



UNIVERSITÀ
DI TRENTO

Department of
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Sustainable Digital Education Technologies in Universities

A Multi-Dimensional Framework

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DETs & Digitalization of Higher Education

Digital Education Technologies (DETs) encompass hardware and software resources that produce, share, and store information electronically to support and enhance learning efficiency, academic productivity, outcomes, and accessibility.

In the context of higher education institutions, **Digitalization** refers to the increasing adoption and integration of digital and computer-based technologies into university operations, teaching, learning, research, and administration.

The impact of Digitalization

Advantages

- Accessibility and Inclusion
- Academic productivity
- Cost efficiency
- Innovative teaching methods

Disadvantages

- Institutional autonomy
- Data governance
- Lock-in and contractual constraints
- Environmental impact

→ **The problem of DETs selection**

Research question

“How can higher education institutions evaluate the sustainability of digital education technologies?”

Main goal

Devise a framework that assists decision makers in the selection of sustainable digital education technologies



Sustainability

Brundtland report

“meeting the needs of the present without compromising the ability of future generations to meet their own needs”

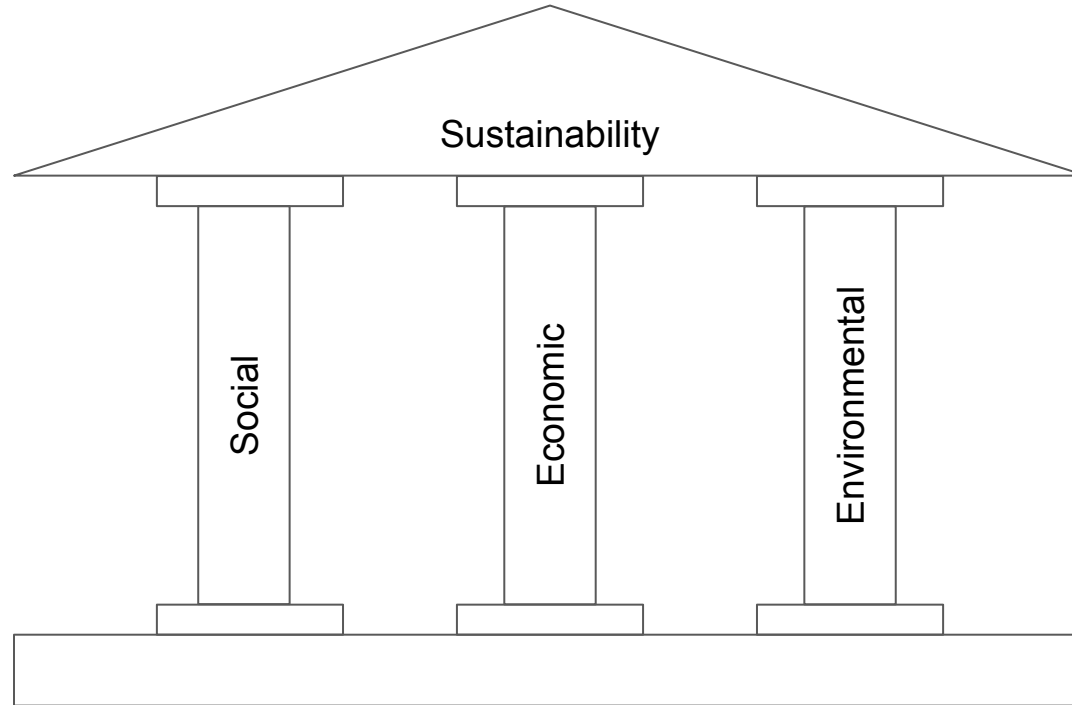
Sustainable Development Goals: Target 4

“ensure inclusive and equitable quality education and promote lifelong learning opportunities for all”

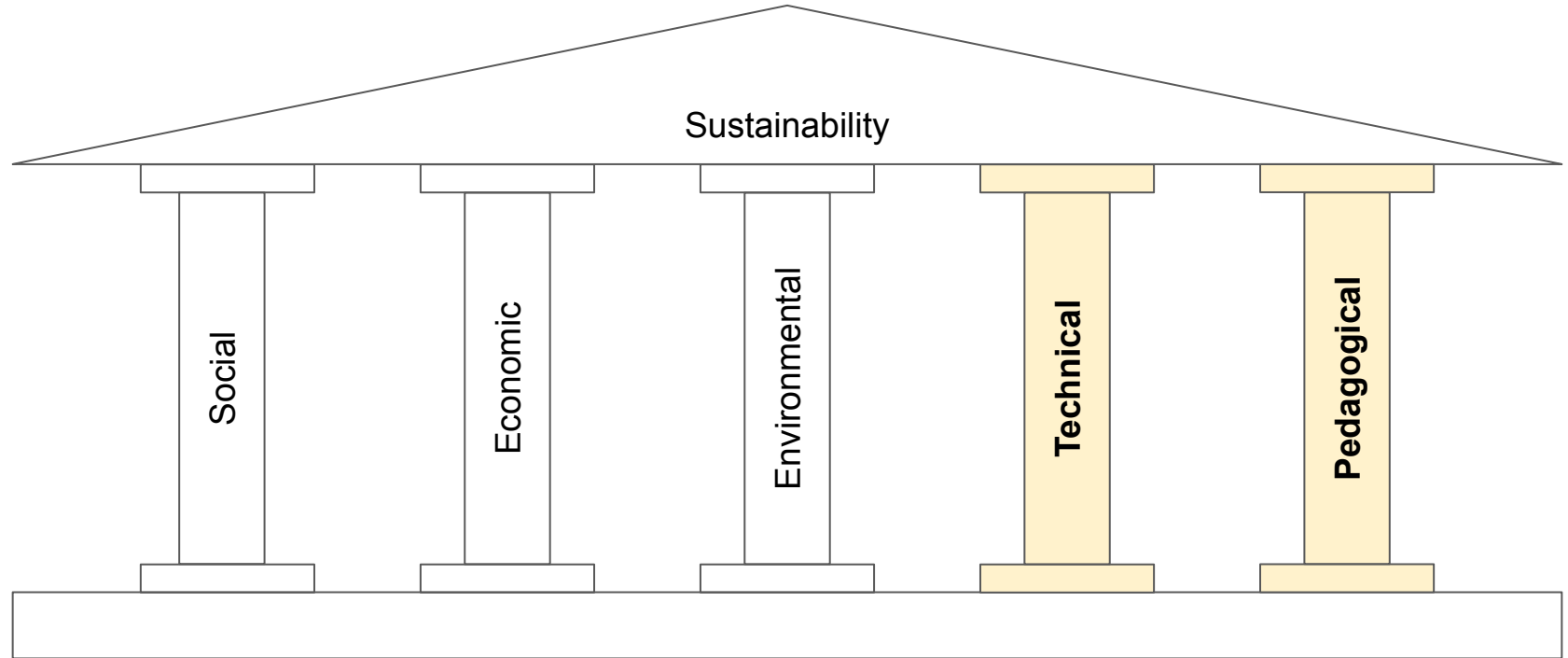
Sustainability is the ability to be maintained or improved over the time

Three Pillars of Sustainability

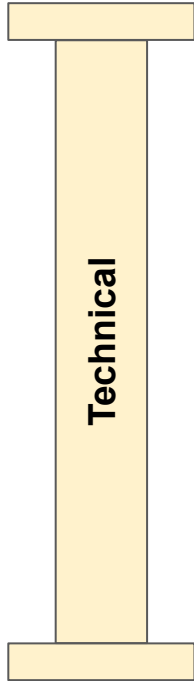
Purvis et al.



Sustainability dimensions for DETs



Sustainability dimensions for DETs



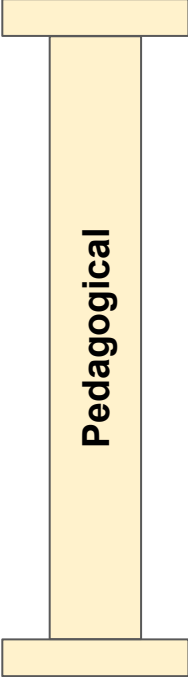
A DET should remain operational, efficient and adaptable over the time

A DET should grant the Quality of Service in depth of time

Andrikopoulos et al. - Software Sustainability in the Age of Everything as a Service

Lago et al. - Framing sustainability as a property of software quality

Sustainability dimensions for DETs

A diagram consisting of a yellow vertical pillar with a yellow rectangular base and a yellow rectangular top. The word "Pedagogical" is written vertically in black text along the center of the pillar.

Pedagogical

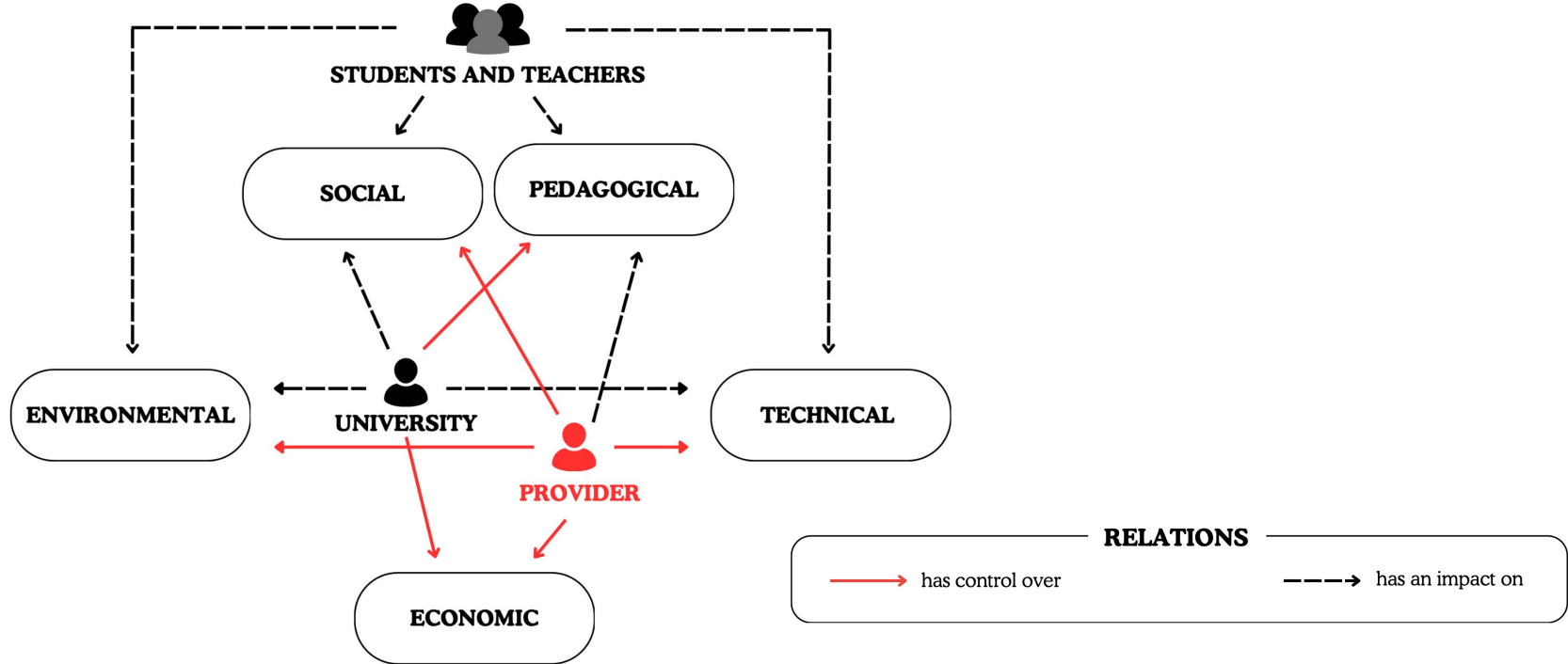
The ability of DETs to effectively support and enhance teaching and learning practices in a long-term, meaningful, and inclusive manner

Schuetze et al. - Digitalization of Higher Education: an Introduction

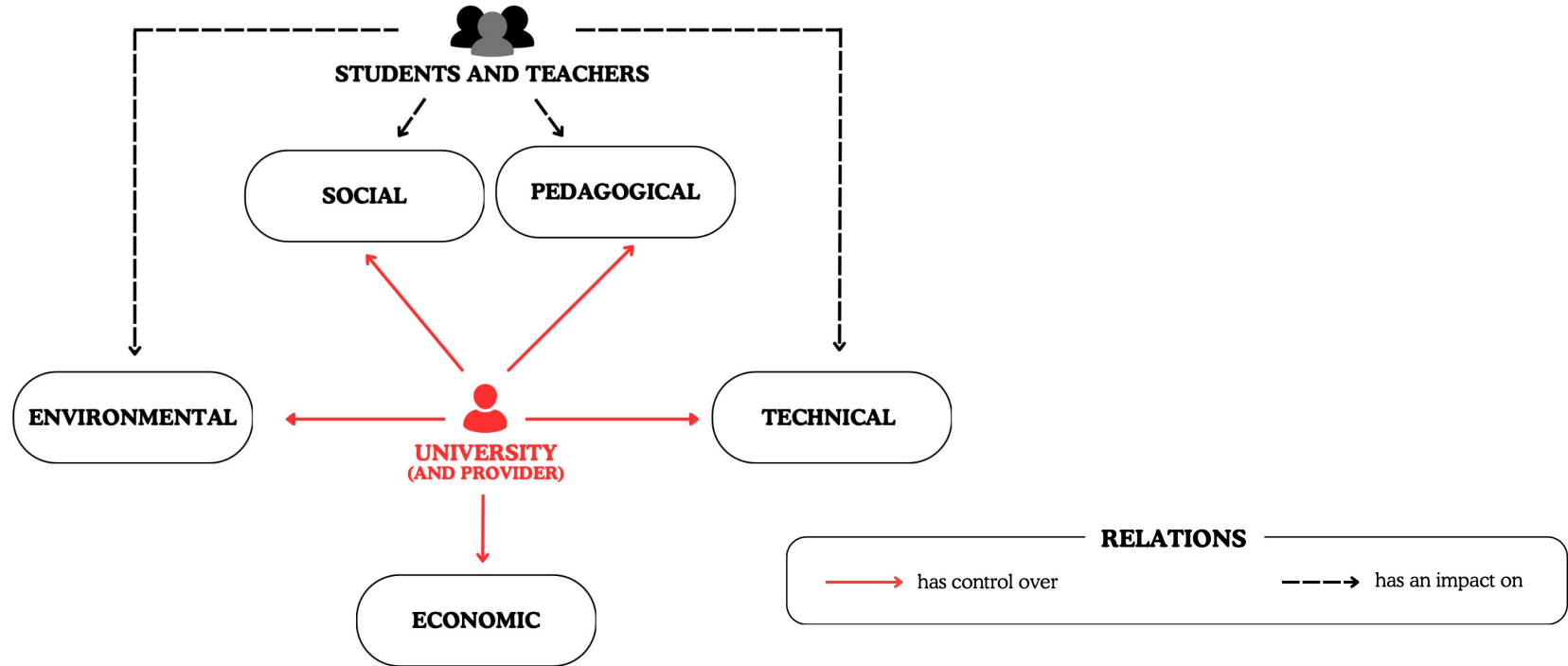
Lacka & Wong - Examining the Impact of Digital Technologies on Students' Higher Education Outcomes

And many others!

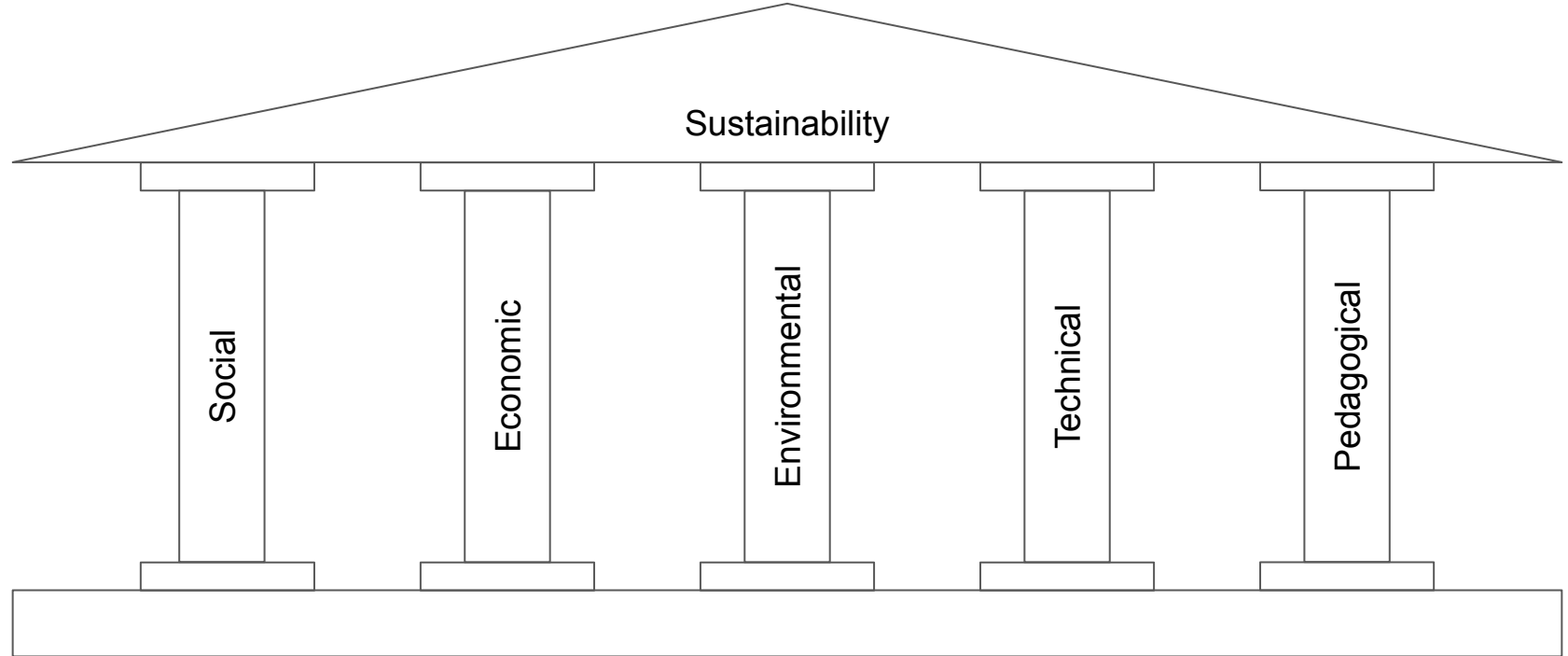
Impact of outsourcing



Impact of outsourcing



Sustainability dimensions for DETs







Assessment methodology

Traffic-light model

Good	
Acceptable	
Bad	
Not applicable	

Scoring system

+1 point	
0 point	
-1 point	
Not considered	

Economic dimension

Indicator	Metric
Return of Expenses	Generated value relative to expenses
Provisioning	Quality of provisioning
Scaling policies	Waste of resources
Vendor Synergies	Use of lock-in practices
Exit costs	Expenses of cost/migration

Provisioning indicator

The provisioning indicator is the relation between:

- cloud-based or local resources allocated
- resources required to ensure the efficient operation

Considering the expected users, the result is the **cost per user**

Technical dimension

Indicator	Metric
Availability	Uptime (%)
Reliability	Error rate (%)
Scalability	Support of scalability techniques
Adaptability	Degree of integration (e.g., SSO, 3rd party services)
Maintainability	Ease of configuration, updates, and upgrades
Repairability	Interventions allowed

Maintainability indicator

The maintainability indicator assess whether the DET is:

- easy to be configured
- easy to be updated and upgraded
- supported by documentation
- supported by community, developers or the company

Social dimension

Indicator	Metric
Community awareness	Awareness about the DET
Involvement in sustainability	Distance to sustainability claim
Inclusion	Compliance with accessibility guidelines
Privacy policy	Protection and ethical use of user data, transparency on data collection
Capability	Required internal capacity and knowledge

Privacy policy indicator

The privacy policy indicator ensures proper collection and use of users' data, examining:

- content of the policy
- readability of the policy
- sub-processors involved
- security measures to ensure data protection

Pedagogical dimension

Indicator	Metric
Engaged with instructional practices	Engagement in pedagogical research and educational context
Usability	Usability framework
Impact on education	Learning curve, workflow integration, output quality, and adaptability to the academic context
Purpose	Potential to solve the problem

Usability indicator

The privacy policy indicator determines whether the DET is accessible, efficient and user-friendly

Evaluation can be done with:

- usability heuristics
- usability tests
- surveys
- automated tools

Environmental dimension

Indicator	Metric
Energy consumption	kilowatt-hours (kWh)
Carbon emissions	Material footprint (kg - tons per unit)
Raw material consumption	Carbon footprint (kg CO ₂ -eq)
Sustainability in design	Consideration of sustainability principles in design and development
Sustainability through design	Promotion of sustainability practices

Sustainability in design indicator

The sustainability in design indicator evaluates how sustainability is taken into account from the early design phases of the DET

Can be inferred from:

- design goals in documentation and reports
- DET characteristics



FINAL SCORE



COMMUNITY
EDITION

4/21

CLOUD-BASED

4/24

SERVER PRO

8/21

ENVIRONMENTAL

Sustainability in design
Sustainability through design
Carbon emissions
Raw material consumption
Energy consumption



PEDAGOGICAL

Purpose
Impact on education
Usability
Engaged with instructional practices



SOCIAL

Capacity
Privacy Policy
Inclusion
Involvement in sustainability
Community



TECHNICAL

Maintainability
Reparability
Adaptability
Scalability
Reliability
Availability



ECONOMIC

Vendor synergies (Look-in)
Exit costs
Scaling policies
Provisioning
Return of Expenses



Key insights

- Cloud-based performed best in the economic and technical dimensions, reflecting the motivations that lead universities to rely on external providers
- Cloud-based performed worst in the environmental dimension
- Community edition suffers technical limitations
- Pedagogical is the same for every version, that share the same core functionalities
- Self-hosted versions can mitigate some critical issues of the cloud-based version

(this slide was not included in the original presentation, the content was said by the student while showing the result)

Limitations

Scoring system and indicator weighting issues

- equal indicator weighting creates imbalances across sustainability dimensions
- the scoring system may be too strict, lowering final scores

Addressing “red zones”

- is this enough to exclude the DET from the selection?

Challenges of multi-dimensionality

- requires broad working group
- requires expertise among multiple disciplines

Conclusions and Future work

- Expanding case studies
- Refining indicators
- Improving environmental metrics
- Optimizing scoring and weighting
- Validation and practical application