ENGineering and INdustry Innovative Training for Engineers (ENGINITE)

PROJECT NUMBER
2017-1-CY01-KA202-026728

A1 course

Engineering Systems Thinking: Re-engineering by Simplifying

Prepared by CUT

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1. PART A: General Information

Title: "Engineering Systems Thinking: Re-engineering by Simplifying"

Keywords (4-5): *engineering problem solving, shift graduates, globally optimal solutions, globally optimal solutions, engineering systems*

Authors: Elpida Georgiou, Stylianos Yiatros

Duration: 1 day online reading/study on Google Classroom, 1 week f2f

Language of materials: English and Greek

Type & number of sessions:

Day 1 (3 hours)	Day 2 (3 hours)	Day 3 (3 hours)	Day 4 (3 hours)	Day 5 (3 hours)
• Ice breaking games – system dynamics • Simplifying a system – a structural engineering model: show the approach, give problem to individuals and discuss: reflect on answers. Ask peers to review • Understanding systems – biomimicry approach: Select an ecosystem and identify the key stakeholders. Who is involved and how. Structured template • 10 min reflection	• Report and reflection on their organism. Who is involved, are there any closed loops. Draw on the circular concepts from the online course. Can we find a man-made system Factory, city operations etc, supply chains, that could mimic some of the organisms identified (see lect 3 organisms and split in groups of 5). • Reflection	• Report and reflect on previous day's work • Systems thinking game 2: Changing perspectives • Role playing: people in groups having different roles (and agendas) debate a proposal • Stop at fixed time. Tell people to show their cards with their agendas. Who won/was winning • Introduction to main exercise: define a structure for seeking a problem. Form groups (3 groups of 5). Select a problem close to each group's heart. Assign role to each member. • If not you can propose some	• Reflection with everyone together (how did they feel in their roles. What difficulties did they face) • 1hour structured surgery with each group	• Presentations and Q&A with other groups • Reflection and closing

Number of participating engineers: 20-25 engineers

Group's setting: Mixed gender, multidisciplinary groups of engineers, 5-7 members in each (per guidelines of PBL literature)

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2. PART B: Module Overview & Key Learning Outcomes

Module overview:

In this module the participating engineers will be trained to develop their engineering solving skills in order to fill the gap between their graduate knowledge and their professional skills. Specifically, this course aims to shift graduate mindset in engineering problem solving, moving away from solving 'part' or 'point'-problems and focusing on optimal solutions of the overall system. The solutions emanating from systems thinking usually lead to "doing more with less", globally optimal solutions. The participants will be introduced to the concepts of systems thinking through problem-based learning techniques which will be applied on relevant engineering systems. The graduate engineers will be requested to apply a holistic analysis in real-life systems problems of their interest and to design an effective multidimensional solution.

Key learning outcomes:

Upon completion of the course, participants should be able to:

- Develop an appreciation of systems concepts
- Recognize the important elements of systems thinking in solving problems across scales, sectors and disciplines
- Appreciate the merits of Problem Based Learning for learning new techniques
- Identify and define system problems or challenges with a system thinking approach (possible optimum solutions).
- Appreciate the tremendous power of holistic iterative thinking
- Develop a sound understanding of particular systems thinking methodologies and tools
- Develop Entrepreneurial and innovation skills by challenging conventional solutions
- Develop the art of simplifying complexity through systems thinking
- Gain experience in multi-disciplinary systems thinking problem solving through case studies
- Define and assess the positive outcome through a system's thinking problem solving approach.

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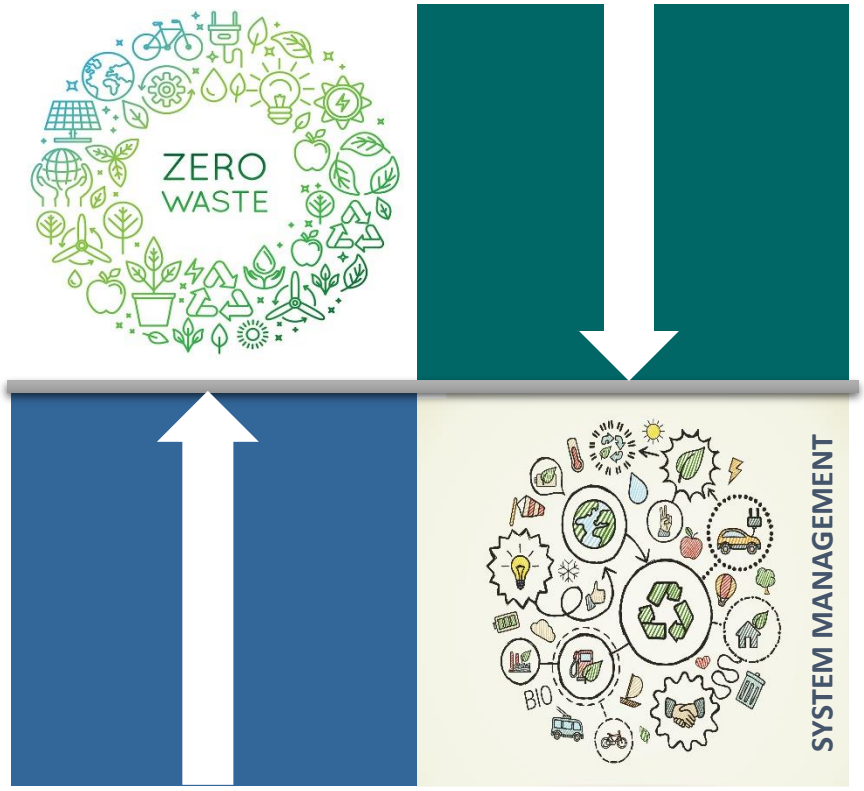
3. PART C: Problem – based- Learning Scenario

Waste management on a campus

The University Council has announced a call to fund the most efficient proposal for the "Waste management on the campus of Cyprus University of Technology". Cyprus University of Technology is a young university based in the city center of Limassol and along the coastline of Limassol town. There are also some parts of the University that are located around the city. You have *to find the information that you need and* to propose a waste management system plan for the university and you have only 1 week until the deadline submission. Your plan has to create both micro and macro scale scenarios taking into consideration the concepts of circular economy where possible. This proposal has to be planned in such a way that it could be applied as a guidance for any other University campus. Once you prepare your proposal you have to present it to the government in order to get the funding for your proposal.



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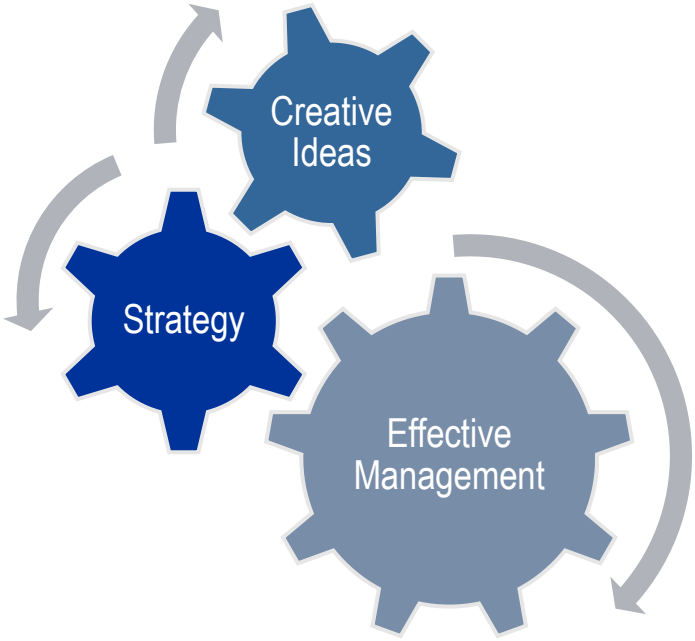

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4. PART D: Pre-Module Preparation

4.1 Background Information

Books:

- System thinking a primer by Donella Meadows Project
- Doing it differently 2nd edition by Patrick Godfrey and David Blockley
- Systems thinking made simple: new hope for solving wicked problems by Derek Cabrera & Laura Cabrera, 2015
- Thinking in Systems: a Primer, Chelsea Green Publishing Co., D. Meadows, 2015
- Seeing the Forest for the Trees. A Manager's Guide to Applying Systems thinking, Nicholas Brealy International, D. Sherwood, 2002
- Practical Creativity and Innovation in Systems Engineering, Wiley Series in Systems Engineering & Managements, Wiley-Blackwell, A. Engel, 2018
- Gathering and Using Information Starter and Development Packs, Student Skill Packs Series, Sheffield Hallam University
- University Campus Solid Waste Management, Combining Life Cycle Assessment and Analytical Hierarchy Process, P. T. Ghazvinei, M. A. Mir, H. H. Darvishi, J. Arifin, 2017
- Systems Thinking Managing Chaos and Complexity, 3rd Edition, J. Gharajedaghi, 2011
- S. R. Covey, *"The 7 Habits of Highly Effective People",* New York: Simon & Schuster, 1989
- P. M. Senge, A. Kleiner, C. Roberts, R. B. Ross, and B. J. Smith, *"The Fifth Discipline Field book",* New York: Currency Doubleday, 1994

Articles:

- Evaluation of solid waste management at campus using the "Zero Waste Index": the case on campus of Islamic University of Indonesia, *MATEC Web Conf.,* Kasam, F. Mulya and S. A. Prasojo, 2017
- Garcia-Holguera, M., Clark, O.G., Sprecher, A. and Gaskin, S., 2016. Ecosystem biomimetics for resource use optimization in buildings. *Building Research & Information*, *44*(3), pp.263-278.
- Starkman, G.D., 2015. Large scale evolutive systems: what can they teach us?. *Rendiconti Lincei*, *26*(2), pp.261-264.

Websites:

http://www.academyforchange.org/our-work/

https://www.plectica.com/publications

https://medium.com/age-of-awareness/holistic-worldviews-an-introduction-9002d4ede3d4

https://www.edsurge.com/news/2017-12-22-beyond-design-thinking-why-education-entrepreneurs-need-to-think-in-systems

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https://www.lifehack.org/629157/how-to-make-difficult-problems-easier-to-solve-with-systems-thinking

http://www.cornellpolicyreview.com/learning-systems-thinking-at-the-graduate-level/

https://www.plectica.com/publications

http://davidsibbet.com/category/graphic-facilitation/

Online content:

https://toolbox.biomimicry.org/core-concepts/systems/

https://stdaily.ghost.io/

http://complexitylabs.io/courses

https://medium.com/@jamieschwandt/the-critical-thinkers-ooda-loop-6a69e878c153

https://www.su.se/sustainablecampus/how-to-do/waste-management

http://www.grove.com/

Videos:

https://www.facebook.com/paul.claptoncaputo/videos/10154997406652264/?t=5

https://www.facebook.com/Ce.center.vn/videos/966551466763412/?t=169

https://www.youtube.com/watch?time_continue=25&v=pVRO3nKWdLM

https://www.youtube.com/watch?v=s5jKL1OxbcE

https://www.youtube.com/watch?v=Cg3OA1s8-SI

https://www.youtube.com/watch?v=14r7f9khK70

https://www.youtube.com/watch?v=9STFO5HjuP8

https://www.youtube.com/watch?v=tovU6ul1w2g

https://www.youtube.com/watch?v=Kr_DGf77OhM

https://www.youtube.com/watch?v=O_4hO7R3Vtc

https://www.youtube.com/watch?v=GB74q_VWIS4

https://www.youtube.com/watch?v=vmq_mKhQo38

https://www.youtube.com/watch?v=XGqrNi3kTLc

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

https://www.youtube.com/watch?v=NWCg-QmSE7A

https://www.youtube.com/watch?v=eec0UYGIeo4&list=PLEXqjIYY5zi6hWCvm5idXYLH2Qtv7fT-f

Blogs:

http://blogs.ucl.ac.uk/uclse/category/systems-thinking/

http://blog.eie.org/systems-thinking-skills-in-the-engineering-classroom

Example / approaches:

http://www.cornellpolicyreview.com/understanding-the-struggles-of-small-coffee-producers-in-chiapas-a-systems-thinking-approach/

http://www.cornellpolicyreview.com/how-can-we-use-systems-thinking-to-find-a-solution-to-the-problem-of-poverty-in-panama/

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4.2 Case Study additional material

The last years, the European reports revealed that Cypriots create more waste than most in EU. See below some reports about that subject.

https://cyprus-mail.com/2018/04/29/view-waste-management-fiasco-avoided/

http://cyprus-mail.com/2016/03/23/cypriots-create-more-waste-than-most-in-eu/

http://english.cyprustimes.com/2017/07/29/waste-management-unit-limassol-operate-early-october/

The University Council has announced a call to fund the most efficient proposal for the "Waste management on the campus of Cyprus University of Technology".

The Problem that you are called to investigate must be addressed through the systems thinking process and should be designed in a holistic view. You should provide a practical way that you define your problem and to design your solution. The process that you are going to follow should be presented. More specifically, the investigation process, the model that you will propose, the integration of systems, the design and the performance of the system.

You should focus on a whole system and on relations between the several subsystems. In addition, you should give attention to the process and dynamics of the system that you are going to design. The system design that you are going to produce should satisfy a multiple number of functions and you must display the interaction between the parts and how they affect each other.

Your target and the primary and other objectives should be defined, in addition to the discussion of the challenges that you faced, and the structure with the stages that you will follow and the tasks that you will complete in order to reach your target. The resources that you are going to use must be presented as well.

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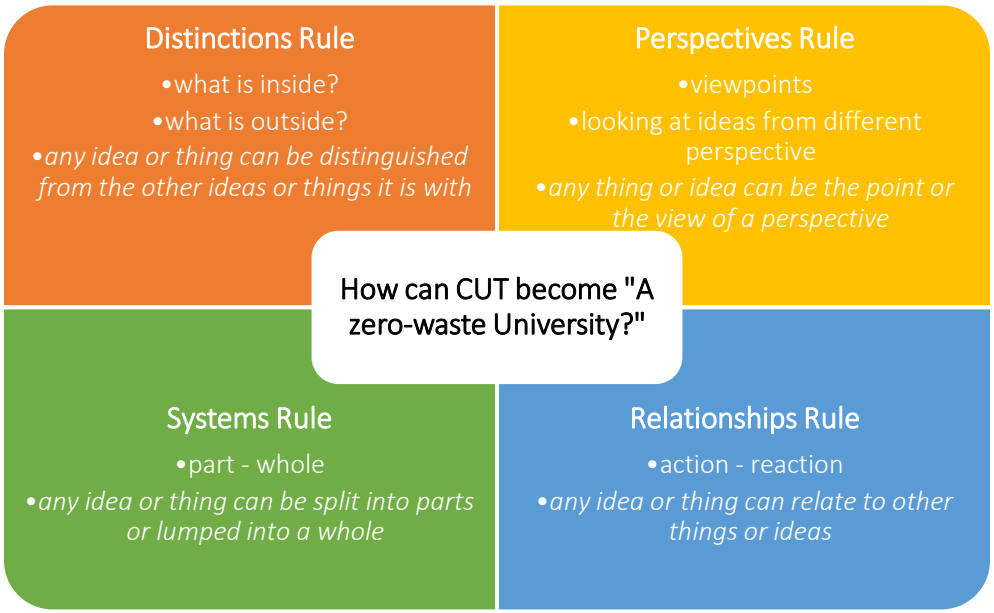

Figure 1: Four simple rules for systems thinking (DSRP) by "Systems thinking made simple, new hope for solving wicked problems by Derek Cabrera & Laura Cabrera"

You can follow the "Mission Mental Model" for the process of your design through the systems thinking process.

The waste management design that you will propose:

- Should be in interaction with the waste management system of the government
- You should consider:
  - a techno-economic study
  - feasibility study
  - an environmental impact assessment
  - the urban planning regulations
  - the construction drawings of your plan
    - spatial study
- You should propose concepts for the circular economy in your design
  - Measures and actions for the relation between the economic development and the environmental impacts that are connected with the waste production
- You could also use the technology in your proposal (maybe an application or something)
- How your waste management design will interact with the rest of the city? Or interact with the community?

In your waste management plan, attention should be given in the waste production changes that minimize waste production through the reduction of specific wastes, the reduction of organic and hazardous waste and the increase of reuse and recycling.

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Moreover, you may define some measures for the prevention measures for organic waste, of paper, plastic, of electric and electronic supply, of clothing and fabric, of construction or demolitions.

You should define the sectors that you address and control the measures that you propose (teaching rooms, offices, labs, gym).

You have one week to propose a waste management system plan for the University with a name or a logo for it. Your plan has to create both micro and macro scale scenarios. This proposal has to be planned in such a way that it could be applied as a guidance for any other University campus. Once you prepare your proposal you have to present it to the government in order to get the funding for your proposal.

The deliverables that you should submit are the following:

- A short report that will include:
  - Executive summary (2 pages)
  - The problem definition
  - Your proposed solution and design
  - Your analysis (SWOT and quantitative if necessary)
  - Your drawings
- A reflective summary for individuals
- Moreover, you will be called to present your design solution in a 20 minutes presentation and then some questions will be followed

Some information that you may need for your project are following:

Cyprus University of Technology (CUT) buildings and campus map:

CUT is a relatively new University based in the city center of Limassol and along the seaside of Limassol town. Some parts of the University are located around the city. The University consists of 60 buildings. Below, in the link that is following links you can find the CUT campus map and the list of the University buildings.

https://www.cut.ac.cy/map/?languageId=100

https://www.cut.ac.cy/university/administration/administrative-services/ems/University+Campus/Campus+Infrastructure/

CUT waste management at the moment:

There is already some work done regarding the waste management of the University from the office of environmental policy of the University as you can see in the link that is following. The CUT collects and manages all the dangerous wastes that are produced from labs. These wastes cannot be left in the environment because of their dangerous effect in order not to occur any destruction. For this reason,

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CUT has made a cooperation with a company (licensed from the Department of the Environment of the Ministry of Agriculture, Rural Development and Environment) for the collection and management of the specific wastes.

The collection and management system of recycle materials begun at CUT in the beginning of 2010. The responsible office for the supervision and management of the recycle system at the University is the green@cut. The recycled materials that the CUT produce are the paper, PMD, batteries, electrical and electronic supplies, printer toners and glass.

http://green.cut.ac.cy/

Limassol waste management at the moment:

There are some waste management facilities in the city that the University is located (Limassol). The Facility for the solid waste management (OEDA) of Limassol region and its transit station of solid wastes in Kantou, the Innovating Environmental Solutions Center (IESC) which incorporated in 2010 and has been operating in partnership with the Advance Medical Waste Management Ltd, and CYLUBS Co Ltd.

Some information and statistics during the years for Cyprus can be found in the below documents:

http://ec.europa.eu/environment/waste/framework/pdf/Waste%20Summary_CY.pdf

https://www.unece.org/fileadmin/DAM/stats/documents/ece/ces/ge.33/2012/mtg1/Municipal_Waste_Management_in_Accession_Countries.pdf

https://www.researchgate.net/profile/Dafnis_Coudounaris/publication/292982618_Mediterranean_Urban_Waste_Management_Project_MUWM_2001-2003/links/56b393ac08ae5deb2657ddf2/Mediterranean-Urban-Waste-Management-Project-MUWM-2001-2003.pdf

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5. PART E: Module Overall Presentation

Discussion questions:

- Can you define the specific problem that your team has to investigate?
- Do you thing that it is feasible for Cyprus University of Technology to be a zero-waste University?
- In what ways can the problem be solved?
- What further information would your team need in order to complete the solution?
- Do you thing that there is a way to connect the waste management of the University with the rest of the city? Or even with the rest of the country system?
- Are there any interactions between the technical, environmental and economic points of view?
    - How they affect each other?
- Why Cyprus is in the highest positions in Europe for the waste that produces?
- Can you use technology in your system?
- How will the community be affected from your plan?
- Do you have any restrictions from the society or from the policies?
- What solution would you suggest?

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6. PART F: Post – Module (Post – Training)

6.1 Reflective questions

Opening questions:

- How would you define the problem you are facing?
- What kind of things do you want to explore?
- Did you classify/categorize the problem areas?
- Did you make a plan?

Navigating questions:

- Is this helping us to get where we want to go?
- Is this useful?
- Does this make sense?
- Should you make some adjustments based on what we have learned so far?

Experimental questions:

- What else works like this?
- What are we missing?
- How would you handle if you were the government?
- What if you are wrong?

Closing questions:

- What is feasible?
- How can you prioritize these options?
- Who is going to do what?

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6.2 Assessment document

6.2.1 Problem based learning assessment

	Bad	Good	Excellent
Definition of the problem			
Analysis of the problem			
Discover what they need to learn			
Identify, find, use of appropriate resources			
Critical selection of knowledge			
Application of selected information to the problem			
Reflection of gained knowledge effectively			
Self-direct the learning strategies			
Group meetings evaluation			
Participation skills in their teams			
Problem Solved?			

6.2.2 Case study assessment

		Bad	Good	Excellent
Systems thinking	Develop of appreciation of systems thinking			
	Use of systems thinking methodologies and tools			
	Frame the problems with the systems thinking approach			
Case study	Report			
	Project folder			
	Professional presentation			
	Individual contribution to the presentation			
	Timeline			
	Reflective questions (e.g. how does it work? can you give me an example? can you describe it in terms of a real-life scenario?)			

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Consortium

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P2-AALBORG UNIVERSITET [AAU]

P3-CUBEIE L.L.C. [CUBEIE]

P5-TECHNICAL UNIVERSITY OF CRETE [TUC]

P6-GRANTXPERT CONSULTING LTD [GrantXpert]

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