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INTELLECTUAL OUTPUT O1

INNOVATIVE OPEN TRAINING MATERIAL ON CIRCULAR ECONOMY AND DIGITISATION FOR VET LEARNERS IN THE WOOD&FURNITURE SECTOR

Unit 1

INTRODUCTION TO THE CONCEPT OF SMART FURNITURE. DIGITAL FURNITURE VS. INTELLIGENT FURNITURE. EVOLUTION.

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1 INTRODUCTION. DIGITAL AND TECHNOLOGICAL FURNITURE

The concept of **digital furniture** is generally associated with furniture design using 3D CAD software. The product is not necessarily in physical existence, hence the term "digital". Designer Andrés Reisinger, as can be seen in Dezeen webpage [1] has several digital models of furniture. In one case, The hortensia chair, the product has been produced.

Figure 1. Deep Space sofa. Exists only digitally

Figure 2. Virtual Hortensia Chair

Figure 3. The first real version of the Hortensia chair

Figure 4. Digital model of desk table avalaible in www.turbosuid.com. [2]

[1] https://www.dezeen.com/2021/02/23/andres-reisinger-the-shipping-digital-furniture-auction/
[2] https://www.turbosquid.com/3d-models/3d-office-desk-model/471820

Another related concept is **Technological Furniture**, furniture that uses certain types of technology, either mechanical elements or any type of electrical or electronic gadget, to provide a differential value. The objective of this type of furniture is to provide the user with various services of interest that increase the functionalities of the element in question, normally by means of integrated devices. The main challenge to overcome in this regard is to achieve a perfect adaptation of the devices to the furniture, so that an attractive and functional design is accompanied by a reliable and innovative technology that adds value to the furniture and constitutes a differentiating factor with respect to the traditional concept.

In this video from HiTech | SMART FURNITURE SOLUTION | Great Space Saving Ideas 2018 | By Tech Knock we can be aware of different models of integration in furniture, mainly with mechanical devices and imaginative designs.

https://www.youtube.com/watch?v=gZmwr7iU3xw

Below are some examples of this type of products, in which electronic gadgets (touch screens, screens that change image, sound, etc.) are integrated.

Figure 5. : https://www.trendhunter.com/slideshow/hightech-furniture

For a piece of furniture to be considered "intelligent", it must not only integrate some kind of technology, but it must also meet two conditions:

- It must be able to recognize environmental conditions. For example, it must be able to measure environmental conditions (temperature, humidity, sound, lighting, etc.), identify the user or his physiology, identify its location, etc.
- It should be able to modify some of its characteristics to adapt to changes in the environment or communicate this change to the user for decision making. For example, it could automatically change the conditions of the environment (turn on/off lights, turn on the air conditioning, etc.), or it could automatically adapt to the height of the user if we were talking about a chair.

Some examples of furniture that could be considered are:

1.1 Children's furniture

Bbsitter Cot. This cradle incorporates a sensor that detects crying and makes the cradle learn with which movement the baby calms down, so that it can repeat it when necessary. It also incorporates a Night Light or Night Light, temperature and humidity level meter, everything you need to create a safe and comfortable environment in the baby's room. It can be controlled via an APP.

Figure 6. Micuna Bbsitter Cot

1.2 Office Furniture

Gaia by Actiu® is a smart platform for healthy and efficient high-performing spaces that incorporates sensors into the work environment to gather data on how it is used and the conditions of the environment, providing valuable data to facilitate making changes in order to improve how it is used. This, together with greater energy efficiency, cuts down on costs while safeguarding people's health because the better the conditions, the greater the comfort and well-being.

Sources: https://www.actiu.com/en/articles/news/gaia/

2 SMART FURNITURE DEFINITION

Until now, the furniture industry has concentrated solely on producing practical, functional and visually appealing products. However, permanently connected smart furniture, which represents a huge challenge for the industry, is already making its way into homes. In addition, manufacturers are increasingly creating devices that can be controlled in an intuitive and simple way.

A possible definition might be:

> Smart Furniture is designed, networked furniture that is equipped with an intelligent system or controller operated with the user's data and energy sources. Smart Furniture is able to communicate and anticipate the user's needs using a plurality of sensors and actuators inside the user's environment, resulting in a form of user-adapted furniture or an environment that satisfies the user-declared needs and non- declared needs for the purpose of improving their quality of life in a smart world.[3]

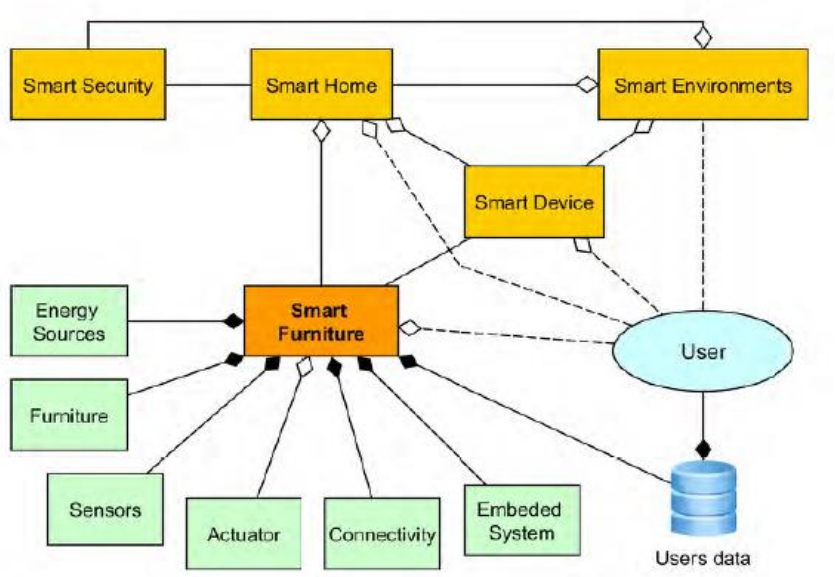


Figure 7 Role and position of Smart Furniture within the Smart City umbrella according to the UML design.(Krejcar et al., 2019)

[3] O. Krejcar et al., "Smart Furniture as a Component of a Smart City—Definition Based on Key Technologies Specification," in IEEE Access, vol. 7, pp. 94822-94839, 2019, doi: 10.1109/ACCESS.2019.2927778.

Several studies mention that the most important characteristics for a Smart Furniture are :

(1) Design
(2) Functionality
(3) Safety in Use
(4) Customization
(5) Structural Design

The design of the Smart Furniture is its most important feature, as every user needs to use the furniture for its primary purpose. The second and fourth characteristics, ``Functionality'' and ``Customization'', however, require more specific information, which characterizes the ability of the user to satisfy his/her declared and nondeclared needs.

We can classify the ways of approaching the concept of intelligence in furniture in several ways (Sar & Wang, 2020) :

2.1 MECHANICAL INTELLIGENCE

Mechanical intelligence is that the mechatronic device composed of various parts is implanted in the body of the furniture and the mechanical structure or transmission mechanism is operated through a certain manual control. The drive system converts the electrical signal from the control into a series of action commands, carried out by the power provided by the motor with the appropriate gears, which enable the whole system to operate.
Through a simple touch, light press and other actions, the user can initiate the automatic opening or closing of the furniture cabinet or drawer and automatic lifting, rotation, expansion and other functions of the desktop. In this way, it breaks through the limitations of traditional furniture in size, style and function, completes the upgrade and transformation of traditional furniture, realizes mechanical intelligence, and meets the needs of users for multiple specific functions.

2.2 ELECTRONIC INTELLIGENCE

Electronic intelligence is the combination of advanced and cutting-edge electronic technology products and traditional furniture through wired or wireless electronic remote control or touch control to realize the intelligent functions of furniture. The user only needs a simple touch action to control the automatic operation of the furniture through an induction device, and realize the adjustment of various functional parameters. Such as playing audio and video, turning LED lights on and off or adjusting the brightness of the light.

2.3 IOT INTELLIGENCE

IOT Intelligence IOT (Internet of Things) intelligence is to implant advanced intelligent systems or intelligent components (**sensors, embedded systems, etc**.) into the furniture body and connect **intelligent hardware**, **APP software and data platforms through the network**, with the network center and data center as the core. In addition, it also makes use of mobile intelligent terminal devices (mobile phone, tablet computer, etc.) and wireless network

technology to realize data processing and the control of furniture. The application of Internet of Things technology can integrate the intelligent furniture control system into the **intelligent home control system**. Intelligent furniture **can be regarded as a subsystem of the Internet of Things** and developed into a kind of terminal, which can realize the deep interaction between humans and furniture and finally realize the intelligent operation of family life.

3 SMART MATERIALS. The application of intelligent materials in furniture

Throughout history, furniture has undergone great changes in its function, shapes and materials used for its manufacture. In addition to solid wood, the appearance of new materials derived from wood and other materials such as plastic, metal, etc... Has allowed the generation of a set of furniture with new properties, functionalities, etc...

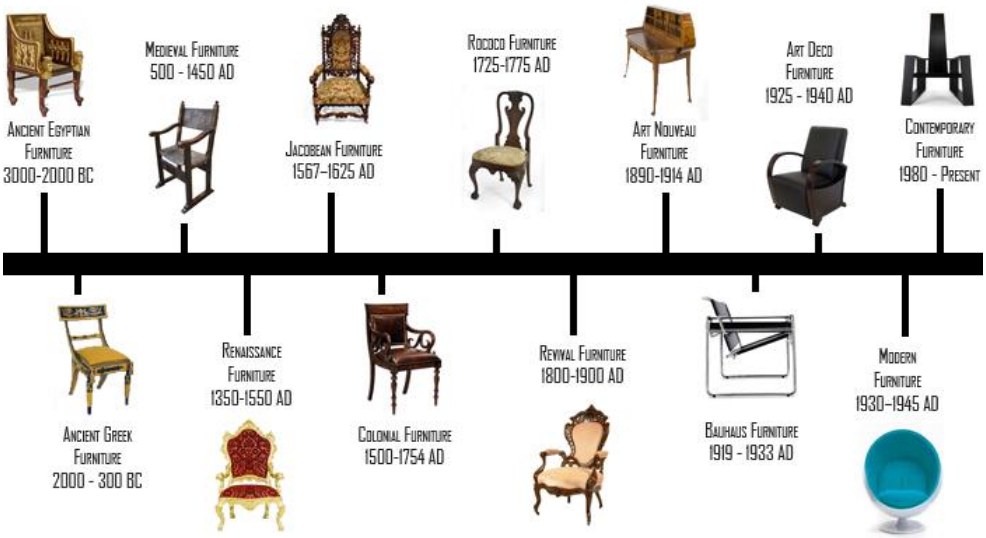


Figure 8. Evolution of Furniture design.
Source :https://www.onlinedesignteacher.com/2016/02/furniture-design-history.html

In an advanced age of science and technology, glass, plastic and artificial leather have gradually been applied more for furniture, since tube and canvas furniture were made by Marcel Breue of the Bauhaus School of Design in the early 20th century.

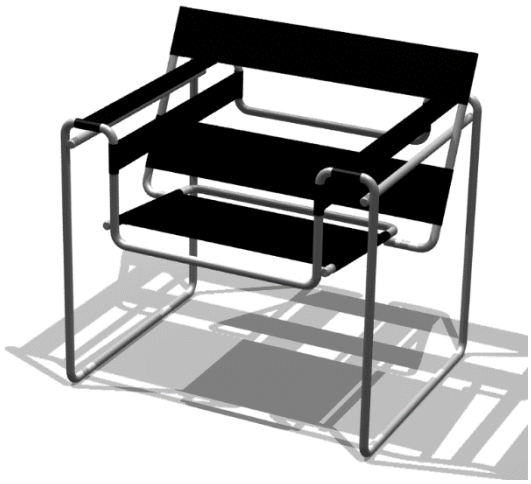


Figure 9. B3 Chair. Marcel Lajos Breuer. Source: wikipedia

After World War II, composite plastic furniture became popular with the public because of its competitive price, bright color and fashion. The appearance of cermet in the 1950s ushered in the era of composite materials. Aluminum and plastic sheets and fiberglass-reinforced plastics followed.
Today's furniture materials tend to be diverse, composite and high-performance, more in line with the integration features of the manufactured part of modern furniture.

We are currently witnessing the continuous emergence of innovative materials that have greater or lesser application in the furniture industry.

The main reasons driving this continuous innovation are:

1.- Need to differentiate with the technology of less developed countries: application of new technologies, such as telecommunications, nanotechnology, active materials, ...

2.- Social pressure to find materials and processes more respectful with the environment and from renewable sources: "Green procurement" and specifications of public administrations are increasingly requesting this type of materials.

3.- Products and materials that preserve the safety and comfort of the user: fire safety, need for clean air in the home, comfort, ...

4.- Need for a better use and energy efficiency.

5.- Materials and products that adapt to the growing mobility of the user and to the size of the homes.

6.- Demographic curve tending to an aging population: mobility problems, vision problems, etc.. and the need to lead an independent life.

One of the greatest advances has occurred with the emergence **of nanotechnology** and properties not known or studied until now, which has resulted in improved :

- Mechanical properties
- Dimensional stability
- Thermal properties
- Fire behavior
- Permeability to gases and liquids
- Electrical properties
- Optical properties

The main types of materials where improvements and innovations have taken place are:

- MDF (Medium Density Fiberboard)
- Paints and varnishes
- Adhesives
- Fabrics
- Foams

3.1 Types of smart materials

Smart materials and systems are divided into two classes, as can be found in some scientific articles (Al-baldawi, 2015) :

1. **Materials undergo changes in one or more of their properties** (chemical, electrical, magnetic, mechanical, or thermal) in direct response to a change in external stimuli in the surrounding environment. The energy input to a material affects the internal energy of the material by altering the material's microstructure and the input results in a property change of the material.

2. **Smart materials that transforms energy from one form to another**. The energy input to a material changes the energy state of the material composition, but does not alter the material, it stays the same, but the energy undergoes a change.

Type 1 materials include the following:

- Thermochromics - an input of thermal energy changes the material's color. https://www.youtube.com/watch?v=xg2iJLDUHSw
- Phototropics - materials that change color when exposed to light.
- Magnetorheological and electrorheological - the application of a magnetic field (or for electro-rheological - an electrical field) causes a change in micro-structural orientation, resulting in a change in viscosity of the fluid.
- Thermotropic - an input of thermal energy (or radiation for a phototropic, electricity for electrotropic and so on) to the material alters its micro-structure through a phase change. In a different phase, most materials demonstrate different properties, including conductivity, transmissivity, volumetric expansion, and solubility.
- Shape memory - an input of thermal energy (which can also be produced through resistance to an electrical current) alters themicrostructure through a crystalline phase change. This change enables multiple shapes in relationship to the environmental stimulus.
- Mechanochromics - materials that change color due to imposed stresses and/or deformations.
- Chemochromics - materials that change color when exposed to specific chemical environments or conditions. Electrochromics - materials that change color when a voltage is applied. Related technologies include liquid crystals and suspended particle devices that change color or transparencies when electrically activated.
- Phase-changing materials - use chemical bonds to store and release heat.
- Adhesion-changing materials - change the attraction forces of adsorption or absorption of atoms or molecules when exposed to light or electrical field.

Type 2 materials include the following:

- Light-emitting materials, that convert an input energy to an output of radiation energy in the visible spectrum, are including:
  - ✓ Photoluminescents (input is radiation energy from the ultraviolet spectrum · Electroluminescent (input is electrical energy) https://youtu.be/KeskG-bFG9o
  - ✓ Chemoluminescent (input is chemical reaction)
- Piezoelectrics (an input of elastic energy - strain produces an electrical current. Most piezoelectrics are bidirectional in that the inputs can be switched and an applied electrical current will produce a deformation - strain).
- Thermoelectrics (an input of electrical current creates a temperature differential on opposite sides of the material)
- Photovoltaics (an input of radiation energy from the visible spectrum produces an electrical current)
- Electrostrictives (the application of a current produces elastic energy - strain which deforms the shape of the material)
- Magnetostrictives (the application of a magnetic field produces elastic energy – strain

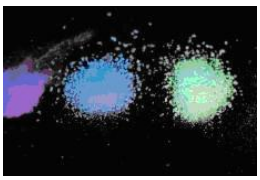
The following are some examples of materials used in the furniture and habitat sector.

3.2 Active materials

They have the capacity to respond to an external agent: light, temperature, humidity, ..., responding in such a way that the desired state is reached again.

- **Photochromic coatings**

Change color according to radiation



- **Electrochromic glass (privacy preserving)**

Some examples :
https://www.youtube.com/watch?v=eiK25QAeoiA
https://youtu.be/9GOa7bg39UY

- **Thermochromic Coating**

It changes color when exposed to high temperatures. The temperature range covered usually ranges from -15 ºC to 70 ºC, it is used to identify heat sources to avoid burns, warning alert system for any internal and external problem and to monitor the evolution of patients, to indicate in rooms the regulation of an adequate temperature in public facilities, guide element for safety evacuation**.**

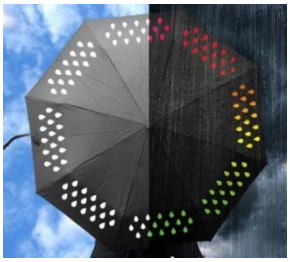
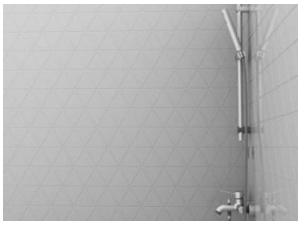
Figure 10. Furniture with thermochromic material. https://www.technocrazed.com/new-thermochromic-furniture-changes-color-at-the-touch-of-your-skin

An example :

https://youtu.be/SCen_sr0668

- **Hydrochromic Coatings**

This type of materials chage its color according to humidity, becoming transparent with high humidity. The main use of this coatings, is warn of water leaks, humid areas, ...
Also can be used on sheets, upholstery, etc.. to warn of high humidity levels produced by the user.


- **Shape Memory Materials (SMA)**

As an example there are metal alloys of nickel and titanium that recovers its original shape after being heated at high temperature.
Products can be manufactured with the polyurethane foam, forming the shape of the product in question. Once the product is ready, it can be compressed for sale and subsequent decompression by the end user. Thus, we are reducing its dimensions for a better use of transport and distribution spaces. Then it has to be assembled aided by a heat source, for example, with the application of heat, through a mechanism that is connected to a plug, the material acquires heat up to approximately 70°C and the chair recovers its original state in a few minutes.

An example :

https://youtu.be/gSu4DHPcxSM

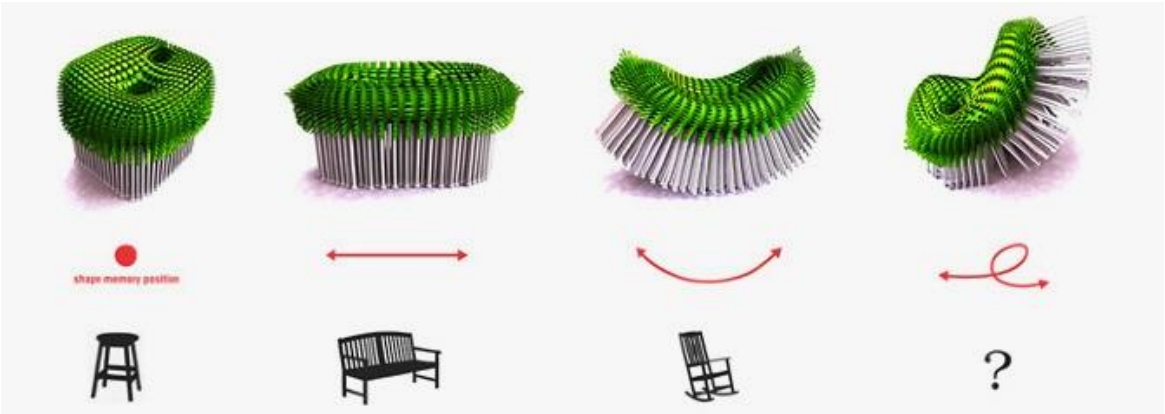


Figure 11. Multipede chair. https://www.marvelbuilding.com/adjustable-chair-elastic-weird-form-multipede-chair.html

- **New textile materials**

There are examples such as fabrics coated with Nanospheres, developed in Switzerland with Nanosphere microporous technology, which reject any trace of water or stains such as tomato, honey, oil and blood.

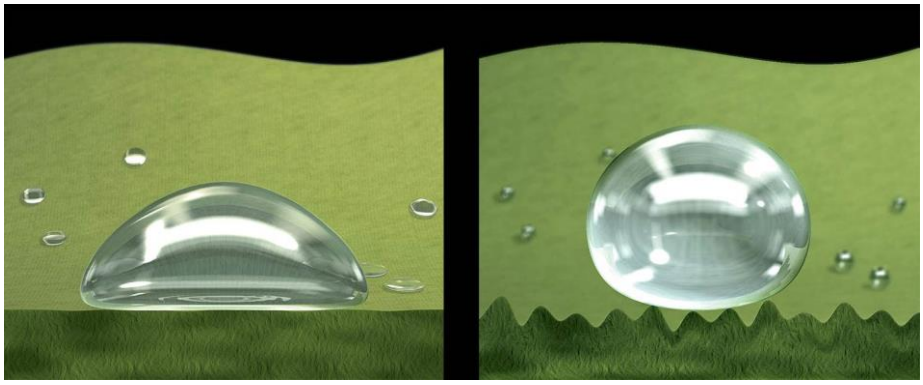


Figure 12. Nanosphere technology. https://www.schoeller-textiles.com/

Video from Schoeller textiles :
https://youtu.be/DWtcAh9Wrl8

Evidently, the improved quality of use and resistance has made the price of the material high since it was launched on the market. It is a new environmentally friendly material that can be used in home furnishings. We can also find lightweight materials, used in smart furniture, usually employs a solar battery that stores energy which is then released in the form of light. Without radiation and coating film, it is much more environmentally friendly for panel and furniture.

With the development of society and the improvement of living standards, more attention is being paid to the needs of certain groups such as the elderly and the disabled.
to the needs of certain groups such as younger or older people, for whom these types of materials have a greater acceptance and application.

Furniture is inevitably oriented towards high-end consumers and certain segments of the population.

There are databases of innovative products, such as the one generated in the European Erasmus+ MIMWOOD project. http://www.mimwoodproject.eu/plataforma/
Other interesting source of information about smart materials are the following webpages :

https://materialdistrict.com/#moved
http://www.innovatheque.fr/fr
http://es.materfad.com/materiales
https://materialconnexion.com/
http://www.goodfellow.com/sp/
https://www.jeccomposites.com/
https://www.bournetoinvent.com/projects/gcse_de_theory/4.html#sec-4-9

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