Contributing to a Transition towards a Sustainable Society: Education Matters

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Abstract: This research aims to shed insights and produce supportive tools to help stimulate the design of education programs. First a characterization of opportunities and challenges for education programs is given from a global sustainability standpoint. Second a characterization of what education programs may contain and take into account from a full sustainability standpoint, as an outline of education programs in a desired future at a principle level, is provided to help inspire purpose-led education services organizations. Third an outline of possible tools and strategies to help strategically close the gap between the current unsustainable state and the desired sustainable future is provided. A special focus is put on the Template for Sustainable Product Development (TSPD) process tool, originally used to help industries in their production chain, but here adapted as the "Sustainability Potential" Express Strategic Assessment for Education Programs to benefit education programs stakeholders. The authors also propose a set of three abilities acting in synergy: *Creativity*, "*Knowledge Making"* & "*Open Values"* (CKMOV) that are at the heart of Strategic Sustainable Development and thus may help form three equally vital pillars, which education programs may strategically take support from while helping society transition to a sustainable equilibrium.

Keywords: Education, Fundamental Human Needs, Strategic Sustainable Development, Template for Sustainable Product/Service Development, TSPD, Creativity, Open Values, Knowledge Making, CKMOV.

Statement of Collaboration

This study has been going through a process in which the collective intelligence of a team of diverse backgrounds, personalities and skills was put to the test, while the team shared a common goal of finding plausible ways future education programs may help society satisfy fundamental human needs in a globally sustainable society within a thriving biosphere.

Kim Davis brought to the team his inquisitiveness and a systemic perspective on this broad subject. His project management, facilitating and proofreading experience were welcome to open up the research process and close the remaining gaps.

Changkun Shen facilitated the case study in China by participatory research actions and played a key role in bridging the language and culture gap between the team and Chinese target organizations, in order to precise and update validating insights on key findings.

Aymeric Maratea conducted some interviews in France to validate some of the key results. He also acted as administrator to keep the thesis report in the best shape as possible.

Thanks to this collaborative work, we have learned more about ourselves and how to work collectively, fueled by our common purpose of delivering a useful outcome to all stakeholders, and particularly to the people who work directly every day with, education & sustainability.

Kim Davis, Aymeric Maratea, Changkun Shen

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Our thoughts are with S.

Executive Summary

Introduction

Society is at a crossroads. Scientific studies show human activities are shifting Earth's sub-systems increasingly outside of their previous half-million years variability range. In consequence business-as-usual scenarios would, with high probability, lead to exceeding various tipping points within the lifetime of Net Generation children. Humanity thus faces the unattractive prospect of irreversibly altered global living conditions. Faced with this biophysical reality, policies of incremental improvements omitting strategic guidance to attain clearly defined goals, may prove lacking.

This fundamental crisis seems driven by four major trends: a *growing population* applying an *inequitable and inefficient resource allocation system,* is exhausting *overwhelmed supportive eco-systems* through the *wasteful over-consumption of their declining resources*. The prevalent ethos seems to essentially express that "More *is* Better… always".

These trends interact through feedback loops in complex ways, yet inter-actions depend on peoples' values and actions. There is nothing entirely pre-ordained about the crisis. Deadlock is not an available option, business-as-usual then ensures moving towards radically altered life conditions.

A durable system means its equilibrium-preserving elements are sustained. Scientists helped formulate society's *sustainability challenge*: systemic design weaknesses systematically erode (i) Earth's ecosystems' abilities to function within the dynamic equilibrium zone humanity evolved in; (ii) society's ability to globally fulfill fundamental human *needs* (since resources are not equitably allocated to that end and are instead used to create, and then meet, the market-fueled *desires* of those who can afford them, under the auspices of a mathematical "ideal market" theory).

The Framework for Strategic Sustainable Development[1] (FSSD) provides an evolving platform being: *robustly systematic* through whole systems

[1] A scientific and strategic framework to guide actions towards well-defined sustainability goals.

thinking, *comprehensive* by its inclusion and organization of diverse methodologies & tools, *strategic* through the periodic refinement of smart pathways following multiple capitals optimization criteria, and *inspirational* through fostering authentic dialogue about shared purpose. The FSSD enables organizations to raise well-being by following a globally risk-reducing path to "full sustainability", transitioning from where they currently stand. Backcasting from sustainability principles[2] and purpose-led trade-off optimization are used to constrain negative *hidden*[3] outcomes, while integrating fundamental human needs[4] (FHNs).

As Deborah James puts it: "*The future is not a result of choices among alternative paths offered by the present, but a place that is created—created first in the mind and will, created next in activity*." Education shapes cultures, influencing values and the actions people support through the acquisition, dissemination and furthering of knowledge. A fundamental Human Right, education is also a synergic satisfier[5] able to meet several fundamental human needs. This research explores how education programs may help society decrease its unsustainability to avoid its negative impacts.

Research Questions

Primary Research Question
How could a strategic sustainable development (SSD) approach improve the design of education programs (EPs) to promote sustainability while not contributing to socio-ecological unsustainability?

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[2] principles, underpinned by scientific laws, systematizing conditions under which society may successfully endure. Criteria for sustainability principles are: necessity, sufficiency generality, specificity, disjointness. Currently these principles are thus expressed in the FSSD: *SP1*-avoid fostering buildup of substances extracted from the Earth's crust; *SP2*- avoid fostering buildup of substances produced by society; *SP3*: avoid systematic degradation of nature by physical means; *SP4*: avoid systematically undermining people's capacity to meet their needs

[3] under the sustainability challenge

[4] FHNs are independent of cultural beliefs, religion, age, gender, wealth or worldview. They may be represented in a matrix format along three axis: (i) axiological axis, comprising the needs of *Affection, Creation, Identity, Freedom, Leisure, Participation, Protection, Subsistence, Understanding*; (ii) the existential axis, comprising the needs of *Being, Doing, Having, Interacting*); and (iii) the contextual axis comprising increasingly larger contexts: *Self* (personal), *Social* (group), *Environment* (society within the biosphere) (Max-Neef et al. 1989)

[5] a relative way by which one or more fundamental human needs may be realized / actualized.

Secondary Research Questions (SRQs)

1. How may current EPs contents or processes contribute to unsustainability?
2. In a sustainable society, what may future EPs' contents or processes cover?
3. What potential tools and strategies may be of use to education services when devising EPs, in order to help strategically close the gap between the current unsustainable state and the future sustainable one?

Methods

The authors used Maxwell qualitative research design model to interrelate goals / research questions / conceptual framework / methodology and validity, and the Blessing Design Research model[6] to structure four stages:

1. *Criteria Stage*: formulate measurable success criteria;
2. *Descriptive Study I Stage*: create reference model of concepts / tools;
3. *Prescriptive Study Stage*: select appropriate concepts from the previous phase; suggest improvements to tools;
4. *Descriptive Study II Stage*: apply concepts / tools in practical cases; evaluate results according to criteria expressed in the first stage.

In the first stage, this study expressed three criteria of practicality, generality and purposefulness. In the second stage, it used document analysis, dialectical research, logical inference and brainstorm to create reference models. In the third stage, the authors created an initial version of a customized Template for Sustainable Product Development[7] for the field of education. In the fourth stage, they used survey, study case (China) and interviews to develop the final version called "Sustainability Potential" Express Strategic Assessment for Education Programs (SPESA-EP).

Results

Main findings linked to SRQ I [Sustainability issues in current EPs]

Main systemic issues in EPs, at the root of sustainability challenge:

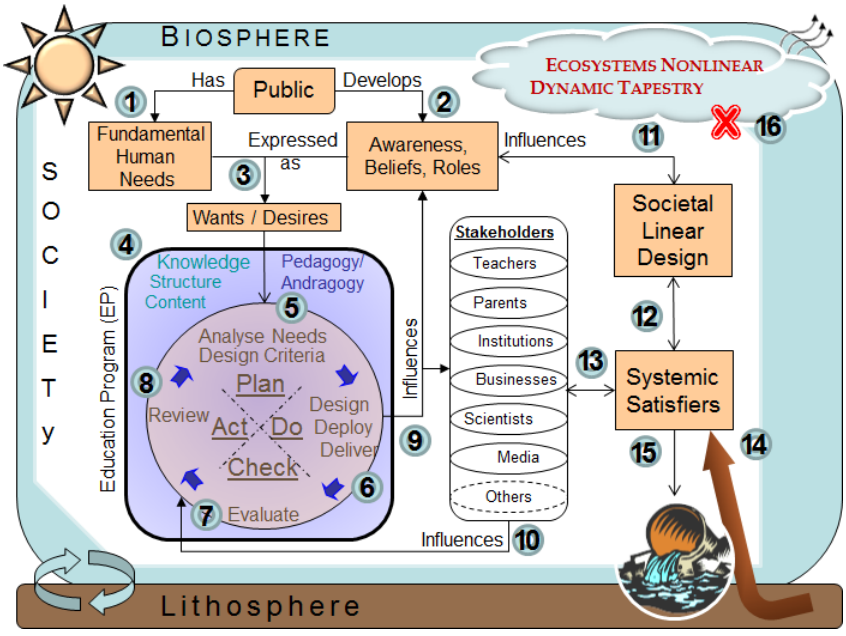
[6] an engineering design research method that iteratively combines description and prescription

[7] a sustainability-centric strategic tool designed to help stakeholders gain quickly, and in a straightforward way, an overview of persistent and sizeable sustainability challenges and opportunities in society for particular products, services or product-service systems

- Lack of shared language and scientific success criteria on sustainability;
- Over-emphasis on reductionism creating isolated study dominions generates fertile ground for sustainability challenge, by discounting transversal studies, overlooking cause-effect relationships, and limiting the systematic and purposeful pursuit of sustainability to existing niches;
- Systematic bias in selecting specific contents over favoring resilience fluency;
- Over-emphasis on an homogenization of rational knowledge detached from shared ethical values, at the expense of fostering creativity and commonality of purpose;
- Reduction of public investment resources per student leaves EPs vulnerable to mission and standards reorientation through non-public economic ties;
- Social cohesion in question despite homogenization of knowledge and hierarchical control of education process.

Other main findings:

- Case study findings: a focus on China's education system through the education program of the Youcheng Foundation;
- Education Programs Life-Cycle Model: This systemic model gives a high-level view of education programs through a whole-system global sustainability outlook, in society, within the biosphere.



Model of an Education Program Life-Cycle (EPLC)

Main findings linked to SRQ II [Processes and contents in future EPs]

Process. An education program which accomplishes its stated goal while (i) not violating implicitly or explicitly through its contents or delivery process the Sustainability Principles; and (ii) enhancing humanity's ability to equitably and peacefully satisfy the Fundamental Human Needs for all present and to come.

Contents. The contents is categorized according to the three key abilities of Creativity, Knowledge Making and Open Values, each addressing a semantic field relevant to addressing non-trivial issues—see CKMOV model hereafter)

Contents/Activities raising skills / practice in *Creativity*

- *Overarching goal*: Developing one's own creativity and multiple intelligences in the socially beneficial context of cooperating to maintain societal sustainability within a thriving biosphere;
- Non-reductionist cross-cultural trans-disciplinary resilience skills and practice;
- Eight-capitals (intra-personal, inter-personal, cognitive, living, material, economic, cultural, spiritual) capacity-building;
- Facing complexity by putting into practice holistic / integral principled worldviews;
- Engagement (with others and the world) based on common purpose, competence, fairness, agency.

Contents/Activities raising skills / practice in *Open Values*

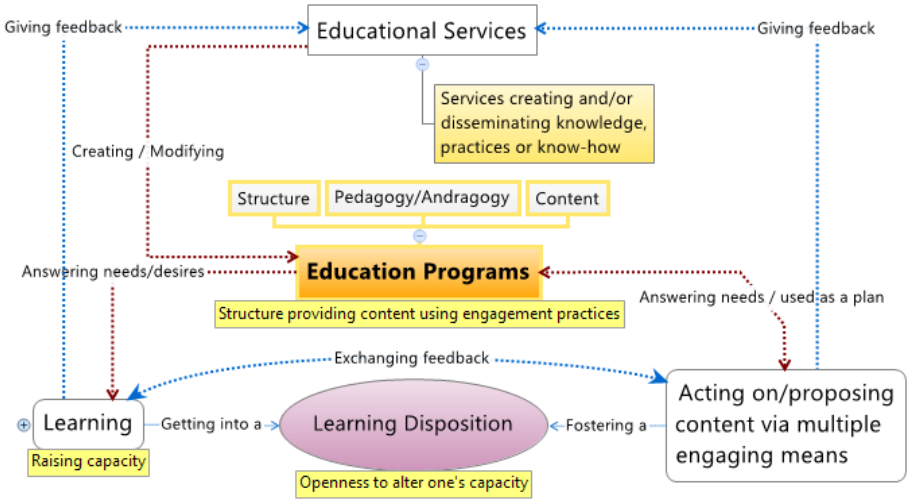
- *Overarching goal*: Nurturing intra-personal authenticity and self-esteem to be able to sustain ambiguity and multiple polarities simultaneously — Nurturing inter-personal / participatory leadership in fostering social biodiversity for resilience;
- Open dialogue, respectful disagreement, multi-stakeholder intercultural mediation, power asymmetry mitigation;
- Ethical / resilience / open / steady-state / sharing / integral systems equilibrium economics;
- Multilevel glocal citizenships with operative use of person-environment rights & duties in increasingly larger contexts;
- "Local through large-scale" well-being by sustainable commons, social canvas democracy engineering.

Contents / Activities raising skills / practice in *Knowledge Making*

- *Overarching goal*: Sustainability principles from complex adaptive systems / systems thinking;
- Non-reductionist principles to face complexity (such as "Simplicity without Reduction");
- Learn to adaptively learn, unlearn, relearn;
- Sustained mindfulness granting critical self-reflexive knowledge;
- Practicing effectiveness *("doing the right thing")* before efficiency *("doing something right")*.

Contents / Activities raising Skills or Practice, categorized by the Creativity – Knowledge Making – Open Values abilities from the CKMOV model

Education Programs and Learning Interactions Model: emphasizes the "Learning Disposition" as a mutually nurtured *actively cooperative relationship* between agents placed in *symmetrical* roles of co-learning / co-teaching, going beyond purely self-interested rational motivations.



Education Programs and Learning Interactions Model

Main findings linked to SRQ III [Tools and strategies to close the gap]

SPESA-EP. The "Sustainability Potential" Express Strategic Assessment for Education Programs (SPESA-EP) is a custom Template for Sustainable Product Development. It focuses on the Plan (Analyze needs/Design

Criteria) and Do (Design) phases (see EPLC figure) to help education programs stakeholders quickly gain an overview of main opportunities and challenges from a full sustainability lens. The "Present Situation" section informed SRQ I, while the "Future Possibilities" part informed SRQ II.

Key questions aim at providing meaningful conceptual springboards from which to use a whole-system global sustainability outlook, in examining the purpose and aims of EPs while going through needs, delivery and stakeholders cooperation. These questions are used as the basis for a creative and informed dialogic process between a sustainability practitioner and a trans-disciplinary team of stakeholders, including decision-makers. Harvesting the results through a standardized format yields an evolving "template" that can be used by field experts to inform their own thinking.

Answers are SP-positive (respecting Sustainability Principles) propositions initially filtered through a FSSD-informed lens expressing: (i) systemic and strategic views; (ii) a definition of success breaking from discrete causes to agreeing with systemic conditions for society's continuing existence into the indefinite future; (iii) an observance of fundamental human needs; (iv) competency/fluency, agency, and fairness values to foster trust. They denote the authors' attempt to capture a value shift, from EPs addressing individualistic / vested interests needs through an under-performing model (education in a "knowledge factory" based on 19th century industrial model) to rejuvenating EPs to address fundamental human needs for all in a 21st century model (integral practices to unlock full potential and fuel values-based creative answers to the sustainability challenge).

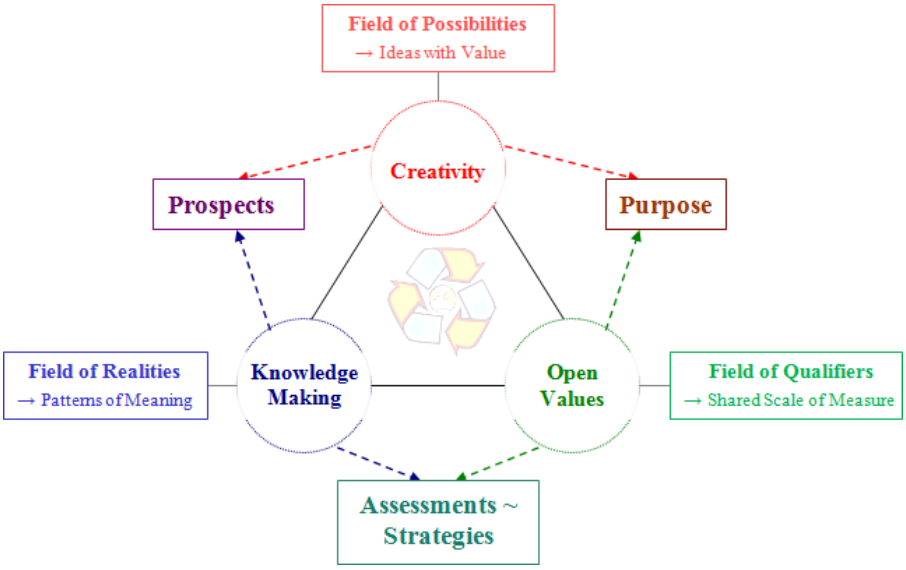
CKMOV Model. This model forms the hypothesis that basic developmental abilities working synergistically form a minimum set of satisfiers necessary (though not sufficient) to help address multi-stakeholder multi-cultural complex issues. Each ability

(i) addresses a semantic field relevant to addressing non-trivial issues: *Realities*—regroups patterns of meaning gained through all intelligences, using reason, intuitive knowledge and senses—"What is?"; *Possibilities*—regroups novel ideas with potential to create value by satisfying fundamental need(s) and/or desire(s)—"How can it be?"; *Qualifiers*—regroups concepts around shared measurement scales, to clarify one's values rankings, to oneself and with others—"Why should this be?";

(ii) is a high potency synergistic satisfier: each arguably underlies and/or strengthens many satisfiers given by Max-Neef in each of the nine rows of the FHNs matrix. Thus not only does each support individual FHNs, but their synergistic interrelations bolsters the quality of this support;

(iii) being integral to FSSD: The FSSD supports initiatives whose outcomes are driven by the creation of shared *purpose*, informed by possible *prospects*, and guided by *assessments and strategies*. The authors argue that at the intersection of the semantic fields of: Realities/Possibilities reside *prospects,* or "expectations of particular events, conditions, or developments of definite interest or concern"; Qualifiers/Possibilities resides *purpose,* an "intended potential goal"; Realities/Qualifiers reside *assessments* and *strategies*, i.e. "estimations of the importance, size, or value of something" and "approaches systematically using resources to reach intended / desired goals".

Three base abilities are thus suggested as satisfiers (see figure below): Creativity – Knowledge Making – Open Values. *Creativity* is "the process of having original ideas that have value". *Knowledge Making* as a process creates meaning out of (inner & outer) perceptions. *Open Values* refers to fostering an open attitude leading to authentic exchanges with others, clarifying values and helping to assess impacts while mediating conflicts.



Intersections of the Semantic Fields and Satisfiers

CKMOV enables re-interpretations of planning methods such as backcasting and forecasting, as well as the ABCD method used by the FSSD.

Main findings related to the Primary Research Question [How could an SSD approach improve the design of EPs to promote sustainability?]

- A systematic approach to "educate unsustainable behavior" out;
- Fostering Backcasting from Sustainability Principles;
- Systematic spiraling learning process.

Findings relate to each other: unsustainability-deepening issues in current EPs (SRQ I) are answered by strategies and tools (SRQ III) to yield desired outcomes in future EPs (SRQ II). In the following table the main findings from SRQ III are integrated within the Primary Research Question findings.

<table>
<tr><th>Secondary Research Question I</th><th>Primary Research Question</th><th>Secondary Research Question II</th></tr>
<tr><td>Lack of shared unambiguous language and scientific success criteria on sustainability</td><td>A systematic approach to "educate unsustainable behavior" out</td><td rowspan="3">An educational program which accomplishes its stated goal while (i) not violating implicitly or explicitly through its content or delivery process the Sustainability Principles; and (ii) enhancing humanity's ability to equitably and peacefully satisfy the Fundamental Human Needs for all present and to come. A key feature is a shared learning experience leading to empathic engagement with others, and in extension, with the world</td></tr>
<tr><td>Over-emphasis on reductionism creating seemingly unconnected disciplines of study generates fertile conditions for the sustainability challenge, by marginalizing transversal studies, overlooking cause-effect relationships, and limiting the systematic and purposeful pursuit of sustainability to existing niches</td><td>Fostering backcasting from Sustainability Principles</td></tr>
<tr><td>Education Programs Life-Cycle Model</td><td>Systematic spiraling learning process</td></tr>
<tr><td rowspan="3">Over-emphasis on an homogenization of rational knowledge detached from shared ethical values, at the expense of fostering creativity and commonality of purpose</td><td rowspan="3">CKMOV</td><td>Content/Activities raising skills / practice in Creativity</td></tr>
<tr><td>Content / Activities raising skills / practice in Knowledge Making</td></tr>
<tr><td>Content/Activities raising skills / practice in Open Values</td></tr>
<tr><td>Systematic bias selecting specific content over fluency</td><td rowspan="3">SPESA</td><td rowspan="3">Education Programs and Learning Interactions Model</td></tr>
<tr><td>Social cohesion in question despite homogenization of knowledge and hierarchical control of education process</td></tr>
<tr><td>Reduction of public investment resources per student</td></tr>
</table>

Correspondence between Research Question Findings

Discussion

Main findings related to first SRQ [Sustainability issues in current EPs]

Strengths. While empirical findings cannot be called absolutely original,

(i) these seek to address end purposes of education programs rather than the means to achieve these, and they identify significant, substantial yet precise issues in education programs as important components of the root causes and feedback loops enabling the sustainability challenge to endure—thus they qualitatively satisfy the "general" criteria defined in the Criteria Stage;

(ii) this understanding, seized upon by committed leadership, can lead to enable the globally purposeful co-creation of "SP-positive" local curricula—the findings qualitatively satisfy the "purposeful" criteria;

(iii) the EP life-cycle model synthetizes in a simple yet inclusive way trending relationships between education program life-cycle, fundamental human needs, and practices compounding the sustainability challenge. This understanding may help create fertile conditions for society to systematically decrease its unsustainable behavior over time and decrease the risk of crossing planetary boundaries thresholds;

Weaknesses. The findings may suffer from some of the following

(i) The spectrum of education programs runs the gamut of human activities in many formats: since a comprehensive analysis is not possible, this research necessarily sampled a variety of sources that could never account for all subtleties; access to a narrow range of experts necessarily creates a certain bias, and while the authors tried to alleviate this by talking to experts from different cultures, a western bias still permeates the findings;

(ii) the relativistic / cultural nature of the authors' worldviews implies an underlying ranking of values: the prescriptive phase of the research acknowledges this underlying ranking by the authors. Yet because of time constraints and availability of experts, the subsequent descriptive phase II was not as dialogue and validation-rich as the authors intended, thus further research may have to broaden the depth / breadth of that phase's outcomes, confirming some propositions while infirming or contrasting others;

(iii) The model's generality (losing subtleties) may leave too many details out, giving a semi-static view of a system. While the model is depictive, it may be challenging to operationalize. Another issue is that it illustrates just one cyclical mode of updating education programs. A PESTLE analysis for

example may have yielded further clues in reform trends, and a causal loop diagram may have given a more dynamic view.

Finally, the authors aren't experts in the education field, which can be taken as a strength and a weakness (as commented by some experts): findings may benefit from a creative, "fresh eyes" perspective, yet they may suffer through this unfamiliarity from partialness or discrepancies.

Main findings related to second SRQ [Processes or contents in future EPs]

Strengths. The findings have the following positive traits:

(i) by filling a contents mosaic within three non-overlapping semantic fields relevant to addressing non-trivial issues (a) they fulfill aptly the "general" criteria from the Criteria Stage from having a whole-systems global sustainability outlook; and (b) they fulfill suitably the "purposeful" criteria by including the satisfaction of the Sustainability Principles;

(ii) by offering a vision of a widely inclusive process, and contents features organized within differentiated semantic fields synergistically working together, the findings acknowledge that education programs live in widely differing contexts depending on global as well as on local conditions: it is thus more strategic to postulate goals than specific ways to achieve them;

(iii) the model represents in a simple way the learning disposition, a mental process of openness towards learning, as a positively willed relation between two agents (or group of agents) in symmetric and transposable situations of co-learning / co-teaching.

Weaknesses. The findings have the following weaknesses:

(i) the same three weaknesses as with the findings answering the secondary research question I apply here again, i.e. western bias, need for added validation, and interpretation of findings may seem impractical to burdened stakeholders;

(ii) the model's simplification of a multi-dimensional and complex process linked to multiple consciousness states may miss important features. Many dimensions are abstracted in the learning disposition, some of which find

their cause in intrinsic motivators, some of which are socio-economic, ethical or moral, etc. Additionally, no difference is made between children / adults learning engagement modes, whereas empirical studies show that some dualisms reflect adulthood maturation compared to childhood (e.g. adults develop character leading to fluency and agency, whereas children start by favoring *easy* over *hard*, *fast* over *slow* and *simple* over *complex*).

Main findings related to third SRQ [Tools and strategies to close the gap]

Strengths. The ***SPESA-EP*** can (i) serve an extensive number of education programs of differing structure, contents and engaging formats due to its generality; (ii) highlight potential issues and opportunities present in an education program both explicitly and implicitly, through a whole-system sustainability principles lens; (iii) trigger creativity in an informed way through an inclusive values-rich dialogue; (iv) foster a purposeful dialogue between stakeholders about contents and processes used in the EP; (v) help diverse stakeholders share a common understanding of significant opportunities challenges and from a full sustainability lens; (vi) help identify improvements that make long-term sense from a strategic sustainable development perspective, while enabling further prioritization for short- and mid-term planning; (vii) help develop stakeholders' strategic abilities from gradually improving disparate aspects to focusing on closing the gap between current reality and envisioned goals.

The ***CKMOV model*** can (i) help people tackle complex issues thanks to its generality and its purposefulness in combining synergistic abilities of high potency, that sustain the fundamental human needs; (ii) serve to re-interpret familiar tools to provide new insights; (iii) help develop new tools; (iv) be well-suited to support the educational shifts proposed by ESD.

Weaknesses. The abstract, almost principle-like level of the findings (i) demands a local re-interpretation (in terms of culture, and specificity of the education program under scrutiny) of a complex tapestry linking global trends; (ii) necessitates prior conceptual training with systemic concepts that need first be understood to make a successful interpretation; (iii) compete with many, more circumscribed issues that education practitioners consider in developing an education program, thus the whole exercise may prove demanding to burdened stakeholders—the findings may be seen as failing the "practical" criteria developed in the Criteria Stage. An answer to

this issue would be to first “localize” the findings to a specific culture / education program, and to feed stakeholders engagement with appropriate incentives and resources as well as strategically foster coherent alignment of the different levels co-creating the conditions for the EP’s quality;

Conclusion

It is the authors’ contention that a minimum set of satisfiers, helping to fulfil fundamental needs and thus to address multi-stakeholder multi-cultural complex problems, should include at least three basic satisfiers acting in synergy: Knowledge Making, Creativity, & Open Values. The weaving of these satisfiers can be found in the purposeful design of the Framework for Strategic Sustainable Development to address 21st century’s main challenge: satisfying fundamental human needs for all, indefinitely.

Current education programs overwhelmingly emphasize the first satisfier at the high cost of weakening, or even sacrificing, the two others. Such strategy, which may have seemed efficient in a "large, local and empty" world, finds itself increasingly unable to answer modern issues in a "small, global and crowded" Earth, because people are not contents anymore to be spectators, but increasingly want to participate in tuning into and co-creating the world they live in.

Education programs in the 19th and 20th century bore the weight of only a few billion people, and in these times it seemed enough to support them on the sole pillar of Knowledge Making. Yet education programs in the 21st century have to help society transition peacefully from 7 billion to close to ten billion, while at the same time ensuring everybody’s chances to live a decent life in which at least fundamental human needs are satisfied.

The hard-earned lessons of the 20th century demonstrate that Knowledge Making alone is not up to the task. Thus education programs have to undergo a structural transformation if society is to successfully address today’s and tomorrow’s complex challenges. From being supported by a single pillar, their 21st century evolution asks for renewed harmonious reinforcement provided by three pillars of equivalent vitality: Knowledge Making, Creativity & Open Values.

Glossary

ABCD Method: one of the key tools in the Framework for Strategic Sustainable Development. Its whole-systems approach interconnects scientifically-derived Sustainability Principles (SP), strategic-by-design Backcasting from Principles (BSP) using Strategic Guidelines (SG), as well as creative, visioning & convergence-building tools in an integrated way. The primary output of the ABCD method is a "Sustainable Organization in a Sustainable World" Strategic Action Plan customized to the organization. The ABCD four-step process entails: **step "*A*"** during which the organization builds a shared language and mental model, to create a vision of the organization within a sustainable society (i.e. respecting sustainability principles); **"*B*"** during which the organization conducts an assessment of the current reality from its own perspective (i.e. how do its activities respect the sustainability principles); **"*C*"** during which alternatives to current unsustainable practices are freely formed; **"*D*"** during which the planning team prioritizes the list of actions created in the "*C*" step, using the three Prioritization Questions and other criteria informed by its vision and mission.

Anthropocene: epoch in which Earth's biological / geophysical processes are significantly influenced by humans (newly suggested epoch term).

AQAL's Four Quadrants Model: four irreducible categories of Wilber's model of manifest existence. All Quadrants recognizes that each worldview is looking through a particular set of eyes when viewing the world and that only when we honor all four perspectives do we get a full view of the world. The four views are: Individual Interior - the thoughts and beliefs, feelings, emotions and values of the individual; Individual Exterior - the words, actions and behaviors of the individual; Social Interior - the beliefs, values and culture of the collective; Social Exterior – the external structures and systems of the collective.

Backcasting: a planning method to answer issues demanding behavior change, used spontaneously for example by people planning their next holidays, and used strategically, for example in the health field, to treat patients. Planning starts with an envisioned vision of future success (the goal), then strategic pathways are built from the present situation to this future goal. This method is especially adapted to planning in complex systems (which may explain why humans evolved using it to plan non-trivial endeavors), specifically addressing the issue of bringing change by breaking from trends (like taking a holiday, curing illnesses or reducing unsustainable activities). This method belongs to the strategic level of the **Five-Level-Framework**.

Biosphere: the self-regulating living space in which all Earth ecosystems interact. Open to energy and closed to matter exchanges with space.

Blessing's Model: an engineering design research methodology (DRM), using a fluidly interacting four-steps analysis (*Criteria Stage, Descriptive Study I Stage, Prescriptive Study Stage, Descriptive Study II Stage*).

BSP - Backcasting from Sustainability Principles: backcasting from a vision of future success defined using **Sustainability Principles**.

Complex System: a system sensitive to initial conditions, constituted of many parts interacting through feedback loops (negative or positive) with unknown delays, thus producing possibly counterintuitive behavior in unpredictable ways.

Education: Selecting and perpetuating valuable information, worldviews, practices or know-how, altering mind-set or abilities of an individual or a group.

Education Services: the broad category of services offering formal education through education programs. This includes the global institutionalized education public services, as well as countless less formal services offered by all three spheres of society—public, private or governmental.

Education Programs: formalization of knowledge / know-how / skills as a set defining structure, contents and pedagogy/andragogy engagement practices.

Five-Level-Framework for Planning in Complex Systems (5LF): a generic thought-structuring tool helping the planning process in complex systems, that reduces complexity arising in multi-stakeholders endeavours by rendering explicit at which level information is exchanged between stakeholders. It consists of five distinct and interrelated levels: System (objective description), Success (subjective goals), Strategic Guidelines (intentionally designed valuation of the steps to reach the goal), Actions (practical steps), Tools (helping instruments).

Framework for Strategic Sustainable Development – FSSD: application of the Five Level Framework for Planning in Complex Systems, with a sustainable society in a thriving biosphere as an envisioned successful future.

Full Sustainability: a high maturity level in awareness, knowledge and practices about societal sustainability. It also refers to an actor (human or organization metaphorically moving through the funnel – see next definition) having some sustainable practices but desiring to completely eliminate its unsustainable activities, to contribute reaching a fully sustainable world.

Funnel Metaphor: society follows an imagined path into a closing funnel, illustrating the range of optimal options available as resources decline. The lower wall represents society's rising demand, consumption of non-renewed resources, and degradation of the socio-ecological system. The upper wall represents the systematically reduced ability for the biosphere to support society growing desires. An organization "hitting the wall" encounters prohibitive, multiple capitals costs and has lost room to manoeuver, leading to failure and systemic reconfiguration.

Fundamental Human Needs (FHNs): according to Max-Neef et al., FHNs are finite, few and classifiable, the same in all cultures throughout history. They may be represented in a matrix format along three axis: (i) the axiological axis, comprising the needs of *Affection, Creation, Identity, Freedom, Leisure, Participation, Protection, Subsistence, Understanding*; (ii) the existential axis, comprising the needs of *Being, Doing, Having, Interacting*; and (iii) the contextual axis comprising increasingly larger contexts: *Self* (personal), *Social* (group), *Environment* (society within the biosphere).

Integrated Product Development – IPD: a systematic approach to the integrated, concurrent design of products and their related processes. This approach is intended to help developers, from the outset, to consider all elements of the product life-cycle from conception through post-waste renewal, including quality, cost, schedule and user requirements.

Method for Sustainable Product Development (MSPD): a tool created to allow product designers to integrate a full sustainability perspective into the product development process by combining the FSSD with the *integrated product development model*. It includes a management tool, a product development process model, SPA modules, and a prioritization matrix.

Multiverse: Hypothesis that multiple universes (with their own space-time laws) exist. The theory rests on two concepts: that space is infinite (or at least sufficiently large) in size and almost uniformly filled with matter.

Planetary Boundaries: conceptualization of a "safe operating space for humanity", based on the analysis of Earth's key sub-systems variability range in the timeframe of human existence.

Principle: a basic condition to be met for a system to continue in a certain state.

Prioritization Questions: three questions belonging to the Strategic Level of the 5LF to help prioritize actions towards attaining the defined success in the system:

- Does this action proceed in the right direction with respect to the Sustainability Principles? (*Effectiveness* criteria)
- Does this action provide a flexible platform for future improvements? *(Resilience* criteria)
- Is this action likely to produce a sufficient return on investment (in multiple capitals: human, social, environmental, infrastructural, financial) to further catalyze the process? (*Value* criteria)

Satisfiers: relative way or means by which needs are satisfied. A satisfier may contribute simultaneously to the satisfaction of different needs, or conversely, a need may require various satisfiers in order to be actualized / realized.

Scenarios: simplified narratives about the future to guide planning efforts (with the help of the public and of designers, social scientists, computer modelers, etc.)

Simplified Model of Education Interactions*:* model that shows the connexions between the services offering formal education, based on the approach of education programs development.

Strategic Decision Support Systems – SDSS: interactive systems helping decision-makers use data-driven models to strategically solve complex problems.

Strategic Guidelines: see above **Prioritization Questions**

Sustainability – or Sustainable Development (from Brundtland): development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:

- the concept of **needs**, in particular the essential needs of the world's poor, to which overriding priority should be given; and
- **limitations** imposed by the socio-economic political organization of society and the nature of technology used to meet present and future needs.

Sustainability Challenge: deeply embedded societal design flaws stand at the root of a systematic erosion (i) of earth's ecosystems' abilities to function within the dynamic equilibrium zone humanity has evolved in; and (ii) of society's ability to fulfill vital / fundamental *needs,* since resources are not equitably shared among all but are used to satisfy the market-fueled *desires* of those who can afford them.

Sustainability Principles: generic whole-system existential conditions to be locally contextualized with shared values, that if respected by system actors, will

sharply reduce their risk of involuntarily destroying the system. Sustainability principles at least satisfy criteria of necessity, sufficiency, generality, specificity, disjointness. In the FSSD: *SP1*–avoid fostering build-up of substances extracted from the Earth's crust; *SP2*–avoid fostering build-up of substances produced by society; *SP3*–avoid systematic degradation of nature by physical means; *SP4*–avoid systematically undermining people's capacity to meet their needs.

System Conditions: In a sustainable society nature is not subject to *systematically increasing*

SPI. *concentrations* of substances extracted from the Earth's crust
(such as fossil carbon, metals, radioactive substances…)

SPII. *concentrations* of substances produced by society
(such as nanoparticles, endocrine disrupters, synthetic DNA, GMOs…)

SPIII. *degradation* by physical means
(such as large scale clear-cutting of forests, over-fishing, fracking…)

and, in that society

SPIV. people are not subject to conditions that *systematically undermine* their *capacity* to meet their needs
(such as from the abuse of power by armed, political, economic, or psychological control…)

"**SP-positive" education programs**: Programs using SPs to foster the widest possible societal choices while being compatible with global sustainability

"**SP-neutral" education programs**: Programs that do not refer to SPs.

Template for Sustainable Product/Service Development (TSPD): a tool / process helping product development teams to arrive faster and more easily at an overview of the major sustainability challenges and opportunities of a product category in the early development phases. It also informs creative communication between top management, stakeholders and product developers.

Youcheng Foundation: the China Entrepreneurship Foundation, under the supervision of the China State Council Poverty Alleviation Leadership Group. Founded by entrepreneurs from Mainland, Hong Kong and Taiwan in May 2007.

UNESCO: United Nations organization to establish the "intellectual and moral solidarity of mankind".

Willard Levels of Sustainability Awareness: 1. Pre-Compliance; 2. Compliance; 3. Beyond Compliance; 4. Integrated Strategy; 5. Purpose & Passion

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1 Introduction

1.1 Society's Sustainability Challenges

Since the launch of the landmark book "*Silent Spring*" (Carson 1962) credited to have started the environmental movement in the United States (EPA 1978), a mounting documented evidence demonstrates that despite technological advances, society's goal of satisfying its wants and desires is pushing against various kinds of limits: physical / environmental, social, economic (Stockholm 1972; Brundtland 1987; Villeneuve 1990; Rio 1992; Daly 2005; Stern 2006; TEEB 2010). This tension between desires and limits severely distresses more than a billion people unable to eat suitably[1].

Cheap oil as the fuel of western society's atypical growth in the last centuries may be ending: global Peak Oil[2] was reached in 2011 (IEA 2011). Other natural resources are also declining as demand swells, fuelled both by population growth and higher consumption per capita. To persist enjoying looked-for resources while simultaneously lessening damaging impacts to ecosystems they depend on, societies' *understanding* of their role in the biosphere must shift (Senge 1990). This would fuel innovative ways to cyclically obtain, convert, market, distribute, use and renew resources.

1.1.1 Growing Pains or Systemic Collateral Damage?

This crisis is driven by major geo-political, socio-economic and ecological trends. While ardent debates show people's determination to weigh real causes-to-impacts, four key trends keep being cited: a *growing population* applying an *inefficient and inequitable resource allocation system,* exhausting *overwhelmed supportive eco-systems* through the *wasteful over-consumption of their declining resources* (Rees and Wackernagel 1994).

These trends interact through feedback loops in unexpected ways, thereby creating complex living and planning issues. Yet their interlocking and dynamic parts much depend on the values people embrace and the actions people take. There is nothing universally pre-ordained about the crisis.

[1] and constrains most people. Secured access to resources (usually through finance and/or influence) constitutes an "insurance" by which people may try to offset those limits for their own group.

[2] Point of maximum oil production, after which market economics predicts constantly rising costs.

Society is at a crossroads: continuing "business as usual" which would lead it to face rising risks of climate change, loss of bio-diversity, water and energy scarcity, etc. (IPCC 2007) flagged as conflict magnifiers[3]; or finding opportunities in the crisis and the strength of will to make challenging yet inspirational changes for a future worth living in (Robèrt et al. 2002, 213).

The proverb "*The road to hell is paved with good intentions*" captures that good intentions are not enough, when delayed systemic feedbacks act on boundaries of laws of Nature. Agreeing on genuine answers to the complex issues societies face requires elements such as shared values for individual actions to flourish into large-scale cooperation, and solid knowledge and know-how based on principles rooted both in systemic trends and emergent properties. As Deborah James puts it: "*The future is not a result of choices among alternative paths offered by the present, but a place that is created—created first in the mind and will, created next in activity*."

1.1.2 Society's Means to Create Change: the Economy in a Funnel

To better understand sustainability issues, let us examine some narratives humans conceived on how societies build means to *sustain* their endeavors.

Political economy. From the ancient Greek οἰκονομία (oikonomia, "management of a household, administration") whose roots are οἶκος (oikos, "house") + νόμος (nomos, "custom" or "law"). As a recent human discipline (1776), it analyzes the production, distribution and consumption of products/services (PS) (the term "political" was dropped to make it seem values-free). Several schemes co-exist at all times: (i) gift—valuable PS are freely given, reflecting relationships; (ii) barter—PS are exchanged directly (without using an exchange medium); (iii) market—PS prices are assumed to be fixed by supply and demand, yet influencing factors may be linked in other indirect ways to resources (such as system rules, subsidies, taxes, rumors, marketing, mono/oligopolies control, collusion/corruption, HFT[4]).

[3] "*While climate change alone does not cause conflict, it may act as an accelerant of instability or conflict, placing a burden to respond on civilian institutions and militaries around the world*." (Pentagon 2010, pp. 84-85)

[4] High-Frequency Trading: computerized sub-second "flash" stealth investment positions. This trend exacerbates market dominance by "fast traders", i.e. those paying most for algorithms and server farms, yet may increase market instability in uncertain times to the point of crash (Easley et al., 2010). May lead to a "normalisation of deviance", i.e. "*unexpected and risky events come to be seen as ever more normal (e.g. extremely rapid crashes), until a disaster occurs*." (Foresight 2012)

Resources. Population growth coupled with individualistic mindsets and the attendant technological shifts may increase resource use and destruction rates. These show a sharp increase since the industrial age, ushered in through Newcomen's steam engine invention (1712). Previously, there was little change in the production rate, and thus in resources use rate, for all recorded history (Keynes 1930). Now since science shows matter is neither created nor destroyed but transformed, is an unceasingly growing use of resources an issue at all for society, as it projects itself into the future?

Market forces in neo-classical economics. Current neo-classical political economy theory asserts that market forces of supply & demand "naturally" take care of pricing issues. Moreover, based on Adam Smith's concepts and on his followers' attempts to fit social behavior into abstract mathematical models of idealized markets[5], the market is deemed to self-regulate through an "invisible hand" (Smith 1776). Through "ideal" competition, prices of rarefying resources rise, thus limiting consumption. This creates prospects to find lower-priced alternatives, stimulating novelty using other resources and/or knowledge. Physical limits aren't that limiting, since human ingenuity breaks through them by always finding substitutes, which the market always adequately prices. As long as growth continues, the market can correct in the long-term any "temporary" deviations, since temporary setbacks will be offset by future gains. Because this theory only considers ideal markets, externalities[6] are neatly ignored.

[5] An ideal market has three core characteristics (inexistent in a real world as shown by 2001 Nobel Prize in Economic Sciences Joseph Stiglitz): (i) a competitive equilibrium price ensuring the efficient allocation of resources (consistent incentive system), (ii) negligible transaction costs and (iii) perfect / instantaneous information available to all stakeholders (Yomekura 1995)

[6] Costs/benefits not reflected in market prices, incurred through actions not agreed upon by affected parties. For example, impacts of the current food production system cause social, environmental, health and social responsibility issues directly feeding species extinction, biodiversity loss, climate change, some epidemics (such as the H1N1 "swine flu" pandemic), and selective starvation through commodities-based derivatives speculation (Henn 2012). A similar case can be made with loss of lives / economic losses of non-smokers due to tar-laced second/third-hand smoke, air pollution causing more than a million deaths worldwide per year (World Health Organization), etc. Each time, some firms gain (e.g. in food transformation, banking/investment, tobacco, fossil fuels industry) by privatizing profit while *socializing* (externalizing) the associated human lives and socio-economic costs. On this subject, Stiglitz said: "*The theories that I (and others) helped develop explained why unfettered markets often not only do not lead to social justice, but do not even produce efficient outcomes. Interestingly, there has been no intellectual challenge to the refutation of Adam Smith's invisible hand: individuals and firms, in the pursuit of their self-interest, are not necessarily, or in general, led as if by an invisible hand, to economic efficiency*."

The funnel metaphor. To illustrate the insight that the pool of available choices shrinks as resources decline, scientists developed the funnel metaphor (Figure 1.1) (Broman et al. 2000). They formulated the ensuing *sustainability challenge*: deeply embedded societal design flaws stand at the root of a systematic erosion (i) of earth's ecosystems' abilities to function within the dynamic equilibrium zone humanity has evolved in; and (ii) of society's ability to fulfill vital / fundamental *needs,* since resources are not equitably shared among all but are used to satisfy the market-fueled *desires* of those who can afford them.

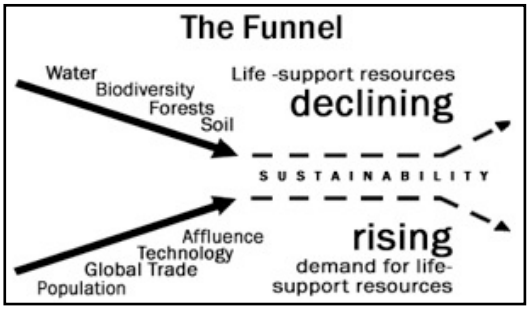


Figure 1.1. Funnel Metaphor Showing Issues Rarefying Society's Choices

So what could those vital needs be? Which ensure well-being, and which are desirable yet whose absence would not deprive of equal opportunities?

1.2 Shared Goals: Human-Scale Development

Human-Scale Development emphasis, as crafted by economist Max-Neef et al. (1989), puts the emphasis on people realizing their vital needs, rather than on objects people create through economic means. These needs are few, absolute, classifiable, and work as a system in which simultaneities, complementarities and trade-offs are continually assessed. As Max-Neef puts it: "What changes both over time and through cultures are not the needs, but the way or the means by which the needs are satisfied. […] needs are satisfied within three contexts: (a) with regard to oneself (*Eigenwelt*); (b) with regard to the social group or community (*Mitwelt*); and (c) with regard to the environment (*Umwelt*)."(Max-Neef 2009)

1.2.1 A Shared Trait: Fundamental Human Needs

The Fundamental Human Needs (FHNs) are independent of cultural beliefs, religion, age, gender, wealth or worldview. They may be represented in a

matrix format along three axis: (i) the axiological axis, comprising the needs of *Affection, Creation, Identity, Freedom, Leisure, Participation, Protection, Subsistence, Understanding*; (ii) the existential axis, comprising the needs of *Being, Doing, Having, Interacting*); and (iii) the contextual axis comprising increasingly larger contexts: *Self* (personal), *Social* (group), *Environment* (society within the biosphere) (Figure 1.2).

Apart from the "Subsistence" prerequisite, the FHNs all account for well-being: not being able to realize any of them causes a corresponding poverty.

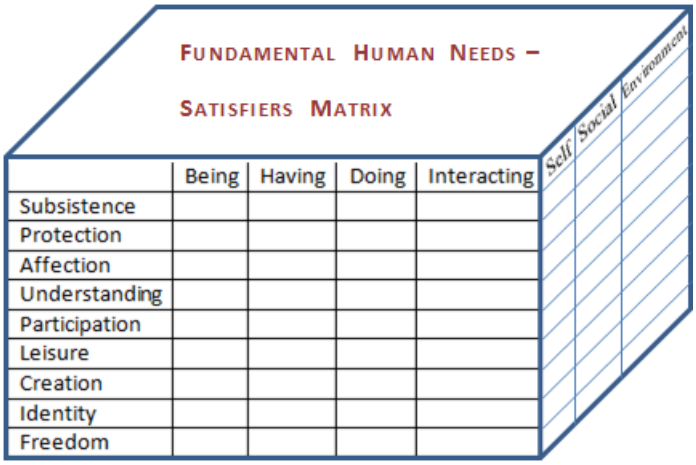


Figure 1.2. Fundamental Human Needs Matrix

1.2.2 A Wealth of Satisfiers

Filling this matrix are the "satisfiers", the relative ways (processes) by which needs may be realized/actualized. While the theory states that needs are few (ten, if including "Transcendence" along the axiological axis, a "potential" FHN), there are countless satisfiers combinations: each group/ individual uses a custom and dynamic mix to actualize its needs in time.

A single satisfier may serve several needs at once. Schools, for example, partly satisfy at least the needs of Creation, Identity, Participation and Understanding. Yet fulfilling someone's need for Participation requires more than just a school. The value of a satisfier depends not only on its nature but also on the larger contexts in which it can deliver its service.

Thus a satisfier may be (i) *singular*—satisfying one FHN; (ii) *synergistic*—

satisfying several FHNs or reinforcing other satisfiers; (iii) *a pseudo-satisfier*—partially satisfying a FHN; (iv) *inhibiting*: satisfying a FHN while inhibiting one (or more) other one(s); and a "*depleter*" or "*destroyer*" —acting to deplete one (or more) FHN(s). At a macro level, differing societies implementing particular cultural / political / economic policies can be interpreted as using distinct blends of satisfiers to actualize the FHNs.

After having examined the context in which society gives itself the means to pursue its endeavors, yet realizing that "business-as-usual" yields a finite horizon society, is there a platform by which humanity can both address the issues raised by the funnel metaphor systematically while upholding the fundamental human needs (or even "personhood" needs, as scientists deem some animal species to be intelligent enough to merit that distinction)?

1.3 Means to Action: the Framework for Strategic Sustainable Development

1.3.1 Framework for Strategic Sustainable Development

The Framework for Strategic Sustainable Development (FSSD) is a systems-responsive strategic platform, helping to systematically decrease society's unsustainable activities in a step-wise manner. Its goal is to help society last indefinitely in its dynamic equilibrium with Nature, while averting untimely collapses (Robert 2000 and Robert et al 2002). The FSSD started in Sweden through the cooperative work of a cross-section of scientists and practitioners of various disciplines and backgrounds, with the intent of being robust, strategic, comprehensive, fair and inspiring.

1.3.2 System Level

To accomplish this, the FSSD uses a synergistic whole-system framework: the Five-Level Framework for Planning in Complex Systems (5LF – See Table 1.3) (Robèrt 2000). Much as an operating system for sustainability applications, it can then add various existing tools in an orchestrated way to provide a "full sustainability" strategic platform.

1.3.3 Success Level

In order to achieve its goals, the FSSD is built using systems thinking and scientifically-derived principles. It notably makes use of the "Simplicity

Without Reduction" principle, by which one simplifies a complex system's understanding not by ignoring constituent parts (as with reductionism), but by grasping which core principles stand at the root of basic functional mechanisms. This may yield useful data to draw assorted conclusion from, particularly on the conditions for existence of this complex system.

System Conditions. A scientific consensus process has led to the development of four sustainability principles (Robèrt 1994; Holmberg 1995; Robèrt et al. 1997; Holmberg et al. 1999; Broman et al. 2000; Robèrt 2000; Robèrt et al. 2000; Robèrt et al. 2002; Ny et al. 2006), as least-constraining guidelines still helping to avoid systematically increasing the risks of

- reaching planetary boundaries tipping points, i.e. changes in Earth's ecosystems to which humans (and other species) are not adapted;
- the biosphere losing its ability to provide ecosystem services on which society fundamentally depends;
- disrupting various social support structures within society.

These principles are meant to provide the highest degree of flexibility and freedom of action compatible with creating unbounded yet durable societies, while still providing clear guidelines to any organizational group, of any size and purpose, on how not to ruin such an outcome. The current wording of the sustainability principles is as follows (Ny et al. 2006, 64)

Table 1.1. System Conditions for Society's Durable Existence

In a sustainable society nature is not subject to *systematically increasing*

SPI. **concentrations** of substances extracted from the Earth's crust
(such as fossil carbon, metals, radioactive substances…)

SPII. **concentrations** of substances produced by society
(such as nanoparticles, endocrine disrupters, synthetic DNA, GMOs…)

SPIII. **degradation** by physical means
(such as large scale clear-cutting of forests, over-fishing, fracking…)

and, in that society

SPIV. people are not subject to conditions that *systematically undermine* their **capacity** to meet their needs
(such as from the abuse of power by armed, political, economic, or psychological control…)

1.3.4 Strategy Level

The FSSD introduces strategic guidelines to help reach desired success: the backcasting planning methodology, and key prioritization questions.

Backcasting. A very natural planning methodology, it starts from the future envisioned goal to plan needed steps from the present, as seen in Figure 1.3.

This method contrasts with forecasting, a planning methodology projecting existing trends into the future, which tends to favor only incremental deviations from present conditions.

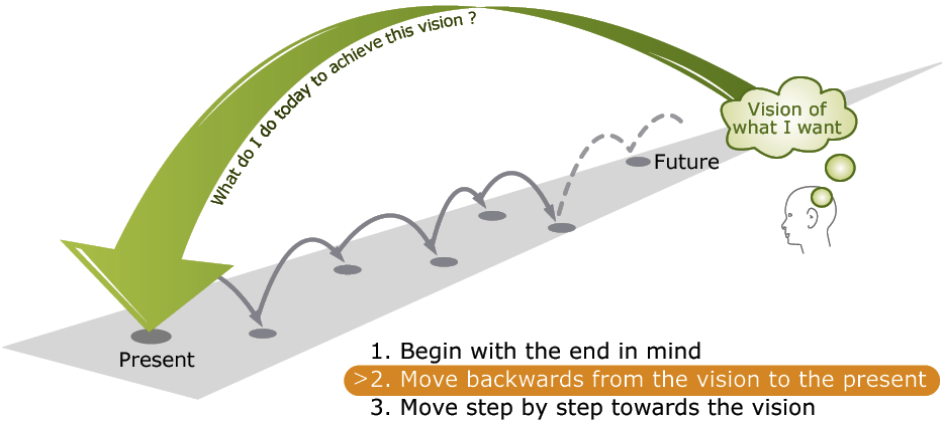


Figure 1.3. Backcasting (TNS 2011)

Backcasting from System Principle (BSP). To add robustness in the face of change, one can use system principles as guidelines towards success, such as the Sustainability Principles. Consensus on those principles being achievable, BSP is flexible enough to cover many strategic paths and powerful enough to address systemic issues.

Prioritization Questions. The following three key questions are then used as criteria to prioritize actions, along with risk considerations (probability, severity, urgency) and other questions dependent on the topic:

- "Does this move us in the right direction" (*effectiveness* criteria)?
- "Is this part of a flexible platform" (*resilience* criteria)?
- "Is this a good return on investment (human, social, environmental, infrastructural, financial" (*value* criteria)?

1.3.5 Actions Level

Sustainable Product/Service Development. Product Development (PD) refers to activities related to the creation of opportunities in new / existing markets, providing useful products / services to answer them (Ulrich & Eppinger 2003). Usually, teams of different specialties such as sales and marketing, design, programming, production, distribution, etc. cooperate to create a product in successive phases from concept to delivery, while working as much as possible in parallel to minimize time-to-market.

This happens especially when organizations structure departments and processes to use pools of resources for which all compete, in a rationalization attempt. Balancing specific projects' goals with their own objectives, departments may then resort to a "need-to-know" information policy vis-à-vis other departments during consecutive PD phases. In that case, the information more reliably shared becomes the one for which measurable criteria exist, especially at the management level, and the qualitative information may have a hard time competing against the quantitative, since the latter is usually easier to obtain and justify.

Yet systemic impacts may be hard to understand on the basis of already existing, highly abstracted, management data. The nature of the information passed on from one phase of development to the next, or from one group to the next, has an impact on developing quality products from a sustainability perspective. Evidently, the more measurable sustainability criteria become, or the more central to the purpose of either the product or the business, the more chance suitable information would reliably be passed and acted upon.

Thus the sooner sustainability requirements are part of the PD process, the more likely profitable sustainability can be used for economic advantage. As with software, in which bug prevention is hundred times more cost-effective than bug eradication after production, "putting sustainability into" a product after it is produced is akin to asking to "put economy into" it after market delivery: a risky proposition leading to a likely-to-fail assignment.

1.3.6 Tools Level

In the context of FSSD, tools designate the means (concepts, methods, indicators, etc.) used to systematically evaluate and monitor actions, in order to reach the desired goal (shared vision of a sustainable world).

To sidestep reductionist approaches, several methods have recently emerged such as the general Method for Sustainable Product Development (MSPD) (Byggeth et al. 2006), and a more focused one using Templates for Sustainable Product Development (TSPD) (Ny et al. 2008).

The MSPD introduces the FSSD to help product developers make better decisions, by offering them a structured way to make sense of complex patterns of meaning (whole-system relationships, impact boundaries) in the context of strategic decisions towards sustainability objectives. The MSPD helps selecting "strategic pathways" at various stages of PD, ensuring the sustainability objectives are not drowned out by other considerations, but on the contrary, help the organization fulfill its vision while rooting out unsustainable activities (Ny et al. 2006).

The TSPD focuses on the first phases of PD, concepts and design, to help developers quickly gain an overview of the general opportunities and challenges a product-line offers. Key questions are used as the basis for a creative and informed dialogue between a sustainability practitioner and a trans-disciplinary team of product developers, usually including management. The resulting answers are put in a standardized format, creating an evolving "template" for this product-line.

1.4 Leverage Points: Education – Cause and Way Forward

Etymologically, the word education is derived from educare (Latin) "bring up", which is related to educere "bring out", "bring forth what is within", "bring out potential" and ducere, "to lead".

From the interplay of the many forms of interactions people experience (within the world of their mental models; within society with other humans; within the biosphere, within the multiverse) rises the transfer of knowledge and cultural habits. Some of this transfer occurs through formalized experiences as teaching/training and organized learning, some of it occurs through informal and even unconscious ways (Karabanov et al. 2010).

"*Education is society's main instrument for reproducing itself and can be a key ingredient for social change*" (Birdsall et al. 2005, 23). Education shapes cultures, influencing the values and actions people support through

the acquisition, dissemination and furthering of all kinds of knowledges. Education is an inalienable Human Right[7] (Article 26 of the UDHR[8]).

1.4.1 Systemic View: the Roots of the Public Education System – Past to Present

Causes. Historically, while laicized public education slowly formed in western countries (from 18th Century on), Cartesian precepts from the Age of Enlightenment, embedded in a new capitalist system fed by the Industrial Revolution, shaped the narrative: mechanistic (rather than arbitrary or emergent) values were used in deciding "how children grow", or rather, in "how to best develop children"—for industrious aims (Robinson 2006).

The new capitalist system seemed to provide the affluent[9]. As for the rest: "*Abject poverty was seemingly permanent and endemic; abject poverty in the midst of economic growth did not seem worse than abject poverty amidst economic stagnation*" (Galbraith 1998). All this while other anchors weakened in strength (religions, monarchic absolutism, Earth's status in the Solar System, human status in the evolutionary Tree of Life), and while reductionism's standing rose ("efficiently" reducing complexity).

The simple, mechanistic[10] capitalist system worked exclusively through linear models[11] (non-linearity calculus was invented in the 20th Century). It is no surprise that economists, abstracting complex social deeds through "usefulness" curves / equations, articulated theories about individuals with "asocial" wants within linear models of production / consumption (Ibid.). Thus industrializing societies influential bodies developed a societal model of integration serving the national interest, under a thought movement to

[7] i.e. not tributary (in theory) to national laws. In practice nations implement the protection of rights in ways dependent on values and social norms priorities, culture, jurisprudence, resources, etc.

[8] Universal Declaration of Human Rights. See Appendix B on Article 26

[9] Thus economics being called "the dismal science" by Thomas Carlyle, and what Galbraith calls the "tradition of despair" in Smith, Ricardo and Malthus works (Galbraith 1998)

[10] Its transactions discharged from morality and relationships vagaries/complexities (Graeber 2011)

[11] Malthus' warning about limits were not heeded, since these limits seemed to recede away with new investments (strongly for the investors, infinitesimally for the masses). They represented a peculiar sort of "upper-class social pact" based on trust in the virtues of money, if not in the virtues of peoples whose egoism was excused and even encouraged in a "rational" economic analysis of the "Invisible Hand" for the good of all : small and local re-investments in one's community had the advantage that since one is affected by them, one is careful over what gets funded, how resources are used, who profits and how social relations are reshaped (Dobb 1973).

manage education in a "clockwork" fashion mirroring how the cosmos was deemed to work (monasteries/churches were long the time-keepers). All children regardless of abilities or preferences would (when not working at the factory) go through the same curriculum at a fixed pace. Arguing that progress and prosperity was at stake, industrial interests greatly influenced this mold to get people fit for their model of work, to ensure an unimpeded growth through soaring productivity in a managed society (Simon 1960).

Thus parting with the "organic" metaphor—tutors ingraining seeds of knowledge and helping children make them grow—society engineered a large-scale "industrial-strength" education system: Sir Ken Robinson describes it through metaphors of manufacturing, mining, and fast-food.

Societal consequences. Under an "endless growth" policy some economists praised, that soaring productivity was stressed as a lead indicator of rising societal output through product development. Yet this systematic hunt for productivity bore the costs of adversely impacting outcomes through several reductionisms: *knowledge reductionism*—over-simplifying complex issues; *issue reductionism*—false starts / dead-ends; *cooperation reductionism*—frail trust / relationships; *scope reductionism*—short-term thinking; *truth reductionism*—"fit-to-mental-model" view (see Shiva 1989).

What was neglected and now manifests in the sustainability challenge, is that the rising (though very inequitably shared) affluence in goods was bought for by systematically using (and collapsing) Nature's increasingly dilapidated capital, i.e. by running a growing environmental resources and services debt[12] (Daly 2005). In a nutshell, impacts were long overlooked by locally emphasizing an idealized, Cartesian, linear and reductionist aim of

[12] Some economists argue the incurred debt is better paid off by future generations (endlessly leaving it to their descendants), theorizing endless growth helps better-off and better technology-equipped people to more easily pay it (see Partridge 2003 for at-length discussion). Yet they don't address the issue that some portrayed growth (formally, GDP-based) is really debt, since capital is burnt (literally, as with fossil fuels). Also, nations wage war / strong-arm other nations to acquire resources; large economic entities "manufactured" conflicts to satisfy growth "requirements". Even the rise of regular use of coinage in markets (to trade goods), can be traced to governments establishing them both to maintain large-standing armies while pursuing dominion (Graeber 2011, 238-239). Can all this truly leave descendants better off and be counted as growth, globally? These (and other) cases of market failure show that the "free market" is a mathematical ideal and that market pressure can grow so large that externalities can become the dominant part of transactions (for most of society, if unchecked).

the economy (grow a mechanistic ideal market) while turning a blind eye to issues (externalities). Peter Senge captures this issue with the first of eleven laws: “Today's problems come from yesterday's "solutions"” (Senge 1990).

It stands to reason that if society still faces long-standing issues, education has not yet been able to give people the needed abilities to eradicate them appropriately. Education programs (EPs) probably share responsibilities in furthering the deeply embedded societal design flaws of the sustainability challenge, implicitly and/or explicitly. An education program promoting an uncritical view of “free market” for example spreads an inexistent utopia, which in turn may impel in time the creation of large externalities. One can then ask how EPs impact, and can help solving, the sustainability challenge.

Modern societal trends. In keeping with the utilitarian view of 19th Century economists, education viewed through an economic lens is less seen as the fertile ground to help refine societal knowledge for itself (guided externally by values society deems important) or to attain self-realization, and more deemed as the industry’s reservoir of brain power while being personally used as the tool to acquire job-securing skills. Education reforms were many in the last decade in OECD countries, to keep up with the world's accelerating pace of change (OECD 2012). Countries almost uniformly couched their reforms with the primary aim of training their population to serve industrial needs (called “upgrading the workforce” or “upgrading the human resource” in OECD 2007), to stay competitive vis-à-vis other countries. They proceeded with a “productivity mindset”, rather than creating conditions helping people deepen their unique potential / cultivate diversity, or aiming at creating a better society (except insofar as it is an ever more productive, endlessly growing, *normatively* consumerist society—in which consumption becomes the pinnacle of self-expression). The result is a complex tapestry of reforms that may serve a narrow purpose for a limited time, but may fall short of the general purpose of enhancing learning for all to help people satisfy their fundamental human needs.

This intense pace of reforms, even though possibly warranted, accelerates “credential inflation”, a high turnover of diplomas that lose recognition at an increasingly faster rate (i) in other countries, as nations that can’t keep up evaluating so many changing educative offers err on the side of cautious protectionism; (ii) as time passes and especially after a generation’s time, as a growing part of the workforce needs to refresh its skills, while more and more people go through the education system (Collins 2011).

One example reform in the United States (No Child Left Behind Act of 2002), is criticized for rote memorization, standardized contents (that can be delivered through technology) and "teaching to the test": funding-starved public schools have high incentives to make children pass standardized tests required to obtain funding, rather than enabling children's creative and critical thinking, mindfulness or self-understanding. Ever more people get educated in this conforming way, through methods ratifying passive consumerism of *standardized truths* more than the active exploration of (outside-of-the-box) knowledge. This at a time when decisions increasingly acquire vital importance, since intricate inter-dependencies are escalating. The larger question is: "Can the conforming incentive to 'teach to the test' bring oneself in a disposition to deal with complex systemic patterns where the trends are part of the issue, since the ability to fluently use divergent thinking in a collectively coherent way is likely required to formulate pathways sidestepping the problematic pattern?" (Manteaw 2008).

Moreover, education helps society recurrently answer the question: "How does culture help people mediate the tensions between (i) their individualistic and social self; (ii) individual and group needs?" (Partridge 2007, ch. 22). Put in other terms, how do people live the creative tension between their "direct" or "first-order" individual needs and desires, and their "second-order[13]" desires expressed as common values and norms of their communities? Or in yet another way, is education a private and personal investment or a public and collective investment? (Barber 2007).

In conclusion, education trends seem to show that economic tenets continue to shape initiatives, pitting members of society to act competitively for access to the best resources: to wit the latest incarnation of this trend pushed through in part by technology, of (i) research being sold to private interests; (ii) education programs being increasingly influenced by wealthy donors; (iii) education prices going through high inflation rates even though credential dilution lowers the economic value of degrees; and (iv) the economic view that education's role is to create competitive human capital for the labor market answering the imperatives of an increasingly globalized and financial market (in some countries undermining the resilience of local impoverished communities) (Bartlett et al. 2002).

[13] for philosophers, expressing whether the first-order desires themselves are deemed desirable by the people who experience them

1.4.2 Means to an End: Paradigm Shifts – Can Technology Deliver?

Louis Gerstner, the former CEO of IBM, once said, "Computers are magnificent tools for the realization of our dreams, but no machine can replace the human spark of spirit, compassion, love, and understanding."

There is a market rush to push technology into the classroom, turning it into a techno-playground, or alternatively to fit the classroom into a screen, learning becoming a series of gaming adventures. This rush resembles the one to establish postal courses in the U.S. in the 1920s (Carr 2012). It remains unclear whether these initiatives yield effective learning (Richtel 2011), which topics are suited without loss in learning quality, what biases are introduced in people's mindsets, which abilities are traded for which, and who does this trend particularly favor (also what other unintended impacts may emerge from this experiment)? Also unclear if learning motivation[14], or quality, can be sustained on little relationship-building.

The Maori concept of "ako" clarifies the latter. It describes a reciprocal teaching / learning relationship, whereby "educator" and "student" teach / learn from each other. Yet the built knowledge is not all: "*Embracing the principle of ako enables teachers to build caring and inclusive learning communities where each person feels that their contribution is valued and that they can participate to their full potential. This is not about people simply getting along socially; it is about building productive relationships, between teacher and students and among students, where everyone is empowered to learn with and from each other*." (TKI 2009)

Yet computers are rigid (dealing only with previously fixed scenarios), and they necessarily work with simplified abstractions. They are blind both to the context in which one exercises one's four existential needs (Being-Doing-Having-Interacting), and to unexpected yet needed actions that a person may decide to take while interacting with someone else[15]. At issue is not just the "quantity" of learning about a subject, but its quality in how it affects the behavior at present (Stamm 2009). Can computer-mediated education create quality learning on par with "ako", and aren't educator ~student relationships themselves a form of learning (making a difference

[14] In leading programs, many sign up but usually less than 15% finish the course (Carr 2012).

[15] A recent study reveals that in chimpanzees, some neurons fire only after eye contact, activating particular neuronal paths. Will computers one day act depending on *attentional relations*?

in low or high motivation and affecting performances—see Toste 2012) conspicuously less prevalent or even absent the more technology is used?

Learning with technology "rewires" the brain differently than using pen and paper. The same is true about learning through play[16] and senses rather than through directed instruction; learning alone rather than in groups; learning *with* living beings rather than *through* devices. Studies on technology-aided learning so far bring Senge's law to mind. First, a national teacher survey concludes : "*Students are having issues with their attention span, writing, and face-to-face communication, and, in the experience of teachers, children's media use is contributing to the problem*" (CSM 2012).

Second, MRI studies show the rise of Internet Addiction Disorder (IAD) or issues with internet games. On the latter, a recent study states that "*Two task-related fMRI studies of individuals with online game addiction indicated that cue-induced activation in response to Internet video game stimuli is similar to that observed during cue presentation in people with substance dependence or pathologic gambling*." The study adds its own research on IAD: "*IAD has abnormal white matter integrity in brain regions involving in emotional generation and processing, executive attention, decision making and cognitive control. The results also suggest that IAD may share psychological and neural mechanisms with other types of substance addiction and impulse control disorders*[17]." (Lin & al. 2012)

There are other types of reasons why technology may serve only a limited part of practicing actual learning. A first is alluded to by the founder and chairman emeritus of MIT's Media Lab, Nicholas Negroponte, one not aversive to technology and its use: "*I believe that we get into trouble when*

[16] Educators advocate learning through play, before about the "age or reason" or seven years old. "A growing consensus among psychologists and neuroscientists maintains that children learn best when allowed to explore their environments through play. Preschools are increasingly turning away from play-based learning to lectures and testing. Placing heavy emphasis on academics early in life is not only out of line with how young brains develop, it might even impede successful learning later on." (Tullis 2011)

[17] It continues: "[…] *Taking the findings from the two studies together, it may be concluded that IAD in adolescence is not associated with morphological changes in white matter at the macroscopic level, but rather impaired white matter microstructural integrity, which might be attributed to demyelination*." Note: demyelination is a degenerative process that erodes away the myelin sheath that normally protects nerve fibers, exposing them and cause problems in nerve impulse conduction that may affect many physical systems. It is seen in a number of diseases, particularly multiple sclerosis. (MedTerms)

knowing becomes a surrogate for learning." He asserts that inherent to intructionism[18] is a "misguided" mental model that there is some adequately standardized way to teach everybody a subject[19] (in essence, referring to the lack of "ako"). This is an equivalent of asserting "The map is not the territory": presentations, books or hyper-linked videos go only so far compared to real-life interactions in complex situations.

Another key aspect is fitness-to-purpose compared with costs. As Richtel explains, technology investment by resource-starved universities and schools means controversial trade-offs: "*In a nutshell: schools are spending billions on technology, even as they cut budgets and lay off teachers, with little proof that this approach is improving basic learning.*" (Richtel 2011). Yet despite the lackluster results, despite rising concerns about pitfalls in cognitive health, despite trade-offs correlated with lower learning quality such as decreasing teacher-to-student ratio, technology is heavily pushed in the name of "national competitivity" (Ibid.) These trade-offs ought to be systemically assessed, also bringing in the value-chain cascading effects of technology: resource wars (e.g Congo war over Coltan), labour issues, etc.

Some high-level employees and executives of Silicon Valley technology companies do the inverse bet, sending their children to non-technology Waldorf schools (Richtel 2011 - 2). This poses questions akin to the ones asked in "The End of Education" (Postman 1995) (see Appendix C): "What ought education's role to be regarding the fashioning of mindsets whereby deferred gratification becomes harder, through the introduction of increasingly pervasive technology training people to have constant and rapid feedback? What kind of public does this tend to create? What does this mean for democracy and addressing complex issues where rapid gratification may be long absent and even delayed after one's departure?"

The Cynefin[20] framework's (Snowden 2002) categorisation of decision contexts (Fig. 1.4) may help to discern where technology best delivers. Value / purpose choices straddle several realms, including the Complex one, while programming is suited to the "Known" and "Knowable" realms

[18] Education theories based on teachers delivering standard contents within a predetermined schedule

[19] He is even "alarmed" at this turn of event, because this "misguided" theory according to him receives ample support from world-scale technologists such as Google, Bill Gates, and MIT

[20] "(Cynefin) describes that relationship – the place of your birth and of your upbringing, the environment in which you live and to which you are naturally acclimatised." - Kyffin Williams

(capturing "best practices" to translate them into repeatable algorithms, i.e. chunks of defined circumstances and best answers). Thus technology by itself leaves the "Complex" part of experiences untouched, relationships and emergence being ignored by its (mostly static) programming.

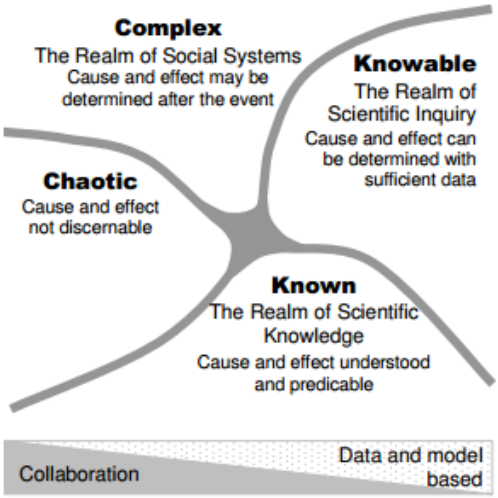


Figure 1.4. Cynefin Categorisation of Decision Contexts

1.4.3 The Maze of Learning: a Cornucopia of Theories

Nowadays learning theories comprise four "standard" families (Table 1.2).

Table 1.2. – Learning Process in Standard Learning Theories

Theories[21]	**Behavio-rist**	**Cognitivist**	**Humanist**	**Social and situational**
Learning process as…	Change in behaviour	Internal mental process (insight, information processing, memory, perception, etc.)	A personal act to fulfill potential	Observation / interaction in social contexts, from the edge to the center of a community of practice

These diverse theories emerged as learning evaluations made in diverse environments became more trans-disciplinary. Still unsettled is the matter

[21] A more complete table (Appendix B) adds each theory': i. theorists; ii. locus of learning; iii. purpose of education; iv. educator's role; v. manifestations in adult learning.

of learning as a uniquely defined uniform process (at the neuronal level?) or whether inner experience creates an inherent "fuzziness" to how people tune in to learning, making them use different pathways as they see fit. Formalized learning is traditionally experienced in institutional settings of public schooling (as a public service) going through education programs.

1.4.4 Fitness-to-Purpose: a more Purposive Education?

Successful alternatives. Diverse successful EPs exist, such as Waldorf and Montessori. An integral model of education, using an "All Quadrants All Levels" approach [22], led to the "Twelve Commitments of Integral Education" (Esbjörn-Hargens 2007) as twelve "forms of engagement… modes of interaction [and/or] ways of knowing the world[23]" (Figure 1.5).

	Interior	Exterior
Individual	**Upper Left (I)** *Educational Experiences* Contemplative Critical Somatic	**Upper Right (It)** *Educational Behavior* Skillful Practical Active
Collective	**Lower Left (You, We)** *Educational Culture* Connective Perspectival Ethical	**Lower Right (Its)** *Educational Systems* Ecological Social Global

Figure 1.5. Twelve Commitments of Integral Education

[22] see glossary: AQAL

[23] "*Some of the listed principles focus on the understanding and development of internal mental, emotional, or spiritual capacities (the upper left quadrant); some prioritize collaborative, community, or ethical elements (lower left); some emphasize in-the-world action, the creation of artifacts, or physical embodiment (upper right quadrant); and others highlight the systemic factors in classrooms, the institutions of education, or social and political realities (lower right quadrant)*." (Murray 2009)

Education for Sustainable Development. Education for Sustainable Development (ESD), currently under the aegis of UNESCO, is an umbrella name for many forms of education that already exist. ESD "allows every human being to acquire the knowledge, skills, attitudes and values necessary to shape a sustainable future". ESD emphasizes educational shifts in order to help people tune in the abilities they need to foster a sustainable future (Figure 1.6) (ESD 2010)

From	***To***
• Passing on knowledge	• Understanding and getting to the root of issues
• Teaching attitudes and values	• Encouraging values clarification
• Seeing people as the problem	• Seeing people as facilitators of change
• Sending messages	• Dialogue, negotiation and action
• Behaving as expert - formal & authoritarian	• Acting as a partner - informal & egalitarian
• Raising awareness and	• Changing the mental models which influence decisions & actions
• Changing behaviour	• More focus on structural and institutional change

Figure 1.6. Educational Shifts of Education for Sustainable Development

UNESCO was tasked by the United Nations to put in place a Decade of Education for Sustainable Development (DESD), spanning from 2005 to 2014.

1.4.5 Education Programs and the Framework for Strategic Sustainable Development

The FSSD aims to achieve full sustainability in a systematic and strategic way via the Five-Level Framework for Planning in Complex Systems (5LF). What may its perspective lend to education programs? Table 1.3 shows what the five levels entail (i) for a generic system; (ii) for the whole of society within the biosphere (what the FSSD generically proposes for the five levels); (iii) for education programs in society within the biosphere.

Table 1.3. Five-Level Framework for Planning in Complex Systems

Name / Level	Generic Five-Level Framework	Framework for Strategic Sustainable Development	
	Generic System	**Whole society within the Biosphere**	**Education Programs in society within the Biosphere**
SYSTEM	Objective account: Boundaries / parts, rules / processes, flows / stores, dynamic balances, feedback loops, stakeholders, needs	Society within the biosphere, along with laws/norms, humanity and Fundamental Human Needs	Education Program (EP) provided by an educational Service (ES) in society within the biosphere, laws/norms, humanity and Fundamental Human Needs
SUCCESS	Subjective account: Goal(s) of the planning endeavor	Society within the Biosphere, satisfying the Sustainability Principles	i. EPs Goals in ES Vision ii. Whole-systems global sustainability outlook iii. Satisfaction of the Sustainability Principles
STRATEGY	Prioritization and selection criteria for actions needed to reach goal(s)	○ Backcasting from above principles ○ Three Prioritization Questions	○ Backcasting from i. using ii. fulfilling iii. ○ Three Prioritization Questions ○ Other prioritization criteria to reach EP goals
ACTIONS	Needed actions to reach goal(s)	Actions fostering a durable society free of unsustainable activities	Actions helping to reach EP's goals while satisfying Sustainability Principles using a global outlook
TOOLS	Supporting tools	ABCD method, systematic evaluation / monitoring of actions	Systematic evaluation / monitoring of actions

1.4.6 A Model of Education Programs

"Education programs" is defined as the formalization of knowledge, know-how or skills as a set defining structure, contents and pedagogy/andragogy (engagement practices). Figure 1.7 illustrates the education program model used in this research.

"Education services" is here defined as the broad category of services offering *formal* education, meaning formalized through the creation of education programs. This includes the institutionalized education public service in operation the world over, as well as countless less formal services offered by all three spheres of society—public, private or governmental.

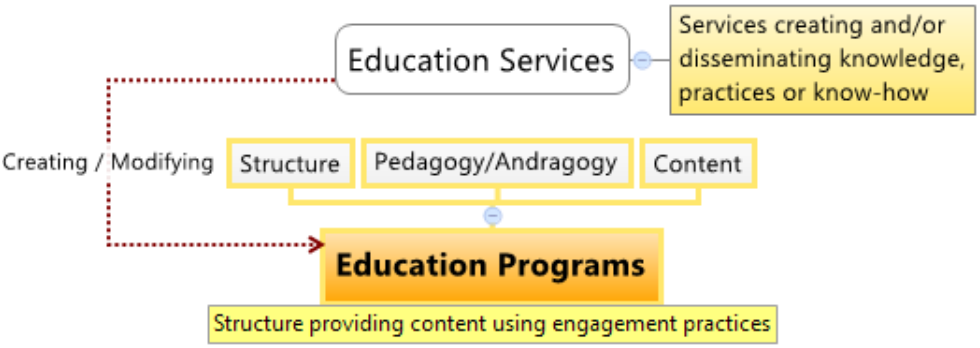


Figure 1.7. Simplified Model of Education Programs

1.5 Scope of Research

1.5.1 Research Purpose and Scope

Purpose. The purpose of this research is to understand

(i) how some education programs function (mainly in higher education, although some findings may apply to K-12 as well) to gain an overview of challenges and opportunities through a full sustainability lens;

(ii) which concepts may contribute in inspiring future education programs (higher education and K-12), helping society to transition from current unsustainability to global sustainability; and

(iii) what concepts and tools may be of help towards that end.

1.5.2 Research Questions

The research questions express the inquiries made to understand how sustainability can become a strategic component of education programs, the Primary Research Question (PRQ) expressing the central inquiry.

Primary Research Question

How could a strategic sustainable development approach improve the design of education programs to promote sustainability while not contributing to socio-ecological unsustainability?

Secondary Research Questions

Each of the Secondary Research Questions (SRQs) expresses a different aspect of the Primary, while all of their answers contribute in answering it.

1. How may current education programs contents or processes contribute to unsustainability?

2. In a sustainable society, what may future education programs contents or processes cover?

3. What potential tools and strategies may be of use to education services when devising education programs, in order to help strategically close the gap between the current unsustainable state and the future sustainable one?

1.5.3 Assumptions and Limitations

Time constraints and limited access to experts may affect findings. Moreover, their introduction into general education programs may prove to be politically polarized, depending on citizen involvement, societal levels and cultural biases (USA and China having their own policy preferences).

The authors wish to design multiple versions of the TSPD tool, to account for education programs differing in sustainability maturity levels, according to levels defined by Bob Willard (Five-Stage Sustainability Journey): 1. Pre-Compliance; 2. Compliance; 3. Beyond Compliance; 4. Integrated Strategy; 5. Purpose & Passion (Willard 2005). Yet to address the bulk of education programs within time constraints, they focused on developing a

version for sustainability maturity levels 1 to 3, adapting the following organizational definitions to education programs:

- *Pre-Compliance*: initiatives ignore any notions of sustainability and flout environmental, health, and safety regulations. Illegal and unsustainable operations (corrupt environments);
- *Compliance*: initiatives manage liabilities by obeying all safety, health, environmental and labor regulations. Legal yet unsustainable operations;
- *Beyond Compliance*: initiatives move to Stage 3 when management realizes it can save money with proactive, operational eco-efficiencies. Sustainability initiatives still marginalized within specialized niches.

1.5.4 Expected Outcomes

Two types of outcomes are expected from the research: the findings informing the thesis research questions; and the outcome of the dialogue with education practitioners as they may form a revised understanding vis-à-vis sustainability. On the former, the authors expect to find

- different visions and ideas on what sustainability is and means;
- an agreement that soft skills (mediations, consensus-making, artistic skills, etc.) are necessary to bring about change;
- a lack of consensus about how to practically teach or learn about "sustainability", but a general agreement that education is important;
- goodwill and ideas towards sustainability, but
- a general lack of strategy, and a general lack of means.

On the latter, the authors expect the FSSD could help practitioners refine a scientific perspective about sustainability. They hope the dialogue will spur discussions about a refined systemic vision for educational offers, helping to align the goal of delivering an education program with the one of fostering, through learning materials and hands-on experience, a mind-set suitable for life-long learners to embark on their own sustainability journeys.

2 Methods

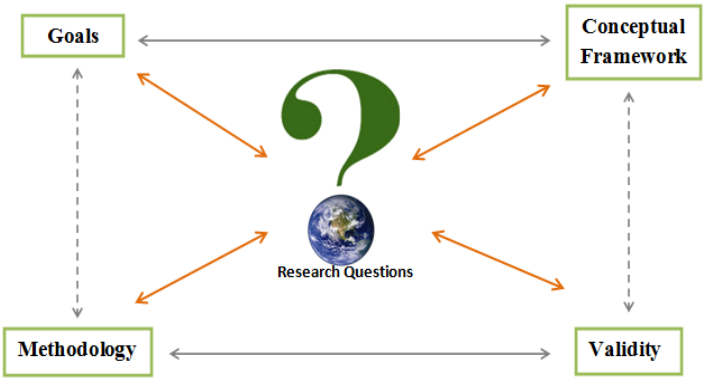
It is the mark of an educated mind to be able to entertain a thought without accepting it.
Aristotle

2.1 Research Design

2.1.1 Maxwell Model

The general methodology used in this research is based on Maxwell's model for qualitative research design (Maxwell 2005).

Figure 2.1. Maxwell Model of Qualitative Research



How the model is used in this thesis. Research questions do not exist in a vacuum: answers depend on what is considered and what is taken for granted. It is thus important to consider the interplay of research questions with research goals, central concepts, methodology and its validity. The following Questions & Methods matrices illustrate how this thesis links methods to research questions, to find evidence and guide the research.

Table 2.1. Questions & Methods Summary Matrix

Questions	Document Analysis	Interviews / Surveys	Logical Inference	Dialectic / Brainstorm	TSPD
PRQ	X	X	X	X	X
SRQ 1	X	X	X	X	X
SRQ 2	X	X	X	X	X
SRQ 3	X	X	X		

What do I need to know?	Why do I need to know this?	What information will answer the questions?	Where can I find the information?	Who has the information?
Primary Research Question				
How may strategic sustainable development (SSD) improve the design of education programs (EP), to promote sustainability while not contributing to socio-ecological unsustainability?	To find a useful process by which education stakeholders may collaborate in improving EPs, more effectively helping society move towards a sustainable dynamic equilibrium.	○ Learning theory / practice ○ SSD theory / practice ○ ESD theory / practice ○ Sustainability in EPs ○ Insights from narratives, best practice, emergent coherence, experiments	○ Document Analysis ○ Expert advice ○ Structured interview ○ Survey ○ TSPD	○ Internet / Library ○ Practitioners ○ Experts / Advisors ○ Peers / Colleagues
Secondary Research Questions				
1. How may current EPs contents or processes contribute to unsustainability?	To gage the current place of sustainability in EPs: "Where do we start from?"	Current sustainability / unsustainability contents of EPs Current processes in EPs	○ Document Analysis ○ Structured interview ○ Survey ○ TSPD I-III (1st part)	○ Internet / Library ○ Practitioners ○ Experts / Advisors ○ Peers / Colleagues

What do I need to know?	Why do I need to know this?	What kind of information will answer the questions?	Where can I find the information?	Who has the information?
2. In a sustainable society, what may future EPs' contents or processes cover?	To understand the functional case, sustaining the goal: "Once having passed the starting phase, how do we operate?"	Role of ES regarding sustainability Sustainability vision and goals of various organizations	○ Document Analysis ○ Expert advice ○ Structured interview ○ Survey ○ TSPD I-III (2nd art)	○ Internet / Library ○ Practitioners ○ Experts / Advisors ○ Peers / Colleagues
3. What are some potential tools and strategies ES may use in devising EP in order to help strategically close the gap between the current unsustainable state and the future sustainable one?	To propose some recommendations to ES so their EPs help close the sustainability gap.	Insights from narratives, best practice, emergent coherence and novel actions delimited by the conceptual framework. Analysis and interpretation of the survey and interview results	○ Document Analysis ○ Expert advice ○ Structured interview	○ Internet / Library ○ Practitioners ○ Experts / Advisors ○ Peers / Colleagues

Table 2.2. Continued

2.2 Design Research for Data Collection and Exploration

Engineering design research is a relatively new field with increasing studies, using differing methodologies of low coherence (Blessing 2002). The general design methodology used in this research is based on Blessing's model for design research: Design Research Methodology (DRM). Consequently, a four-staged approach is used to understand how to design more effective components of education programs, or tools likely to help the design of more effective education programs:

- **Criteria Stage**: formulate measurable success criteria;
- **Descriptive Study I Stage**: reference model of existing concepts / tools. This stage refers (i) to a conceptual study in order to understand each concept / tool in relation to the success criteria, and (ii) to an analysis of specific operational parameters;
- **Prescriptive Study Stage**: appropriate concepts from the descriptive phase I are selected; improvements to tools are suggested;
- **Descriptive Study II Stage**: applying concepts / tools in practical cases; evaluate results according to the measurable criteria for success expressed in the criteria stage.

The DRM is iterative and adaptive: depending on context and the nature of what is designed, the methodology allows to size the effort in stages as appropriate, and also allows for backtracking between stages.

2.2.1 Criteria Stage

The authors chose the following success criteria to measure the effectiveness of the tools and concepts they propose:

- purposeful: may be used by practitioners to generate ideas of value (opportunities and areas of concern) concerning the sustainability aspects and impacts of education programs they are stewards of;
- general: may be used by practitioners from different cultures and applies to a large class of education programs;
- practical: may be used by practitioners with little training.

Validity
General criteria to assess the quality of principles (used in the genesis of the Sustainability Principles) inspired this part. To form creative, non-prescriptive tools, the criteria of *necessity* and *sufficiency* were left out.

2.2.2 Descriptive Phase I Stage

Method - Document Analysis

Education as a subject has produced a copious amount of documentation. The authors went through documents to extract relevant information.

Table 2.3. Document Analysis

Type	Activity
Purpose	○ To get a system view and boundaries of useful concepts ○ To understand concepts relationships, interdependence and contexts ○ To study templates for sustainable product development (TSPD)
Topics	○ Education, learning / teaching theories and practices ○ Cognitive theory, neurophysiology and psychology ○ Communication and dialogue ○ Systems thinking, feedback, change mechanisms and creativity ○ Economic theories ○ Strategic Sustainable Development (SSD) / Templates for Sustainable Product Development (TSPD) ○ Fundamental Human Needs, satisfiers and values ○ Education about sustainability / Sustainability in general education
Sources	○ Peer-reviewed dissertations and thesis ○ Academic articles, peer-reviewed and non-peer-reviewed ○ Internet sites (organizations, universities, institutions, media, etc.)
Outcomes	○ Extract facts, concepts, theories, behaviors and critical analysis of education, learning and teaching in societies ○ Extract facts, concepts, theories, behaviors and critical analysis of current causes of unsustainability ○ Comparison of questions in several TSPD

Validity
The amount of information released on education theory and practice, as well as its entanglement with societal cultural values and norms, finally yielded models necessarily simplifying interactions of a complex nature.

Method - Survey

Survey methodology uses groups sampling to explore the groups' preferences and average understanding on issues.

Table 2.4. Survey

Type	Activity
Purpose	○ Have a short discussion related to sustainability awareness ○ Understand needs, conceptual design of education service, and organizational stakeholders / Learn about strategic actions ○ Collect key information to improve the TSPD
Sample Questions	○ What is your definition of sustainability? ○ Who are your critical stakeholders? ○ What would be, for you, the best way to influence your behavior toward sustainability with new tools and support? ○ How do you measure the impact or influence of your work? ○ To what extent would you agree that meeting human's need outweighs protecting the ecological system? ○ What is your description of education service towards sustainability in an envisioned future?

Validity
Due to the small interviewees number, the collected findings could not represent a general education outlook in sustainability education.
The authors sought a diversity of respondents, i.e. various nationalities / maturity level of sustainability and education / level of engagement.

Method - Brainstorm

Brainstorming is a group creativity technique in which the members spontaneously share their ideas without judgement, to spark more ideas.

Table 2.5. Brainstorm

Type	Activity
Purpose	○ To spark / use creativity while suspending judgment
Topics	○ Sustainability ○ Needs, Desires, Satisfiers ○ Purpose of Education, Learning, Teaching ○ Ways to educate, learn, teach ○ Outcomes of Education, Learning, Teaching
Sources	○ Creative thought process and dialogue
Outcomes	○ Space of possible initial TSPD answers ○ Avenues of further research

Validity
The brainstorms produced were limited by the fact that the authors had slim possibilities, because of timing constraints and availability of experts, to conduct such activities with diverse participants.

Methods - Logical Inference and Dialectical Research

Education referring to the humanities discipline, this research collected raw data by use of traditional methodologies in humanities, such as logical inference and dialectical research, both forms of qualitative research aiming to discover new understanding, rather than testing hypothesis.

Table 2.6. Logical Inference and Dialectical Research

Type	Activity
Purpose	○ To explore boundaries of contrasting paradigms / spark creativity ○ To create thought experiments, exploring competing ideas, perspectives and arguments, and possible impacts of issues ○ To investigate issues from different stakeholders perspectives
Topics	○ Nurture vs. Nature / Economic vs. Environment ○ Machine vs. Human / Growth vs. Limits ○ Interconnections vs. separateness / Individual vs. group ○ Objective vs. subjective / Learning by observing vs. learning by doing ○ Science vs. Art ○ Values and contending satisfiers for human needs / desires
Sources	○ Thoughts and dialogue
Outcomes	○ Space of possible initial TSPD answers ○ Criticism of author's models and theories / evaluation of results

Validity
This approach led to thought experiments the authors believe were helpful in showcasing opinions, to understand the relativistic / cultural nature of value judgements and ideas, which in turn helped in a better understanding of the authors' underlying ranking of values.
It was also used to understand some of the prevalent paradigms in today's education system, as well as the ones used by interviewees.

Method - Interview

This method aims at getting the opinion and expert judgment of the interviewee(s) on a subject or range of subjects.

Table 2.7. Interviews

Type	**Activity**		
Purpose	o Have a structured discussion to develop a better understanding of how organizations, considered to have a high sustainability awareness level, proceed in their sustainability awareness communications and actions; o Get some traceability of the information received (educative books and presentations, website material) from NGOs acting to promote sustainability; o Collect key information to improve the TSPD		
Questions	**Q1** Definition of sustainability? **Q2** Organizational strengths from a sustainability perspective? **Q3** Main challenges preventing reaching the goal of sustainability? **Q4** How to deal with these challenges? **Q5** How to verify that proposed actions are helpful in promoting sustainability awareness?		
Interviewees	Patrick Barbier	Mayor Adviser	Muttersholtz Ariena
	Delphine Latron	Development officer	Maison de la Nature du Ried et de l'Alsace centrale
	Yann Delahaie	Programs developer	Ariena
	Corinne Di Trani	Responsible for education / information	Parc Zoologique et Botanique
	Agostini	Responsible for sustainable development	Pierre et Marie Curie High School
	Loïc Duchamp	Curator of the natural reserve	Parc des Vosges du Nord
	Hans Christensen	Business Developer	CoreSource – Consulting (Sweden)
	Hélène Bastian	Responsible for Businesses Relations	Ariena – NGO (France)
	Luo Jarder	Professor	Tsinghua University (China)
	Pinar Ozuyar	Deputy Director	Center of Energy, Environment and Economy – Ozyegin University (Turkey)

Validity
The top three questions with most significance were asked to each interviewee, while the other questions were assigned randomly according to their sustainability maturity. The authors sought a diversity of sources, to be able to generalize from different cultural background and social situations However, the feedbacks were mostly from developed countries in Europe or America, which introduces a "western world" bias into the results.

2.2.3 Prescriptive Stage

In this stage, the aim is to prescribe concepts or tools answering the purpose of the design. The authors decided to create a process tool, based on the Template for Sustainable Product/Service Development (TSPD) architecture. This tool design already incorporates the temporal nature of the first two secondary research questions, i.e. present and future situations.

Template for Sustainable Product/Service Development. The TSPD is a generic process tool, designed to help stakeholders gain quickly, and in a straightforward way, an overview of persistent and sizeable sustainability challenges and opportunities in society. It facilitates an informed and creative communication between stakeholders to support the creation of "sustainability-friendly" features in any kind of product/service. The TSPD process was first applied to pure products—television sets in the Matsushita corporation (Ny et al. 2008)—and later to services.

Usage of the TSPD is recommended in the initial phases of physical products development (Needs Analysis, Conceptual Design phases), while for intangible services or programs, Review phases are also suitable.

Guide to the template. A TSPD Guide was developed along with the tool to help users understand its usage and the concepts it refers to. The guide contains explanations for key concepts of the FSSD and Human-Scale Development: backcasting, sustainability challenge and funnel metaphor, sustainability principles, fundamental human needs and satisfiers.

Table 2.8. Initial TSPD for Education Programs

Type	Activity
Purpose	To create a first version of a TSPD adapted to education programs (EPs)
Format	○ Societal desires / needs to which EPs answer (Template I) ○ Current situation (B) / Future possibilities / vision (C) ○ Impacts of conceptual design of education programs (Template II) ○ Current situation (B) / Future possibilities / vision (C) ○ Stakeholder communication / cooperation (Template III) ○ Current situation (B) / Likely possibilities (C)
Process	○ TSPD questions ○ selection of formulation following the comparisons done through document analysis of previous TSPD versions ○ TSPD answers ○ Formulation of criteria for the selection of relevant concepts ▪ Break from addressing particular discrete causes of sustainability issues, to strategically address systemic impacts of the Sustainability Principles disregard ▪ Observance of fundamental human needs ▪ Contribution to fairness – equitable responsibility sharing ○ selection of concepts following the dialectical research, logic inference and brainstorm iterative steps ○ formulation of answers
Outcomes	Initial version of the TSPD for Education Programs

Validity
This process was led by inputs and ideas from the previously mentioned methods. A large variety of sources was used to seed the initial version, to ensure systemic boundaries were large enough to accommodate EPs diversity.

2.2.4 Descriptive Study II Stage

From initial to intermediate Template for Sustainable Product/Service Development: usage of key findings

Key findings from surveys and interviews were used to modulate the initial TSPD, yielding an intermediate version.

Table 2.9. Guide to the TSPD and Intermediate TSPD Creation

Type	Activity
Purpose	○ To create a guide to the use of the TSPD ○ To use the key findings from interviews and surveys to formulate better questions and answers
Process	○ Guide to the use of the TSPD for education programs ○ Explanation of "Why?" and "What?" about the TSPD ○ Illustration of the TSPD process ○ Brief explanations of concepts and terminology ○ Questions and answers modification ○ Extraction of key findings from interviews and surveys ○ Analysis of the relevance of findings for TSPD modifications ○ Where relevant, questions / answers modifications
Outcomes	Intermediate version of the TSPD for Education Programs

Validity
This process used key findings obtained through a triangulation from a variety of sources and respondents to modulate the initial TSPD version. It iteratively referred to the FSSD, to add scientific rigor to assertions.

From intermediate to final TSPD: expert recommendations

Experts were invited to comment on the TSPD. In the Youcheng case study (section 3.3), the initial TSPD was used to stimulate a dialogue, whose outcome was synthetized. The synthesis was used to modulate the Intermediate version of the TSPD to get a finalized version (section 3.4).

Table 2.10. From Intermediate to Final TSPD: Expert Recommendations

Type	Activity	
Purpose	○ To get experts / education practitioners comments	
Process	○ Explanation of the TSPD intent, structure, and commentary ○ Document appraisal by expert, in dialogue with authors ○ Analysis of expert's comments ○ Where relevant, answers modifications	
Contributors	Dara Barlin	Education Policy Consultant
	Genevieve Emond	Educational Consultant, Founder MUZA, Creative Educational Solutions
	Michelle Holliday	Founder, Thrivability Montreal
	Ling Hui	Department Director, Youcheng
	Shi Min	Media Officer, Youcheng
	Tang Min	Deputy Chairperson , Youcheng
	E. Peter-Davis	Founder, ECO-Conseil - European Institute for Environmental Counselling
	Wang Ping	Chairperson, Youcheng
	Miao Qing	EaglePlan Project Manager, Youcheng
Outcomes	○ Final version of the TSPD for Education Programs	

Validity
This review yielded the correction of blind spots. On the other hand a larger diversity of experts from different programs would have been helpful in vetting the final TSPD to become a truly general template.

Practical use: Strategic Decision-Support System (SDSS) success criteria

Table 2.11. Practical Use of Final TSPD: Success Criteria for SDSS

Type	Activity
Purpose	○ To use the final TSPD to formulate success criteria for "Design Space", an education program taking the form of a strategic decision-support system (SDSS) online learning tool ○ Enablers and Barriers for "Design Space"
Process	○ For each question of templates I –II – III in future possibilities ○ Examine the answers and imagine how those intersect with the development and/or the function of "Design Space" ○ From this reflection, develop enablers and barriers
Outcomes	○ Success criteria for "Design Space"

Validity
Due to time constraints, this study could not fully test the SDSS concepts, and the authors recommend using the TSPD to further SDSS as a future research.

2.3 Contributions of Design Research Stages to Results

2.3.1 Criteria Stage

Outcomes used for other stages

This stage yielded the three criteria given in section 2.2.1.

2.3.2 Descriptive Study I Stage

Intermediate outcomes used for other stages

This stage yielded several intermediate outcomes (not shown) used in the next stages, from the methods outlined previously.

Final outcomes shown in the Results section

This stage yielded generic education programs (i) learning interactions model (section 3.1); and (ii) life-cycle model (section 3.2).

2.3.3 Prescriptive Stage

Intermediate outcomes used for other stages

This stage yielded the initial TSPD (not shown), refined in the next stage.

Final outcomes shown in the Results section

This stage yielded a model about a minimum set of satisfiers helping to address complex issues: the CKMOV model (section 3.3).

Other outcomes shown in Appendix

This stage yielded (i) TSPD Questions and Differentiated Maturity Sustainability Levels (Appendix E); (ii) the TSPD Guide (Appendix F); (iii)

Towards a Similarity between the FSSD's Sustainability Principles and Education for Sustainability Principles (work in progress) (Appendix I); (iv) Education Program Vivid Description and Stretch Goals (Appendix J).

2.3.4 Descriptive Study II Stage

Intermediate outcomes

This stage yielded the intermediate TSPD (not shown), refined in this stage.

Final outcomes shown in the Results section

This stage yielded (i) the Youcheng case study (section 3.4); and (ii) the final TSPD (section 3.5).

3 Results

We have to go from what is essentially an industrial model of education, a manufacturing model, which is based on linearity and conformity and batching people. […] We have to recognize that human flourishing is not a mechanical process; it's an organic process. And you cannot predict the outcome of human development. All you can do, like a farmer, is create the conditions under which they will begin to flourish.

Sir Ken Robinson

This section contains the final results of the iterative four-stages process described in the methods section. First two models are shown in sections 3.1 and 3.2: generic education programs (i) learning interactions, and (ii) life-cycle. The Youcheng case study results that helped develop the final version of the TSPD follows in section 3.3. Section 3.4 covers the TSPD final version, and section 3.5 covers a model about a minimum set of satisfiers helping to address complex issues: the CKMOV model.

3.1 Education Programs and Learning Interactions

Figure 3.1 shows the authors' education programs interactions model.

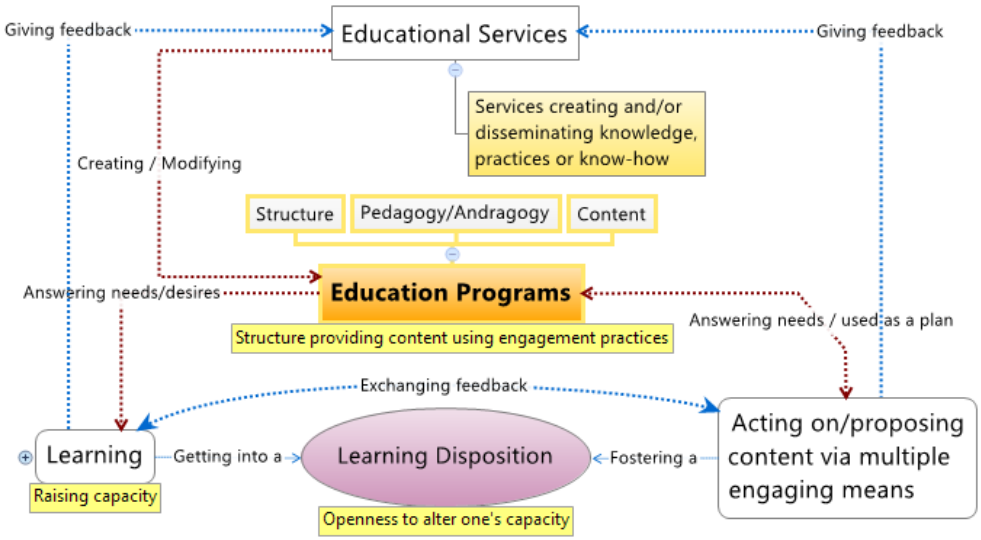


Figure 3.1. Education Programs and Learning Interactions Model

Three interactions are added to the education programs model (Figure 1.6), emphasizing an openness towards learning labeled "Learning Disposition", as a mutually nurtured *actively cooperative relationship* between agents

placed in *symmetrical* roles of co-learning / co-teaching going beyond purely self-interested rational motivations, that modulates the quality of successful learning outcomes: without it learning may be more difficult, more time-consuming, less engaging and may lead to less acquired competency, in terms of retention or depth and breadth of know-how.

The agent proposing selected contents may be other than a person. In cases this agent is endowed with an ability to learn (be it a person, an animal, or even a computer program) the roles are interchangeable, particularly when the learning relates to complex behavior or processes.

3.2 Model of an Education Program Life-Cycle

The following model of an EP life-cycle helps to conceptualize interactions and outcomes of education programs within society within the biosphere through a whole-system global sustainability outlook (Fig. 3.2).

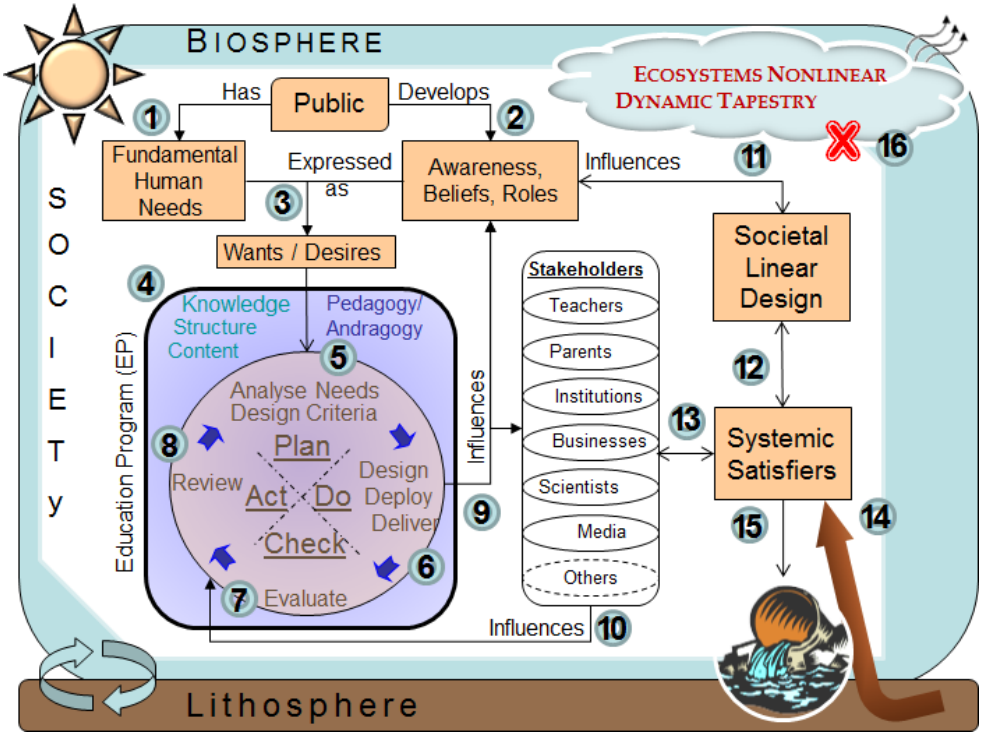


Figure 3.2. – Model of an Education Program Life-Cycle

1. The "Public" experiences Fundamental Human Needs (FHN) independently of age, wealth, gender or mental models. Affection – Creation – Freedom – Identity – Leisure – Participation – Protection – Subsistence – Understanding (– Transcendence[1]).

2. The public continuously develops awareness, attitudes and roles under various mechanisms and while responding to events.

3. The public's fundamental human needs, as well as developed awareness, beliefs and roles, may reveal themselves through the expression of wants or desires to satisfy those fundamental needs.

4. Education Programs (or more broadly educational offers brought by education services groups or individuals) go through an evolutionary cycle of development.

5. In the *Plan Phase*, two activities take place: analysing the needs of the public, and establishing criteria for the success of the educational offering, taking into account the public's wants and/or desires.

6. In the *Do Phase*, three activities take place: designing the EP by establishing its content, structure and engagement delivery methods; deploying it through the needed processes to reach the public; and delivering its contents in the intended structure with the chosen pedagogies/andragogy.

7. The *Check Phase* is about evaluating the effectiveness of the EP according to the success criteria established in the *Plan Phase*.

8. The *Act Phase* is about reviewing the activities surrounding the EP after having done its evaluation, in concert with stakeholders, to make necessary arrangements in the evolving local and global contexts.

9. The delivery of the EP, i.e. teaching / learning activities by both parties of the educational offer, in return shapes back the awareness of the public, its beliefs and roles. Stakeholders who participate in the design, deployment and delivery or the EP may be influenced in different ways by those activities, depending on their beliefs and roles.

10. Stakeholders may influence the actions taken after the EPs evaluation.

[1] Discussed in the original Human-Scale Development theory as a slowly evolving, plausible FHN

Awareness, beliefs and roles influence society's design, and vice-versa. The main paradigmatic design aims at producing an unlimited number of products/services in the attempt to satisfy human desires through material consumption. The processes to create those disposable possessions are designed in a linear form: from resources acquisition as inputs to successive transformation procedures, to delivery, usage and disposal.[2]

Society's design into mostly parallel linear processes tending to favour the accumulation of wealth in plutocratic fashion works at odds both with people's desire of a relatively equitable society, and with natural processes: these are non-linear, circular and without waste (handled by living organisms adept at using that resource in particular niches[3]). If the coin of oligarchic design—evolved through the exercise of power, negotiations, violence, slavery, debt, chaordic processes and chance—produced on one side fortunes vastly larger than what was needed for the fulfilment of the dominant minorities' desires, its other side defaulted on the satisfaction of fundamental needs for all, an unsustainable deal that has historically led to unsatisfactory (and sometimes violent) outcomes.

Systemic satisfiers are never evenly distributed in society, thus some stakeholders are privileged[4]. Even if one says that such a bias comes from new systemic conditions, the reproduction of the system itself must have an educational root, since this human attitude is not controlled genetically.
The emergence of public education from the 18th century throughout the "Enlightenment" era, under the auspices of industrialism, added a new goal: creating for the needs of industry a mass of literate workers (going only to primary school), a smaller number of secretarial clerks with administrative skills (going to secondary school), and finally a small ruling elite endowed with the knowledge of the times (going to university). Capitalism now having evolved through the 20th century, more and more people are getting increasingly specialized education in emerging fields the industry is spreading into, to nourish its (unnaturally) limitless appetite.

The systematic undermining of peoples' ability to fulfil their fundamental human needs violates the **fourth Sustainability Principle**.

---

[2] "*We presently live in a linear "take, make and waste" economy in which natural resources are running out and ecosystems are being destroyed*" (Louise Vet, director of the Netherlands Institute of Ecology).

[3] "*Nature runs on sunlight. Nature uses only the energy it needs. Nature fits form to function. Nature recycles everything. Nature rewards cooperation. Nature banks on diversity. Nature demands local expertise. Nature curbs excesses from within. Nature taps the power of limits*."
—Janine Benyus in Biomimicry, 10th Anniversary World Congress on ZERI

[4] For example women have generally enjoyed fewer freedoms than men for almost 3,300 years, even if societies are deemed to have "progressed" in other ways. In real terms, many societies' choices of satisfiers systematically over-emphasized one gender's control over the other.

14 Society extracts metals, minerals, fossil fuels and radioactive elements from the lithosphere to fuel production. These processes "leak" materials going from cradle to disposal, in ways that systemically increase the concentration of these substances in the biosphere.

This is inherently unsustainable, from the **first Sustainability Principle**.

15 The various linear production processes society uses to create systemic satisfiers to human desires and fundamental human needs are all "leaky", i.e. various transitory products may be "lost" in the environment at various stages, wasted without valorization, creating growing externalities (such as CO_2 emissions pushing climate change). As stated in the Rio '92 declaration:
"The major cause of the continued deterioration of the global environment are the unsustainable patterns of consumption and production, particularly in industrialized countries, which is a matter of grave concern, aggravating poverty and imbalances".
The systematic increase of manmade compounds within the biosphere, driven by strong incentives to indefinitely grow production patterns, results in an inevitably increasing destabilization of natural dynamic equilibriums.

It is thus not in accord with the **second Sustainability Principle**.

16 Those various linear production processes also create vast ecosystems transformations, as the various dynamic equilibriums created through millions of years of natural cycles are more and more perturbed by the vast flows of human operations, to the point that some scientist say humanity has entered a new Age: the Age of the Anthropocene, as mankind is now radically altering ecosystems through the massive weight of its collective overuse of resources.

This continuous undermining of ecosystems' effective operation violates the **third Sustainability Principle**.

3.3 Education Programs - Minimum Set of Key Satisfiers

Hypothesis. It is the authors' contention that key developmental abilities, working together, may form a minimum set of satisfiers necessary to help address Multi-stakeholder Multi-cultural Complex Issues (MMCIs) (though not sufficient[5]): each ability (i) addressing a particular semantic field[6]; (ii)

[5] In particular, the question of initial motivation is assumed to be present, i.e. people *want* to solve the issue in some way in the beginning. If it is not the case, a "sparking" event may be needed

being a synergistic satisfier of high potency (addressing many fundamental human needs simultaneously); (iii) being an integral part of the FSSD.

The authors propose a possible set of three key abilities acting in synergy: *Creativity*, "*Knowledge Making"* & "*Open Values"* (hereafter CKMOV). The demonstration will be as follows: (i) Finding relevant non-overlapping semantic fields; (ii) Finding synergistic satisfiers of high potency to these fields; (iii) Showing how these satisfiers are implicitly part of the FSSD.

Relevant non-overlapping semantic fields – Important questions. History shows that in order to address non-trivial issues, people ask certain types of questions, variations owing to the level of details enquired about. This in time became known as the "Five Ws and a H" ("Who? – When? – Where? – What? – Why? – How?") used as a check-list to complete a report.

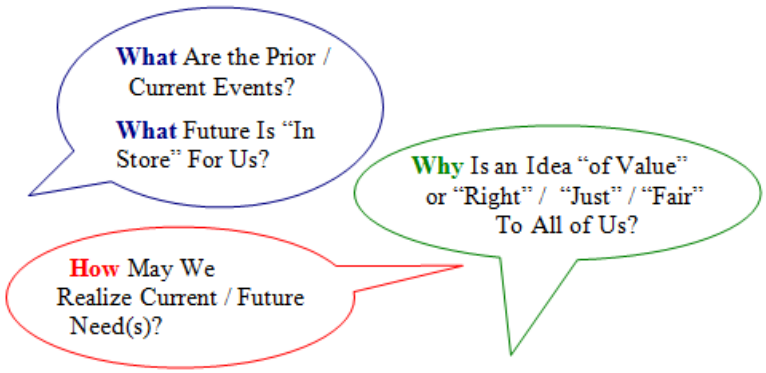


Figure 3.3. Addressing Issues with Three Questions "What-Why-How"

A set of three questions is obtained when the first three are answered by the group at the present time, locally: "Who? – *Us*…"; "When? – *Now*…"; "Where? – *Here*…". In the smaller set remain necessary questions (Fig. 3.3) to understand the particulars of issues the local group faces at present.

The first type of questions is about events leading to the current situation, and events unfolding after decisions are made and actions taken – the *What*. The second is about the ranking of values, or the criteria by which decisions' and actions' merits are assessed – the *Why*. The third is about possibilities, i.e. different ways of satisfying fundamental human needs, since satisfiers are inherently subjective – the *How*.

[6] Denotes a segment of reality symbolized by a set of words sharing a semantic property

Relevant non-overlapping semantic fields – Identification of the semantic fields. These types of questions each refer to one semantic field, about:

- **Realities**: this field regroups patterns of meaning gained through the different intelligences, using senses, rationality and intuition. It is about making sense of reality, using abstract symbols to conceptualize it, model it and understand it. It also makes use of "immediate" knowledge or "gut feelings", i.e. using unconscious and conscious faculties to discern and organize patterns — "*What is?*".
- **Possibilities**: this field regroups novel ideas having a potential of creating some form of value or capital in a possible future, usually by satisfying one or several fundamental need(s) and/or desires—"*How can it be?*". Yet an idea may create value at different contexts. Thus one has to clarify if and how this value is shared with other stakeholders at the group or environment contexts.
- **Qualifiers**: this field regroups the concepts about shared measurement scales, to clarify one's values rankings, to oneself and with others—"*Why should it be?*". It also includes concepts of authentic, clarifying dialogue about values, during which potential conflicts are mediated.

Figure 3.4 illustrates key concepts and processes each field refers to, along with the types of questions they answer to.

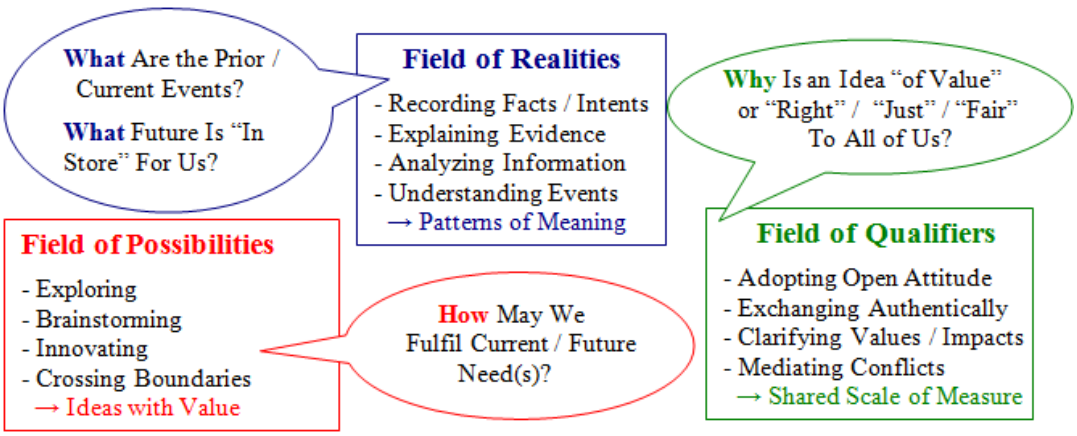


Figure 3.4 Semantic Fields Related to "What-Why-How" Questions

Appendix H gives several examples of other ternary sets of categories pertaining to these three semantic fields.

Identifying synergistic satisfiers relevant to the semantic fields. To find contenders for a minimum set of non-overlapping and highly synergistic satisfiers that may credibly help address MMCIs, the authors sought for "base abilities" that (i) address one semantic field each; (ii) arguably underlie and/or strengthen many satisfiers given by Max-Neef in each of the nine rows of the FHNs matrix. Thus not only does each support individual FHNs, but their synergistic interrelations bolsters the quality of this support (Figure 3.5). Although it is not proven that the CKMOV are the only satisfiers with these properties, the authors leave to further research other possible contenders.

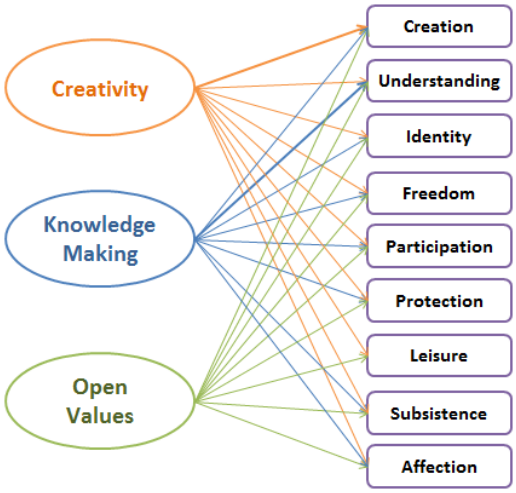


Figure 3.5. Synergistic Satisfaction of the Fundamental Human Needs

While together they act as highly synergistic abilities, each of the CKMOV satisfiers helps to meet interrogations in a semantic field (Figure 3.6):

- **Realities** - "What is?": *Knowledge Making* as a process creates meaning out of (inner & outer) perceptions. It unearths / creates knowledge and know-how, by recording facts and intents, explaining evidence, analyzing information and understanding events. Not limited to purely rational knowledge, it also includes intuitional / immediate knowledge through any vehicle (play, art, relationships, meditation, spirituality, etc.);
- **Possibilities** - "How can it be?": *Creativity* is "the process of having original ideas that have value" (Robinson 2004), to fulfill perceived / real needs. This entails enabling intentional change through trial-and-error, techniques, hunches or even epiphanies leading to paradigm shifts;

- **Qualifiers** - "Why should it be?": *Open Values* refers to adopting an open attitude to exchange authentically with others, leading to clarifying values, helping to assess impacts while mediating conflicts. This enables the creation of shared scales of measure by which to appreciate the attributed value to solutions in large contexts (social and environment).

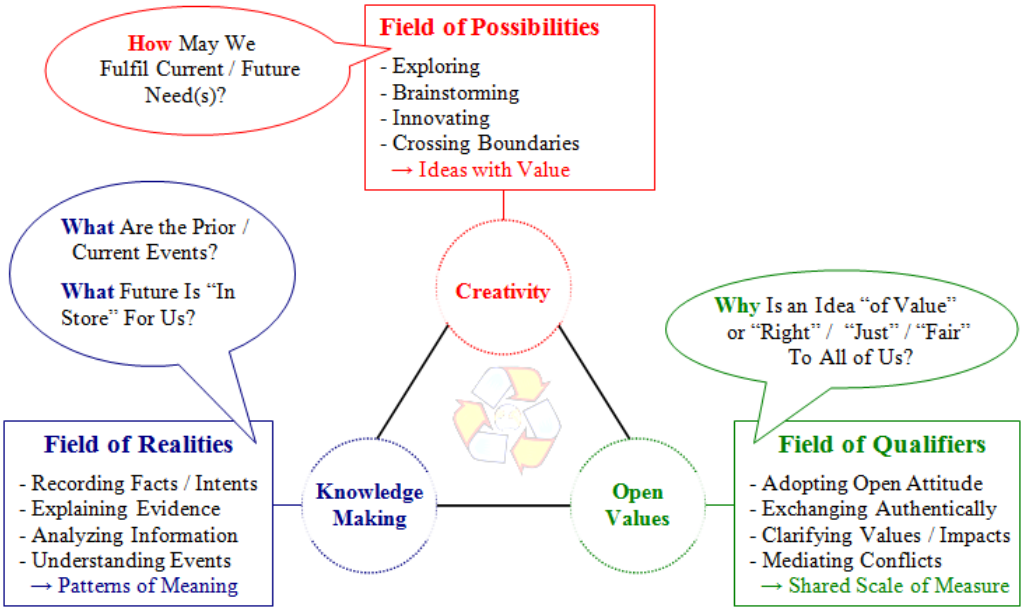


Figure 3.6. Satisfiers for the Semantic Fields of MMCIs Inquiries

Intersection of the synergistic satisfiers with the FSSD. The CKMOV are intertwined with the FSSD, thanks to its design from the onset. At the heart of the FSSD stands a systematic spiraling learning process aimed at enabling organizations to improve their *awareness* (of complex adaptive systems interdependent dynamic interactions); their *trust* (in taking lead roles addressing the sustainability challenge) and their *visioning* (in creating prosperous well-being without destroying dynamic equilibriums supporting society). These goals each are supported by CKMOV: awareness by Knowledge Making, trust by Open Values, visioning by Creativity.

Going one step further, the FSSD supports initiatives whose outcomes are driven by the creation of shared *purpose*, informed by possible *prospects*, and guided by *assessments and strategies*. Two substantiations are here given to show how closely these are related to CKMOV.

The first concerns itself with what resides at the intersections of the three semantic fields (Figure 3.7). It is argued that at the intersection of the semantic fields of

- **Realities / Possibilities** reside *prospects,* or "expectations of particular events, conditions, or developments of definite interest or concern";
- **Qualifiers / Possibilities** resides *purpose,* an "intended potential goal";
- **Realities / Qualifiers** reside *assessments* and *strategies*, i.e. "estimations of the importance, size, or value of something" and "approaches systematically using resources to reach intended / desired goals".

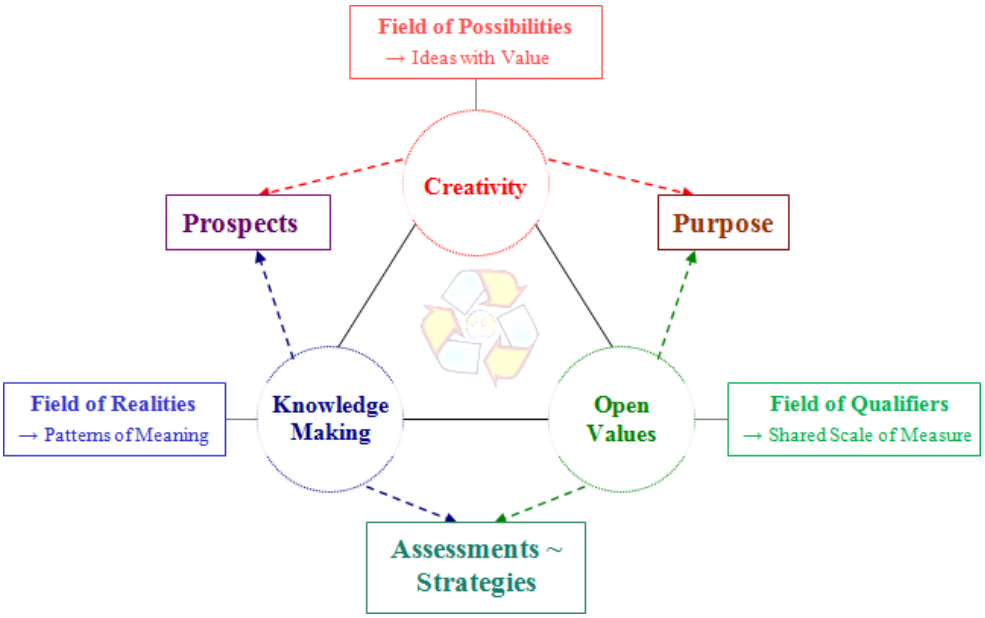


Figure 3.7. Intersections of the Semantic Fields and Satisfiers

Thus the satisfiers of these semantic fields, the CKMOV, act as enablers to these mental objects central to the FSSD.

The second substantiation addresses through a conceptual exploration the re-interpretation of planning methods. Here the authors re-interpret the ABCD process method of the FSSD (the treatment of the two methods of forecasting and backcasting is found in Appendix H). A mapping can be done between what resides at the intersection of the semantic fields in Figure 3.7 and Figure 3.8. At the intersection of the semantic fields of

- **Realities / Possibilities** reside prospects, mapped to *Creative Solutions* (C step)
- **Qualifiers / Possibilities** resides purpose, mapped to *Vision* (A step)
- **Realities / Qualifiers** reside assessments and strategies, mapped to *Awareness* (A step), *Baseline* (B step), *Prioritization* (D step) [and possibly *Evaluation* as E step of an extended ABCD-E method].

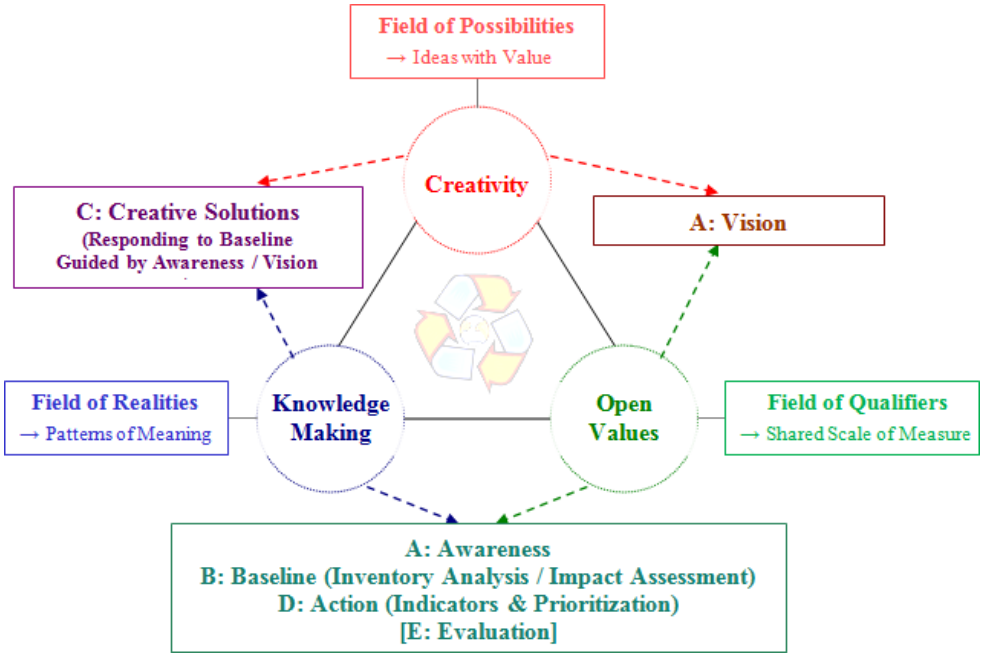


Figure 3.8. Re-interpretation of the FSSD ABCD Process Tool

Thus again the CKMOV act as enablers to this key planning method of the FSSD. The apparent dichotomy between these abilities is more symbolic convenience than fact. The ABCD method engages people in a "whole experience" during which these abilities interact together continually.

3.4 Case Study - Youcheng Findings

This research identified the Youcheng Foundation (China Social Entrepreneur Foundation) as a target organization, since their staff achieved a high sustainability awareness in the test survey. Youcheng, as a widely recognized NGO in China, has a mission of poverty eradication and of

advocating entrepreneurship through education programs, one of which (Eagle Plan) is the focus of this research's case study.

A presentation and workshop were given to the Youcheng staff to introduce some FSSD notions. Based on this content, the long-term development roadmap of Eagle Plan was assessed from a sustainability perspective. Several thorough interviews with the chairperson and external consultant experts of Youcheng were done prior to summarizing the findings.

Table 3.1 shows the results of the Youcheng study, that served as an application of the initial TSPD and helped modulate the final TSPD. To make it easier to follow all the findings, they were structured with the five-level framework (5LF) (System – Success – Strategy – Action – Tools) to organize them in a logical way (more detail is found in Appendix G).

While all these results originate in China's reality and (partly) reflect China's education programs, the experience could serve other countries as well, since all interviewed experts have a deep understanding on the issue of education not only in China but also in other settings: they had also reviewed other nations' education programs performance in terms of sustainability. This research attempts to reflect this generalization to a more global situation with the usual validity caveats, as well as possible misinterpretation due to translation. Some of the descriptions directly came from interviewees' statements, others were summarized.

Table 3.1. Summary of Findings for the Youcheng Study (5LF format)

LEVEL	Findings
SYSTEM	○ **No common awareness of sustainability itself among the involved participants of EPs (Education Programs)** Some education participants may analyze complex challenges only across the socio-economic spectrum while ignoring environmental perspectives, others even take what is happening for granted. What we are supposed to consider is how to arrive at a globally shared view of sustainability at the principle level. ○ **Differentiated progress towards sustainability-informed EPs** The US may lead revolutionary and cutting-edge pedagogies and curricula in this regard, but developing countries like China fall behind in many cutting edge research and customized content, structure and policies. The uniqueness of EPs would be found when it comes to Scandinavia and the EU.

	○ **Education innovation with political / socio-economic reforms** Culture shapes EPs, particularly due to specific socio-historical circumstances. Within a country such as China, after achieving the shared goal of sustainability-informed EPs and in order to remove unnecessary administrative burdens, political and socio-economic reforms would be announced simultaneously with innovative education policies, to gain real efficiency on a larger scale. ○ **Identifying goals and core advantages** EPs are different based on what they aim at, thus identifying goals is the first step to take actions towards sustainability. Furthermore, knowing local conditions can better help in strategic planning. Taking the Eagle Plan for instance, the core purpose is to dedicate to China nationwide poverty eradication and to train future leaders for public affairs. Accordingly, EPs in Youcheng would prefer to discover and nurture the cross-background talents to maximize their advantages on cross-background platform establishing.
SUCCESS	○ **Closely relating to human well-being** In China, society and even academic fields increasingly face the challenges of dishonesty. As a way to shape human beliefs and personality, EPs have to strengthen the essence of urging people to pursue truth and to promote trust in society. This would make a direct positive impact on human well-being, as well as contributing to the harmony of society both in material and spiritual aspects. ○ **Diversity** Although online learning increasingly challenges traditional schooling (Khan Academy is popular for its innovation), traditional schooling still dominates the delivery of EPs. EPs including sustainability aspects will embrace co-existence and synergy of diverse forms. Additionally, EPs could be customized on local culture. ○ **Openness** EPs increasingly evolve from one-dimensional lecturing to group learning, and everybody is encouraged to pursue education through a lifelong involvement, even as a "No Standard Answers" approach is more and more being recognized among education stakeholders. ○ **Inclusion** The planning of EPs would fully allow for the norms and preferences of local communities, even for a favored religion. As an example in China, Positive Psychology, Sinology and Personality theories would always be present in sustainability-informed EPs.
STRATEGY	○ **The People oriented development** First of all, EPs is closely linked with public's motivations. If the curricular activities answer individual curiosity and the pedagogy

	adheres to the normal phenomenon of "Views derive from anecdote ", the EPs function well in terms of essence of education. In Chinese philosophy, real knowledge originates from the People, specifically meaning the grassroots class, so we need to learn from the People and in turn serve the People in real life. ○ **Clustered loop cooperation platform** Above all, legitimate regulations or laws are strongly required to guide EP development, then the first step is to verify the feasibility and replicability of mental model EP in today's world; the second step is to invite and establish fair and positive competition mechanism and democratic governance; then follow-up actions like encouraging all runners in a innovational environment can be taken. ○ **Per capital investment and assistant resource allocation mechanism** For teachers, within an EP, better financial support may insure teacher retention. For students, their desires should be met through a fair allocation of education resources. To that end, the prerequisite is to identify accountability and create traceability. Finally, the education governing body ought to know where to end, i.e. when it is sufficient.
ACTION	• Inspire individual's curiosity to be roused by education • Ensure the accessibility of education resources for students • Take part in projects relating to rural community development, youth development • Encourage critical thinking • Build educator's pedagogical / teaching skills capacity • Reinforce the outreach and other cooperation • Leverage peer learning • Address the educational demands of marginalized groups • Inherit and innovate on the traditional culture • Nourish living expertise and sharpen individual's skills well in rough grassroots life • Build friendships through social capital, etc.
TOOL	With the research questions in mind, the authors think the following tools used in this case study would contribute to a sustainable outlook by EPs: Online learning, Career mentorship, Small scale community driven learning, Social entrepreneurship, Leadership workshop, Participatory Learning, Enthusiasm exhibition, Action research, Supplementary values shaping, Accompanied life upbringing, Problem-solving skills, etc.

3.5 Template for Sustainable Product/Service Development

3.5.1 Guide to the TSPD

The guide to the TSPD (see Appendix F) is an accompanying document to the TSPD, serving the purpose of informing EP stakeholders about

- the TSPD purpose, structure and process;
- a simplified model of EP life-cycle, illustrating various interactions and leverage points to consider, if one has the goal to use the FSSD to develop EP contributing to a transition towards a sustainable society;
- concepts key to the FSSD platform, such as the funnel metaphor and sustainability challenge, backcasting and the sustainability principles;
- concepts central to the Human-Scale Development theory such as fundamental human needs and satisfiers, with an illustration of education-related satisfiers to the fundamental human needs;
- satisfiers helping to establish useful conditions towards problem resolution

3.5.2 TSPD for Education Programs

Structure and content. The TSPD for Education Programs contains questions and answers addressing current and future times, structured in three parts modeled on the work of Henrik Ny and colleagues (2006) (Figure 3.9). The TSPD contents results from document analysis, logical inference/dialectical research, brainstorms, interviews, surveys, case study.

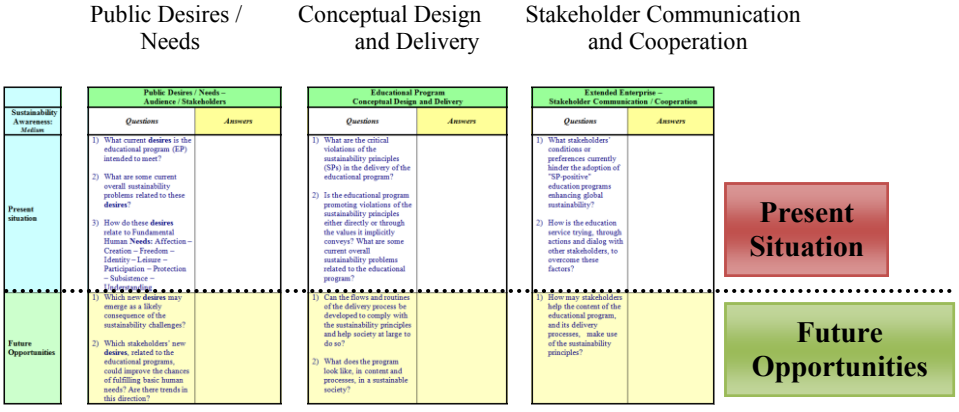


Figure 3.9. Structure of the Template for Sustainable Product Development

***First template*: Public desires / needs**

"Public": audience of an EP, i.e. ideally all children, and learning adults
"desires": the desires expressed by the public (relative, subjective)
"needs": the fundamental human needs (absolute, objective)

***Second template*: Conceptual design and delivery**

"Conceptual design": the design of the concepts used throughout the EP
"delivery": actual activities and actions providing the educational offer

***Third template*: Stakeholder communication / cooperation**

"Stakeholder": all the interested parties in the educational offer
"communication": exchanges between the stakeholders
"cooperation": working towards common goals / shared purpose

The TSPD contents first expresses the author's answer to the question: "What are meaningful questions concerning three areas: Public desires / needs - Conceptual design and delivery - Stakeholder communication / cooperation, from the point of view of the FSSD and Human-Scale Development?" Those questions were adapted from subsequent revisions of the TSPD by MSLS / MSPI researchers (students and knowledge facilitators alike), to account for intangible products (services).

Secondly, it expresses answers as *SP-positive* propositions initially filtered through a FSSD-informed lens expressing: (i) systemic and strategic views; (ii) a definition of success breaking from discrete causes to agreeing with systemic conditions for society's continuing existence into the indefinite future; (iii) an observance of fundamental human needs; (iv) competency/fluency, agency, and fairness values to foster trust. The current broadening of applicability to EP of the TSPD tool is its first known application to one of the fundamental features of the education system.

***First template*: Public desires / needs**

Learning is widely perceived to be necessary to become social persons, i.e. accomplishing an essential part of peoples' potential. While taking many shapes, education programs play a "level-playing field" role, instilling to many (in developed countries more than 90% of the population) a common understanding of concepts societies emphasize and transmit (OECD 2012).

This seems the result of a utilitarian view of education programs, in which education seems to be given to help acquire skills or competencies for the

integration of individuals into society's productive force, and less deemed as the principal means to maximize everybody's potential and uniqueness.

The provided answers represent the authors' attempt to capture a value shift from creating EPs addressing the public's needs as specified by a now under-performing model (education in a "knowledge factory" based on an industrial model) to creating EP addressing fundamental human needs in a 21st century model (integral transformation to achieve fuller potential).

***Second template*: Conceptual design and delivery**

Education programs obviously come in various shapes, designs and intents. Yet the majority of institutions share a major task: to educate year in and year out more than a billion pupils throughout the world. To educate adults throughout a lifetime requires a myriad other EPs, making education one of the most significant societal endeavor in terms of scope and importance.

Educating more than two billion people on a continual basis requires vast resources (products and services): energy, infrastructure, goods, transport, as well as people with a wide variety of skills, both general and specialized. While the authors did not find comprehensive information about the education sector global resource footprint, total yearly capital expenditure stands well upwards of $150G (excluding salaries) (OECD 2012).

Like with any organization using physical products and intangible services, a full picture must consider material and energy flows impacts across time throughout the life-cycle of the product/service offering, across value-chains. Assessing committed infrastructure, energy, waste, transport and procurement per EP-cycle (one iteration of an EP's operations, say yearly) would provide a way to compare the impacts of different EP[7].

A generic methodology to achieve this goal for Product-Service System[8] (PSS) offerings was introduced by Henrik Ny and colleagues (2012) using a multi-layered breakdown of the needed processes. Table 3.1 shows an

[7] To be more meaningful, these impacts would have to be apportioned to outcomes, or benefits.

[8] "…a system of products, services, supporting networks and infrastructure that is designed to be competitive, satisfy customer needs and have a lower environmental impact than traditional business models." (Mont 2001, p. 239)

example breakdown of such processes for an arbitrary EP, with three layers: (i) Education Service (ES) Personnel; (ii) Service Providers to ES; (iii) Value-Chains to Service Providers to ES.

Table 3.2. Education Program Value-Chain Impact Evaluation Table

Layer 0 Public Frontline (Teachers)	1st Layer Back-Office | Education Services (ES) Personnel	2nd Layer Provider | Service Providers to ES	3rd Layer Provider | Value-Chains to Service Providers to ES	refer to TSPD Resource	SP1	SP2	SP3	SP4
Learning (knowledge - know-how - skill)				EP				
	Infrastructure							
		Construction Mgmt						
			Stone-Clay-Glass	Non-Metallic Minerals				
			Cement	Cement				
			Metals	Metals				
			Plastics	Plastics				
			Wood Products	Wood				
			Chemicals	Chemicals				
			Energy	Energy				
			Wastes	Wastes				
			Transport	Transport				
			…	…				
	Education Programs							
		Ressources Mgmt						
			Energy	Energy				
			Water	Water				
			Wastes	Wastes				
			Transport	Transport				
			…	…				
		Procurement Mgmt						
			Furniture	Furniture				
			Electronics	Electronics				
			Office Equipment	Office Equipment				
			Chemicals	Chemicals				
			Special Equipment	*Varies*				
			Live Organisms	*Varies*				
			Transport	Transport				
			…	…				
		HR Mgmt						
			Market					
			Transport	Transport				
			…	…				

Impacts of components at lower-level layers are assessed against the SPs. Higher-level layers "inherit" lower-level evaluations in their own estimate.

A new column added by the authors ("refer to TSPD Resource") introduces the concept that components at lower-level layers could each in the future refer to a TSPD resource about it, i.e. in the future TSPDs may be used for Cement, Plastics, Minerals, Transport, Energy, Water, etc.

The answers provided represent the authors' attempt to capture implicit or explicit values widely disseminated in most modern societies' EP, as well as the mechanisms which have a discriminately large impact on the satisfaction of fundamental human needs for all, within sustainability limits.

***Third template*: Stakeholder communication / cooperation**

As education is one of the fundamental means by which society perpetuates itself, all society is a stakeholder. Education is thus a key field when considering making long-lasting change. Indeed, even if change-makers inventing new ways of practice can disseminate them by means other than education (such as commerce or policies), those practices stand a much better chance of being adopted by a large portion of the population when they become part of an educational offer. Sustainability is a case in point.

The provided answers express the author's analysis of some important factors possibly hindering the adoption of "SP-positive" education programs: legacy issue, lack of information, need of shared mental model, need of incentives / skills / resources, vested interests, etc. Each factor can be overcome by several actions, the strategy being to identify key factors creating the most friction between stakeholders who can implement effective changes in the education programs, and then addressing these concerns systematically and effectively.

The following tables show the final outcome of the TSPD after the iterative process described in the Methods section.

Table 3.3. TSPD Template I - Public Desires / Needs – Present Situation and Future Opportunities

Public Desires / Needs —|— Present Situation	
1) What current desires is the education program (EP) intended to meet?	i. Acquiring, mastering and extending theoretical and practical knowledge about the world, competencies, skills, know-how and know-why; ii. Acquiring / increasing autonomy and the ability to satisfy (one's own or other's) needs and desires; iii. Developing abilities opening up life choices and enhancing their satisfaction; iv. Enhancing one's own social recognition; v. Creating / knowing oneself in the world, through self-aware critical thought; vi. Personal growth / Self-realization.
2) What are some current overall sustainability problems related to these **desires**?	i. Acquired knowledge or know-how may improve particular competence but does not necessarily improve discernment regarding sustainability issues; ii. Insufficient knowledge about systemic impacts may induce to increase sustainability challenges; iii. Gaining skills without cooperative values may breed inflexibility or intolerance, leading to entrenched positions and possible conflicts; iv. Underlying value-system may impel disregard for sustainability; v. Absence of long-term purpose may lead to strategies systematically over-emphasizing short-term returns thus enhancing the risk of rising unsustainability; vi. Higher ability to influence society through enhanced social status in conjunction with higher materialistic / consumerist behavior may lead to increasing global unsustainability; vii. Narrow self-realization may lead to highly individualistic / egocentric / confrontational / arrogant / fearful personality unable to effectively act creatively and cooperatively in society.
3) How do these **desires** relate to Fundamental Human **Needs**: Affection Creation Freedom Identity Leisure Participation Protection Subsistence Understanding?	Desires the education program (EP) may aspire to fulfill are all basically triggered by FHN. The EP is thus a possible satisfier of several FHN, depending on its content, delivery process and means to help its public appropriately internalize ("create meaning from") the learning experience. Most of the above-mentioned desires relate to enhancing one's ability to oversee one's path in life, i.e. relating to personal and inter-personal capacity-building. Fulfilling those desires enables one to either enhance one's ability to benefit from existing satisfiers, or to alter / to create satisfiers more suited to one's preferences, purpose and situation. The transformative experience of going through the EP process stands thus at the basis of creating the necessary conditions, in each human being going through it, for achieving her/his total potential. Conversely, an EP formulation which does not take into account the fulfillment of FHN may severely hamper one's ability to develop one's potential and will instead contribute to one's poverty, as well as to society's poverty.

Public Desires / Needs —|— Future Opportunities	
1) Which new desires may emerge as a likely consequence of the sustainability challenges?	<u>Creativity</u> i. developing one's own creativity and multiple intelligences towards the socially beneficial co-creation of a sustainable society in a thriving biosphere; ii. nurturing social trust and capacity to project oneself in a common future with others through an engagement based on common purpose, competence, fairness, agency; iii. eight-capitals (intra-personal, inter-personal, cognitive, living, material, economic, cultural, spiritual) systemic and chaordic capacity building; iv. being oneself with others effectively in a world of constant change and uncertainty; v. non-reductionist cross-cultural trans-disciplinary resilience skills and practice; vi. facing complexity by putting into practice holistic / integral principled worldviews; vii. sublimate stress to use it as a creative tool; viii. creating "waste-as-a-resource" industries to replace polluting / de-polluting ones ; ix. optimizing using bio-mimicry; x. non-reductionist sustainable sector-by-sector production through backcasting from sustainability principles using eco-systemic substitution and dematerialization. <u>Knowledge Making</u> i. sustained mindfulness granting critical self-reflexive knowledge; ii. learn to adaptively learn, unlearn, relearn; iii. mixed intelligences co-innovation skills and practice; iv. Non-reductionist principles to face complexity (such as "simplicity without reduction"); v. sustainability principles informed by complex adaptive systems / systems thinking; vi. strategic decision-support systems for effective values-based trade-offs analysis; vii. values-based knowledge business models sustaining public well-being within a thriving biosphere; viii. developing / using technologies increasing (vs. substituting for, thus likely decreasing) one's inner resources; ix. "effectiveness before efficiency" skills and practice; x. mitigation / adaptation skills and practice.

Table 3.3. Continued

Table 3.3. Continued

<table>
<tr><th colspan="2">Public Desires / Needs —|— Future Opportunities</th></tr>
<tr><td></td><td>Open Values
i. nurturing intra-personal authenticity and self-esteem to be able to sustain ambiguity and multiple polarities simultaneously;
ii. open dialogue, respectful disagreement, multi-stakeholder intercultural mediation, power asymmetry mitigation;
iii. inter-personal / participatory leadership in fostering social biodiversity for resilience;
iv. participatory global governance handling socio-environmental issues (specially conflicts over key resources such as water and energy) through subsidiarity principle;
v. multilevel glocal citizenships with operative use of person-environment rights and duties in increasingly larger contexts;
vi. social / creative economy cooperatives in sharing / swap / access economy;
vii. ethical/resilience/open/steady-state/sharing and integral systems equilibrium economics;
viii. local energy/time-based exchange systems as debt-free /interest-free currencies;
ix. restoration and “thrivability” skills and practice;
x. “local through large-scale” well-being by sustainable commons, social canvas democracy engineering.</td></tr>
<tr><td>2) Which stakeholders’ new desires, related to the education programs, could improve the chances of fulfilling fundamental human needs? Are there trends in this direction?</td><td>Each of the nine existential rows of the Fundamental Human Needs matrix (i.e. the row for Affection, the row for Creation, etc.) can be filled with satisfiers (bearing in mind that satisfiers are societal, group or personal subjective choices varying in time). As an example, Human-Scale Development theory’s satisfiers for the Creation Fundamental Human Need are:
<table><tr><td>Creation</td><td>imagination, boldness, inventiveness, curiosity</td><td>abilities, skills, work, techniques</td><td>invent, build, design, work, compose, interpret</td><td>spaces for expression, workshops, audiences</td></tr></table>Thus improving the chances of fulfilling fundamental human needs could be done by identifying which combination of the above-mentioned desires under the heading of the three overarching abilities (Creativity, Knowledge Making & Open Values) (i) make better use, or alternatively strengthen, several of these satisfiers; (ii) more systematically align with respecting one or more sustainability principles, simultaneously acknowledging the present while enabling the emergence of a shared vision of a desired future.</td></tr>
</table>

Table 3.4. TSPD Template II - Education program Conceptual Design and Delivery - Present Situation and Future Opportunities

Education program Conceptual Design and Delivery —|— Present Situation	
1) What may some significant violations of the sustainability principles look like, in the delivery of the EP?	i. Infrastructure: possible over-emphasis on fossil fuels/minerals (SP1–SP3–SP4) ii. energy: possible over-emphasis on fossil carbon/nuclear fuels (SP1–SP3–SP4) iii. transport: possible over-emphasis on fossil fuels / pollutants (SP1–SP2–SP4) iv. procurement: possible over-emphasis on non-renewable materials (SP1–SP2–SP4) v. waste: possible over-dependence on filling landfills with harmful substances such as e-waste / synthetic compounds (SP3–SP4) vi. people: possible lack of time due to multiple responsibilities, to unbalanced program, to lack of adequacy between teacher / student ratio, leading to increasing stress and possible burn-out of teaching staff (SP4) vii. research: possible over-emphasis on the creation and/or use of synthetic compounds foreign to nature, whose eco-systemic impacts are unpredictable yet aren't built to be used / recycled in closed loops (SP2–SP4); viii. control: hierarchically stressful forms of personal and institutional relations, stifling creativity through cognitive blocks acquired by repetitive judgment (SP4).
2) Is the EP promoting violations of the sustainability principles either directly or through the values it conveys? What are some current overall sustainability problems related to the EP?	Current education programs may i. stifle each person's own unique creative potential by over-emphasizing particular types of intelligence, resulting in failed opportunities for society to find creative solutions to the sustainability challenge; ii. systematically emphasize some subject matters and engagement strategies to favor economic pursuit over sociocultural functions; iii. over-emphasize "hard skills" leading to a culture of competitive individualism over "soft skills" leading to a culture of cooperation, an education program design choice detrimental to the satisfaction of fundamental human needs for all, within sustainability limits; iv. over-emphasize contents learning over "fluency learning processes" learning; v. over-emphasize reductionism as a way to cope with knowledge complexity, resulting in silos of disconnected knowledge, stifling a genuine understanding of inter-related sustainability issues and how to overcome them in a strategic manner; vi. promote the usage of technological knowledge outside of a strategic framework to eliminate unsustainability;

	vii. over-emphasize a conceptual framework implying human beings are separate from the rest of nature, that some politico-economic constructs are either independent from or on the same level as laws of nature, and that nature can be "negotiated" with (as humans negotiate agreements) by humans "outsmarting" it; viii. implicitly and explicitly market the concept of endless quantitative growth, over-looking fundamental limits coming from natural laws in the finite settings of planet Earth, thus markedly intensifying resource usage and endangering long-term survival; ix. over-emphasize a value-system in which financial capital, being the most amenable to reductionism and power concentration, is held in higher esteem than other capitals, leading to increasing societal inequalities; x. underplay mature forms of traditional knowledges from indigenous sources that preserved natural capital (the Commons) and applied sustainable practices for centuries, using non-market strategies.
Education program Conceptual Design and Delivery —|— Future Opportunities	
1) Can the flows and routines of the delivery process be developed to comply with the sustainability principles and help society at large to do so?	The services delivering the education program may have some of the best environments to simulate new flows and routines to comply with the sustainability principles. They may use part or all of their education programs to develop original solutions to be tested out and then carried out by society at large. These original solutions may bring in motivated people, either staff or education recipients, having a positive effect on the education program reputation. They may also bring in additional financial resources.
2) What does the program look like, in contents or processes, in a sustainable society?	An education program which effectively realizes its stated goals while (i) not violating implicitly or explicitly through its contents or delivery process the sustainability principles, and (ii) enhancing humanity's ability to equitably and peacefully realize the fundamental human needs for all present and to come.

Table 3.4 Continued

Table 3.5. TSPD Template III - Stakeholder Communication / Cooperation - Present Situation and Future Opportunities

Stakeholder Communication / Cooperation —|— Present Situation	
1) What stakeholders' conditions or preferences currently hinder the adoption of "SP-positive" education programs enhancing global sustainability?	Current stakeholders of education programs—parents, teachers, government institutions, education professionals, suppliers, science and technology community, business community, media, etc. may i. be burdened with a legacy issue, from prior frameworks lacking (i) scientific rigor and (ii) a built-in strategic component; ii. need objective, accurate and timely information about SPs; iii. need to develop a shared mental model on the contents of an "SP-positive" education program, and on how to express trade-offs vis-à-vis potential alternatives to unsustainable practices; iv. need, to design and deliver an "SP-positive" education program, to be freed from dis-incentives, to get appropriate skill training, to obtain needed resources; v. attribute low present value to future benefits, thereby protecting vested interests from their evolution in more sustainable forms; vi. not see themselves as partners and leaders in transformational change (structural and institutional) helping to (i) remove short-term incentives hindering the adoption of "SP-positive" education programs to institute and (ii) guide societal progress; vii. have ties to economic entities still (i) using unsustainable processes and (ii) whose influence on research doesn't induce a systematic reduction in unsustainable practices to create wealth and well-being; viii. have ties with entities mainly aiming to maximize economic competitivity through innovation, at the expense of general safety, health and well-being aspects. ix. live and work in a competitive environment stifling the possibility of trying out innovative ways of adopting "SP-positive" education programs helping to enhance global sustainability .
1) How is the education service provider trying, through actions and concertation with other stakeholders, to overcome these factors?	Policies and resources from regulatory bodies, resources and know-how from the private sector and the public sphere, as well as human resources may converge to either create, transform or adhere to innovative and transformative education programmes addressing the sustainability challenge

Table 3.5 Continued

Stakeholder Communication / Cooperation —|— Future Opportunities	
1) How may stakeholders help the contents of the education program, and its delivery processes, make use of the sustainability principles?	The mounting pressure from unsustainability may increasingly drive stakeholders to prioritize resources and attention to EPs helping to equip people with three key basic capacities needed to resolve multi-cultural multi-stakeholder complex issues, in their search to attain (chosen outcomes as) goals (e.g. how to live comfortably and peacefully within sustainability principles, in a world inhabited by over 9 billion people): *(i) creativity* to propose and develop value-adding ideas as innovative possible paths to reach these goals, addressing societal issues or improving human / ecosystem well-being and societal outlook; (ii) *open values* to give people an open discourse ability to authentically exchange about their values and mediate conflict in a respectful public space, in order to help bring about the positive collective deliberations essential to make responsible, strategic and fair choices (in a fast-changing world) about the creative paths. Those choices being informed by (iii) *knowledge making* (theoretical / practical) to understand how complex adaptive systems (on which people depend) function, how human behavior impacts them, and how people's development is affected by issues of trust and asymmetric power. <u>Success</u> Formulating goals as building a shared vision of a desired common future, establishing common success criteria to reach the goal of co-creating EP enhancing local and global sustainability <u>Strategic guidelines</u> Establishing strategic guidelines, to assess each action's effectiveness in going stepwise towards goals <u>Action</u> Starting early, to let children connect with nature and to pursue, through them and with their parents, activities that empower communities to create the opportunities to learn, discuss, connect, plan, implement and monitor results of specific regional and local solutions that inspire hope, directly involve stakeholders, and lead to specific and tangible immediate benefits. To do so, it may be fruitful to i. foster the participatory dialogue of community actors; ii. build a shared vision of a desired common future; iii. collaborate within academia to build an "education case" to bring those opportunities to fruition; iv. taking advantage of national / transnational programs for innovative training or fostering new occupational—e.g. eco-counseling—activities.

3.5.3 A few reactions to the TSPD process tool.

The following reactions were given to the TSPD process tool.

Table 3.6. Reactions to the TSPD Process Tool

Reactions	
Dara Barlin, Education Policy Consultant	"The tool addresses the micro level, which is vital to understanding the very basic building blocks. It seems like it could be a useful consultation document for those in schools of education and policy communities, folks who think about education theory and systems change. It's great at bringing up questions that will allow people to think more deeply about the issues... and consider questions at a nuanced level which haven't been asked yet. Also, the research community." "Bringing people together and asking them a set of ten questions from the tool, and then supporting them in coming up with their own answers and creating action plans (and then supporting them in implementing those action plans) would be a fabulous model!"
Michelle Holliday, Thrivability Montreal	"What if this were made more bite-size by applying it to a specific educational scenario? Business education... Quebec undergraduate education... adult continuing education... elementary school education... And/or maybe we pick one aspect to look at: in what ways does our current approach to Quebec university education inhibit creativity (for example)? There's a whole series in all of these questions..."
Geneviève Emond, Educational Consultant	"The questions are very original and can be of great use to curriculum developers."

4 Discussion

If you want to support an education program, don't drum up people to collect concepts and don't assign them techniques and processes, but rather let them tune in to their longing for the endless immensity of the interplay between creativity, knowledge and values.

The authors

In this section, the authors clarify and analyze some key findings aiming to answer the research questions. Also discussed are some strengths and weaknesses of the research.

4.1 First Secondary Research Question

How may current education programs contents or processes contribute to unsustainability?

4.1.1 Main Findings

Lack of shared unambiguous language and scientific success criteria on sustainability. The general lack in education programs of shared and actionable language concerning sustainability, and of scientifically valid success criteria to systematically address the sustainability challenge, has left a void filled with short-term reforms prone to produce repeatable outcomes favoring the status quo: "teaching to the test" bits of standardized contents amenable to treatment by technological means and treatment.

Over-emphasis on reductionism creating seemingly unconnected disciplines of study generates fertile conditions for the sustainability challenge, by marginalizing transversal studies, overlooking cause-effect relationships, and limiting the systematic and purposeful pursuit of sustainability to existing niches. Public education bears in content, process and delivery the mark of its roots in the Enlightenment period at the time of the Industrial Revolution, an era rich in reductionist thought. Education programs were not equipped with the contents and processes to prepare people to avoid causing negative externalities and unintended consequences (in dominated, resource-rich countries) part of the sustainability challenge.

Systematic bias in selecting specific contents over favoring resilience fluency. Education tends to over-emphasize contents teaching over satisfying the learning of purposeful fluency, by using a reductionist lens to systematically favor particular subject matters / intelligences / skill sets,

using a conceptual framework implying that people (i) stand separate from nature whose limits can be disregarded, and (ii) act purely rationally in their own self-interest, thus their well-being can be solely measured by the production / consumption of a free-market limitless growth imperative satisfying their endless wants.

Over-emphasis on an homogenization of rational knowledge detached from shared ethical values, at the expense of fostering creativity and commonality of purpose. Despite creativity being one of three key satisfiers helping to answer multi-stakeholder multi-cultural complex issues, the goal of stimulating creativity has been a distant second to fostering knowledge outcomes (see previous point) at the root of the sustainability challenge. The goal of fostering the practice of an open attitude to exchange authentically and critically with others, leading to a participative citizenry skillful at clarifying values and helping to prudently assess impacts of new development while averting or mediating conflicts, is also underplayed.

Reduction of public investment resources per student leaves EPs vulnerable to mission and standards reorientation through non-public economic ties. The growing population trend brings into question education funding, as more people get educated, and for longer periods of time. Insufficient resources may have several causes. China's case of enrollment high growth rate[1] poses the challenge that classes may have over a hundred students supervised by one teacher, with the corresponding potential for creativity stifled in the fear of losing discipline. In North America, sociopolitical choices are currently driven by economic creed[2]. In both cases the outcome is a largely competitive environment unfavorable to ESD practices, but friendly to standardized test results (favoring the status quo) and to businesses (whose influence on research may induce an increase in unsustainable practices, if a framework such as the FSSD is not used).

Social cohesion in question despite homogenization of knowledge and hierarchical control of education process. Education may improve equality of prospects and social justice, starting with conditions of equitable access alleviating particularly trying conditions (e.g. food-scarcity poverty

[1] Higher education's gross enrolment rate soared from 7% to 25% (Yao et al. 2008, 3), without a matching growth rate in education resources

[2] e.g. in the United States, the neoliberal policies enshrined in the "No Child Left Behind" Act

or disabilities). Then again, access to education does not guarantee addressing the sustainability challenge, if on the other hand disseminated worldviews and applied policies overall intensify inequalities between people, threatening societal cohesion and social trust.

Education Programs Life-Cycle Model. This model helps to conceptualize interactions and outcomes of education programs in society within the biosphere, through a whole-system global sustainability lens (section 3.2).

4.1.2 Critical Assessment

Strengths. While empirical findings cannot be called absolutely original,

(i) these seek to address end purposes of education programs rather than the means to achieve these, and they identify significant, substantial yet precise issues in education programs as important components of the root causes and feedback loops enabling the sustainability challenge to endure—thus they qualitatively satisfy the "general" criteria defined in the Criteria Stage;

(ii) this understanding, seized upon by committed leadership, can lead to enable the globally purposeful co-creation of "SP-positive" local curricula—the findings qualitatively satisfy the "purposeful" criteria;

(iii) this awareness can lead to formulating strategies to avoid this outcome. More detail is given in the treatment of the other research questions;

(iv) the EP life-cycle model synthetizes in a simple yet inclusive way trending relationships between education program life-cycle, fundamental human needs, and practices compounding the sustainability challenge. This understanding may help create fertile conditions for society to systematically decrease its unsustainable behavior over time and decrease the risk of crossing planetary boundaries thresholds;

Weaknesses. The findings may suffer from some of these issues

(i) The spectrum of education programs runs the gamut of all human activities in all possible formats: this research necessarily sampled a variety of sources, but that could never account for all subtleties present in the education field; access to a narrow range of experts necessarily creates a certain bias, and while the authors tried to alleviate this by talking to experts from different cultures, a western bias still permeates the findings;

(ii) the relativistic / cultural nature of the authors' worldviews implies an underlying ranking of values: the prescriptive phase of the research acknowledges this underlying ranking by the authors. Yet because of time constraints and availability of experts, the subsequent descriptive phase II was not as dialogue and validation-rich as the authors intended, thus further research may have to broaden the depth / breadth of that phase's outcomes, confirming some propositions while infirming or contrasting others, to enable the globally purposeful co-creation of "SP-positive" local curricula;

(iii) The model's generality (losing subtleties) may leave too many details out, giving a semi-static view of a system. While the model is depictive, it may be challenging to operationalize. A third issue is that it illustrates just one cyclical mode of updating education programs. A PESTLE analysis for example may have yielded further clues in reform trends, and a causal loop diagram may have yielded a more dynamic view.

Finally, the authors aren't experts in the education field, which can be taken as a strength and a weakness (as commented by some experts): findings may benefit from a creative, "fresh eyes" perspective, yet they may suffer through this unfamiliarity from partialness or discrepancies.

4.1.3 Comparison With Other Studies

The findings are compared with some conclusions given in two studies.

Guidelines and Recommendations for Reorienting Teacher Education to Address Sustainability and ***Education for All – The Quality Imperative***. The collaborative result of over 30 institutions in 28 countries, these two reports (UNESCO 2005, UNESCO 2004) highlight the following issues:

(i) "Lack of vision or awareness of the role education could play in achieving sustainability";
(ii) "Too many disparate initiatives, too little time for thinking about new ideas, and too little encouragement to think 'outside the box' or make links between initiatives, particularly where cultural norms or existing mission statements don't mention sustainability";
(iii) "Lack of policy or resources such as funding";
(iv) "public/private partnerships are being promoted increasingly as a way to mitigate the impact of uncertainties and insufficiencies in public expenditure. They raise quality and equity issues, however, since communities differ in their ability to attract government expenditure as well as raise private funds."

These concerns mostly focus on an *internal* perspective (from the point of view of education practitioners), aiming at addressing the quintet of vision, skills, incentives, resources, action plan of a re-engineering initiative (Ambrose 1987). This perspective highlights that in view of the breadth and depth of sustainability concerns, a strong backing from a re-engineering standpoint is likely necessary to foster real and lasting change.

The transformative and adaptive potential of integral pedagogy on the secondary educational level. This study (Feldman 2008) concludes:

"The progressive educational principles, models, and value-orientations were developed in a social and cultural context that was critical of mainstream institutional forms of education. In the mirror image of each of the principles is a pointer to some elements of traditional education seen as detrimental, such as: knowledge presented as fragmented bits or in disciplinary silos, inadequately connected to real life practice and concerns; cognitively impoverished metaphors for learning such as the "pipe line" model; rote memorization, teaching to the test, and standardized curricula; hierarchical and oppressive forms of personal and institutional relationships; capitalistic, materialistic, and bureaucratic educational systems."

These concerns focus on an *external* perspective, from an *outsider* point of view. The previously highlighted sustainability issues show there is a strong correspondence between the concerns of alternative / progressive education practitioners and the concerns about addressing the sustainability challenge.

4.1.4 Conclusions

From these findings and if the pace of education reforms continues, EPs may continue to undergo large changes in the coming years. Addressing fundamental human needs, in a way that over time resorbs the sustainability challenge to avoid crossing planetary boundary thresholds, will likely necessitate the combined energies of all stakeholders. The issues and boundaries of this "problem space" lead to a few conclusions:

(i) issues are systemic, complex, multidimensional, interdependent, long-term, dynamic and hinge on relations within ecosystems. Thus satisfying needs based on forecasting trending issues is too narrow: a more open, systematic yet normative (based on shared purpose) approach is needed to avoid compounding long-existing issues while opening up opportunities;

(ii) in "Leverage, Resistance and Success of Implementation Approaches", Paul C. Nutt asserts that the best decisions are made through a process by which a decision leader makes sure the necessary and sufficient information is gathered, and enables the stakeholders to make the decision (Nutt 1998). Thus satisfying needs adequately necessitates a process where stakeholders can create and exchange knowledge through the lens of values and purpose, to feed their creativity in making appropriate choices.

4.2 Second Secondary Research Question

In a sustainable society, what may future education programs' contents or processes cover?

4.2.1 Main Findings

Process. An education program which accomplishes its stated goal while (i) not violating implicitly or explicitly through its contents or delivery process the Sustainability Principles; and (ii) enhancing humanity's ability to equitably and peacefully satisfy the Fundamental Human Needs for all present and to come. A key feature is a shared learning experience leading to empathic engagement with others, and in extension, with the world.

Content. The contents is categorized according to the three key abilities of Creativity, Knowledge Making and Open Values, each addressing a semantic field relevant to tackling non-trivial issues–see CKMOV model.

Table 4.1. Contents / Activities Raising Skills / Practices in CKMOV

Contents/Activities raising skills / practice in *Creativity*

- *Overarching goal*: Developing one's own creativity and multiple intelligences in the socially beneficial context of cooperating to maintain societal sustainability within a thriving biosphere;
- Non-reductionist cross-cultural trans-disciplinary resilience skills and practice;
- Eight-capitals (intra-personal, inter-personal, cognitive, living, material, economic, cultural, spiritual) capacity-building;
- Facing complexity by putting into practice holistic / integral principled worldviews;
- Engagement (with others and the world) based on common purpose, competence, fairness, agency.

Contents / Activities raising skills / practice in *Knowledge Making*

- *Overarching goal*: Sustainability principles from complex adaptive systems / systems thinking;
- Non-reductionist principles to face complexity (such as "Simplicity without Reduction");
- Learn to adaptively learn, unlearn, relearn;
- Sustained mindfulness granting critical self-reflexive knowledge;
- Practicing effectiveness *("doing the right thing")* before efficiency *("doing something right")*.

Contents/Activities raising skills / practice in *Open Values*

- *Overarching goal*: Nurturing intra-personal authenticity and self-esteem to be able to sustain ambiguity and multiple polarities simultaneously — Nurturing inter-personal / participatory leadership in fostering social biodiversity for resilience;
- Open dialogue, respectful disagreement, multi-stakeholder intercultural mediation, power asymmetry mitigation;
- Ethical / resilience / open / steady-state / sharing / integral systems equilibrium economics;
- Multilevel glocal citizenships with operative use of person-environment rights & duties in increasingly larger contexts;
- "Local through large-scale" well-being by sustainable commons, social canvas democracy engineering.

Education Programs and Learning Interactions Model. This simple model emphasizes an openness towards learning labeled "Learning Disposition", as an active relationship essential to the quality of successful learning outcomes, between a learning agent and an agent proposing selected content, whose roles are exchangeable to reflect co-learning.

4.2.2 Critical Assessment

Strengths. The findings have the following positive traits:

(i) by filling a contents mosaic within three non-overlapping semantic fields relevant to addressing non-trivial issues (see 3.5.1) (a) they fulfill aptly the "general" criteria from the Criteria Stage from having a whole-systems global sustainability outlook as advocated at the Success level in Table 1.3;

and (b) they fulfill suitably the "purposeful" criteria from the Criteria Stage by including the satisfaction of the Sustainability Principles (see Table 1.3);

(ii) by offering a vision of a widely inclusive process, and contents features organized within differentiated semantic fields synergistically working together, the findings acknowledge that education programs live in widely differing contexts depending on global and on local conditions: it is thus more strategic to postulate goals than specific ways to achieve them;

(iii) the model represents in a simple way both the learning disposition, a mental process of openness towards learning, and the relation between two agents (or group of agents) in symmetric and transposable situations mediated by this disposition.

Weaknesses. The findings have the following weaknesses:

(i) the same three weaknesses as with the findings answering the first SRQ apply here again, i.e. western bias, need for added validation, and interpretation of findings may seem impractical to burdened stakeholders.

(ii) the model's simplification of a multi-dimensional and complex process linked to multiple consciousness states may miss important features. Many dimensions are abstracted in the learning disposition, some of which find their cause in intrinsic motivators, some of which are socio-economic, ethical or moral, etc. Additionally, no difference is made between children / adults learning engagement modes, whereas empirical studies show that some dualisms reflect adulthood maturation compared to childhood: adults develop character leading to fluency and agency, whereas children start by favoring *easy* over *hard*, *fast* over *slow* and *simple* over *complex*. Future models may reflect these differences, in further research.

4.2.3 Comparison With Other Studies

People's Sustainability Treaty On Higher Education. Drafted by representatives of twenty-five higher education agencies, organisations, associations and student groups rooted in different parts of the world, this Treaty was written for RIO+20 events (after this research's findings were settled). Stating that authoritative documents steadily argued higher education must transform itself if it wants to make a useful contribution to sustainable development, the signatories assert that:

- Transformation is complex and a long term ambition;
- Transformation must be guided by vision and clarity of purpose;
- Transformation of knowledge structures is required;
- Transformation requires fostering respect for and understanding of different cultures and embraces contributions from them;
- Transformation of lifestyles as well as professional competences is required;
- Transformation requires the development of innovative competences;
- Transformation requires effective leadership;
- Transformation strategies need information and decision-making tools.

All these transformation points are well represented within the main findings of secondary research questions I and II. This research thus reflects a growing trend in academic circles that systemic change is needed within the education system, to genuinely address the sustainability challenge.

The signatories also commit to change at the curriculum level: "*Perhaps the greatest challenge of all is to reorient the higher education curriculum so that it aligns with sustainable development. This requires not just the inclusion of relevant subject matter and the pursuit of inter- and trans-disciplinary approaches but also the development of education for sustainable development competences of university and college educators as well as learners. Competences associated with: systemic thinking; critical reflective thinking; futures engagement and values clarification; the ability to deal with complex and contradictory situations; the capacity to work in partnership in order to facilitate transformative actions towards sustainability are vital*."

This research thus widely supports the Treaty's statements.

Learning dispositions and transferable competencies: pedagogy, modelling and learning analytics. Since the Education Programs and Learning Interactions Model was created, a study going further into the subject examined the multi-dimensional aspects of learning disposition and deep engagement, reporting progress on the design / implementation of learning analytics based on a research validated *learning power* concept (Buckingham 2012). While this study goes beyond the simple model introduced herein, the authors believe that their model highlights a vital component: the learning disposition as a mutually nurtured *actively cooperative relationship* between agents placed in *symmetrical* roles of co-learning / co-teaching, beyond purely self-interested rational motivations.

4.2.4 Conclusions

The possibilities and boundaries of the "solution space" to SRQ II lead to a few conclusions on some components of promising pathways:

(i) while the unfolding sustainability challenge is great, there is tremendous unlocking potential in pursuing the aim of attending to it, which brings the appealing prospect of an unparalleled age of creative transformations;

(ii) to really address the sustainability challenge, it seems prudently responsible and sensible to help people acquire mental models up to the task, and let them practice together the actualization of these models in the real world. Yet there must be a willingness to address such complex issues. This is where nurturing learning disposition is essential, because learning is impoverished without it, which leads through reductionism to solving simpler issues (leaving the real challenge to next generations). Without it, it seems more unlikely that people would continue tuning in, develop and nurture, of their own volition and at all life stages: (a) a social wisdom feeding a motivational hope and the courage to face difficult decisions; (b) an open-mindedness and willing diligence to negotiate them to mutual benefit (even with others of differing opinions); (c) the inner resource-fulness, or grit, to consistently follow through with strategically planned actions under the guidance of life-defining choices and shared purpose.

(iii) motivation studies point to key intrinsic motivators precursors of effective learning outcomes: autonomy, relatedness, competence (perceived competence | competence valuation) (Vansteenkiste 2006). In parallel, studies on trust determinants show that important precursors are confidence in the other party's competence, fairness and concern (O'Brien 1995). These findings taken together suggest that an institution may possibly foster positive learning disposition and effective learning outcomes showing its concern through a fair and competent process, by helping people to develop and conciliate relatedness, competence and autonomy (in increasingly inter-dependent social settings, though, a potential friction point to attenuate);

(iv) the previously mentioned studies place emphasis on autonomy as a stronger control in the hands of individuals. Yet other studies indicate that the individualistic control trait is cultural, not universal, while the need for control may be lessened while still yielding outstanding accomplishments in complex and interdependent social settings. Hernandez and Iyengar (2001) show that the personal agency ethos (self-enhancing actions) is

characteristic of western culture, whereas collective agency ethos (group-enhancing actions) permeates non-western societies. Brown (2011) studies show that late (further developed) action-logic [3] practitioners exhibit abilities unavailable to earlier action-logic development. He posits that one facet of effective conscious leadership in action is the ability to "Embrace uncertainty with profound trust". As one such late action-logic practitioner says: "It's a paradoxical process whereby releasing to the process, therefore giving up control, one gains a much superior emergence."

(v) the mechanisms of external vs. intrinsic motivators would have to be considered in creating promising pathways, since evidence from motivation crowding theory shows that in certain cases external incentives may displace intrinsic motivators (Frey 1997). Arguably, complex issues depending on many known and unknown factors, having the reassurance that another person is internally motivated may (in the case relationships are preserved) be a stronger trust factor for someone than if that other person's motivation is based on contingencies;

(vi) this begs the question if the current competitive bias in EPs adequately fosters learning dispositions. A study on non-competitive social behaviour shows it boosts the cognitive "executive function" (including working memory, self-monitoring, and the ability to suppress external and internal distractions) (Ybarra et al. 2010). Children (mainly boys) now increasingly dispensed calming drugs, it begs the question if a non-competitive class environment wouldn't help decrease the "prescription-class" syndrome[4];

[3] "Self-transformation toward fully and regularly enacting the values of integrity, mutuality and sustainability is a long, lifetime path that most of us follow as we grow toward adulthood, but that very few continue traveling intentionally once we become adults. Each major step along this path can be described as developing a new *action-logic*: an overall strategy that so thoroughly informs our experience that we cannot see it." (Torbert 2010)

[4] Considering that "*Total excess cost of AD/HD in the US in 2000 was $31.6 billion*" (Swensen & al. 2003), it is well worth to note that engagement with nature, such as a 20-minute guided walk in a safe park, can boost ADHD-diagnosed children concentration's performance levels to the same or higher level than "*the peak performance boosts shown for two widely prescribed ADHD medications-Metadate CD and Concena-on a similar task*." (Kuo 2010, 23). On top of that effect, numerous benefits for cognitive functions, positive social behavior, crime reduction, and even altruism are documented. In the same way health meta-studies show that while society diminished some long-standing health-related issues, new ones are caused by the system itself, i.e. by a sedentary lifestyle heavily spent in chairs, consistently consuming non-healthy food while ignoring exercise requirements (Katzmarzyk 2012), can it be said that cognitive/social health issues are caused in part by the same sedentary lifestyle in which nature is more and more absent?

(vii) EPs in a sustainable society may also address intelligence differently, first by making it one of its tasks to foster a person's intelligences[5] synergistically, and second by fostering the development of co-intelligences, i.e. organized group intelligence. This is especially important since it has been shown in a quasi-mathematical fashion (Page 2007) that diversity trumps unicity in complex systems, i.e. that under certain conditions complex issues are always better addressed by groups with larger diversity than groups with lower diversity, even if the latter have uniformly more expertise in the particular subject under study. This effect has also been recently getting review under the name "Wisdom of Crowds".

This discovery has significance for EPs, since the predominant model today mostly lies in fostering uniformity / homogeneity in knowledge: studies show that divergent thinking hits a plateau or decreases as children go through the standard education system (Kim 2011). The resulting uniformity, from the point above, thus bears a large cost: lower-grade solutions to complex issues. Since cognitive science has also shown that when people cannot cope with a complex issue, the brain "helps" by substituting instead (and somewhat without the person's conscience) an easier problem to solve, one that presumably disregards previously known yet upsetting limits or constraints[6], this uniformity may play a non-trivial role in continually *reaffirming* the sustainability challenge.

4.3 Third Secondary Research Question

What potential tools and strategies may be of use to education services when devising their education programs, in order to help strategically close the gap between the current unsustainable state and the future sustainable one?

[5] as for now at least seven fit through objective criteria: linguistic, logical-mathematical, musical, spatial, bodily-kinesthetic, interpersonal and intrapersonal (Gardner 1983)

[6] a phenomenon called attribute substitution (Kahneman 2004). This may explain the already widespread tendency to reductionism, which may increase as society metaphorically goes deeper into the funnel and choices decrease in number, until they turn binary and reality is interpreted through a "black- and-white" mindset

4.3.1 Main Findings

SPESA-EP. The main process tool from this research to answer this question, the "Sustainability Potential" Express Strategic Assessment for Education Programs (SPESA-EP) is a member of the Template for Sustainable Product Development family made for Education Programs (see section 3.3). It focuses on the Plan (Analyze needs / Design Criteria) and Do (Design) phases, to help EPs stakeholders quickly gain an overview of general opportunities and challenges from a full sustainability lens.

Key questions aim at providing meaningful conceptual springboards from which to entertain a whole-system global sustainability outlook, while examining the purpose and goals of the EPs going through needs, delivery and stakeholders cooperation. They are used as the basis for a creative and informed dialogic process between a sustainability practitioner and a trans-disciplinary team of EPs stakeholders, usually including decision-makers.

Answers are SP-positive (respecting Sustainability Principles) propositions initially filtered through a FSSD-informed lens expressing: (i) systemic and strategic views; (ii) a definition of success breaking from discrete causes to agreeing with systemic conditions for society's continuing existence into the indefinite future; (iii) an observance of fundamental human needs; (iv) competency/fluency, agency, and fairness values to foster trust. Harvesting the results of the dialogic process through a standardized format creates an evolving "template".

The "Present Situation" section informs secondary research question I, while the "Future Possibilities" part informs secondary research question II.

CKMOV Model. The "Creativity – Knowledge Making – Open Values" model forms the hypothesis that key develop-mental abilities working synergistically form a minimum set of satisfiers necessary (though not sufficient[7]) to help address multi-stakeholder multi-cultural complex issues: each ability (i) addressing a semantic field relevant to addressing non-trivial issues; (ii) being a synergistic satisfier of high potency; (iii) being an integral part of the FSSD (see section 3.5).

[7] In particular, the question of initial motivation is assumed to be present, i.e. people *want* to address the issue in some way at the start. If it is not the case, a "sparking" event may be needed

Notably, it shows why the minimum set of satisfiers has at least three components: there are three non-overlapping semantic fields relevant to addressing non-trivial issues, addressing the *What*, the *Why* and the *How*[8].

CKMOV enables novel re-interpretations of mental tools such as the backcasting and forecasting planning methods, and the ABCD method used by the Framework for Strategic Sustainable Development.

4.3.2 Critical Assessment

Strengths. The ***SPESA-EP*** can (i) serve an extensive number of education programs of differing structure, contents and engaging formats due to its generality; (ii) highlight potential issues and opportunities present in an education program both explicitly and implicitly, through a whole-system sustainability principles lens; (iii) trigger creativity in an informed way through an inclusive values-rich dialogue; (iv) foster a purposeful dialogue between stakeholders about contents and processes used in the EP; (v) help diverse stakeholders share a common understanding of significant opportunities challenges and from a full sustainability lens; (vi) help identify improvements that make long-term sense from a strategic sustainable development perspective, while enabling further prioritization for short- and mid-term planning; (vii) help develop stakeholders' strategic abilities from gradually improving disparate aspects to focusing on closing the gap between current reality and envisioned goals.

The ***CKMOV model*** can (i) help people tackle complex issues thanks to its generality and its purposefulness in combining synergistic abilities of high potency, that sustain the fundamental human needs: as stated by Snowden: "*Novel issues require decision makers to reflect upon what they want to achieve […] The methods of value focused thinking and the exploration, evolution and elicitation of values, weights and utilities […] will lie at the heart of decision analyses in the complex space*" (Snowden 2002); (ii) serve to re-interpret familiar tools to provide new insights; (iii) help develop new tools; (iv) be well-suited to support the educational shifts proposed by ESD.

Weaknesses. The abstract, almost principle-like level of the findings (i) demands a local interpretation (in terms of culture, and specificity of the

[8] the *Who* / *Where* / *When* being addressed in immediate terms through *Us* / *Here* / *Now*

education program under consideration) of what is really a tapestry linking global trends; (ii) necessitates prior conceptual training with systemic concepts that must first be understood to make a successful interpretation; (iii) compete with many other, more circumscribed issues that education practitioners consider in developing an education program, thus the whole exercise may prove demanding to burdened stakeholders—the findings may be seen as failing the "practical" criteria developed in the Criteria Stage. A likely answer to this issue would be to first "localize" the findings to a specific culture / education program, and to feed stakeholders engagement with appropriate incentives and resources as well as strategically foster coherent alignment of the different levels co-creating the conditions for the EP's quality; Additionally, these tools need more vetting through practical inquiries, a subject of further research.

4.3.3 Comparison With Other Studies

The Creativity Crisis: The Decrease in Creative Thinking Scores on the Torrance Tests of Creative Thinking. This study analysing creativity test scores in the United States from 1966 asserts that since 1990, even as IQ scores have risen, creative thinking scores have significantly decreased (Kim 2011). It concludes: "*To reverse decline in creative thinking, the United States should reclaim opportunities for its students and teachers to think flexibly, critically, and creatively. Standardization should be resisted. Novel creative thought and expression should be encouraged, and opportunities should be made available for participation in active, critical discussion. Older children still need time for reflective abstraction, and they also need their parents and teachers to pay attention to them and support their creative endeavors*."

The SPESA-EP topics on contents / activities raising skills / practice in creativity (Developing one's own creativity and multiple intelligences; Non-reductionist cross-cultural trans-disciplinary resilience skills and practice; Eight-capitals capacity-building; Putting into practice holistic / integral principled worldviews; Engagement based on common purpose, competence, fairness, agency) reflects similar thinking.

Next we turn to two studies that, taken together, yield an intriguing picture that we interpret through CKMOV. First a study of the "dark side" of creativity (Gino 2012) shows that "*dispositional creativity is a better predictor of unethical behavior than intelligence*" and that "*greater ability to justify their dishonest behavior explained the link between creativity and*

increased dishonesty". Second a poll of business leaders showing they identified creativity as the first "leadership competency" of the future[9] (IBM 2010). The business side thus shows its preference and willingness to create the changing conditions to attain their goals, in essence to "create the future", not just to "discover the future". Taken together, one cannot help but being reminded of the aphorism: "The End Justifies the Means."

Using CKMOV as a lens: Knowledge Making and Creativity together may yield, as shown by Gino 2012, more disingenuity. Thus going from an emphasis on Knowledge Making (fed currently by the "Big Data" trend), to one on Knowledge Making and Creativity yet foregoing the third element of the triad (Open Values), would yield partial results advantageous to existing vested interests: the scale of measure in the semantic field of qualifiers would not be shared among stakeholders. Therefore the societal purpose of solving the sustainability challenge would not be solved until the business function of society also included into the production function an equivalent of Open Values (basically obtaining, through effective mechanisms, a social license to creatively operate and co-create the future).

Education for Sustainable Development (ESD) Toolkit - United Nations Decade of Education for Sustainable Development (2005-2014). This brings us to the following insightful strategies of the ESD Toolkit:

(i) reorient curriculum by localizing the global initiative of ESD, to foster a common sustainability awareness adapted to the local culture;

(ii) top-down education policies helping and acting in synergy with bottom-up community deliberation and participation.

Judging from the socio-political system's current responsibility for public education, an authoritative thrust from governments would play a strong role in infusing sustainability awareness into education services. Omission of such processes may cause large delays, and maybe a downfall of global efforts: China's case study validates that dovetailing with local community sustainability goals will assist a systemic transition for society as a whole.

[9] "[…] more than 1,500 Chief Executive Officers from 60 countries and 33 industries worldwide, believe that—more than rigor, management discipline, integrity or even vision—successfully navigating an increasing complex world will require creativity."

As illustrated by SPESA-EP, this remains complicated since a number of stakeholders' conditions or preferences may currently hinder the adoption of "SP-positive" education programs helping to enhance global sustainability. Yet the CKMOV model indicates that emphasizing the Open Values key ability in people may yield to opening up satisfactory avenues.

4.3.4 Conclusions

The strategies and boundaries of this "strategic action space" lead to a few conclusions on the components of promising pathways to this space:

(i) as explored in the Introduction section, technology is sometimes pushed as a complete education solution, or at least as a key strategy to achieve the goal of fulfilling teaching objectives. Yet, the use of technology always comes back to a central question: "What determines the education/learning relations, and what part of it can be reduced to algorithmic calculations?" A puzzling corollary to this question is the rhetorical one: "Would people learn the same way if they never had contact with other people, and were only surrounded by uncaring yet intelligent machines?". Studies answer by the negative, as learning is seen as a total and complex human experience fed by and through exchanges and relationships; although one may answer by the affirmative for the *mechanical* part of learning using rote memorization or in which formal / model-based data may bring insights through self-directed reflection (that is then discussed and refined with other people, presumably). Thus technology may play a supplemental role, but may not successfully substitute for shared purpose determined by the collective interplay of people's worldviews and values;

(ii) as with intrinsic vs. external motivators, the use of technology has to be *critically* assessed (see Appendix C): while it cannot possibly take the role of purposeful collective determinations, it still has a game-changing potential to strongly affect them through the multiple biases it introduces in the human experience, all the while displacing people from previous roles;

(iii) the ESD shifts enhanced through the practice of CKMOV abilities points to CKMOV becoming foundational abilities for future education programs: future EPs may choose to integrate the CKMOV satisfiers as three basic pillars, to nurture basic competencies people in the 21st Century need in building pathways towards addressing the sustainability challenge.

Many of the ESD shifts may be amplified by an informed and systemic approach such as the one of the Framework for Strategic Sustainable Development. A strategically deployed sustainable development needs this kind of foundation to build on, as it advocates a well-defined common language so that people may then build a shared vision of a durable society. Yet people without creativity, with no systemic view, and who are unable (or unwilling/uninterested) to dialogue about how their values (and lifestyle) may affect other people (neighbours or even those far away) may have an exceedingly tough time in reaching this goal, let alone act on it by changing their behavior, an issue an order of magnitude more difficult.

4.4 Primary Research Question

How could a strategic sustainable development approach improve the design of education programs to promote sustainability while not contributing to socio-ecological unsustainability?

4.4.1 Main Findings

Table 4.2. shows how the research questions findings logically relate one to another. The Primary Research Question column subsumes the Secondary Research Question III one. Appendix K shows Table 4.2 in larger format.

Table 4.2. Correspondence between Research Question Findings

<table>
<tr><th>Secondary Research Question I</th><th>Primary Research Question</th><th>Secondary Research Question II</th></tr>
<tr><td>Lack of shared unambiguous language and scientific success criteria on sustainability</td><td>A systematic approach to "educate unsustainable behavior" out</td><td rowspan="3">An educational program which accomplishes its stated goal while (i) not violating implicitly or explicitly through its content or delivery process the Sustainability Principles; and (ii) enhancing humanity's ability to equitably and peacefully satisfy the Fundamental Human Needs for all present and to come. A key feature is a shared learning experience leading to empathic engagement with others, and in extension, with the world</td></tr>
<tr><td>Over-emphasis on reductionism creating seemingly unconnected disciplines of study generates fertile conditions for the sustainability challenge, by marginalizing transversal studies, overlooking cause-effect relationships, and limiting the systematic and purposeful pursuit of sustainability to existing niches</td><td>Fostering backcasting from Sustainability Principles</td></tr>
<tr><td>Education Programs Life-Cycle Model</td><td>Systematic spiraling learning process</td></tr>
<tr><td rowspan="3">Over-emphasis on an homogenization of rational knowledge detached from shared ethical values, at the expense of fostering creativity and commonality of purpose</td><td rowspan="3">CKMOV</td><td>Content/Activities raising skills / practice in Creativity</td></tr>
<tr><td>Content / Activities raising skills / practice in Knowledge Making</td></tr>
<tr><td>Content/Activities raising skills / practice in Open Values</td></tr>
<tr><td>Systematic bias selecting specific content over fluency</td><td rowspan="3">SPESA</td><td rowspan="3">Education Programs and Learning Interactions Model</td></tr>
<tr><td>Social cohesion in question despite homogenization of knowledge and hierarchical control of education process</td></tr>
<tr><td>Reduction of public investment resources per student</td></tr>
</table>

A systematic approach to "educate unsustainable behavior" out. The Framework for Strategic Sustainable Development may first help clarify discernment through science-based semantic tools, helping to characterize sustainability opportunities memes in EPs as well as identify memes part of the sustainability challenge systemic design issues. That approach would help education services "design out" unsustainability from their EPs efficiently, helping them impel solutions to the sustainability challenge before planetary boundaries thresholds are irremediably crossed.

Thus slightly shifting Senge's first law ("*Today's problems come from yesterday's "solutions"*"), a maxim for smart and forward-thinking organizations wanting to systematically root out unsustainable practices (i.e. wanting to prevent leaving the next generation(s) new issues) might be:

Sustainable Organizations Outsmart *YET-TO-STOP!*
(*YE*sterday's *T*hinking, *TO*day's *S*olution, *TO*morrow's *P*roblem!)

or

Distinct Education Programs Learnedly Outsmart *YET-TO-STOP*
(*YE*sterday's *T*hinking, *TO*day's *S*olution, *TO*morrow's *P*roblem)

Fostering Backcasting from Sustainability Principles. Education can be thought of as society's process to hand itself over the proper ways to treat trade-offs when choosing satisfiers. Yet issues discussed in section 4.1.1 (such as over-emphasis on reductionist partitions) skew societal priorities and incentives, yielding a sub-optimal array of choices, poorer satisfiers and an unfolding sustainability challenge. The FSSD's main breakthrough resides in its effective approach in using shared purpose to help reach mutually satisfactory trade-offs, partly by using a shared understanding of basic principles informing both systemic rules and success conditions. A broader support for a stepwise path leading to fulfilling this shared purpose is then within reach. BSP may effectively help education stakeholders create a shared vibrant vision (education for sustainability to safeguard humanity's survival, and leading to prosperity and well-being) while freeing each to pursue this purpose at their level, guided by motivations, skills, and societal opportunities.

Systematic spiraling learning process. At the heart of FSSD stands a systematic spiraling learning process aimed at enabling organizations to gradually improve their awareness, trust and visioning capabilities. This

learning process would be advantageously used in delivering EPs to foster a strong learning disposition, to "co-learn / co-teach unsustainable behavior out" of different practices. Through this process, currently alarming societal unsustainability may gradually yet systematically be addressed and progressively diminish.

4.4.2 Critical Assessment

The FSSD as a process has been systemically engineered to help people formulate a shared vision and attaining it, on a global scale through localized practices, in a stepwise strategic manner.

The FSSD as an object of knowledge is itself developed by scientific processes and taught/learned through an education program. It then stands to reason that objectively assessed, generically effective practices developed in this EP (the Master's in Strategic Leadership towards Sustainability - MSLS) may usefully inform on how to progress towards "SP-positive" EPs of any kind.

The three findings above-mentioned each having been positively vetted in many contexts, academic or not, the recommendation to use them to help stakeholders create "shared understanding and purpose" to effectively reach satisfactory trade-offs; to "design out" unsustainability from EPs; and to "co-learn / co-teach unsustainable behavior out" of human practice to impel long-term solutions to the sustainability challenge, is robust.

4.4.3 Comparison With Other Studies

UNESCO International Commissions on Education - Learning: The Treasure Within. This study states that to overcome the main tensions of the future (global / local, universal / individual, tradition / modernity, spiritual / material) lifelong learning (i.e. learning how to learn based on learning *to know* ⇨ *to do* ⇨ *to live together* ⇨ *to be*) has become a necessity: "The fundamental principle is that education must contribute to the over-all development of each individual, mind and body, intelligence, sensitivity, aesthetic sense, personal responsibility and spiritual values."

The three findings address many of the goals set in the study, through effective tradeoff strategies using shared purpose to find globally optimal satisfiers for these tensions (i.e. metaphorically avoiding the funnel walls), and through a continuous multi-dimensional learning process. Moreover the

SPESA-EP tool can usefully help foster the creative process to periodically refine (i) what this "over-all development of each individual" entails as society continues to progress in dynamic equilibrium within the biosphere; (ii) how EPs design / delivery may yield this improvement; and (iii) how all stakeholders may participate in this dynamic endeavor.

4.4.4 Conclusions

The contents and boundaries of this "5LF space" lead to a few conclusions:

(i) at issue is whether solving the sustainability challenge can be done effectively purely through a collection of personal initiatives, or a collection of private initiatives. The answer to the first question, given the nature of the sustainability challenge, seems negative. Answering the second, a best-case scenario of a collection of enlightened self-interested private initiatives may yield a desired result (a highly non-zero sum game). Still, in facing world-shifting issues, should solutions be left to this highly uncertain fate? This set of private initiatives, whose distribution in time and effectiveness would presumably follow Bell curves, provides only limited insurance of success. In face of such a consuming issue, society would be prudent in giving itself more than adequate insurance;

(ii) public initiatives may systemically complement personal / private initiatives to yield strong societal coordination through level-playing field policies, a stabilizing feature even the market appreciates;

(iii) the ability to effectively coordinate public and collective initiatives depends on the public actually existing in its own eyes, i.e. depends on people's ability to answer by the affirmative the questions of global solidarities, not only to current collective features of society, but also with the next generations and the life-supporting ecosystems on which civilization depends.

The previous questions are timely and relevant since public education[10] currently faces a strong pull from the market, eager to incorporate it in the

[10] The same is happening to the healthcare and national security sectors in neoliberal countries

private sphere as market growth "imperative" pushes people to find new territories to retrieve from the public sphere (and from the Commons[11]);

(iv) the previous question can then be rephrased as: "*Can an increasingly privatized education system foster a public that can effectively address the sustainability challenge before planetary boundary thresholds are crossed?*" While a full answer stands outside scope, two points are worth considering:

(a) As stated by Barber on positive or moral liberty by Rousseau, Kant or Dewey: *"[...] there can be no viable idea of public liberty outside of the quest for a moral and a common life defined by purposes that are to some degree public in character. There can be no securing of liberty that is not also grounded in moral limits and hence in education and civic participation*" (Barber 2007, p.125.) As Tocqueville puts it, the "apprenticeship of liberty" is key to the exercise of citizenship in a free republic, the liberal arts through public schooling being the way to foster it. If one accepts the assertions that liberal arts including training in *public* forms of discourse are necessary to democratic citizens, it follows that important bastions of education must retain their public character, to foster the non-trivial ability to make public choices in one's interest and in the common interest of people one depends on, but does not know about. The alternative would likely increase the likelihood well-being would be undermined as a myriad private voices would try to outcompete each other, while planetary boundary thresholds would silently be passed with overwhelmingly negative outcomes for all;

(b) second, the increasing loss of autonomy by higher education institutions through the introduction of philanthropic grants tied to specific outcomes may also create a systematic diversity-reducing bias. As discussed before, this loss of diversity incurs a high cost to the whole system, in that it tends to foster a "mono-culture crop" of controlling solutions optimal to vested interests: this is akin to using all of one's resources to yield a hypertrophied part instead of developing a whole system. Thus institutions loss of autonomy may foster rigidity, enabling the status quo that led in the first place to the sustainability challenge.

[11] Refers to resources collectively owned or shared, e.g. resources in nature, or elements of culture

5 Conclusion

5.1 Supporting Education Programs for the 21st Century

It is the authors' contention that a minimum set of satisfiers, helping to fulfil fundamental needs and thus to address multi-stakeholder multi-cultural complex problems, should include at least three basic satisfiers acting in synergy: Knowledge Making, Creativity, & Open Values. The weaving of these satisfiers can be found in the purposeful design of the Framework for Strategic Sustainable Development to address 21st century's main challenge: satisfying fundamental human needs for all, indefinitely.

Current education programs overwhelmingly emphasize the first satisfier at the high cost of weakening, or even sacrificing, the two others. Such strategy, which may have seemed efficient in a "large, local and empty" world, finds itself increasingly unable to answer modern issues in a "small, global and crowded" Earth, because people are not content anymore to be spectators, but increasingly want to participate in tuning into and co-creating the world they live in.

Education programs in the 19th and 20th century bore the weight of only a few billion people, and in these times it seemed enough to support them on the sole pillar of Knowledge Making. Yet education programs in the 21st century have to help society transition peacefully from 7 billion persons to an expected ten billion in 2050, while at the same time ensuring everybody's chances to live a decent life in which at least fundamental human needs are satisfied.

The hard-earned lessons of the 20th century demonstrate that Knowledge Making alone is not up to the task. Thus education programs have to undergo a structural transformation if society is to successfully address today's and tomorrow's complex challenges. From being supported by a single pillar, their 21st century evolution asks for renewed harmonious reinforcement provided by three pillars of equivalent vitality: Knowledge Making, Creativity & Open Values.

5.2 Further Research

As mentioned in the Methods section, the authors would like to evolve the SPESA-EP, the specialized version of the TSPD process tool for Education Programs, into multiple versions to approach audiences of different sustainability maturity levels (using the model by Willard). Appendix E shows a work in progress of TSPD questions for two categories of levels: category I corresponding to Willard levels 1-3, category II corresponding to Willard levels 4-5.

The authors believe the following inquiries would yield further insights:

- *Strategic Decision-Support Systems*. To use the final TSPD to formulate success criteria (enablers and barriers) for "Design Space", an education program taking the form of a strategic decision-support system (SDSS) online learning tool;

- *CKMOV model*. To refine the model (i) by refining the modalities of each ability's practical expression; (ii) by experimenting with the model in practical settings;

- *Model of education programs and learning interactions*. To refine the model by reflecting the differences between children, adolescent and adult learning engagement modes;

- *Tension between individual and group, private and public in democracies*. To bring insights by answering the question:
  "Can an increasingly privatized education system foster a public that can effectively address the sustainability challenge before planetary boundary thresholds are crossed?"

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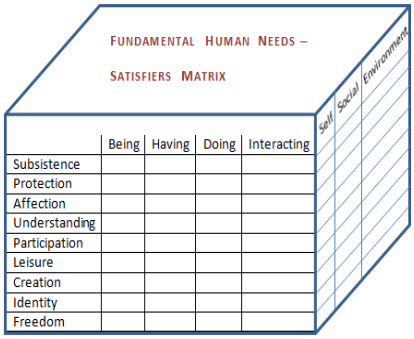
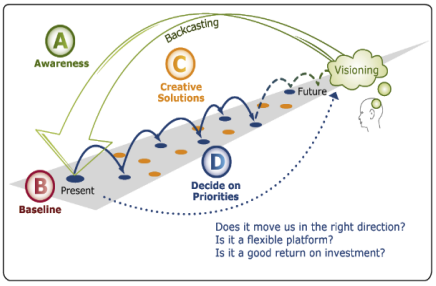
Appendix A FSSD – Attuned Tools for Education Programs

TOOLS	What Is It?	How Is It Beneficial?
Five-Level Framework for Planning in Complex Systems (5LF)	This generic **structuring framework** helping the planning process in complex systems reduces complexity arising in multi-stakeholders endeavors by rendering explicit at which of five distinct yet inter-related levels is information exchanged between stakeholders: **System – Success – Strategy – Actions – Tools**	✓ Making discussions easier, more focused & more productive by structuring & clarifying information exchange between stakeholders of Education Programs
Framework for Strategic Sustainable Development (FSSD)	The FSSD uses the 5LF to help planning in the complex system "society in the biosphere". The purpose of doing this is to bring clarity, rigor & insight to planning and decision-making towards a sustainable society in the biosphere. Two key elements include: 1. the establishment of basic principles (or 'system conditions') for sustainable society in the biosphere, which provides a principle-level definition of "success" (see Sustainability Principles), and 2. the development of strategic guidelines to guide efforts towards success by informing the selection of various actions & tools	✓ Providing a systems-responsive strategic platform to stakeholders of Education Programs, helping them to decrease their unsustainable activities systematically & in a step-wise manner while buffering against systemic shocks ✓ Providing stakeholders of Education Programs an "operating system" for sustainability applications, helping them use various existing tools in an orchestrated, fully strategic way to provide a "full sustainability" robust platform.
Sustainability Principles (SP)	To complement the 1987 Brundtland definition of sustainability & provide guidance for sustainable development planning, scientists & practitioners have developed starting in Sweden in the early 1990s a principle-based definition of sustainability through scientific consensus, synthetized in the Sustainability Principles (SP). These build on a basic understanding of what makes life possible, how our	✓ Providing stakeholders of Education Programs the highest degree of flexibility & freedom of action capable of creating plentiful yet indefinitely durable societies (staving off systemic collapses) ✓ Acting as overarching criteria to guide actions of Education Programs stakeholders towards

TOOLS	What Is It?	How Is It Beneficial?
	biosphere functions and how human societies are supported by Earth's natural systems.	success, i.e. a prosperous sustainable society within a thriving biosphere ✓ Providing clear guidelines to any organizational group, of any size & purpose, on how not to ruin such an outcome
Human-Scale Development (HSD), Fundamental Human Needs (FHN) & Satisfiers	**Human-Scale Development** : a praxis meant to tackle the question of structural poverty, a central question in tackling global environmental challenges "*Such development is focused & based on the satisfaction of fundamental human needs, on the generation of growing levels of self-reliance, and on the construction of organic articulations of people with nature and technology, of global processes with local activity, of the personal with the social, of plan with autonomy, and of civil society with the state*". (Max-Neef 1989) The Fundamental Human Needs (FHN) are independent of wealth, age, gender, cultural beliefs or worldview. They work as a system in which simultaneities, complementarities and trade-offs are continually assessed. They may be represented in a matrix format along three axis: (i) the axiological axis, comprising the needs of *Affection, Creation, Identity, Freedom, Leisure, Participation, Protection, Subsistence, Understanding*; (ii) the existential axis, comprising the needs of *Being, Doing, Having, Interacting*); and (iii) the contextual axis comprising increasingly larger contexts: *Self* (personal), *Social* (group), *Environment* (society within the biosphere) "Satisfiers" are the relative means (subjective, contextual and changing	✓ Providing stakeholders of Education Programs with a sound theoretical model to enable ○ creating an economy of well-being, respecting the needs equally accounting for well-being: an inability to fulfill any of them causes "well-being impoverishment" or even a pathology ○ addressing fundamental needs for all, instead of addressing all desires for some ○ finding appropriate combinations of satisfiers, rooting out "destroyers", pseudo-satisfiers and inhibiting satisfiers, and maximizing synergic satisfiers

TOOLS	What Is It?	How Is It Beneficial?
	in time) by which a person's or group's FHN may be satisfied / actualized / realized.  	
Backcasting From Principles (BSP)	Since it is understandably difficult to make many people agree on detailed images of a distant future because values may differ, while technical and cultural conditions keep evolving, BSP suggests a way to optimize the value-creation proposition for all stakeholders even for an indefinite horizon.	✓ Providing stakeholders of Education Programs an effective way to ○ develop robust strategies (solving more than just today's issues) ○ formulate a shared vision of the imagined future success to effectively & durably engage stakeholders
ABCD Method	The ABCD method is one of the primary tools used by the FSSD. Its whole-systems approach meshes the Sustainability Principles (SP), Backcasting from Principles (BSP), Strategic Guidelines (SG) as well as creative, visioning & consensus-building tools in an integrated way. The output of the ABCD method is (primarily) a Sustainable Development Strategic Plan.	✓ Providing stakeholders of Education Programs robust means to: ○ align around a common understanding of sustainability and identify a 'whole-systems' context for the program ○ build a common language around sustainability as well as creating a vision of what that program would look like in a sustainable future ○ conduct a sustainability "gap analysis" of the major flows and impacts of the program to see

TOOLS	What Is It?	How Is It Beneficial?
	 This method isn't linear but refines its results iteratively in a spiral approach. A new addition to the "ABCD" method is an "E" step, for Evaluation…	how current activities are augmenting the risks of rising unsustainability. The analysis usually includes an evaluation of products & services, the energy-water nexus, 5-capitals (human, social, environmental, infrastructural & financial) from 'cradle to cradle', informed by SP and FHN, in order to understand how to positively introduce change ○ brainstorm potential solutions to the issues highlighted in the baseline analysis without any constraints ○ prioritizes the measures that move organizations toward sustainability fastest, while optimizing flexibility as well as maximizing social, ecological and economic returns
Strategic Life-Cycle Management (SLCM)	The SCLM is an advanced life-cycle approach making use of socio-ecological LCA methodologies, guided by Sustainability Principles (SP) as system boundaries	✓ Providing stakeholders of Education Programs the means to strategically use LCA methodologies, focusing on issues based on the vision of their respective organizations, while having at their disposal a sound, scientifically robust trade-off analysis tool using Sustainability Principles
Template for Sustainable Development (TSPD)	The TSPD focuses on the first phases of product development, concepts & design, to help developers quickly gain an overview of the general opportunities & challenges a product-line offers. Key questions are used as the basis for a creative & informed	✓ Letting stakeholders of Education Programs gain quickly & in a straightforward way an overview of persistent & sizeable sustainability challenges & opportunities

TOOLS	What Is It?	How Is It Beneficial?
	dialogue between a sustainability practitioner and a trans-disciplinary team of product developers, usually including management. The resulting answers are put in a standardized format, creating an evolving "template" for this product-line.	for a particular product-service line; ✓ facilitating an informed creative communication between stakeholders of Education Programs to support the creation of "Sustainability-Enriched" programs in all fields
Art of Hosting	The Art of Hosting and Convening Meaningful Conversations explores hosting as an individual and collective leadership practice. It is a "deep engagement" set of participatory practices	✓ Providing stakeholders of Education Programs a way to meaningfully and effectively ○ go from fragmentation to connection ○ ground actions in that which is meaningful ○ access and draw wisdom from all collective intelligences ○ lead from the "field" ○ shift patterns of organizing & interacting

Appendix B Education and Learning Theories

Human Right # 26 : The Right to Education

1. Everyone has the right to education. Education shall be free, at least in the elementary and fundamental stages. Elementary education shall be compulsory. Technical and professional education shall be made generally available and higher education shall be equally accessible to all on the basis of merit.

2. Education shall be directed to the full development of the human personality and to the strengthening of respect for human rights and fundamental freedoms. It shall promote understanding, tolerance and friendship among all nations, racial or religious groups, and shall further the activities of the United Nations for the maintenance of peace.

3. Parents have a prior right to choose the kind of education that shall be given to their children.

Four orientations to learning

Aspect	Behaviourist	Cognitivist	Humanist	Social and situational
Learning theorists	Thorndike, Pavlov, Watson, Guthrie, Hull, Tolman, Skinner	Koffka, Kohler, Lewin, Piaget, Ausubel, Bruner, Gagne	Maslow, Rogers	Bandura, Lave and Wenger, Salomon
View of the learning process	Change in behaviour	Internal mental process (including insight, information processing, memory, perception)	A personal act to fulfil potential.	Interaction /observation in social contexts. Movement from the periphery to the center of a community of practice
Locus of learning	Stimuli in external environment	Internal cognitive structuring	Affective and cognitive needs	Learning is in relationship between people and environment.

Purpose in education	Produce behavioral change in desired direction	Develop capacity and skills to learn better	Become self-actualized, autonomous	Full participation in communities of practice and utilization of resources
Educator's role	Arranges environment to elicit desired response	Structures content of learning activity	Facilitates development of the whole person	Works to establish communities of practice in which conversation and participation can occur.
Manifes-tations in adult learning	Behavioral objectives Competency - based education Skill development and training	Cognitive development Intelligence, learning and memory as function of age Learning how to learn	Andragogy Self-directed learning	Socialization Social participation Associationalism Conversation

Merriam, S. B., and Caffarella, R. S. 1991. Learning in adulthood. San Francisco and Oxford: Jossey-Bass Publishers.

Appendix C Neil Postman's *The End of Education*

"Technology education is not a technical subject. It is a branch of the humanities. Technical knowledge can be useful, but one does not need to know the physics of television to study the social and political effects of television. One may not own an automobile, or even know how to drive one, but this is no obstacle to observing what the automobile has done to American culture.

It should also be said that technology education does not imply a negative attitude toward technology. It does imply a critical attitude. To be "against technology" makes no more sense than to be "against food." We can't live without either. But to observe that it is dangerous to eat too much food, or to eat food that has no nutritional value, is not to be "antifood." It is to suggest what may be the best uses of food. Technology education aims at students' learning about what technology helps us to do and what it hinders us from doing; it is about how technology uses us, for good or ill, and about how it has used people in the past, for good or ill. It is about how technology creates new worlds, for good or ill. […] I would include the following ten principles.

- All technological change is a Faustian bargain. For every advantage a new technology offers, there is always a corresponding disadvantage
- The advantages and disadvantages of new technologies are never distributed evenly among the population. This means that every new technology benefits some and harms others.
- Embedded in every technology there is a powerful idea, sometimes two or three powerful ideas. Like language itself, a technology predisposes us to favour and value certain perspectives and accomplishments and to subordinate others. Every technology has a philosophy, which is given expression in how the technology makes people use their minds, in what it makes us do with our bodies, in how it codifies the world, in which of our senses it amplifies, in which of our emotional and intellectual tendencies it disregards.
- A new technology usually makes war against an old technology. It competes with it for time, attention, money, prestige, and a "worldview."
- Technological change is not additive; it is ecological. A new technology does not merely add something; it changes everything.
- Because of the symbolic forms in which information is encoded, different technologies have different *intellectual* and *emotional* biases.
- Because of the accessibility and speed of their information, different technologies have different *political* biases.
- Because of their physical form, different technologies have different *sensory* biases.
- Because of the conditions in which we attend to them, different technologies have different *social* biases.
- Because of their technical and economic structure, different technologies have different *content* biases."

Appendix D An Education Including Sustainability – Education Program Satisfiers

Here the authors take the example, given in Max-Neef's et al. theory of Human-Scale Development, of general satisfiers of the fundamental Human Needs, to give example satisfiers related to education programs.

Fundamental Human Needs	Being (qualities)		Having (things)	
	General satisfiers examples	Education/Learning competencies examples	General satisfiers examples	Education/Learning competencies examples
Subsistence	Physical health, emotional health, mental health, spiritual health	Autonomy, self-determination, reliability, virtue	Food, shelter, security	Endurance, people skills, organizational skills
Protection	Care, adaptability, autonomy	Tolerance, responsibility, adaptibility, autonomy	Social security, health systems, work	Self-control
Affection	Respect, sense of humour, generosity, sensuality	Respect, honesty, generosity, gratefulness	Friendships, family, relationships with nature	Patience, flexibility, benevolence
Understanding	Critical capacity, curiosity, intuition	Critical capacity, thoroughness, intuition (not over-emphasizing rationality)	Literature, teachers, educational policies	Knowledge, discernment, teachers, education policies
Participation	Receptiveness, dedication, sense of humour	Justice, resourcefulness, receptiveness, dedication, dependability, diligence	Contributions, responsibilities, duties, work, rights	Contributions, enthusiasm, loyalties, discretion
Leisure	Imagination, tranquility, spontaneity	Imagination, spontaneity	Games, parties, peace of mind	
Creation	Imagination, boldness, inventiveness, curiosity	Creativity, boldness	Abilities, skills, work, techniques	Initiative
Identity	Sense of belonging, self-esteem, consistency	Authenticity, honesty, truthfulness, honor	Language, religions/ spitituality, work, customs, values, norms	Wisdom
Freedom	Autonomy, passion, self-esteem, open-mindedness	Autonomy, passion, self-esteem, open-mindedness	Inalienable rights, equal rights	Equal rights

In the Doing existential category, the authors showed as an example that for each need, there exists satisfiers that are dependent on the three basic abilities of Creativity, Open Values and Knowledge-Making.

Fundamental Human Needs	Doing (actions)		Interacting (settings)	
	General satisfiers examples	Education/Learning competencies examples	General satisfiers examples	Education/Learning competencies examples
		Creativity (C) Open Values (V) Knowledge-Making (K)		
Subsistence	Feed, clothe, rest, work	Practice *(CVK)*, Train *(K)*	Living environment, social settings	Social environments
Protection	Co-operate, plan, take care of, help	Co-operate *(CVK)*, plan *(CVK)*, take care of *(CV)*, help *(CVK)*	Social environment, dwelling	Social environments
Affection	Share, express emotions, take care of, make love	Share*(V)*, nurture*(V)*, take care of *(CVK)*	Privacy, intimate spaces of togetherness	Social environments
Understanding	Analyse, study, meditate, investigate	Analyse *(CVK)*, study *(CVK)*, investigate *(CVK)*, meditate *(K)*, making experiments *(CVK)*	Schools, families, universities, communities	Schools, universities, communities
Participation	Cooperate, dissent, express opinions	Cooperate *(CVK)*, dissent *(CVK)*, express opinions *(CVK)*	Associations, parties, churches, neighborhoods	Schools, universities, neighborhoods, communities, study groups
Leisure	Day-dream, remember, relax, have fun	Day-dream *(C)*, remember *(CK)*, relax *(C)*, have fun *(C)*, meditate *(CVK)*	Landscapes, intimate spaces, places to be alone, safe havens	Safe havens
Creation	Invent, build, design, work, compose, interpret	Invent *(CVK)*, build *(CVK)*, design *(CVK)*, work *(CVK)*, compose *(CK)*, interpret *(CVK)*	Spaces for expression, workshops, audiences	Spaces for expression, study groups
Identity	Get to know oneself, grow, commit oneself	Get to know oneself *(CVK)*, grow *(CVK)*, commit oneself *(CVK)*	Places one belongs to, everyday settings	Study groups
Freedom	Dissent, choose, run risks, develop awareness	Dissent (*CVK*), choose (*CVK*), run risks (*CVK*), develop awareness (*CVK*)	Anywhere	Social environments

Appendix E TSPD Questions and Differentiated Maturity Sustainability Levels

Here is presented, as a work in progress, questions developed in the Template I - Present Situation, for two categories of sustainability maturity levels: category I (Willard levels 1-3) and category II (Willard levels 4-5). The present research developed the SPESA-EP ("Sustainability Potential" Express Strategic Assessment for Education Programs) using questions for category I, on the basis that (i) collectively, many more organizations can be assessed at sustainability maturity levels 1-3 than 4-5; and (ii) individually, the unsustainability impact of an organization is greater at sustainability maturity levels 1-3 than 4-5.

	Public Desires / Needs – Audience / Stakeholders	
Sustain-ability Awareness	*Category I*	*Category II*
Present situation	1) What current **desires** is the educational program (EP) intended to meet? 2) What are some current overall sustainability problems related to these **desires**? 3) How do these **desires** relate to Fundamental Human **Needs (FHN):** Affection – Creation – Freedom – Identity – Leisure – Participation – Protection – Subsistence – Understanding	1) What current **desires** is the educational program (EP) intended to meet? 2) How are these desires addressed? a) Is the audience consulted? b) Is the audience treated as a co-creator? 3) Which **values** are taken into account, by whom and for whom? a) How are these values transmitted? b) How is this transmission measured? 4) Which **motivations** are taken into account? a) How are these motivations enhanced/dampened? 5) Is the knowledge transmission adequate to enable self-realization of individualized potential in the context of groups in public life? a) How is it measured? 6) What are some current overall sustainability problems related to these stakeholders **desires**? 7) How do these stakeholders **desires** relate to Fundamental Human **Needs** (including Transcendence) in increasingly larger contexts of self, social and environment? 8) Reflexivity: Which transmitted memes in the EP itself could account for these desires renewal (reinforcing feedback loops of hidden system invariants – "sacred cows")?

Appendix F Guide to the TSPD

"Sustainability Potential" Express Strategic Assessment - Education Programs

WHY?

Designed to assist education programs stakeholders, the **"Sustainability Potential" Express Strategic Assessment - Education Programs** (SPESA-EP)

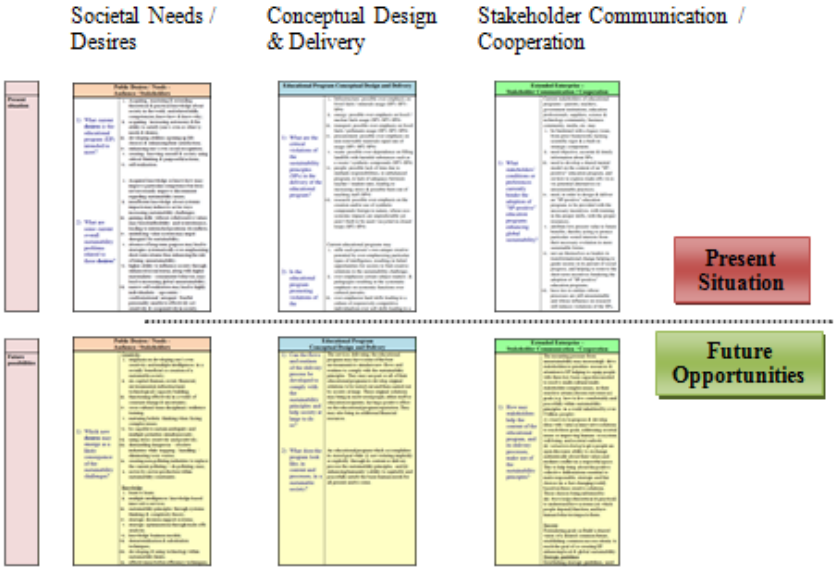
- lets stakeholders gain quickly, and in a straightforward way, an overview of persistent & sizeable **sustainability challenges** & **opportunities** in society; and
- facilitates an **informed creative communication** between stakeholders

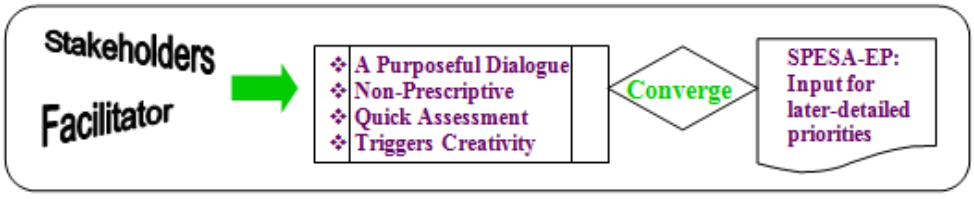
to support the creation of "Sustainability-Friendly" education programs in all fields.

WHAT?

The SPESA-EP consists of three questions-answers sets, each pertaining first to "**Present Situation**" and then to "**Future Opportunities**"

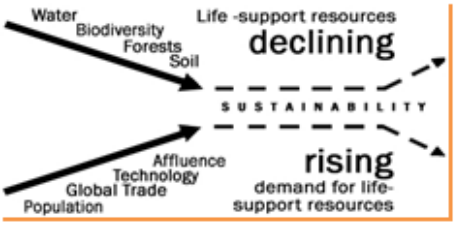
- **Set I** covers **Societal Desires / Needs**—Societal desires fulfilled by EP, and their relation to fundamental human needs
- **Set II** covers **Conceptual Design & Delivery**—"Strategic Life-Cycle Analysis" sustainability consequences of specific EP concepts fulfilling societal needs / desires
- **Set III** covers **Stakeholder Communication / Cooperation**—Societal stakeholders' situations or preferences influencing the EP conceptual design & delivery answering societal needs / desires





The Sustainability Challenge

Society is in the **FUNNEL**, a metaphor reflecting the rarefaction of choices as resources disappear.



Deeply embedded
systemic societal design shortcomings
create conditions for the erosion of

- the earth's physical ecosystems' ability to fulfill natural cycles humans are adapted to;
- the support for fundamental human needs.

The Framework for Strategic Sustainable Development

We create together our vision of the world we want, free of unsustainable activity, & from it
Elaborate the strategic action plan helping us, systematically & in steps, to walk towards it…

A continuously evolving systems-thinking strategic platform…
Created to help systematically decrease unsustainable actions in a straightforward way
To reach and then continuously meet the goal of a fully sustainable society

Needs: uses the Human-Scale Development theory of Fundamental Human Needs (FHN)
Overall system: uses the Five-Level Framework for Planning in Complex Systems (5LF)
Working conditions: uses the Sustainability Principles (SP)

In a sustainable society nature is not subject to *systematically increasing*

SPI. **concentrations** of substances extracted from the Earth's crust
(such as fossil carbon, metals, radioactive substances…)
SPII. **concentrations** of substances produced by society
(such as nanoparticles, endocrine disrupters, synthetic DNA…)
SPIII. **degradation** by physical means
(such as large scale clear-cutting of forests, over-fishing, fracking…)

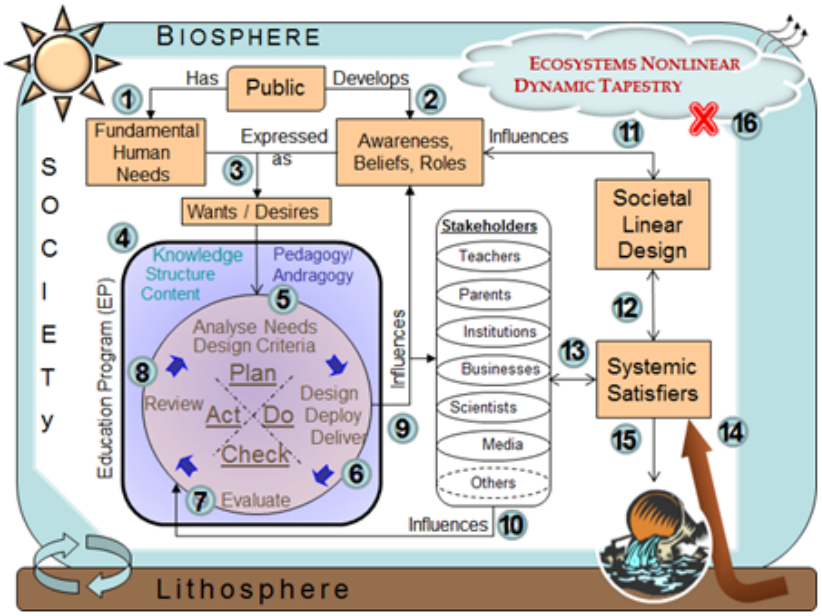
and, in that society

SPIV. people are not subject to conditions that *systematically undermine* their **capacity** to meet their needs
(such as from the abuse of power – armed, political, economic control…)
(Holmberg, John and Karl-Henrik Robert, 2000)

The SP define least binding constraints for society to "function indefinitely".
Working with them leads to a maximum of available options for society as a whole, indefinitely…

A High-Level View of an Education Program Life-Cycle

Simplified model of an EP life-cycle as a visual aid to conceptualize interactions & outcomes



1. Public has fundamental human needs (FHN).
2. It develops awareness, beliefs & roles & responds to events.
3. These may reveal themselves through the expression of wants or desires to satisfy those FHN.
4. Education Programs (EP) go through an evolutionary cycle of development.
5. *Plan Phase*: analysing the needs of the public, & establishing criteria for success.
6. *Do Phase*: designing the EP itself, deploying it to the public, & delivering its contents adequately.
7. *Check Phase*: evaluating the effectiveness of the EP.
8. *Act Phase*: reviewing EP activities in concert with stakeholders, to make necessary arrangements.
9. The EP delivery shapes the awareness of the public, its beliefs and roles. Stakeholders may be influenced in various ways according to their purposes / beliefs.
10. The stakeholders may influence the actions taken after the evaluation of the EP.
11. The awareness, beliefs & roles influence the design of society.
12. This particular design of society in many linear processes works at odds with natural processes.
13. Systemic satisfiers are never evenly distributed in society, tending to advantage some. This is unsustainable, as specified by SPIV.
14. Society extracts from the lithosphere the metals, minerals, fossil fuels, radioactive substances to fuel the production of goods, in a way which systemically increases the concentration of those substances in the biosphere. This is inherently unsustainable, as SPI states.
15. The systematic increase of compounds foreign to nature into the biosphere, fuelled by man-made incentives to indefinitely grow human patterns of production & consumption, result in an inevitably increasing destabilization of natural equilibriums. This runs contrary to fostering a durable society, as stated in SPII.
16. Those various linear production processes create vast ecosystems changes: some scientists say we have entered the Age of the Anthropocene, as mankind bears the responsibility of radically altering landscapes. This systematic undermining of irreplaceable ecosystemic functions is unsustainable, as stated in SPIII.

Value-Chain Impact Evaluation - Education Programs

Method

Description

Product-Service Systems (PSS) Value Chain analyzed through the Strategic Life-Cycle Management (SCLM) tool

Success Criteria

- facilitate a service perspective
- identify links of goods & services
- provide strategic steps to meet long-term socio-ecological sustainability
- be time and cost effective

(NY et al. 2012)

Layer 0 Public Frontline (Teachers)	1st Layer Back-Office (Education Services (ES) Personnel	2nd Layer Provider / Service Providers to ES	3rd Layer Provider / Value-Chains to Service Providers to ES	refer to TSPD Resource	SP1	SP2	SP3	SP4
Learning (knowledge - know-how - skill)				EP				
	Infrastructure							
		Construction Mgmt						
			Stone-Clay-Glass	Non-Metallic Minerals				
			Cement	Cement				
			Metals	Metals				
			Plastics	Plastics				
			Wood Products	Wood				
			Chemicals	Chemicals				
			Energy	Energy				
			Wastes	Wastes				
			Transport	Transport				
			...	...				
	Education Programs							
		Ressources Mgmt						
			Energy	Energy				
			Water	Water				
			Wastes	Wastes				
			Transport	Transport				
			...	...				
		Procurement Mgmt						
			Furniture	Furniture				
			Electronics	Electronics				
			Office Equipment	Office Equipment				
			Chemicals	Chemicals				
			Special Equipment	Varies				
			Live Organisms	Varies				
			Transport	Transport				
			...	...				
		HR Mgmt						
			Market					
			Transport	Transport				
			...	...				

Human-Scale Development & Fundamental Human Needs

WHY?

Human-Scale Development : a praxis meant to answer the question of **Poverty**

"Such development is focused & based on the satisfaction of **fundamental human needs**, on the generation of growing levels of self-reliance, and on the construction of organic articulations of people with nature and technology, of global processes with local activity, of the personal with the social, of plan with autonomy, and of civil society with the state." (Max-Neef 1989)

WHAT?

The Fundamental Human Needs

- Are absolute & common to all people regardless of gender, age, culture or wealth
- **Work as a system, in which individual or groups continuously assess trade-offs, simultaneities & complementarities**

Axiological needs	Existential needs
*Affection * Creation * Identity* *Freedom * Leisure *Participation* *Protection * Subsistence * Understanding*	Being ^ Doing ^ Having ^ Interacting

HOW?	Satisfiers are the relative means by which the FHN are satisfied. A satisfier may ○ satisfy one FHN → singular satisfier ○ satisfy several FHN or reinforce other satisfiers → synergistic satisfier ○ partially satisfy a FHN → pseudo-satisfier ○ satisfy a FHN while curtailing the satisfaction of other FHN → inhibiting satisfier ○ may act to deplete FHN → "depleter" or "destroyer" satisfier

FUNDAMENTAL HUMAN NEEDS & SOME GENERAL / EDUCATION PROGRAMS SATISFIERS

BEING & HAVING EXISTENTIAL MODES

Fundamental Human Needs	Being (qualities)		Having (things)	
	General satisfiers examples	Education program satisfiers examples	General satisfiers examples	Education program satisfiers examples
Subsistence	Physical health, emotional health, mental health, spiritual health	Autonomy, self-determination, reliability, virtue	Food, shelter, security	Endurance, people skills, organizational skills
Protection	Care, adaptability, autonomy	Tolerance, responsibility, adaptibility, autonomy	Social security, health systems, work	Self-control
Affection	Respect, sense of humour, generosity, sensuality	respect, honesty, generosity, gratefulness	Friendships, family, relationships with nature	Patience, flexibility, benevolence
Understanding	Critical capacity, curiosity, intuition	Critical capacity, thoroughness, intuition (not over-emphasizing rationality)	Literature, teachers, educational policies	Knowledge, discernment, teachers, education policies
Participation	Receptiveness, dedication, sense of humour	Justice, resourcefulness, receptiveness, dedication, dependability, diligence	Contributions, responsibilities, duties, work, rights	Contributions, enthusiasm, loyalties, discretion
Leisure	Imagination, tranquility, spontaneity	Imagination, spontaneity	Games, parties, peace of mind	
Creation	Imagination, boldness, inventiveness, curiosity	Creativity, boldness	Abilities, skills, work, techniques	Initiative
Identity	Sense of belonging, self-esteem, consistency	Authenticity, honesty, truthfulness, honor	Language, religions/ spirituality, work, customs, values, norms	Wisdom
Freedom	Autonomy, passion, self-esteem, open-mindedness	Autonomy, passion, self-esteem, open-mindedness	Inalienable rights, equal rights	Equal rights

DOING & INTERACTING EXISTENTIAL MODES

Fundamental Human Needs	Doing (actions)		Interacting (settings)	
	General satisfiers examples	Education program satisfiers examples	General satisfiers examples	Education program satisfiers examples
		Creativity (C) *Values-Expounding Dialog (V)* *Knowledge-Building (K)*		
Subsistence	Feed, clothe, rest, work		Living environment, social settings	Social environments
Protection	Co-operate, plan, take care of, help	Co-operate *(CVK)*, plan *(K)*, take care of *(CV)*, help *(CVK)*	Social environment, dwelling	Social environments
Affection	Share, express emotions, take care of, make love	Share, nurture, take care of	Privacy, intimate spaces of togetherness	Social environments
Understanding	Analyse, study, meditate, investigate	Analyse *(CVK)*, study *(CVK)*, investigate *(CVK)*, meditate *(K)*, making experiences *(CVK)*	Schools, families, universities, communities	Schools, universities, communities
Participation	Cooperate, dissent, express opinions	Cooperate *(CVK)*, dissent *(CVK)*, express opinions *(CVK)*	Associations, parties, churches, neighborhoods	Schools, universities, neighborhoods, communities, study groups
Leisure	Day-dream, remember, relax, have fun	Day-dream *(C)*, remember *(CK)*, relax *(C)*, have fun *(C)*, meditate *(CVK)*	Landscapes, intimate spaces, places to be alone, safe havens	Safe havens
Creation	Invent, build, design, work, compose, interpret	Invent *(CVK)*, build *(CVK)*, design *(CVK)*, work *(CVK)*, compose *(CK)*, interpret *(CVK)*	Spaces for expression, workshops, audiences	Spaces for expression, study groups
Identity	Get to know oneself, grow, commit oneself	Get to know oneself *(CVK)*, grow *(CVK)*, commit oneself *(CVK)*	Places one belongs to, everyday settings	Study groups
Freedom	Dissent, choose, run risks, develop awareness	Dissent, choose, run risks, develop awareness	Anywhere	Social environments

Fundamental Human Needs & example satisfiers (Max-Neef, 1989)

Appendix G China Findings Summary

i. TSPD dialogue in Youcheng:

At this stage the three templates of the initial TSPD were used in a case study done with several stakeholders in China. The study includes detailed result collection and information sorting, prior to the generation of key findings. These findings were helpful in modulating the Intermediate version of the TSPD, to yield the final TSPD.

Template 1

Present Situation: What current desires is the education program intended to meet? & What are some current overall sustainability challenges related to these desires?

- Practical skills for communicating the Grass-roots;
- Promoting the redefinition of the meaning of fulfillment of life, which might better include the material AND spiritual sides within society;
- Nurturing holistic thinking for all when facing complex issues;
- Shaping the awareness that people-oriented development should be taken as a foundational part in the overall development of society, especially for the developing countries;
- Playing the role of extra-curricular in shaping personality by introducing supplementary Values;
- Traditional schooling is an effective channel to approach the goal of influencing the public awareness that is currently popularizing in society;
- Engaging youth in sustainability education, especially for the very young age groups, this would cause long-term consequences and commitments towards sustainability.

For society: citizens' overall population qualities need to be enhanced by especially improving sustainability awareness for school aged children;
For economy: material civilization is over emphasized, not inclining to spiritual and ecological civilization;
For politics: State Interests are valued higher than civil society's desires;
For legislation: there is rarely the relevant laws or regulations to guide the public to act in terms of Systematical sustainability principles.

Future Trends: Which new desires may emerge as a likely consequence of the sustainability challenges?

- Shifting independent disciplinary into trans-disciplinary in order to make everyone a well-round person who knows well about overall truths and emotions;
- Integrating the participatory learning into the processes to better collect the first hand and intuitional information;
- Inheriting the traditional and marginalized culture;
- Innovating on the conventional education with new formats, norms and pedagogies ;

- Introducing the mentorship that focuses on the life experience rather than the simply reciting theories;
- Respecting the norms and preferences in different culture background while broadening and deepening the extent of national and international exchange processes;
- Encouraging the small-scale community driven learning and participation in the process of education;
- Promoting the diversity from contents to form throughout the education;
- Gradually inviting the remote online learning to partly replace the face-to-face learning to reduce the unnecessary economical and ecological footprints;
- Accepting various access to approach the original goal of education, like authentic dialogue and social media tools;
- Verifying the feasibility and replication of current success modes, then building the platform to spread such;
- Focusing on the capacity building of entrepreneurship and leadership.

Template 2

Present Situation: What are the critical violations of the sustainability principles in the delivery of the education program?

SP1:
- Fossil fuel use associated with on duty electric-vehicle use
- Fossil fuel use associated with mobility, transportation and distribution of learning process
- Hazardous substance derived from fossil fuels
- Materials and energy used in the processing and packaging of textbooks, guidebooks and other tangible substances

SP2:
- Chemical pollutants from research experiments
- Harsh material or by-product linked to human health problems
- Official equipment with especially plastic package or brand, is persistent
- Landfill-generated methane

SP3:
- Blind expending of the campus construction on the fertile soil
- Quantity waste from the implementation of education process
- Frequent on-duty flights leading to the loss of birds' sky space and climate change caused by high carbon footprint

SP4:
- A great many educators, especially in developing countries earn the income lower that the average level of all the sectors within current society
- Negative policies or economy impact on retention of teacher and enrollment of student around the world

- High tuition prevents students who lack a scholarship and other economic support to access a high-level education program
- Policies and constraints making students lose creativity and the right to dialogue
- Internet access imbalance influences the information delivery in different districts
- Lack of mentorship of life experience causing recipients to suffer through unwanted barriers throughout their lives

Future Trends: Can the flows and routines of the delivery process be developed to comply with the sustainability principles and help society at large to do so? & What new steps concluded are likely to shape the future debate about education program's delivery?

As it is revealed in some of the current status, here follow critical aspects from varied dimensions:

- Measure public awareness and attitude to embrace sustainability consideration into education;
- Deepen the extent of consensus by committing to deal with conflicts towards sustainability through education process;
- Clarify accountability and traceability when implementing education process;
- Balance diversity and uniformity to achieve sustainability in education and narrow the Inequalities and unfairness of resources allocation for all at large;
- Enhance teacher professionalism in developing rural areas;
- Challenge the current learning model that schooling acts as hub of education;
- Check frequently the involvement feedback to identify gaps between education objectives and actual performance.

Template 3

Present Situation:What stakeholders' conditions or preferences are currently hindering the introduction of more sustainable concept of education program?And what gaps can be identified as response to handle the sustainability problems throughout the external communication and lifecycle processes of the delivery of education program?

- Strengthen the link between international, national and private sectors to inquire the comprehensive and well-rounded agenda and to foster the human capacities building initially;
- Encourage the well-informed strategies of renewable energy utilization from the fundamental policies angles;
- Promote the climate adaptation and mitigation and eventually address the increasing and holistic challenges brought by climate change when education program is running;
- Support the information sharing mechanism to encourage public to independently resolve problems;
- Build the long-term sustainable visions and roadmap that social cohesion is finally cultivated and developed in an enabling atmosphere and stepwise stages;
- Foster international and intercultural dialogue in terms of sustainability to keep

diversity while realizing the desires of the rooted locals to preserve good traditions;
- Enhance the ability of media to transfer information in a free, fair, independent and transparent way, then leading to the public solidarity.

Future Trends: What future stakeholder preferences and conditions would emerge to influence the development of more sustainable contents of education program? & What future strategic value chain cooperation would be particularly favourable for dealing with the sustainability challenges?

- Educators: respect the core mission and initial expectation of society that the education practitioners should take the responsibility to raise the overall ability from both mental and professional aspects;
- Recipients: focus on the capacity building, like practical imagination and creativity;
- Communities: foster the inclusive development environment and adopt the tolerant attitude to diversity;
- Professional associations: draw public concern on how to change current education system and mental model;
- Research partners: seek for the innovative ways to resolve the pressing sustainability problems of education by gearing up the scientific research;
- Investors: synergize market function into sustainable education in a way that it can bring about return and solutions to current education;
- Government: establish relevant policies to assist the change of education;
- Media: facilitate the dialogue within the society to witness and push the process of sustainability in education;
- Competitors: introduce the reasonable, fair and positive mechanism of competition;
- Alumni: form the powerful community to share information and reinforce the impact of external social capital;
- Volunteers: promote pace of sustainable education for all by active involvement;
- Sponsors: apply the entrepreneurship and leadership in the charity and philanthropic career of education;
- NGOs: support the activities that are good for education towards sustainability lobbying stakeholders.

ii. ABCD Analysis:

Educators	
What is Sustainability?	Higher sustainability maturity than ordinary groups; Flexibility and adaptability to new mindset; Directly influence the viewpoints and values of recipients; Widely recognition that their roles in development of sustainable education;
What is Unsustainability	Comparatively low income in developing countries; Lack of holistic and unified views on sustainability; Shortage of a great many qualified education practitioners who master the specific expertise of sustainability; Potentially being killers who decline creativity of recipients when some of them prefer to limit the standard answers as either right or wrong; Over marketization, e.g. teachers in some areas have become the workers of education production line, which is opposite from the pre-position of people's soul trainer;
Envisioned Future	Selecting and mentoring students according to both emotional and rational aspects, the sustainability problems of current society are generated naturally from the rational designing of society; Escaping the constrains by thinking beyond current educational system; Attracting more well-rounded experts from every aspects of society;
Leverage to bridge the Gap	Increasing the financial investment of teachers as well as strengthening the rigor of recruitment processes by systemically thinking sustainability consequences; Preserving teachers by providing the platform for appropriate expertise development and ongoing training, as well as high autonomy, at all level sustainability maturity; Entitling them to break the constrains of current educational paradigm by speaking out their opinions and innovating the new mental model; Posing questions in an attitude of "no standard answers" while Not simply deny any forms of imagination, even fantasy; Reinforcing the cooperation with the qualified organizations; From the utilitarian views, it may just as well introduce the strategic sustainability to educators, because sustainability as a purpose or approach is not thing of metaphysics;

Recipients	
What is Sustainability?	Rich and unexplored imagination in their heads; Relatively border horizon;

What is Unsustainability	Exclusion or limited participation in the process to reform educational systems, especially for some groups; There exists some unreasonable standards of disparities and inequalities for target the resources and enrollment to the high quality programs; Considerable groups' intention to access to education is better facing the variety of selection assessment, so they would subconsciously exclude all the trainings except the capacity of ones where they can directly achieve high standard performance; Specifically for Chinese recipients, they are deeply influenced by Confucius and Mencius, so that they definitely have an explicit purpose to be educated, such as employment, politics. However, there is usually one and only limited grading system to judge their attainment, effort and potential, moreover, most people in society are imperceptibly going along with, even adopt these actions to inhibit the feeling of recipients, this automatically leads to the imbalance of fit human capital growing;
Envisioned Future	Mental health; Deeply involving the community activities; Comprehensively developing the overall diathesis; Applied and useful imagination; Sharing the life experience and every moments of happiness and depression in a place that they will be heard; Including grand-tour or gap year to experience the real life; Diverse choice for follow-up life; Involving some political issues to better understand the negative sides of the society; Cultivating inner peace and harmony status; Consensus on involving education for the reason of sustainability;
Leverage to bridge the Gap	Encouraging skeptical attitude; Explicit regulations to engage sustainability movement; Increasing the per capita investment and fair resources allocation for individuals; Developing new internal mechanism where the recipients' changing and expanding desires will be fully taken into account; Nurturing the ability of dialectical thinking and daring questioning; Innovating on the existing imagination not just for fun, but for serving the public; Participants should have the awareness that it is lifelong engagement, not just passing by once they get engaged with education programs; Glooming the sense of social responsibility;

Forms, Contents and Processes	
What is Sustainability?	Schooling have consistently been recognized the hub of sustainability spreading by normal people; Current education programs have certain core ideology that designed by the professional think tanks; From the economic perspective, education is typically for long term ROI, and it intends for a promising growth prospects; More and more people have realized that education is not only for knowledge transferring and assessing, but also the broader other extent;
What is Unsustainability	Few education programs go beyond missions to embrace a framework to move towards sustainability, or to ground scientific explanations about why sustainability should be emphasized; Most top management of education programs lack sustainability initiatives when make strategies, saying nothing of concerning on the updates and relatively new clues of sustainability, in this case, strategies had no theoretic and experience-based foundation but an ambitious intention; Globalization and standardization leavens the reforms of education more than ever before; Barriers emerge from communication like cultural identity, language; World at risk of fast transformation brings people a strong feeling of uncertainty on everything, education is not exception; Discrepancy between policy objectives and actual performance because critical strategies were unrealistically decided and vaguely stated, but the expected progresses were badly implemented; Lack of the processes to record and sort the relevant data on tracing the progresses towards ultimate sustainability; It is of biases that most involvers think it virtually unfeasibility to unify different backgrounds of educational systems as a universal entirety to face the intended reform of current educational systems; There is no specific societal desires, which are created spontaneously, for education programs, because education usually goes beyond, even drives the development of market and society; The contents of education and method of teaching runs far away from the practical demands of society sectors, it directly leads to the lack of human resources, different from the outer interpretation of surplus labors; Some education programs are designed into copy style or catch-up style regardless of the unique environment they based on;

Envisioned Future	A clustered loop to closely link the other sectors of society; Resourcing a feasible and attainable paradigm of sustainable education program; Contribution to create a society of shared knowledge; Education shouldn't be narrowly considered as a tool to employment in labor market, it should be one of the final pursuit of human, and be the top level of value chain, and be integrated into current monetary system, likewise, the insufficiency of education would be one critical type poverty; Transforming the education elitism to education populism, this may cause short term pressure on overall employment situation, but be meaningful and positive to raise the public awareness, additionally, serve for the long term policy objective towards sustainability; Active engagement of stakeholders, for instance, volunteers can be entrepreneurs, media intensifies the tools as value shaper in a sustainable way.
Leverage to bridge the Gap	Planting sustainability integrated objectives around each stages of education development; Educating in accordance with recipients' aptitude and fully scoping their attainments; Our society should learn to tolerate failure, welcome different views and aptitude; Phasing out the knock-out mechanism, it means discovering potential of every recipients; Introducing multichannel approach; Avoiding privilege and hegemony of any forms where imperative policies could be operated well without abetting individualization; Regulations to guide the competition; Seeking for indicators to evaluate the sustainable progresses; Applying the accountability and evaluation strategies; Building shared, neighborhood and sustainability integrated communities where every education involvers can sense the significance of sustainability; Capitalizing on the successful experiences of some regions in line with both the success factors and sustainability principles; Reinventing civil mobilization to strive for the spaces for open dialogue; Presenting the timely overview of achieved progress of education while strictly complying with the agenda established; Analyzing and comparing the periodic achievements in relation to societal demands, fundamental human needs, market desires in order to refine and adjust the possibly wrong approach towards sustainability; Shedding light on the human capital training about sustainability by community driven development mean; Deleting the middle chain to reduce the unsustainable impact; Avoiding educating in a way that seize a great many resources;

Prioritization --- PROs	Education reform is supposed to be accompanied by supportive policies and stand the scientific reasoning and democratic argumentation; There is no absolute equality except relative adaptation of current policy system and societal performance; Encouraging the dreamers who know themselves to do whatever they want to do as broad as possible within certain constrains; Nurturing the leaders of all fields for future development of society; Not expecting each recipient to concentrate on some field, and accept their diversity of any choices during and after the processes; The intention of recipients decides if education would become a method to occupy resources or other, so how to guide recipients thinking in right direction will be the priority to consider; It should encourage diversity of forms, contents, processes, and embrace the hybrid sharing of fund, administration, evaluation system, pedagogy, civilization, etc; Integrating the grass-root empirical education into the elitist education and providing the platform and resources for the vulnerable groups in case the monopolization by so called elites; Introducing the mentorship and entrepreneurship that is good for inner peace and outer skills of every recipients; Inclining the lever on the rural districts and poor groups to promote the poverty alleviation; Education can't live without market, and it drives the direction of market development in a management sense. Inversely education would prefer to be in line with markets as to realize sustainability of some dimension;
Prioritization --- CONs	Avoiding the competition without clear strategies and purposes; Political aims lead to the imbalance of education development; Elimination itself is a kind of process of education, we can't expect each recipient to be recognized authority of certain fields, as long, they can contribute their advantages to the society in any way; It is a wrong proposition that education can be industrialized through marketing, it just matters how effective education links market and in what direction it works out; education program was not created to cater to the market demands; Over market integrated development exacerbates the poverty situation or cause groups back poverty when education is made use of a method to plunder resources;

iii. China Survey Summary:

Current reality assessment was strictly implemented by the template of sustainable product development, and the four sustainability principles were used to outline the overall challenges or issues throughout the possible processes and contents of education program defined. In general, a series of preliminary findings can be drawn from the statement of practitioners as:

- As information bombs worldwide in contemporary times, for education itself, there are many more way to get solutions, share information than ever before, like mass media, internet, etc.;

- When spreading sustainability related knowledge, that how to make it interesting and useful should be considered as well as posing the significance of creativity, which somehow eases the education processes. However, it could not imply arts teachers are the ones who do well in spreading sustainability related knowledge, due to their normally low maturity of sustainability, all in all, it is also high time to raise the sustainability awareness of the public;
- Apparently, the public prefer not to consider sustainability education as down-to-Earth service, because the current education system influences bottom-line awareness of sustainability as extremely limited, there should be a sentence in mind: public awareness and nature experience decide what we can do and where we can move;
- To make the education more sustainable, the three critical stakeholders, education practitioners, recipients of young generation and governmental sectors, should play a crucial role in the process towards overall sustainability of education;
- In reality, it seems that education practitioners hardly feel satisfied about their income, in some way, this undermines the sustainability principle four that focuses on the human needs;
- Education programs should probably address the limitation of current education system in a participative, collective, interactive and multi-dimension way, rather than leave little space to embrace the weaknesses of recipients.

Appendix H CKMOV minimum set of necessary satisfiers to address complex issues

Table 1 shows possible ternary sets for the three semantic fields.

Table 1. Other possible ternary sets for the semantic fields

Realities	Past	Action	Thing	Reason	Event
Qualifiers	Present	Intention	Value	Emotion	Measurement
Possibilities	Future	Idea	Intention	Imagination	Idea
Realities	Quantity	Body	Context	Certainty	Vision
Qualifiers	Quality	Left Brain	Preference	Assessment	Qualification
Possibilities	Prospect	Right Brain	Choice	Probability	Perception
Realities	Action	Necessity	Scientists	Executive	We Are / Have
Qualifiers	Negotiation	Decision	Judges	Judiciary	We Should Be / Have
Possibilities	Intention	Possibility	Artists	Legislative	We Will Be / Have

The backcasting method is re-interpreted through the CKMOV model.

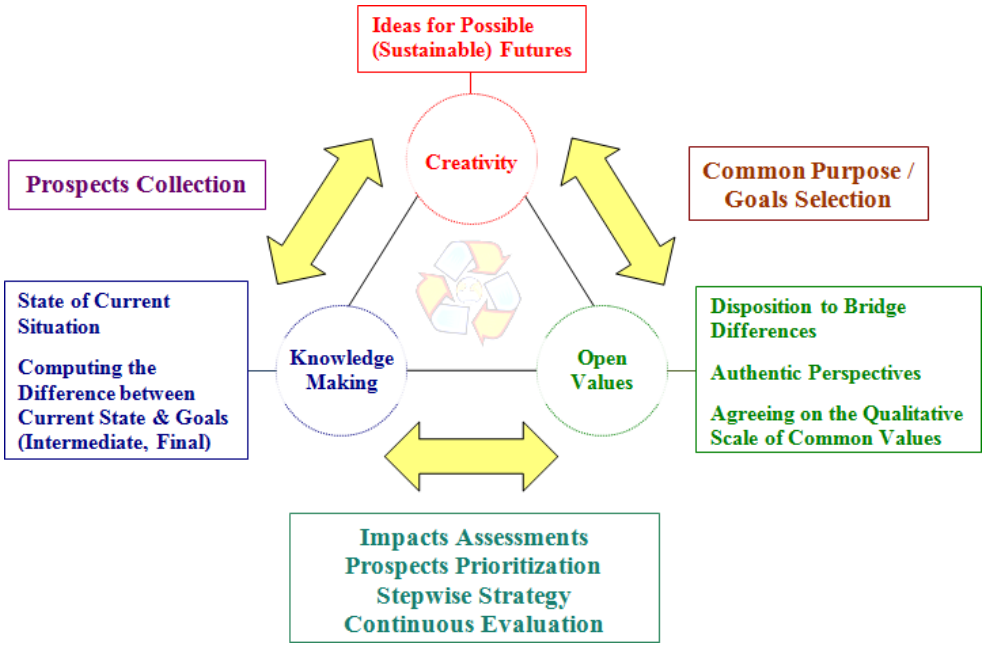


Figure 1. Re-interpretation of the Backcasting planning method

This re-interpretation takes each component of the method and envisions where each would fit within the CKMOV abilities model: semantic fields cover *states* or *outcomes* appropriate to their area of concern, whereas intersections between fields cover *processes* covering steps of the method.

Next, the forecasting method is re-interpreted through the CKMOV model. Creativity is pre-empted in this case compared to Backcasting, as the method emphasizes extending existing trends.

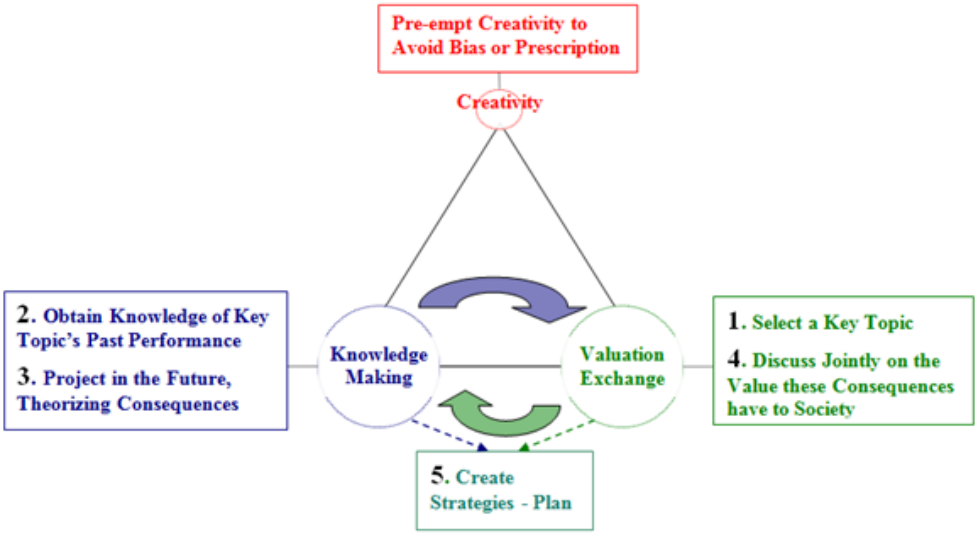


Figure 2. Re-interpretation of the Forecasting planning method

Appendix I Towards a similarity between the Sustainability Principles and the Education for Sustainability Principles

This table show a possible transposition of the Sustainability Principles to similar concepts in education. While the concepts do not map exactly one-to-one (as expected), the authors believe the ideas introduced in this work in progress may spark further creative insights.

The following correspondences are made:

- **1st Principle**: *Earth's crust ~ unconscious mind*. In both cases, a foundational support system that can also act as a gigantic reservoir of resources. Bringing these (substances in the biosphere / memes[1] in the conscious mind) into the biosphere / consciousness field yields potential, yet a systematic *non-integration* may strongly interfere with the well-adjusted harmonious processes tuning the whole system;
- **2nd Principle**: *society ~ other persons*. Here the well-adjusted processes are thought to be increasingly disrupted by the non-integration of crowding creations "foreign" to the eco-system / the psyche. Although source of creativity, change, and possible progress, the cost of complexity dealing with more and more non-integrated creations rises with this increasing source[2]. Tipping points are eventually reached (in non-linear fashion), returns diminish and the whole system may abruptly shift trying to reach a new equilibrium;
- **3rd Principle**: *eco-systems ~ sensory, cognitive processes*. The systematic degradation of healthy sensory and cognitive processes, although triggering mitigation and adaptation, interferes both with the quality and quantity of learning. It may be interesting here to study

[1] "Meme", as used here, refers mainly to the concept of discrete units of thought that propagate through evolutionary processes. Such units may have appeal, i.e. become popular, in a cultural ethos, yet may still lack awareness-expanding characteristics (sensationalist media memes provide many example)

[2] see *The Collapse of Complex Societies (New Studies in Archaeology)* from Joseph A. Tainter, 1990

possible similarities between natural bio-diversity / "cultural bio-diversity", as creative sources for Nature / learning processes;

- **4th Principle**: *needs ~ self / collective reflections, evaluations, practices*. In both cases, the realization of the 4th Principle depends partly on whether the other three are respected by system actors. If the first three principles are on average respected (i.e. *outcomes*, not means, are compelled to *safe operating zones* for humanity), then presumably the 4th principle may in the long term be more easily respected (since it would be safeguarded from systemic hiccups caused by spurning the first three).

Table 1. Similarity between the Sustainability Principles and Education for Sustainability Principles

	Sustainability	Education
	In a sustainable society, nature is not subject to *systematically increasing…*	For sustainable learning, persons are not subject to *systematically increasing…*
1st Principle	…**concentrations** of substances extracted from the Earth's crust	…**concentrations** of unintegrated memes extracted from the unconscious
2nd Principle	…**concentrations** of substances produced by society	…**concentrations** of unintegrated memes produced by other persons
3rd Principle	**…degradation** by physical means	**…degradation** of their sensory or cognitive processes by physical means
	and, in that society	and, in that learning
4th Principle	people are not subject to conditions that *systematically undermine* their **capacity** to meet their needs	people are not subject to conditions that *systematically undermine* their **capacity** to trust self, as well as collective, reflections, evaluations and practices

Appendix J Vivid Description and Stretch Goals

Vivid description
In the future, our education program is synonymous with sustainability. Sustainability, or the ability for Humanity to endure without a finite horizon, is embedded in its core. This aim is kept free from power politics, and economic means serve it. Our education program is looked upon as a role model when it comes to practices and standards... It is the education program of an unbounded time. Our education service serves a leading and important purpose in addressing the sustainability challenge while responding to the fundamental human needs of all society. We will participate in creating a resilient society that will endure through time within renewable limits, with the aim of protecting today's and improving tomorrow's peoples' well-being and prosperity. *Creative exemple of an audacious EP* : co-learners share an authentic experience using creativity, knowledge and values, multiple intelligences & all senses: "A fully sustainable trip around the world".

Stretch Goals	
Core Values within a Full Sustainability Global Vision, Informing a Strategy-Wise Mission	In order to decrease perpetual crisis mode peaking in periodic failure and reboot, to engage stakeholders in building a shared vision of a desired common future, and to anchor the mission as a strategic way to achieve this vision
To Evolve - Within Sustainable Limits	To engage the EP on a sustainability journey using the SPESA - EP and the CKMOV model, including Sustainability Principles in its revisions cycle while gradually reducing knowledge silos
Zero Footprint	To engage in a "Zero Footprint" program involving stakeholders by 2014, using the FSSD's Five-Level Methodology for Planning in Complex Systems - "Education Programs in society within the Biosphere". To set the goal within this program to achieve "Zero Footprint" by 2020
"Sustainable Organization in a Sustainable World" Strategic Action Plan	To apply the Framework for Strategic Sustainable Development and integrated tools (SPESA - EP) in developing a custom "Sustainable Organization in a Sustainable World" Strategic Action Plan to systematically reduce unsustainable activities while building prosperity and well-being. To follow this plan to achieve the "Zero Footprint" Stretch Goal
Enhance Learning Disposition	To foster the learning disposition in all stakeholders to co-learn/co-teach unsustainable practices out of human activities, while increasing prosperity and well-being
Three Pillars of 21st Education	To build trust at all levels by showing concern vis-à-vis stakeholders through a fair and competent process to enhance 21st century competencies: fostering fluency both in autonomy & relatedness, both in personal & inter-personal competence, in fairness & personal / inter-personal leadership through the systematic nurturing of three base abilities, as important to the 21st century as literacy was to the 19th century: Creativity, Knowledge Making, Open Values.
Enhance Public Interest and Governance	To serve the public interest by systematically enhancing the public's ability to develop critical thinking & ethical judgment, to fully become citizens of a globalized world whose resilience is assured by its diversity
Academic Independance	To anchor goal-setting interference by private interests, especially when a conflict of interest is plausible.

Appendix K Correspondence Between Research Questions Findings

Secondary Research Question I	Primary Research Question	Secondary Research Question II
Lack of shared unambiguous language and scientific success criteria on sustainability	**A systematic approach to "educate unsustainable behavior" out**	An educational program which accomplishes its stated goal while (i) not violating implicitly or explicitly through its content or delivery process the Sustainability Principles; and (ii) enhancing humanity's ability to equitably and peacefully satisfy the Fundamental Human Needs for all present and to come. A key feature is a shared learning experience leading to empathic engagement with others, and in extension, with the world
Over-emphasis on reductionism creating seemingly unconnected disciplines of study generates fertile conditions for the sustainability challenge, by marginalizing transversal studies, overlooking cause-effect relationships, and limiting the systematic and purposeful pursuit of sustainability to existing niches	**Fostering backcasting from Sustainability Principles**	
Education Programs Life-Cycle Model	**Systematic spiraling learning process**	
Over-emphasis on an homogenization of rational knowledge detached from shared ethical values, at the expense of fostering creativity and commonality of purpose	**CKMOV**	Content/Activities raising skills / practice in Creativity
		Content / Activities raising skills / practice in Knowledge Making
		Content/Activities raising skills / practice in Open Values
Systematic bias selecting specific content over fluency	**SPESA**	Education Programs and Learning Interactions Model
Social cohesion in question despite homogenization of knowledge and hierarchical control of education process		
Reduction of public investment resources per student		