Evaluation of Youth Competence in the Field of Sustainable Development: Lifecycle Approach

Evaluación de la competencia juvenil en el campo del desarrollo sostenible: enfoque de ciclo de vida

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ABSTRACT:
The ambitious goals for the sustainable future of the global community seek to ensure that “all learners acquire the knowledge and skills needed to promote sustainable development.” It is well known that questionnaire tests can serve as powerful incentives to prompt schools, teachers and students themselves to work towards centrally established education outcomes. Our efforts are devoted to the problem of youth sustainability competence assessment. The essential role of quantity is known for understanding the challenges at sustainability. Sustainable development is the subject of extreme complexity. Among the attempts to capture its main features and quantities, the technique of sustainability performance indicators is well recognized through the concept of Life Cycle Thinking. The life-cycle approach for sustainable development has been undertaken. It provides with well-based qualitative and quantitative outlook at sustainability challenges. Particularly, the assessment of youth sustainability competence has been undertaken towards continuous education system for sustainable development. The results of the study are concerned to the following themes: (a) the family of questionnaires to assess the sustainability competence, based on measuring knowledge, attitudes and behaviors, as well as

RESUMEN:
Los ambiciosos objetivos para el futuro sostenible de la comunidad global buscan asegurar que "todos los alumnos adquieran el conocimiento y las habilidades necesarias para promover el desarrollo sostenible". Es bien sabido que las pruebas de cuestionario pueden servir como incentivos poderosos para motivar a las escuelas, los maestros y los estudiantes mismos trabajar para lograr resultados educativos establecidos centralmente. Nuestros esfuerzos están dedicados al problema de la evaluación de la competencia de sostenibilidad de los jóvenes. El papel esencial de la cantidad se conoce para entender los desafíos en la sostenibilidad. El desarrollo sostenible es el tema de extrema complejidad. Entre los intentos de capturar sus principales características y cantidades, la técnica de indicadores de desempeño de sostenibilidad es bien reconocida a través del concepto de Pensamiento del ciclo de vida. Se ha emprendido el enfoque del ciclo de vida para el desarrollo sostenible. Proporciona una perspectiva cualitativa y cuantitativa bien basada en los desafíos de la sostenibilidad. En particular, la evaluación de la competencia de sostenibilidad de los jóvenes se ha llevado a cabo con un sistema de educación continua para el desarrollo sostenible. Los resultados del estudio se refieren a los siguientes temas: (a) la
1. Introduction

The challenges of the twenty-first century—resource constraints, financial instability, inequalities within and between countries, environmental degradation—are a clear signal that “business-as-usual” cannot continue. The Earth System is passing into a new phase of human experience that will be qualitatively and quantitatively different from the one we have known. Currently there is the first generation with widespread knowledge of how our activities influence the Earth System, and thus the first generation with the power and the responsibility to change our relationship with the Planet (Steffen W., Persson A., Deutsch L., et al., 2011). The level of education and skills is considered to play a key role in securing social cohesion, prosperity and sustainability in the long term. In this sense, “continuous education” has become the umbrella for all prospective training programs and initiatives. Equipping citizens with the knowledge and skills necessary to achieve their full potential, contribute to an increasingly interconnected world, and ultimately convert better skills into better lives is a central preoccupation of policy makers around the world (OECD, 2016). Followed by the similar treatment for the youth education, the concept “Generation for Sustainability” has been proposed that is the functional system with the objective of providing youth to be ready to participate at informed decisions for sustainable development, and to act upon these decisions (Kankkunen M., Makitalo-Siegl K., Voronov A., 2013). Over the past decade, the OECD Programme for International Student Assessment (PISA) has become the world’s premier yardstick for evaluating the quality, equity and efficiency of the youth education at the level of school systems. PISA recommends governments and educators to identify effective policies that they can then adapt to their local contexts. The ambitious goals for the sustainable future of the global community seek to ensure that “all learners acquire the knowledge and skills needed to promote sustainable development” (MFSDG, n.d.). It is well known that questionnaire tests can serve as powerful incentives for students to put greater effort into learning, particularly if the tests have direct consequences for students (Bishop J., 2006; Fuchs T. Woessmann L., 2007). For teachers, the standardized assessments provide a way to compare instructional objectives against the results achieved, and to compare the performance of their students to the performance of students elsewhere in the school system, so that teachers can tailor pedagogy accordingly. At the school level, achievement data can be used to determine how resources and additional support are allocated. They may also trigger intervention by higher authorities (OECD, 2016). Achievement data can also be used to inform the design of education policies, to create more efficient learning environments and to prompt schools, teachers and students themselves to work towards centrally established education outcomes, to provide the innovative curricula design (Kankkunen M., Mäkitalo-Siegl K., Timofeev F., Voronov A., 2016). Assessments can be used also to take stock of students’ performance in order to make decisions about future instruction or to summarize performance for information purposes (Voronov A., 2016).
Sustainability Performance Indicators technique is well recognized after ten-years history of Life Cycle Thinking (Valdivia S., et al., 2011; UNEP/SETAC Life Cycle Initiative, 2012). With the rational heuristic approaches, innovations well based on market theory now are available. Based on the multiple criteria approach, the models of the life cycle chain have been tested (Voronov A., 2011). This model is useful by using the economic, environmental, and social criteria and the innovative market instruments in combining private and public interests. The value chain consists of four stages: mining (Mi), production (Pj), consumption (Ck), treatment (Tl), and provides three markets for resources (R), goods (G), and wastes (W). Every market has supply and demand interests (private) as well as environmental and social interests (public). Two groups of criteria will control the noted markets: economic (by supply and demand), and environmental and social (by damage power). Methods and results of percolation research have a relationship with the structure of complex networks and its dynamics (Christensen K., 2002). At such approach, we can apply the “site percolation model.” The site is “sustainable” or “not sustainable” with a probability of “p or 1 – p.” Open cluster is a connected component of the open vertex graph. The network is said to percolate if there is an infinite open cluster. At the task of sustainability modeling, we have the network: \{Mi, Pj, Ck, Tl\}. It has been shown (Voronov A., 2015) that the critical probability (Δ = 0.20 ± 0.01) is tractable as the threshold, above which the global cluster appears, i.e. the network becomes global sustainable. In turn, the noted probability is the conjunction of three markets (R, G, W), being in equilibrium everyone with the probability “Ω”. The S-type function \( f(\delta) = \frac{4}{3} \times \delta - (\delta - \frac{1}{3})^3 - \frac{1}{27}, 0 \leq \delta \leq 1; \) with the side conditions for the function and its derivative: \( f(0) = 0, f(1) = 1, f'(0) = 1, f'(1) = 0 \) (Voronov A., 2015; Voronov A., Gridneva V., 2013). Therefore, one can find for the threshold value of \( \delta \) the relation: \( \Delta^{1/3} = f(\delta). \) The tested calculations have shown: \( \delta = 0.47. \) Below, the family of methods for measuring the competence of sustainability in accordance with life cycle thinking and threshold conditions is undertaken.

This approach is introduced under the strategy network concept that starts from “skills” (continuous education system for professional competence aimed to sustainable development), through “innovations” (market competitive advantages based on research and technology developments), to “infrastructure” (cooperative efforts for effective activity allocations). The relationship should be seen from a different angle. It should be considered as a necessary transformation of training efforts towards the integrative and holistic approach implied by a systemic view of sustainability in education and society. The society should be called for the urgent mass training efforts towards the Generation for Sustainability (Kankkunen M., Makitalo-Siegl K., Voronov A., 2013; Voronov A., Gridneva V., 2013; Kankkunen M., 2010).

2. Methods

At looking for the development of questionnaire to assess the sustainability competence, we have reviewed (a) “Measuring Knowledge, Attitudes and Behaviors towards sustainable development” (MKAB) (MKAB, n. d.); and (b) the globally accepted report “Indicators and a Monitoring Framework for the Sustainable Development Goals” (MFSDG) (MFSDG, n.d.). The starting point is to develop a questionnaire based at “MKAB.” Thus, the following is mentioned: “Knowledge” is all that is known, an organized body of information. “Attitude” is a way of thinking or behaving. “Behavior” means functioning in some specified way, and stressing the importance of sustainability factors in determining these acts. The framework lists the strategic perspectives and the connections between them that must inform
education and learn for sustainable development (MKAB, n. d.). As an example, these ones are the following:

“socio-cultural perspectives”, including

- human rights,
- peace and human security,
- gender equality,
- cultural diversity and intercultural understanding,
- health,
- HIV/AIDS,
- governance;

“environmental perspectives”, including

- natural resources (water, energy, agriculture, biodiversity),
- climate change,
- rural development,
- sustainable urbanization,
- disaster prevention and mitigation;

“economic perspectives”, including

- poverty reduction,
- corporate responsibility and accountability,
- market economy.

Tests of student’s knowledge, attitude and behavior concerning sustainable development should reflect the topics included into this list (MKAB, n. d.). Selecting the top-rated items from the noted three sets of items, 15 items measuring knowledge and 15 each measuring attitudes and behaviors have been tested. The decision predicate (“P”) is used by the respondent $P(\omega) = \text{True (T)}$, if its opinion on item “$\omega$” is in agree with sustainability, and $P(\omega) = \text{False (F)}$ if its opinion on item “$\omega$” is in agree with sustainability, and $P(\omega) = \text{Question (Q)}$, in other cases ($\omega$ is a sample from the set of items). An example of a decision:

**Knowledge**

$P(\omega) = T/F/Q; \ \omega= \text{“economic development, social development and environmental protection are all necessary for sustainable development.”}$

**Attitude**

$P(\omega) = T/F/Q; \ \omega= \text{“there is no point in getting involved in environmental issues, since governments and industries have all the power and can do what they like.”}$

**Behavior**

$P(\omega) = T/F/Q; \ \omega= \text{“I have changed my personal lifestyle to reduce waste.”}$

The experimental data:

$$K = \{K_{ij}\} | x_j, A = \{A_{ij}\} | x_j, B = \{B_{ij}\} | x_j$$ with $1 \leq i \leq l$, number of items, and $1 \leq j \leq J$, number of respondents, and having elements “T”, “F”, or “Q”. Based on the noted data, it will be possible to assess for every student (j) the current (before/after training) rate of sustainability skills by “Sustainability Competence Probability” (SCP), in the form:

$$SCP(j) = \left(\frac{RK(j)}{I}\right) \ast \left(\frac{RA(j)}{I}\right),$$

and $RK(j)$, $RA(j)$, $RB(j)$ are the values of “right” decisions at $K$, $A$, $B$ sets for student “j”. The last one could be based on statistic approach, because if $R$ is the number of right answers at the experiment of $N$ independent questions, then such result has the probability $P(R, q, N) = q^R(1-q)^{N-R}$, with the parameter “q” for the probability of individual right answer. Therefore, $\max\{P(R, q, N)\}$ by $q$ is $R/N$ that is the best experimental assessment for “the probability of individual right answer.”
3. Results

The experiments for identification of the students’ competence at sustainability theme have been undertaken.

The first part of findings is concerned on the implementation of the experiments with “Knowledge”, “Attitude”, and “Behavior”. The experiments have been provided with three groups of respondents. Group 1 includes high school students of 15–16 years old. Group 2 includes high school students of 16–17 years old. Group 3 includes university students of 19–20 years old. Group 3 has been tested before training (a priori), and it has been tested after (a posteriori) the appropriate training (a 72-hours course devoted to the discussions of “strategic perspectives, and the connections between them for sustainable development”). Before testing (a priori), Groups 1, 2, and 3 were provided with “short introduction” about the experiment’s targets, and briefs on sustainable development. Experiment arrangement: questions are represented by text (electronic screen) and by voice; answers are written (T/F/Q) at the prepared tables via the intensive mode (questionnaire decision is provided during reading the item). Further, we strongly emphasized at this stage that students’ responses would remain confidential. The experiment for Group 3 (a posteriori) has been provided via internet, and was not limited by time for decisions. The issued results are as the following:

- Group 1. The Sustainability Competence Probability, averaged by the respondents of this group (<SCP>), <SCP1> = 0.28
- Group 2. <SCP2> = 0.38
- Group 3 (a priori), <SCP3_apr> = 0.42
- Group 3 (a posteriori), <SCP3_aps> = 0.47

In view of the continuous education, the “Youth Sustainability Competence, YSCP” could be mentioned. For practicing at High School, an initial assessment of YSCP (a priori) was suggested, while after the undertaken training courses, as it was seen from the experiments, the resulting YSCP (a posteriori) increased meaningfully.

The second part of findings is about the applications of “transformation theory of learning” for adequate interpreting of the provided assessments. It involves the model look at the cognitive strategies that are applicable to many kinds of human creativity. The MKAB procedure did not appear to be more difficult against of 45 dichotomy decisions (15+15+15). The last one is required during the line ordering of 10 alternatives, because 10!/2!(10-2)! = 45 (i.e., the number of combinations from 10 by 2). The proposed in this study version of MKAB used the partial ordering (T/F/Q), which is less psychologically difficult because it could be compatible with the individual operative memory. Therefore, the intensive mode questionnaire was used (on-line). In turn, the complexity of MFSDG procedure is ten times higher against the complexity of MKAB procedure. It is for Questionnaires “Wellbeing”, “Efficiency”, and “Safety” like 245, 135, and 96 dichotomy decisions, respectively. So, MFSDG procedure must be used by off-line mode, e.g. by internet, when it is not limited by time, as well as the feedback is assumed to continue the “work with mistakes” by small group collaborations.

The third part of our findings is based on the values seen through the MKAB and MFSDG experiments. They explained the needs for the flow of sustainability information at any organization due to the continuous education that triggered the framework of life cycle thinking for sustainability of the economy. Now we are ready to consider the leading idea provided by the “dissemination principle”. While the quantities of SCP(j) are the random variables (e.g., for Group 3, a posteriori, the experimental probability is P{0.30 < SCP(j) < 0.63} = 0.68), the sustainability implementation mechanism is totally recognized if it has been adopted by the “main proportion” of the stakeholders being above some threshold level. The reviewed life cycle approach has identified the “threshold”, SCP0 = 0.47, i.e., it is the rate, the cumulative competent vote above which provides the sustainability perspective. Therefore, the experiments of this study show the “Rate of the respondents with the SCP not less of the critical level, being of 0.47, RSCP”, RSCP= 0.08, 0.29, and 0.38 for Groups 1, 2, and 3 (a priori), respectively. In turn, for Group 3 (a posteriori), we have found RSCP =
The fourth part of our findings is summarized in Figure 1, Table 1, and Table 2, where the unified functional structure of the proposed questionnaire is represented. They demonstrate the life cycle thinking triad for training (knowledge, attitude, behavior), and business (in the business community the term “the triple bottom line” was coined to explain the importance of achieving sustainability, having three dimensions: economic, social, and environmental) implemented by the functional elements – Data Base (DB-1, 2, 3, 4), as the sustainability principles and goals. Computation modules (CM-1, 2) are assumed for calculations of the quantities SCP, in accordance to the defined allocations between questionnaire items and right solutions (DB-5 – “solutions matrix”), and the quantities of RSCP, in accordance to the identified “threshold”. Control program (CP) with the human-machine interfaces (HMI-1 – input, HMI-2 – output) are assumed to organize MKAB/MFSDG procedures by local/distant mode.

### Table 1
MKAB procedure

<table>
<thead>
<tr>
<th>Module</th>
<th>Function</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>Respondents</td>
<td>Group of J students</td>
</tr>
<tr>
<td>DB-1</td>
<td>Knowledge items</td>
<td>15 items</td>
</tr>
<tr>
<td>DB-2</td>
<td>Attitude items</td>
<td>15 items</td>
</tr>
<tr>
<td>DB-3</td>
<td>Behavior items</td>
<td>15 items</td>
</tr>
<tr>
<td>DB-4</td>
<td>Sustainability principles</td>
<td>15 principles</td>
</tr>
<tr>
<td>DB-5</td>
<td>Solutions matrix</td>
<td>Complexity: 45 dichotomy decisions</td>
</tr>
<tr>
<td>CM-1</td>
<td>SCP computation</td>
<td>SCP(j) = (RK(j)/I)<em>(RA(j)/I)</em>(RB(j)/I)</td>
</tr>
<tr>
<td>CM-2</td>
<td>RSCP computation</td>
<td>RSCP =</td>
</tr>
<tr>
<td>HMI-1</td>
<td>Input interface</td>
<td>Visual, Voice, Written</td>
</tr>
<tr>
<td>HMI-2</td>
<td>Output interface</td>
<td>K={Kij}IxJ, A= {Aij}IxJ, B= {Bij}IxJ</td>
</tr>
<tr>
<td>CP</td>
<td>Control program</td>
<td>Local/Distant mode</td>
</tr>
</tbody>
</table>

### Table 2
MFSDG procedure

<table>
<thead>
<tr>
<th>Module</th>
<th>Function</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>Respondents</td>
<td>Group of J students</td>
</tr>
<tr>
<td>DB-1</td>
<td>Wellbeing indicators</td>
<td>49 indicators</td>
</tr>
<tr>
<td>DB-2</td>
<td>Efficiency indicators</td>
<td>27 indicators</td>
</tr>
</tbody>
</table>
Figure 1
Functional structure of the proposed questionnaire

<table>
<thead>
<tr>
<th>DB-3 Safety indicators</th>
<th>24 indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB-4 Sustainability goals</td>
<td>17 goals</td>
</tr>
<tr>
<td>DB-5 Solutions matrix</td>
<td>Complexity: 476 dichotomy decisions</td>
</tr>
<tr>
<td>CM-1 SCP computation</td>
<td>SCP(j) = KI(j) * KJ(j) * KK(j)</td>
</tr>
<tr>
<td>CM-2 RSCP computation</td>
<td>RSCP =</td>
</tr>
<tr>
<td>HMI-1 Input interface</td>
<td>Written</td>
</tr>
<tr>
<td>HMI-2 Output interface</td>
<td>Dmn (j)</td>
</tr>
<tr>
<td>CP Control program</td>
<td>Distant mode</td>
</tr>
</tbody>
</table>

4. Conclusions
The role of education in promoting economic well-being, with a particular focus on the role of educational quality, is well known. It has been concluded about strong evidence that the cognitive skills of the population – rather than mere school attainment – are powerfully related to individual earnings, to the distribution of income, and to sustainable economic growth. New empirical results show the importance of both minimal and high level skills, the complementarity of skills and the quality of economic institutions, and the robustness of the relationship between skills and growth. International comparisons incorporating expanded data on cognitive skills reveal much larger skill deficits towards the globalization challenges. The magnitude of the change needed requires major structural changes in schooling institutions. As to the skills for sustainable development, we need an education that takes us into the depth of things to provide the “Generation for Sustainability”. Sustainability
demands a specific kind of training. Sustainability Skills, as the “21st century skills”, is not just another issue to be added to overloaded curricula, but a gateway to a different view of curriculum, pedagogy, organizational change, policy and particularly of ethos. Followed by this, among the globalization challenges of 21st century the multidisciplinary information complexity that we need to attain the sustainability targets looks as the corner milestone. To solve a problem of the sustainability level, there is the need for a design activity, comprised of the collaborative multi-criteria decisions towards joining the multidiscipline knowledge. Attitudes are also important, and moreover, it is often necessary to change social structures to be ready for sustainability mode. Change in attitudes takes time and needs a place for observation and reflection on how attitudes influence our behavior and acceptance of ideas. We need to see the relationship the other way around, that is, the necessary transformation of training efforts towards the integrative and holistic approach implied by a systemic view of sustainability in education and society. Followed by such ideas, the undertaken life cycle conception provides us with a well-based qualitative and quantitative outlook at “Generation for Sustainability”. While there is debate about the testing and measurement of cognitive skills, most parents and policymakers alike accept the notion that cognitive skills are a key dimension of schooling outcomes. However, there is the question on whether this proxy for school quality—students’ performance on standardized tests—is correlated, and to which extent, with individuals’ performance in the labor market and the economy’s ability to grow. Until fairly recently, little comprehensive data have been available to show any relationship between differences in cognitive skills and any related economic outcomes. Such analyses generally require tracking individuals over time, a much more difficult data collection scheme. So our approach combined of empirical data (Sustainability Competence Probability, SCP) and the threshold model for life cycle sustainability (Life Cycle Thinking), provides innovative and reasonable outlook. Now we see that the nature of sustainability requires a fundamental change of epistemology, and therefore, of education, and the appropriate questionnaire development. The approaches applied so far have been shown to be necessary but not enough. The calls for the training activity comprised of the individuals’ interaction and supported by a system of decision making in small groups, combined with the specialized assessment methods is the most adequate avenue to open new horizons of embedding of Sustainability Competence into practicing of continuous education. In view of the continuous education, the probability of youth sustainability competence (YSCP), provided by the students at High Schools, is mentioned as the initial base for Higher Education towards the Generation for Sustainability. Therefore, by adopting the sustainability methodology, it could be possible to increase the mass rate of sustainability skills. The appropriate training and assessment procedures towards YSCP could be interpreted like the youth approach to the global inertial mechanism of sustainable development. The undertaken theory and experiments provided calculations and the unified functional structure of the proposed questionnaire, which showed the prospects for productive cooperation between High School and Higher Education to promote the sustainability progress through the life cycle approach. The introduced assessment value of the respondent rate with the SCP not less than the critical level (RSCP) could be mentioned as the determinate for every finite social group (e.g., class, department, school, etc.). Particularly, the sustainability dissemination could be realized through the decision rules based at the “competence of majority” principle. Therefore, the education target towards the Generation for Sustainability could be available by RSCP > 0.5 (the other option: “voting” practice could be required at RSCP > 2/3). The results for Group 3 (a posteriori) confirms that the roadmap moves the ideas of Generation for Sustainability to the reality by the enhanced continuous education system for sustainable development.

References

“Indicators and a Monitoring Framework for the Sustainable Development Goals (MFSDG)”
Date View December 17, 2017 www.unsdsn.org

“Measuring Knowledge, Attitudes and Behaviors towards sustainable development(MKAB)”.
Date View December 17, 2017 www.iisd.org

Bishop J. (2006), “Drinking from the fountain of knowledge: Student incentive to study and
learn–externalities, information problems and peer pressure”, Handbook of the Economics of Education, 2, 909-944


Kankkunen M. (2010) How to do more with less – an entrepreneurial Municipality Approach in Etela-Savo, the Center of Knowledge and Innovation Research (CKIR), Aalto University School of Economics, Finland.


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