Sustainable nanotechnology and education: a European view

Claire Auplat[1], Sonia Ben Slimane[1], Anna Glaser[1], Camille de Garidel-Thoron[2] *(presenting author)*

[1]Novancia Business School Paris, France; [2] CEREGE, France

Keywords: Nanotechnology, Safer-by-Design (SBD), Education, Innovation

*This work has been carried out in the framework of the Labex SERENADE (ANR-11-LABX-0064) and of the A*MIDEX project (ANR-11-IDEX-0001-02), funded by the «Investissements d'Avenir» French Government program managed by the French National Research Agency (ANR)*

Our purpose today…

is to present a European-focused study of university educational initiatives to support the Safer-By-Design (SBD) approach as part of sustainable nanotechnology.

What is the Safer-By-Design (SBD) approach?

Historically speaking, basically three major areas covered by the SBD approach:

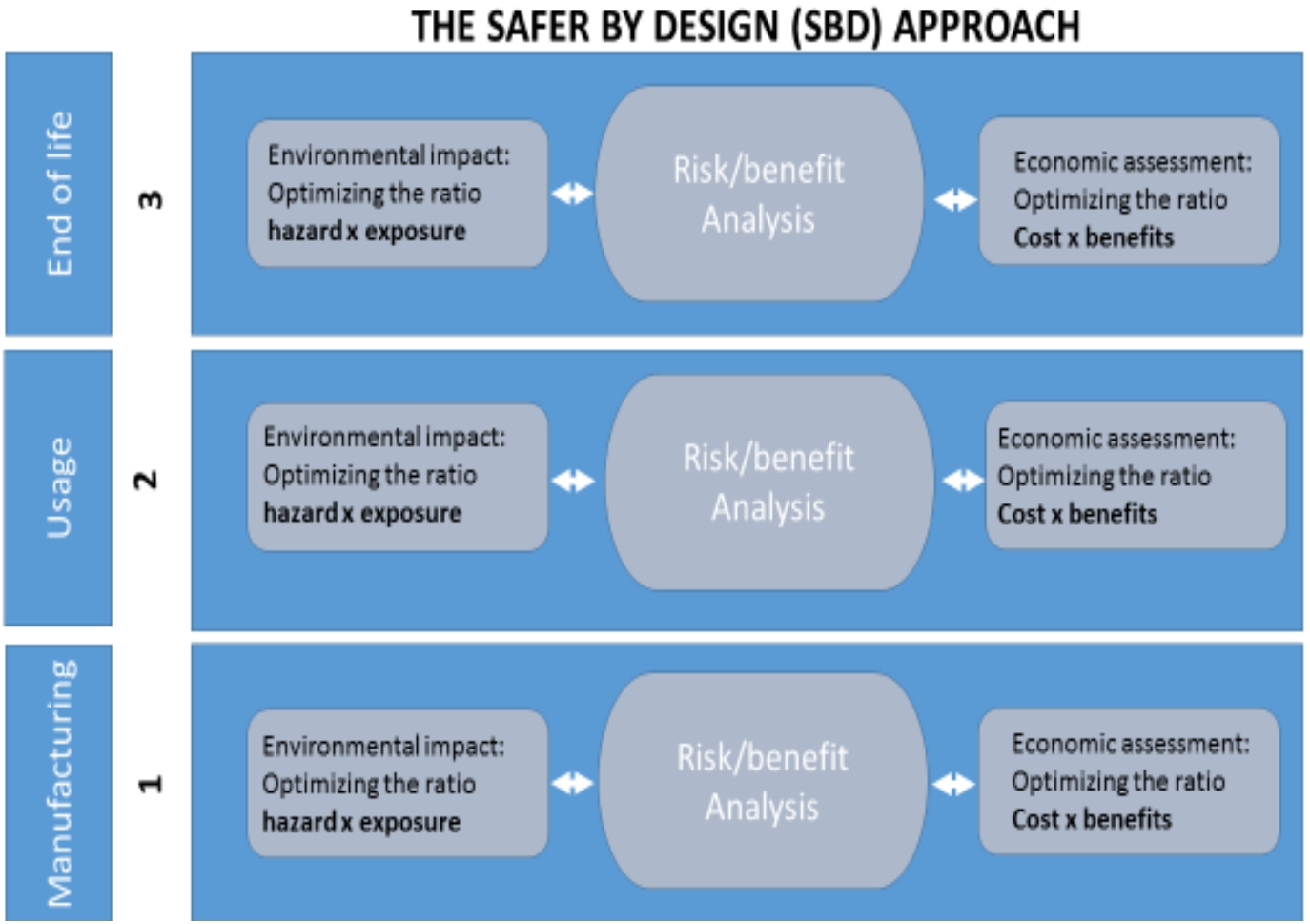
- **Product design:** designing products (machines/tools) so that users are not harmed by them (since 1960s).
- **Urban design**: designing urban places so as to minimize crime (since 1970s) – Crime prevention through better environmental design.
- **User-centered function design:** designing products or services so as to make their use function safer for humans. E.g. modelling risk-based approaches to fire safety in ship design, or drug design (since 2000s).

What is the Safer-By-Design (SBD) approach?

We define the Safe by Design approach as a design process that seeks to minimize health and environmental risk in a life cycle perspective.

The Safer-By-Design (SBD) approach applied to nanotechnology.

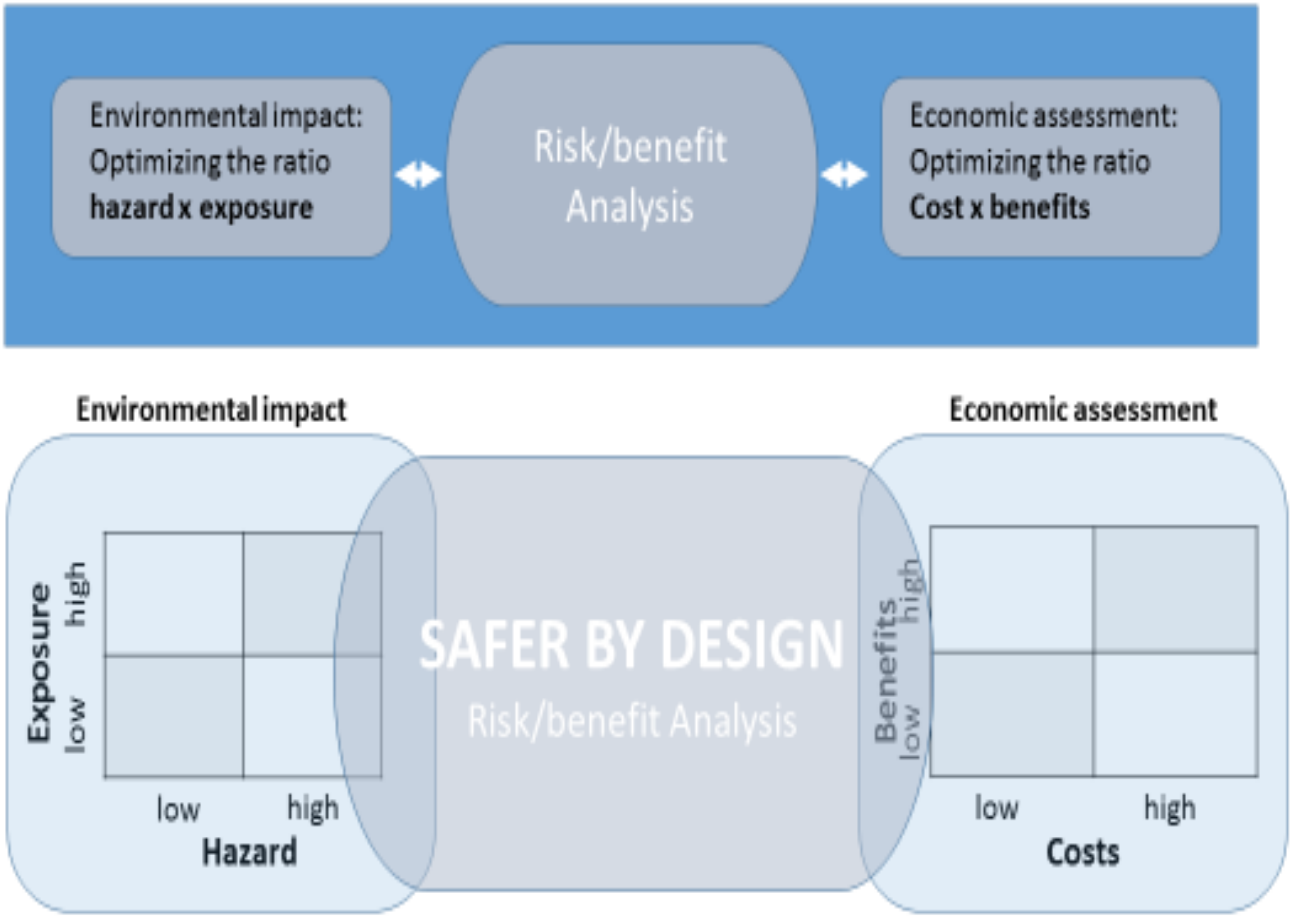
The Novancia Business School defines a multidisciplinary "Safer by Design" approach for each stage of the life cycle



Source: Auplat et al., 2015

The Safer-By-Design (SBD) approach applied to nanotechnology

The SAFER BY DESIGN (SBD) approach at each stage of the life cycle



The SbD approach provides matrix-based scenarios that can be used at each stage of the life cycle to optimize decision making. It should help decision makers and business executives to Identify the best risk/benefit ratio to support their choices.

Source: Auplat et al., 2015

METHODOLOGY

Cross and analyze results from three different studies to map education initiatives referring to the SBD approach for nanotechnologies.

Total absence of SBD, so we looked at eco-design as a first step.

1. **Academic training relating to eco-design and/or to nanotechnologies at Master level in France** (content analysis of various databases including educational and Nano data websites).

METHODOLOGY

2. **Academic training relating to eco-design and/or to nanotechnologies in the institutions of the participants of the NANOSAFE 2014 conference in Grenoble, France** (content analysis of the websites of the institutions of the participants).

3. **Training activities and objectives of the SERENADE LABEX, a major research consortium dedicated to sustainable nanotechnology in France** (semi-structured interviews).

Labex SERENADE : Safe(r) and Ecodesign Research and Education applied to NAnomaterial DEvelopment

"The new generation of materials safer by design"

Coordination CEREGE:
Directors : JY Bottero, J Rose
Deputy director : A Masion

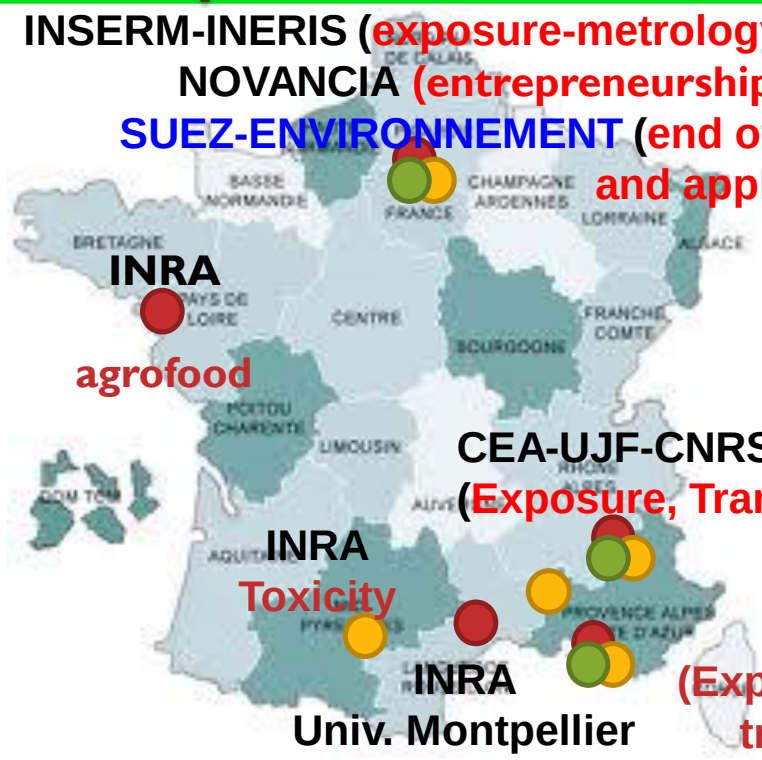
Financial and administrative director: S.Bonifay
Scientific and outreach manager: C. de Garidel-Thoron

Labex Serenade

SERENADE is a Labex, i.e. an Excellence Laboratory, funded for 8 years by the French «Investissements d'Avenir» project. This project proposes an integrated scientific and educational approach to develop new concepts and tools for the Safer and Ecological Design in Nanomanufacturing Processes and Products.

Partners: National consortium
11 academics plus 2 industrials

INSERM-INERIS (exposure-metrology-toxicity)
NOVANCIA (entrepreneurship)
SUEZ-ENVIRONNEMENT (end of life and applications for water treatme



INRA
agrofood

CEA-UJF-CNRS
(Exposure, Transformation)

INRA
Toxicity

AMU-CNRS
CEA; INERIS
(Exposure, Life cycle, transformation, (eco)toxicity)

INRA
Univ. Montpellier
Agrofood
Packaging

ALLIOS (paintings)

Labex added value:
•All (almost) French research organisations
•Academy + industry
•Multidisciplinary

- Synthesis and properties
- Ecotoxicity/toxicity
- Life cycle assessment

Support letters:
Ital Cementi
Union des Industries de la Chimie
Danone
FIPEC (paints)

Serenade

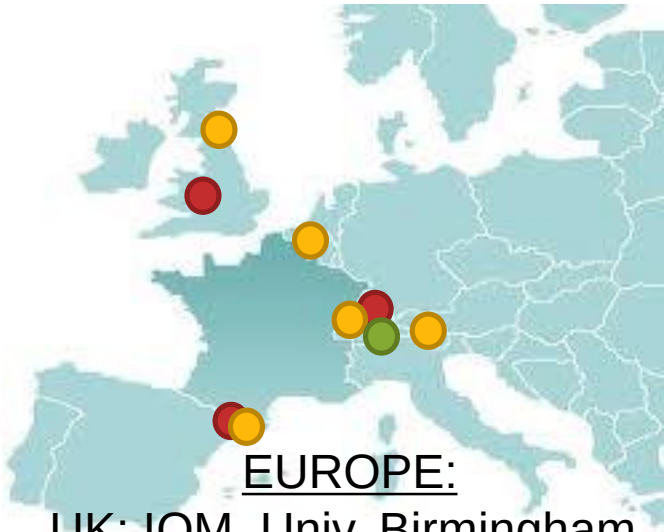
Partners : international networking

USA CEINT :

Duke Univ., Univ. of Kentuky, Virginia Tech, Stanford Univ. Carnegie Melon

CANADA:

Univ. of Montreal



EUROPE:

UK: IOM, Univ. Birmingham,

SZ: EPFL, EAWAG, EMPA

AT : Universität Wien

Be: UCL

SP: ICN2

- Synthesis and properties
- Ecotoxicity/toxicity
- Life cycle assessment

AUSTRALIA

Univ. New South Wales

Objectives :

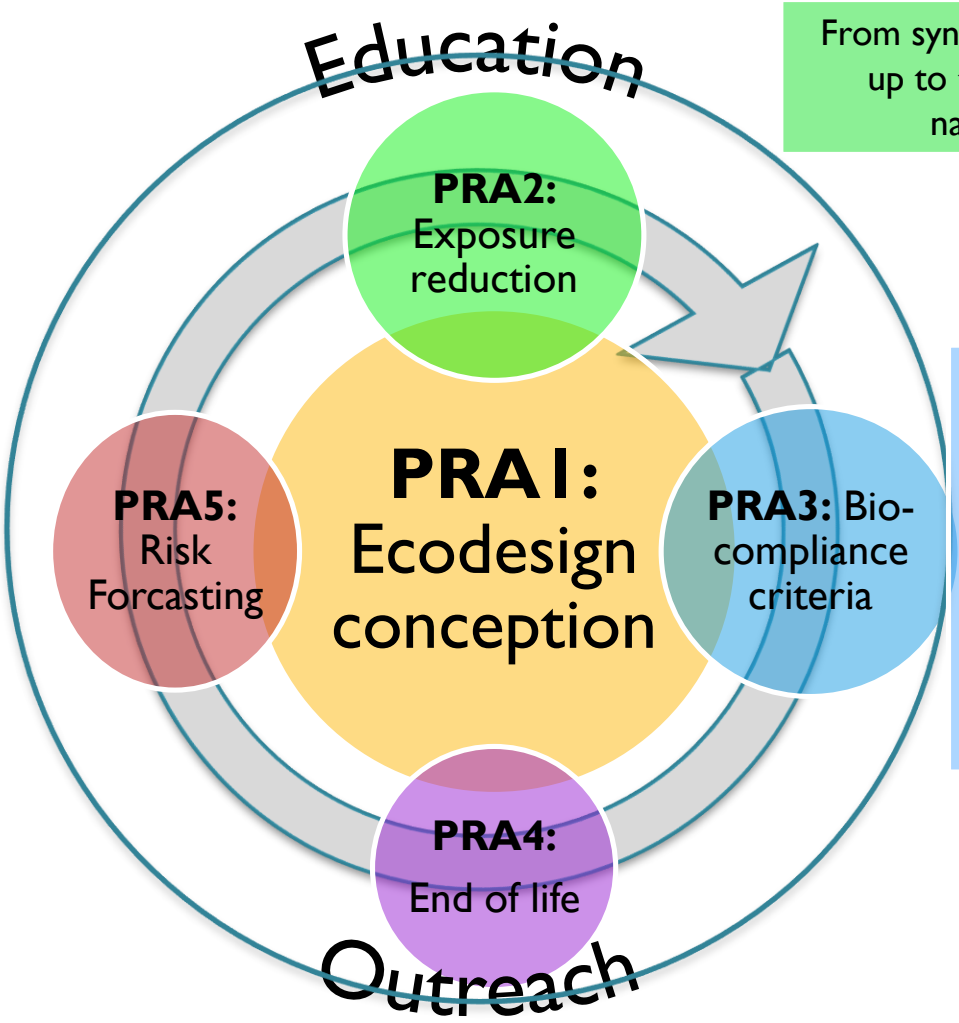
- Design nanomaterials **safer for both human health and the environment** in order to promote the **sustainable and responsible development and competitiveness** of National SMES and companies involved in nanotechnologies.
- Implementation of **metrological tools** for occupational workers, population and environment media.
- Develop a **new approach of the entrepreneurship** by integrating findings on marketing, communication or ethics, which are to day at the core of many nanotechnologies debates into a wider frame and shaping a sustainable market infrastructure for their innovations.

Priority Research Actions (PRA) & Priority Educative Initiatives (PEI) necessary to fulfill the objectives:

From synthesis, intended use up to the end of life of nanoproducts.

To relate properties required by the products in the domain of application with properties required to reduce exposure, hazard and environmental footprint

Risk modeling throughout the Life cycle of products

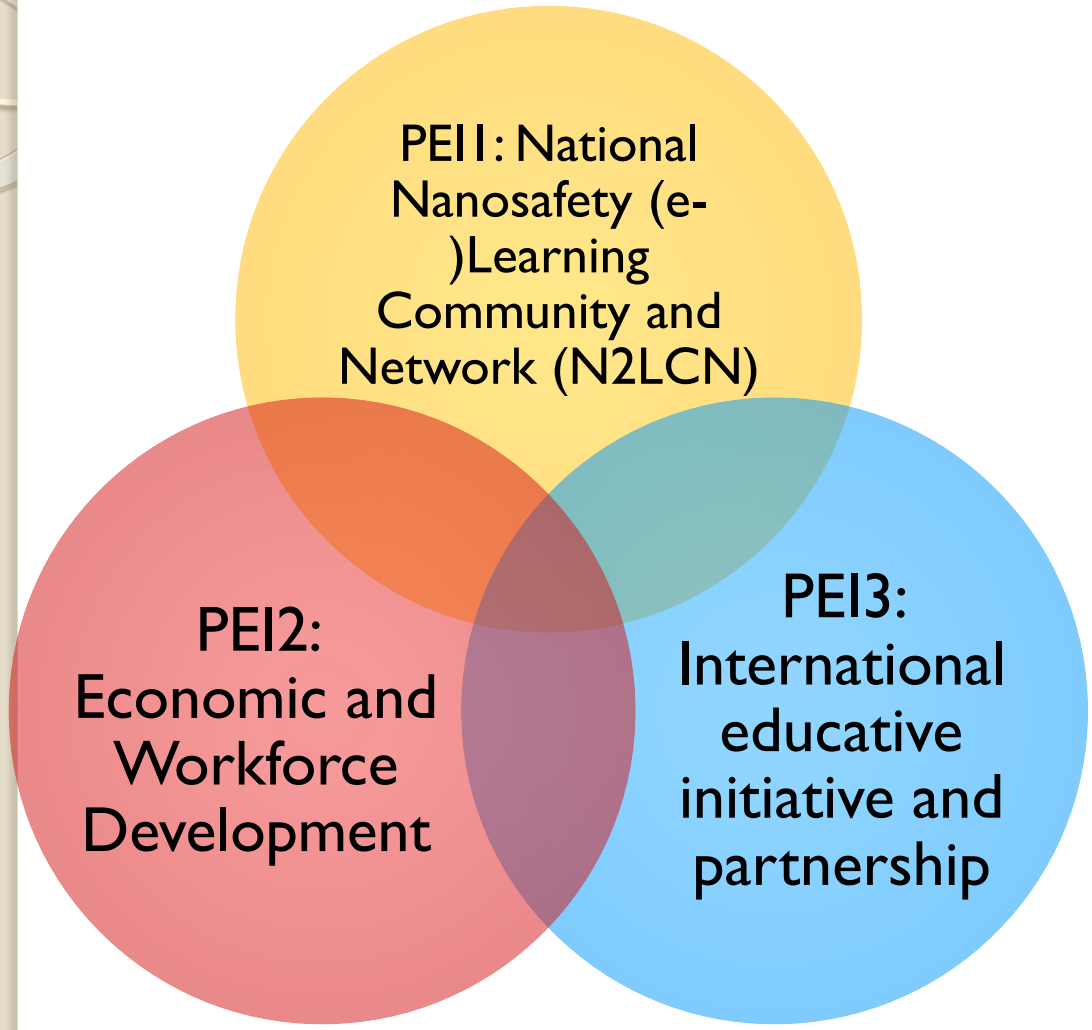


To determine the impacts of nanoresidues on living organisms, human cells and ecosystems, relation between nanoparticle properties and biological effects

With the goal of developing green processes to recycle and/or dispose of nanomaterials and nanoproducts

Serenade

Priority Educative Initiatives (PEI) necessary to fulfill the objectives:



Detect the main missing trainings in order to develop future oriented and more focused trainings in nanotechnologies: industry training or initial skill development, technical upgrading, and professional certification in this emerging field.

Study Number 1- France

Search based on key words nano* and various forms of the term eco-design in relevant databases and websites (Nanowerk, Cnano, CEFIRA, registre de la conférence des grandes écoles, clubnanomicro…).

S1: Existing Master level academic training on eco-design and/or Nano in France

Training	Disciplines
Nanosciences, nanotechnologies	22 (mostly in Physics or Physics and chemistry)
Eco-design	9 (7 engineering or multidisciplinary, 2 in social sciences)
Health or environmental impacts of nanos	12 (11 in biology, chemistry, 1 in social sciences)
Eco-design in nano	1 : M1 students in Master ECPC can apply for CNANO Master (cotutelle i.e double affiliation)

Study Number 2 – mostly in Europe

Master level training crossing eco-design with nanomaterial sciences in the institutions of the participants of the NANOSAFE 2014 congress (Minatec, 18-20 November 2014)

- 31 countries in the world
- 106 academic institutions
- Data search from the institutions' websites

S2: Existing courses on eco-design and nanomaterials science in the world

0 training crossing nanomaterials and eco-design	A few courses on the environmental impacts of nanomaterials	1 course on nanotechnology and ethics	2 courses connecting science and management
	• 1 in Switzerland • 2 in Germany • 1 in India • 1 in Denmark • 0 in the United-Kingdom	• 1 in Germany	• 1 in Switzerland (innovative products design) • 1 in the UK (detecting and answering industrial needs)

Study Number 3 – Serenade partners

Semi-structured interviews with key representatives of the SERENADE LABEX (academic and business partners). Duration : 3 months - 100% response rate.

Three categories of questions :

- Existence of academic or professional training on the LABEX themes
- Constraints and challenges of integrating Safer By Design (SBD) in training
- Actions to initiate or to develop in the future (types of training, course contents…)

Study Number 3 : partners interviewed

Interviewed persons

- 22 persons

Labex's partner institutions

- **18 partners** (AMU/ CNRS/ CDF/IRD/CEA/UJF/CCIR/CIRAD/SupAgro/UnivMonpt2/ UnivAvignon/INSERM/ UPEC/ Ministère de l'écologie/ IFSTTAR/UDS/INP/UPS)

S3: Involvement of LABEX partners in courses relating to SBD and nanotechnology

Most partners are involved in a transversal way in non-specialized Masters (Science, Technology and Health, or Social Sciences) with modules on Nano impacts on health or the environment:

- 3 Masters in Marseille PRNT, SENS, SET
- 1 Master in Grenoble ISM
- 1 Master in Montpellier INGALE
- 2 Masters in the Paris Region: TES , Novancia
- One partner offers a module on eco-design (Novancia)

S3: Involvement of LABEX partners in courses relating to SBD and nanotechnology

Specialized courses on Nano, science, technology and health (mostly with a physics/chemistry orientation) are located mostly in :

- Grenoble : UJF, INSTN
- North West of France (Master Cnano with codirection) : Nantes, Rennes 1, Lorient, Brest

General findings (1/3)

- Academic websites are often incomplete and sometimes not available in English, which renders the assessment of specific initiatives difficult.
- Great lack of congruence in terminology as well as in training contents.
- Total absence of training specifically targeting the Safer By Design (SBD) approach for nanotechnologies.
- Existing training in eco-design does not cover nanotechnology. It mostly targets practitioners with the objective of training experts or managers specializing in environmental assessments in industry.
- Existing nanotechnology programs are circumscribed to schools or departments of hard sciences, particularly physics and chemistry.

General findings (2/3)

- Courses relating to Nano environmental and health impacts tend to be multidisciplinary (chemistry, biology, materials science, physics, etc…
- The design of new courses on the SBD approach requires preliminary understanding of the criteria that will need to be studied at each stage of the life cycle: environmental and health impacts as well as economic dimensions. This is true in all disciplines.
- There is a strong trend toward building new courses uniting several disciplines (chemistry, biology, materials science, physics, etc.).

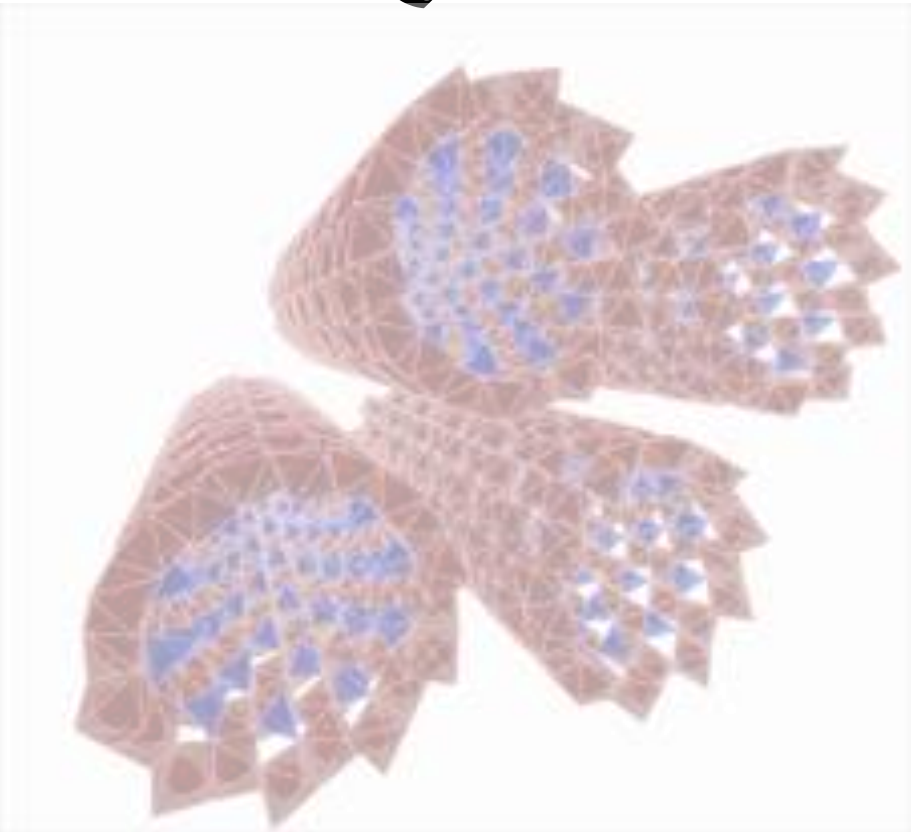
General findings (3/3)

Successful development of the SBD approach in nanotechnologies will require :

- Multidisciplinary contents
- More in-depth training on toxicology, eco-toxicology, and economic aspects of eco-design
- A greater focus on the positive economic impact to be expected from the SBD approach. This means becoming more proficient in comparative economic valuation of various options at each stage of the life cycle

Thank you for your attention

Questions?



Serenade

References

- **Ecodesign**
  - ✓ Wimmer, W. 2010. *Ecodesign: The Competitive Advantage.*
  - ✓ Tuillier, J. 2013. *La filière Eco-activités en Ile de France, monographie économique*
- **Nanotechnologies**
  - ✓ Zucker, L., Darby, M., Freeman R., eds. 2014. *Special issue on knowledge capital in nanotechnology and other high technology industries.*
  - ✓ Riediker, M.2013. *Compendium of Projects in the European NanoSafety Cluster*
  - ✓ Wiesner, M, Bottero J.Y., eds. 2007. *Environmental nanotechnology*
- **Institutional theory, knowledge literature**
  - ✓ He, Zi-Lin, Poh-Kam W. 2012. *Reaching Out and Reaching Within: A Study of the Relationship between Innovation Collaboration and Innovation Performance*
  - ✓ Le Masson, P. , Benoit W., Hatchuel A. 2010. *Strategic Management of Innovation and Design*

References

- Ben Slimane, S. Auplat, C., Fremiot, E. 2014. Bilan prospectif des activités du Labex SERENADE. *Séminaire Labex, CEREGE Aix-en-Provence*, 55pp.
- Ben Slimane, S. Auplat, C., Fremiot, E., Glaser, A. 2015. Activités de formation à l'écoconception dans le cadre du LABEX SERENADE - PEI 2. Rapport préliminaire. *Séminaire Labex, Minatec Grenoble*.
- Zucker, L., Darby, M., Freeman, R. eds. 2014. Special issue on knowledge capital in nanotechnology and other high technology industries, *Annals of Economics and Statistics*: GENES, Groupe des Ecoles Nationales d'Economie et de Statistique.