MAESTRO

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MULTIPLIER EVENT E3

DEFINITION OF NEW COMPETENCES IN THE DOMAIN OF INDUSTRY 4.0 FOR DIFFERENT ENGINEERING PROFILES

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LLA
LEAN LEARNING ACADEMY POLSKA

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POLITECNICO DI TORINO

1. Introduction

RQ1: How to define the archetypes of engineers?

RQ2: How much is there of Sustainability in these archetypes?

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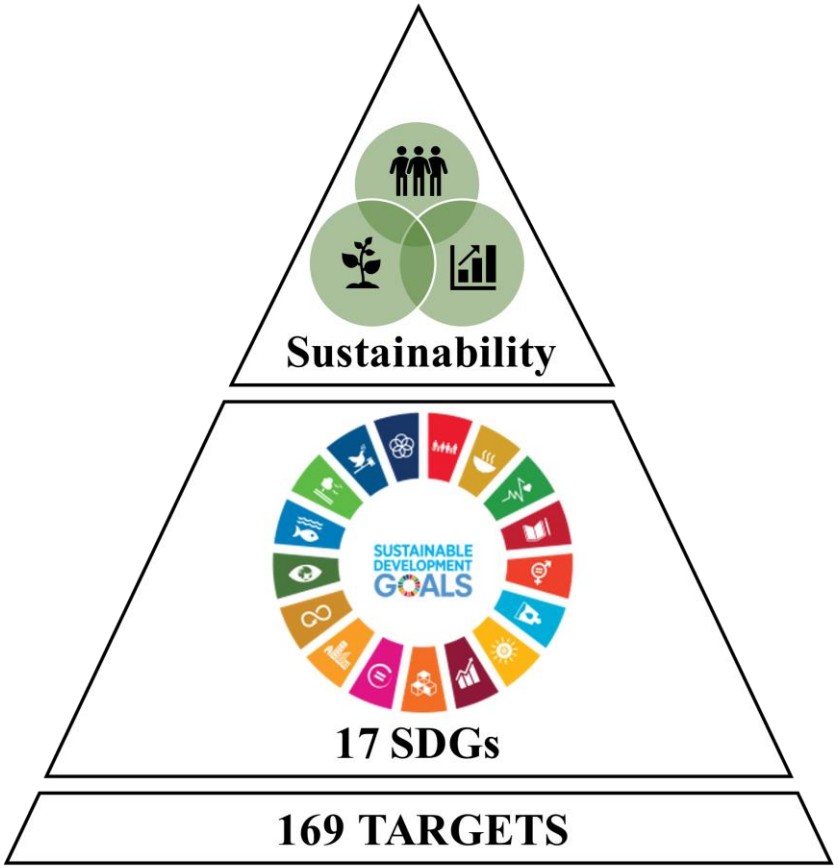
1.1 Sustainable Development Goals (SDGs)



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1.2 Sustainability in engineering educational framework

- **Teachers' course design**: despite good practices for courses design (e.g., [2], [3]), deep integration of sustainability into the core subjects appears to be lacking [1].

- **UNESCO and accreditation bodies**: despite numerous guidelines and standards on teaching the SDGs (e.g., [4]-[6]), a clear and objective understanding on how much a specific engineering is aligned with the SDGs is lacking.

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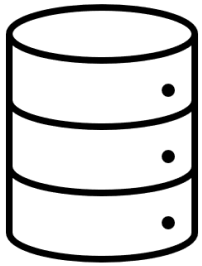
1.3 Sustainability in engineering occupational framework



- **Organizations**: Although many organizations are interested in sustainable management and HSE (e.g., [8], [9]), a compact definition of what engineers are and how they could be associated with sustainability is lacking.

- **ESCO:** European multilingual database deserves attention when describing, identifying, and classifying professional occupations and skills as a result of a specific qualification [7].

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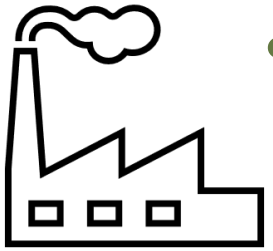
1.4 Industry 4.0 (I4.0)



- **I4.0**: new way of organizing the production methods by bridging the physical and the digital [10].

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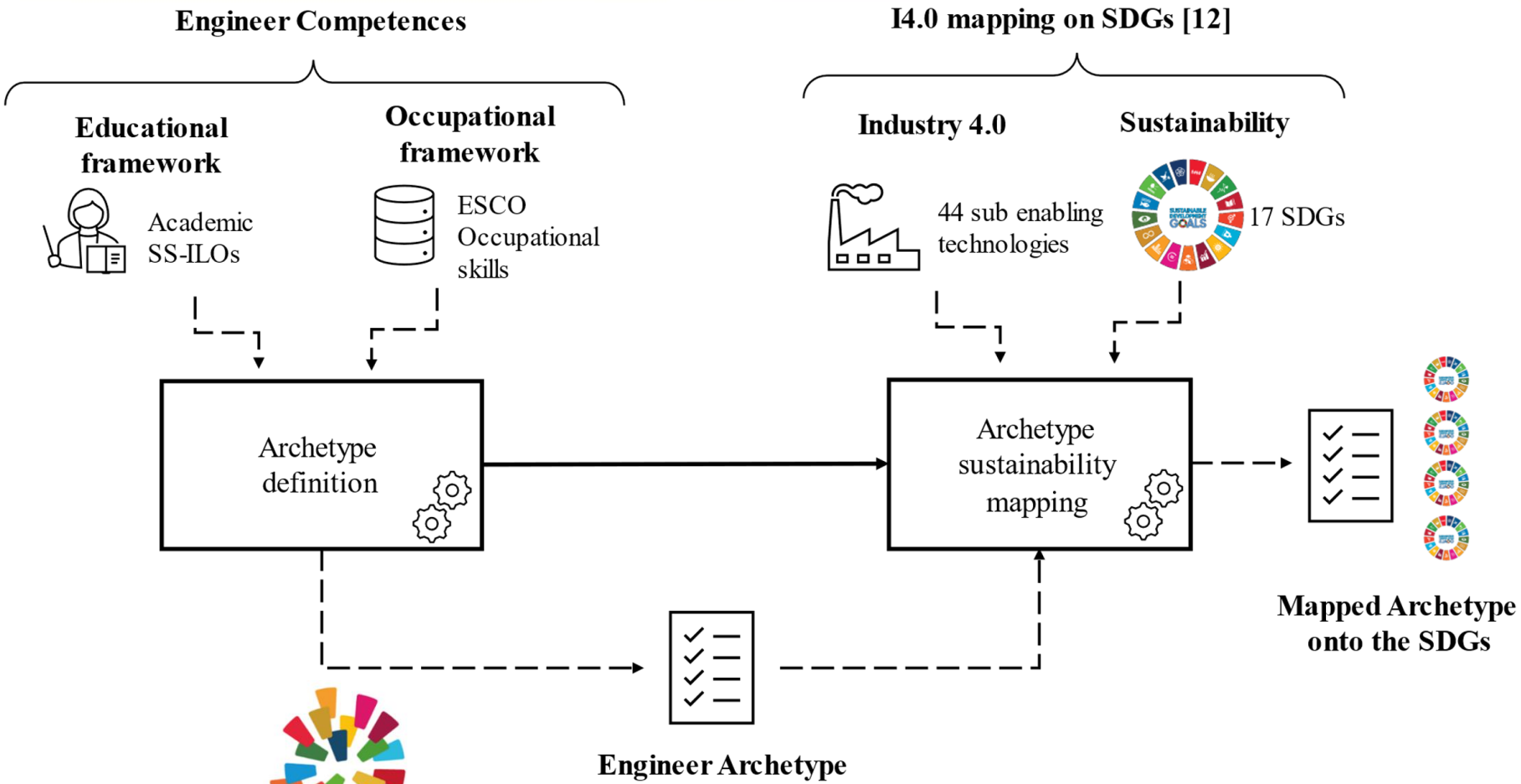
2 Methodology



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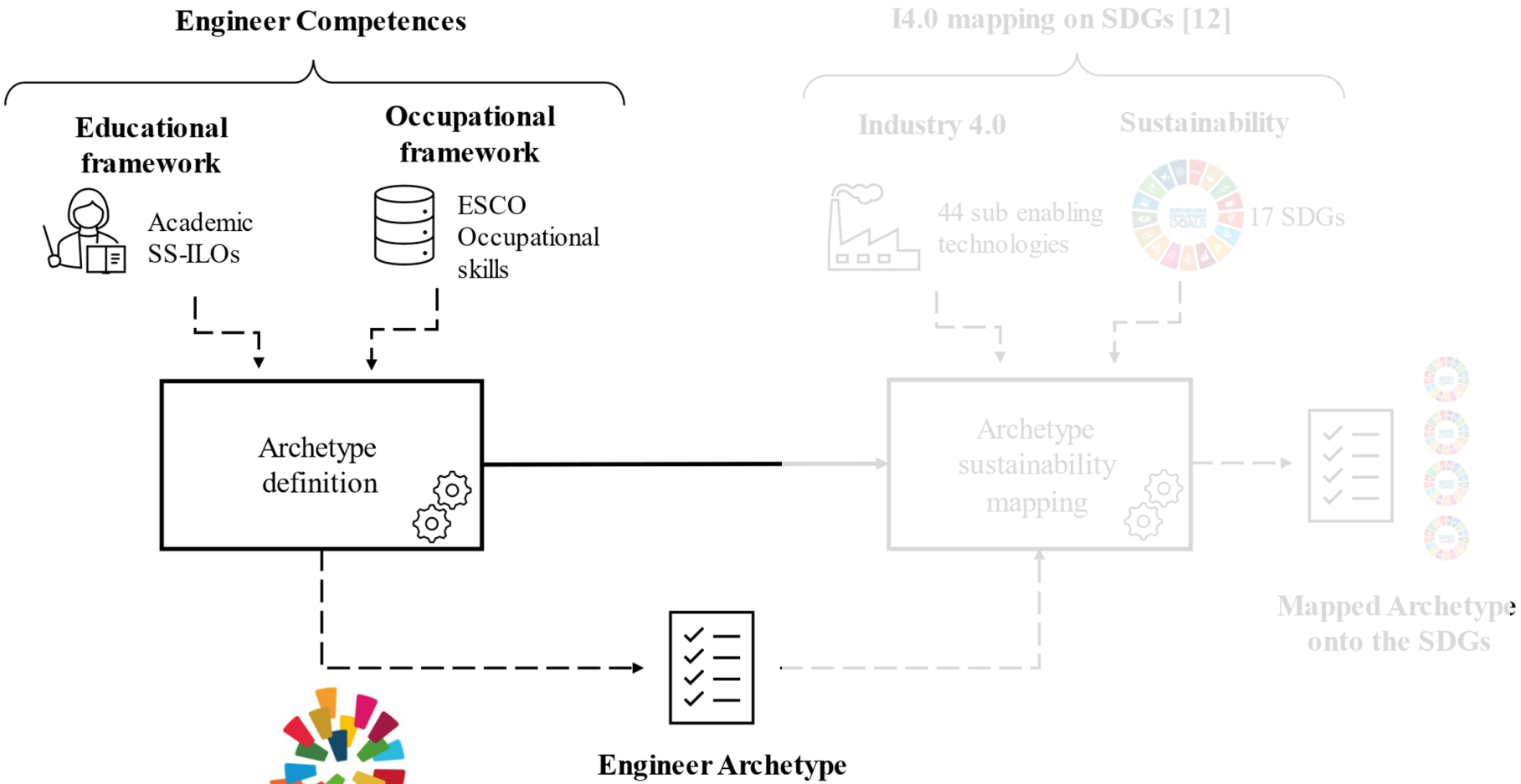
2.1 Archetype definition



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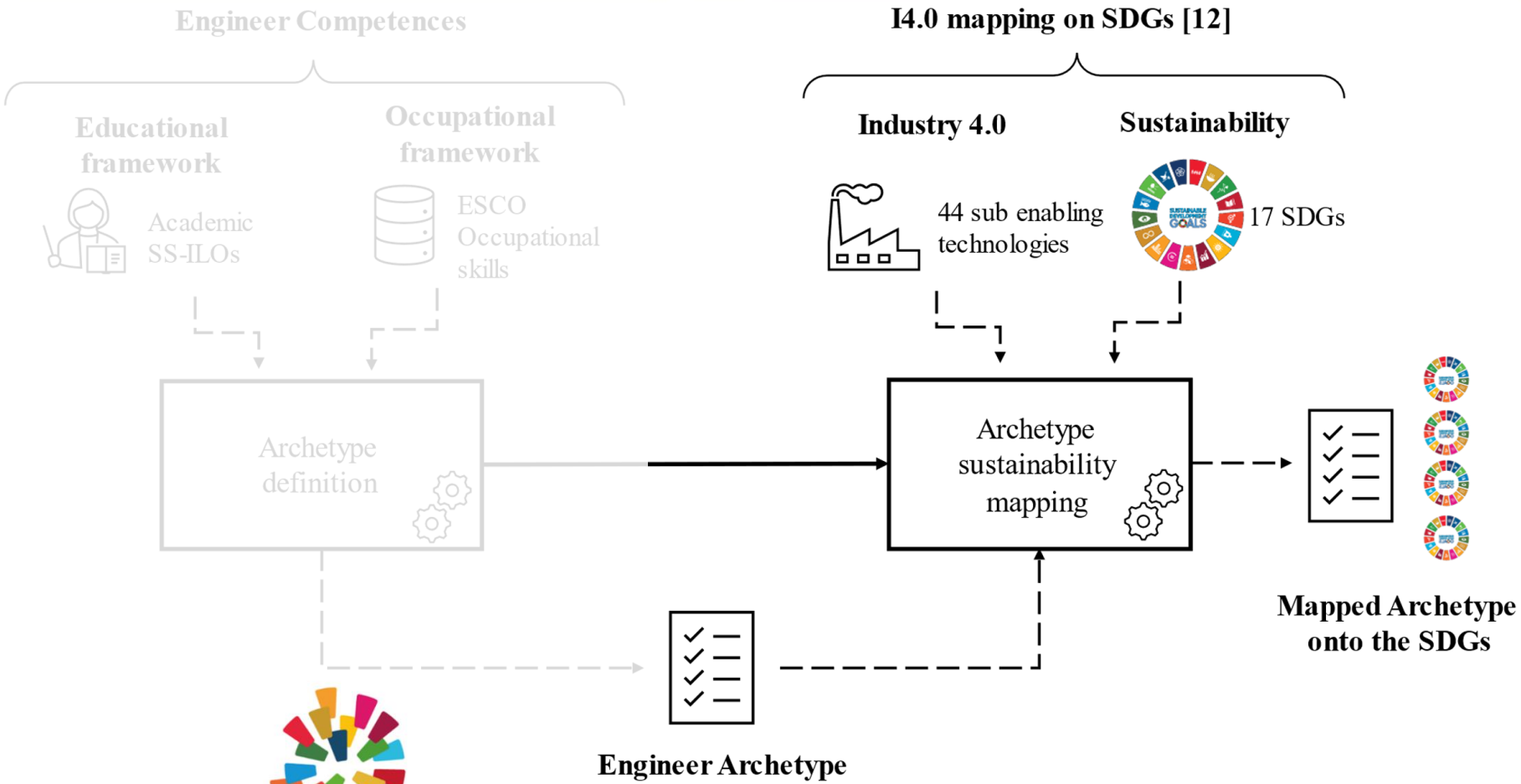
2.2 Archetype sustainability evaluation (1)



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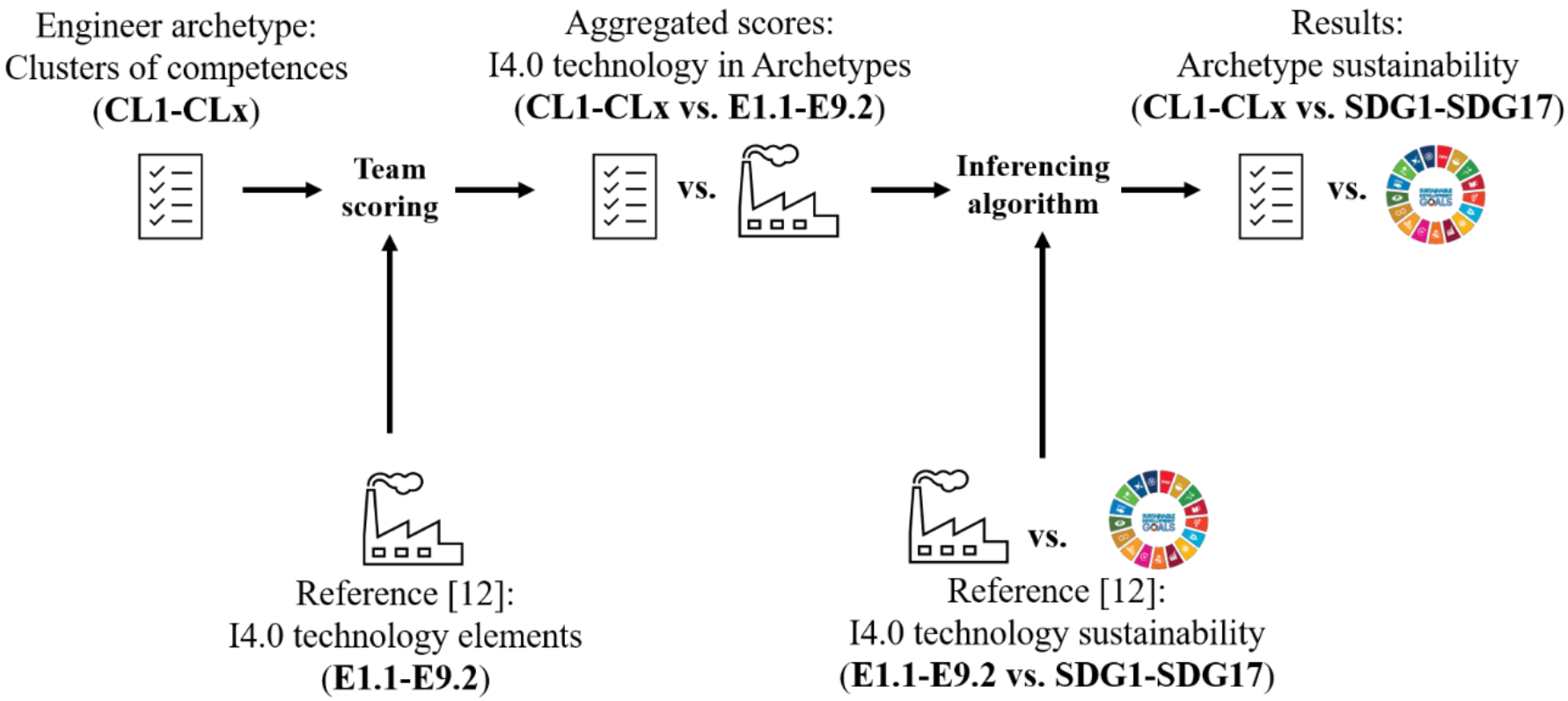
2.2 Archetype sustainability evaluation (2)



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The inferencing Algorithm

for each $column_j$ where j=1 to X (*or CL1-CLX*)
for each $column_k$ where k=1 to 17 (*or SDG1-SDG17*)
for each row_i where i=1 to 44 (*or E1.1-E9.2*)
sum1=sum1+ ($cell_{j,i}$ * $cell_{k,i}$)
sum2= sum2+ ($cell_{j,i}$)
end
The CLj impact onto SDG_{k-8} is computed as the weighted mean= sum1/sum2
end
plot the radar diagrams
end

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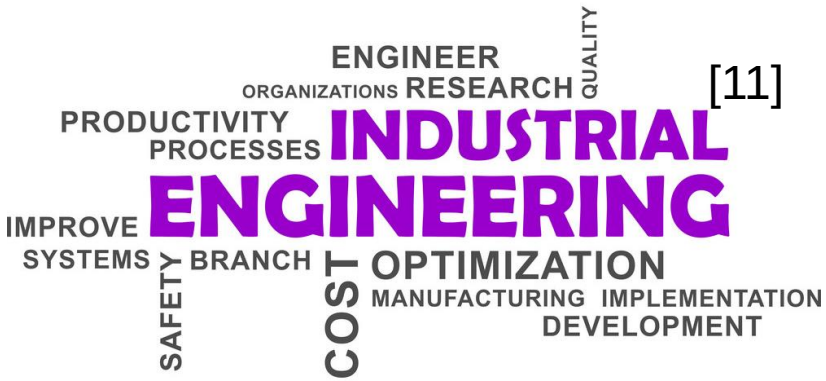
3 Industrial engineer archetype case study



[11]

This professional profile output from these kinds of programs can be positioned in the overlapping of mechanical and management/production engineering.

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3.1 Industrial engineer archetype definition (1)

CL1: Manufacturing Processes.
CL2: Structure, Machine, and Product Design.
CL3: Production IT Tools Infrastructure.
CL4: Manufacturing Automation and Robotics.
CL5: Production Planning and Control.
CL6: Logistics and Supply Chain Management.

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3.1 Industrial engineer archetype definition (2)

CL1: Manufacturing Processes

- Design and Analyze a plan or specification for the design of conventional industrial production systems (e.g., cutting, molding, deformation, welding).
- Design and Analyze nonconventional processes (e.g., advanced additive manufacturing, water jet, laser cutting, industrial adhesive bonding etc.).
- Design and Analyze the best-suited assembly technology, applying technical and economic criteria.
- Use specific software for event-driven flow simulation to develop a balanced manufacturing flow within a factory.
- Use specific software to develop factory layouts with buildings, manufacturing/assembly systems and factory assets.

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3.2 Industrial engineer archetype sustainability evaluation

Industrial Engineer Archetype						Industry 4.0		Sustainable Development Goals																
CL1	CL2	CL3	CL4	CL5	CL6			SDG1	SDG2	SDG3	SDG4	SDG5	SDG6	SDG7	SDG8	SDG9	SDG10	SDG11	SDG12	SDG13	SDG14	SDG15	SDG16	SDG17
1.00	0.75	4.00	7.00	1.75	3.25	E1	E1.1	0.24	0.29	0.57	0.24	0.10	0.29	0.33	0.38	0.90	0.19	0.52	0.48	0.33	0.29	0.33	0.10	0.24
3.00	0.25	1.50	2.25	1.00	1.00		E1.2	0.24	0.38	0.62	0.10	0.10	0.38	0.33	0.29	0.81	0.10	0.71	0.57	0.33	0.33	0.43	0.10	0.14
2.25	0.75	5.25	3.75	0.25	1.00		E1.3	0.24	0.38	0.57	0.43	0.05	0.33	0.43	0.43	0.90	0.05	0.81	0.62	0.14	0.10	0.19	0.10	0.19
2.25	1.00	5.25	3.25	0.75	0.25		E1.4	0.19	0.14	0.67	0.48	0.05	0.48	0.48	0.33	0.90	0.00	0.57	0.52	0.38	0.38	0.38	0.24	0.19
0.75	0.25	1.00	1.75	0.25	1.00		E1.5	0.33	0.33	0.67	0.43	0.14	0.38	0.48	0.48	0.90	0.19	0.81	0.57	0.33	0.29	0.29	0.33	0.33
0.75	0.25	0.75	1.75	0.75	0.25		E1.6	0.14	0.14	0.43	0.24	0.05	0.29	0.33	0.29	0.71	0.05	0.67	0.38	0.24	0.14	0.19	0.14	0.24
1.50	2.75	3.25	3.75	3.00	1.00	E2	E2.1	0.24	0.33	0.76	0.10	0.14	0.62	0.48	0.38	0.81	0.10	0.71	0.57	0.62	0.52	0.52	0.19	0.10
0.75	1.00	3.75	3.25	3.25	4.75		E2.2	0.43	0.52	0.67	0.52	0.24	0.62	0.62	0.52	0.71	0.29	0.81	0.48	0.71	0.52	0.38	0.33	0.29
0.75	0.75	1.50	1.50	5.50	5.00		E2.3	0.38	0.48	0.67	0.48	0.33	0.62	0.62	0.48	0.71	0.33	0.81	0.57	0.67	0.57	0.43	0.43	0.48
0.25	0.75	3.75	1.00	0.75	0.25		E2.4	0.38	0.48	0.57	0.48	0.24	0.48	0.38	0.33	0.62	0.19	0.52	0.52	0.48	0.38	0.33	0.33	0.33
0.25	0.75	3.25	1.00	0.75	0.25		E2.5	0.33	0.24	0.67	0.62	0.29	0.62	0.43	0.52	0.81	0.24	0.62	0.52	0.57	0.48	0.33	0.33	0.33
0.75	2.25	3.00	2.25	6.00	3.00		E2.6	0.38	0.57	0.67	0.52	0.33	0.71	0.62	0.19	0.81	0.19	0.81	0.57	0.62	0.52	0.38	0.33	0.38
4.50	2.25	3.00	4.75	7.00	4.75		E2.7	0.71	0.81	0.76	0.62	0.33	0.81	0.71	0.52	0.90	0.38	1.00	0.57	0.71	0.62	0.48	0.43	0.48
0.75	2.50	3.25	1.00	1.50	2.75		E2.8	0.38	0.48	0.57	0.43	0.29	0.62	0.62	0.52	0.81	0.48	0.71	0.48	0.52	0.38	0.38	0.33	0.33
0.75	2.50	4.00	2.25	0.25	0.75	E3	E3.1	0.33	0.29	0.33	0.38	0.05	0.14	0.29	0.05	0.90	0.10	0.67	0.52	0.14	0.10	0.10	0.19	0.38
0.25	0.75	5.25	0.75	0.25	0.25		E3.2	0.14	0.24	0.29	0.19	0.05	0.24	0.38	0.33	0.90	0.00	0.76	0.43	0.14	0.10	0.10	0.33	0.52
0.75	0.25	5.00	0.75	0.25	1.50		E3.3	0.10	0.10	0.24	0.48	0.05	0.10	0.48	0.52	0.90	0.29	0.62	0.57	0.24	0.05	0.05	0.19	0.38
0.75	0.75	3.50	1.00	0.25	0.75		E3.4	0.14	0.05	0.05	0.24	0.00	0.05	0.33	0.33	1.00	0.10	0.33	0.43	0.19	0.00	0.00	0.14	0.29
7.00	6.00	6.00	3.00	5.50	2.00	E4	E4.1	0.14	0.05	0.33	0.43	0.05	0.33	0.38	0.62	0.90	0.10	0.43	0.62	0.24	0.19	0.14	0.05	0.05
6.00	3.75	4.50	3.00	4.00	7.00		E4.2	0.14	0.10	0.43	0.29	0.05	0.14	0.38	0.57	0.81	0.10	0.38	0.71	0.14	0.00	0.05	0.00	0.00
3.50	1.75	3.25	3.00	4.00	1.75		E4.3	0.05	0.10	0.48	0.29	0.05	0.29	0.43	0.62	0.81	0.05	0.43	0.57	0.19	0.10	0.10	0.00	0.10
0.75	3.00	1.50	1.00	0.25	0.25	E5	E5.1	0.05	0.10	0.48	0.81	0.24	0.05	0.14	0.62	0.90	0.14	0.14	0.24	0.24	0.14	0.14	0.00	0.00
0.50	1.00	1.75	0.75	0.25	1.00		E5.2	0.14	0.10	0.52	0.81	0.38	0.05	0.10	0.71	0.90	0.19	0.43	0.48	0.29	0.29	0.29	0.14	0.29
2.50	0.50	3.25	0.75	1.00	0.50		E5.3	0.24	0.10	0.52	0.90	0.33	0.05	0.29	0.71	0.81	0.24	0.43	0.43	0.29	0.19	0.19	0.05	0.19
0.75	1.00	5.25	2.25	0.25	1.00		E5.4	0.10	0.05	0.52	0.71	0.19	0.10	0.19	0.52	0.81	0.19	0.48	0.57	0.38	0.33	0.33	0.19	0.24
2.50	5.25	5.25	2.25	0.25	1.00		E5.5	0.05	0.05	0.48	0.71	0.24	0.05	0.19	0.52	0.81	0.14	0.29	0.38	0.29	0.24	0.29	0.05	0.00
7.00	2.75	1.75	0.25	1.00	0.25	E6	E6.1	0.00	0.00	0.38	0.10	0.05	0.24	0.24	0.19	1.00	0.14	0.24	0.43	0.24	0.14	0.19	0.00	0.00
7.50	2.75	1.25	0.25	1.00	0.25		E6.2	0.00	0.00	0.38	0.05	0.05	0.24	0.24	0.19	1.00	0.14	0.24	0.48	0.24	0.05	0.10	0.00	0.00
5.50	2.75	1.25	0.25	1.00	0.25		E6.3	0.00	0.00	0.38	0.05	0.05	0.24	0.33	0.19	0.90	0.14	0.29	0.43	0.10	0.00	0.05	0.00	0.00
4.00	5.00	0.25	0.25	1.00	0.25		E6.4	0.10	0.10	0.48	0.10	0.10	0.29	0.33	0.29	0.90	0.14	0.29	0.43	0.19	0.14	0.19	0.00	0.00
3.50	7.50	4.50	1.00	1.00	0.25		E6.5	0.00	0.00	0.38	0.10	0.05	0.05	0.14	0.29	0.71	0.05	0.14	0.29	0.05	0.00	0.05	0.00	0.00
3.00	4.50	3.75	1.00	0.25	0.25		E6.6	0.00	0.00	0.29	0.10	0.05	0.05	0.14	0.29	0.71	0.05	0.10	0.29	0.05	0.00	0.00	0.00	0.00
0.25	0.25	5.50	2.50	1.00	1.00	E7	E7.1	0.05	0.10	0.10	0.05	0.00	0.19	0.24	0.19	0.71	0.05	0.29	0.52	0.05	0.00	0.05	0.00	0.19
0.25	0.25	3.00	0.50	0.50	0.50		E7.2	0.10	0.10	0.19	0.14	0.00	0.14	0.24	0.38	0.81	0.00	0.14	0.48	0.05	0.05	0.05	0.00	0.05
0.75	0.25	7.50	1.50	5.50	1.25		E7.3	0.14	0.19	0.48	0.24	0.05	0.19	0.38	0.57	1.00	0.10	0.57	0.62	0.24	0.19	0.24	0.14	0.33
1.00	0.50	5.50	1.00	4.75	0.25		E7.4	0.14	0.19	0.33	0.29	0.05	0.24	0.43	0.48	1.00	0.05	0.48	0.57	0.14	0.14	0.19	0.14	0.29
0.25	0.75	4.00	3.00	0.75	1.00		E7.5	0.14	0.14	0.48	0.38	0.10	0.24	0.38	0.52	1.00	0.05	0.48	0.57	0.33	0.19	0.19	0.14	0.38
0.75	0.75	4.50	1.50	1.00	1.00		E7.6	0.10	0.10	0.38	0.24	0.05	0.19	0.33	0.43	0.81	0.05	0.38	0.52	0.24	0.19	0.19	0.05	0.29
0.75	0.75	1.50	0.50	0.75	2.25		E7.7	0.48	0.52	0.43	0.38	0.14	0.29	0.52	0.43	0.90	0.24	0.71	0.52	0.24	0.29	0.19	0.33	0.57
1.00	0.75	0.75	6.00	0.25	0.50	E8	E8.1	0.14	0.48	0.52	0.14	0.19	0.14	0.19	0.33	0.81	0.00	0.38	0.33	0.29	0.33	0.29	0.14	0.14
1.00	0.75	0.75	6.00	0.25	0.50		E8.2	0.14	0.38	0.52	0.24	0.29	0.24	0.29	0.33	0.81	0.00	0.38	0.33	0.29	0.33	0.29	0.14	0.14
1.00	0.75	0.75	7.50	0.75	0.33		E8.3	0.19	0.43	0.62	0.24	0.10	0.10	0.14	0.33	0.76	-0.1	0.43	0.24	0.24	0.24	0.24	0.05	0.05
0.33	0.25	3.50	1.00	0.25	0.50	E9	E9.1	0.10	0.10	0.43	0.24	0.05	0.24	0.19	0.29	0.62	0.05	0.62	0.38	0.05	0.05	0.05	0.33	0.33
0.25	0.25	3.50	1.00	0.25	0.50		E9.2	0.10	0.10	0.43	0.19	0.05	0.29	0.24	0.29	0.62	0.05	0.62	0.43	0.19	0.14	0.14	0.33	0.33

O1 paper [12]

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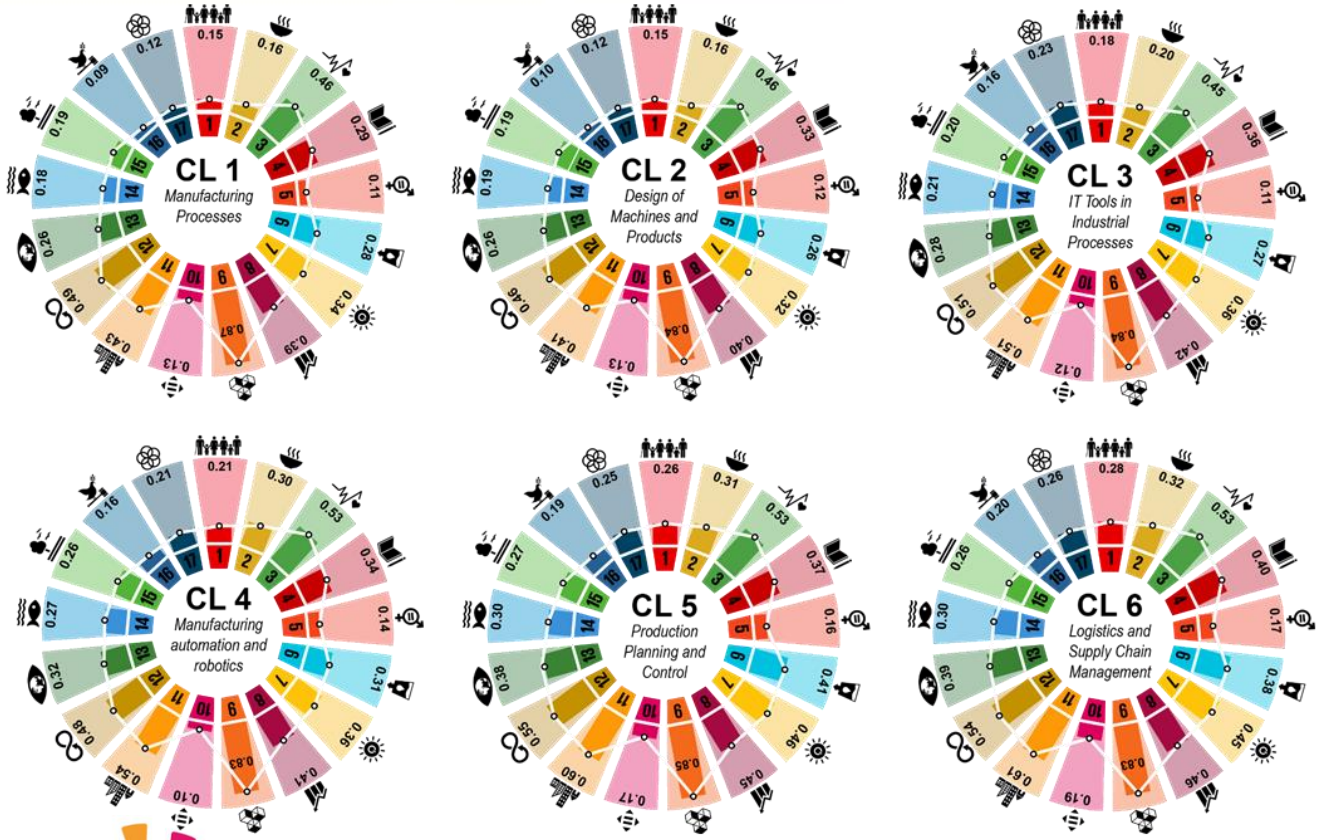
3.3 Analysis of the results of the industrial engineer case study (1)



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3.3 Analysis of the results of the industrial engineer case study (2)

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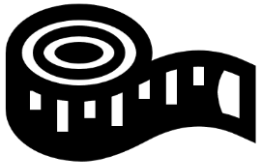
4 Discussion and Conclusion

The proposed methodology:



- **Promote** the culture of **measuring and monitoring** sustainability in engineering disciplines
- **Has been validated** by defining a standard industrial engineer archetype
- **Stimulate interdisciplinarity**

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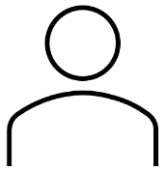
5 Future work

- **Automate** the archetype definition through text mining approach.

- **Redesign** archetypes collaboratively

- Extend mapping the SDGs to a **general archetype** without using the I4.0 technologies as a bridge



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Thank you for your attention

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