material Engineering, University of Aveiro. She has developed professional activity as a teacher in the IST, University of Coimbra and Superior School of Arts and Design. She has been the responsible for the laboratory of ceramic company and director of the Laboratory of CENCAL.

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Paula Gris Grais is in charge for the projects of support to the practice of Design. She coordinates the management of the contests of ideas for enterprises, the organization of national Design prizes and is advisor of several CPD publications, amongst them the "Design Directory" and the "Support to the Industrial Property Rights". She holds a Degree by the College of Fine Arts of Lisbon and a post graduation in Intermediaries of Information for the Industry.

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