Imprint

Research and Innovation in Education for Sustainable Development. Exploring collaborative networks, critical characteristics and evaluation practices.

January 2016
ISBN: 978-3-902959-08-9

Publisher:
Environment and School Initiatives - ENSI, ZVR-Zahl 408619713, Vienna, Austria
Editors: Wim Lambrechts and James Hindson
Proofread: Wim Lambrechts
Assistance: Günther Pfaffenwimmer
Lay-out: Walter Reiterer

CoDeS has been funded with support from the European Commission. This publication of CoDeS reflects the views only of the author, and the European Commission cannot be held responsible for any use which may be made of the information contained therein.
Challenges in evaluating sustainability aspects in complex science education programs in Hungarian primary schools

Mónika Réti
Hungarian Institute for Educational Research and Development, reti.monika@ofi.hu

ABSTRACT
This chapter describes a meta-research project using soft systems methodology (SSM) linked to a participatory development process of complex educational programs for all-day schools in Hungary. The project involved close collaboration between program developers, partner schools and a diverse group of external experts. Part of the project involved developing inquiry-based science education programs where partner schools used reflective tools to prepare modular learning cycles by using online and on-the-spot consultation. This process was supported, guided and evaluated through participatory action research (PAR) using convergent interviews. The SSM research (reflecting on PAR) highlighted challenges linked to incorporating, integrating and implementing elements of sustainability in a science education program. Dealing with complexity, choice of topics, a diverse understanding of sustainability and different emphases on aspects of sustainability were the most persistent challenges.

KEYWORDS
science education, soft systems methodology, sustainability

BACKGROUND
PARTICIPATORY DEVELOPMENT OF SCIENCE EDUCATION PROGRAMS
The Hungarian Institute for Educational Research and Development (OFI), with the support of Social Renewal Operational Programme: TÁMOP 3.1.1., developed a complex educational program for extracurricular activities in all-day schools through close collaboration with partner schools. In this three-year project, science education programs have been prepared based on a number of overarching priorities. The first was to use inquiry-based science learning based on the 5E-model. This model defines the inquiry cycle as a number of steps moving along a sequence: engagement, exploration, explanation, elaboration and evaluation (Trowbridge and Bybee, 1996; Bybee et al, 2006). Other priorities included supporting scientific thinking, educating for sustainability, the use of ICT, fostering parity and inclusion, and promoting international perspectives.
Defined by Section 6 of Government Decree 110/2012 (VI. 4.), a complex education program consists of seven elements: a pedagogical concept, a teaching-learning program, modular teaching-learning sequences, tools (student information sheets, webquests, etc.), assessment and evaluation tools (grids, checklists, reflective tools), a professional development program and a mentoring system. From these elements, the expert team developed the pedagogical framework (via a dialogue with experts and teachers), including success criteria (as a result of a Delphi research), a first version of the pedagogical concept, a proposal for the framework of assessment and evaluation tools, a professional development program and mentoring guidelines. These tools were refined through iterative cycles of trials, piloting and reflection. Then the partner schools prepared teaching-learning sequences (modular learning cycles) reinforced by online and on-the-spot consultation using reflective tools. This process was supported, guided and evaluated through participative action research using convergent interviews. Figure 1 highlights the main elements of the complex pedagogical program as a system (Falus et al, 2012).

Figure 1. The elements of the complex educational program

The science education team collaborated with 8 partner schools (involving 44 teachers and some 1100 students) throughout Hungary. These were all “all-day” schools. These schools, as opposed to regular schools in Hungary, are open from at least 7am to 4pm, and organise activities for pupils throughout the day. All-day schools are a sort of mix of an extended school and other types of open schools. This
way of operation was introduced by the new act on public education in Hungary in 2012: and all day schools offer a different model, new to Hungary. Lessons and extracurricular activities (as well as individual work, sports or relaxation) are part of the schools’ program, in a balanced schedule. In other schools, usually curricular lessons are in the morning hours (usually from 8am to 2pm) and after that the school may or may not offer extracurricular activities in the afternoon.

There were frequent visits to schools as well as collaboration through a digital platform. The modules were prepared by the teachers through intense dialogue and including differing levels of guidance from experts. The lessons were observed either by an expert team member or by another teacher from the same school. The process was guided by pre- and post self-reflection and self-evaluation, as well as peer evaluation. Negotiation and dialogues served as a basis for dynamic evaluation (Guba, Lincoln, 1989). There were at least two waves of action research in each school, one focusing on teachers preparing their own modules, another focusing on adapting a module prepared by another teacher from another school. Figure 2 summarises the main steps in the Research, Development and Innovation (RDI) process framework. Research was based a paradigm of initiating development by recognising and embedding innovative practice in the program (Checkland, 1992, Patton, 2011). Compared with the diagram the actual RDI process included more iterations between cycles of research and development itself.

![Figure 2. The research, development and innovation (RDI) framework of the project](image)

Soft systems methodology (SSM) was used in two ways. First of all, it provided an overarching framework for the RDI process, namely in designing the RDI framework and refining the “problematical situation” (Checkland, 1991) of creating an extracur-
ricular educational program. Secondly, it served as a meta-research tool allowing reflection on results from 22 different participatory action researches, conducted by 4 researchers. As became apparent, SSM as an action-oriented way of tackling dynamic situations (Checkland, 1972) proved to be extremely useful in dealing with differences between schools and individual teachers (which is even more explicit at a national level) and with priorities that cannot necessarily be tracked using other research approaches (Dick, 1999). This was especially relevant in the case of sustainability.

The complex science educational program worked with six priorities, of which some were more and some less, easy to measure. As for the science learning elements, the research team conducted a public Delphi research resulting in 10 success criteria, which served as a starting point for evaluation (Delbecq et al., 1986). Other tools measuring inquiry skills, scientific thinking and students attitudes were also adopted. The presence of inclusion, ICT and international perspectives in the learning environments could also be estimated, using clear criteria and checklists for observation (Dick, 1999). In the case of sustainability, the research team faced greater challenges in evaluation, despite the decision to adopt the criteria used by the Hungarian eco school network (which is based on the quality criteria proposed by Environment and School and Initiatives (Breiting et al., 2005)). As for sustainability learning, defining the need in a curriculum is already a challenge in itself, and top of that, local and individual indicators of learning and achievement can also vary a great deal. As our aim was to create a practical curriculum for schools, which was flexible enough not to be restrictive, but that would inspire teachers and students, space had to be reserved for local collaborations and approaches. At the same time, it was important to examine whether these local approaches still matched the sustainability framework and current values associated with sustainability.

This account is more a description of the learning pathway (and the engaging process) than of the actual result, which is best manifested in the actual educational program created in the project.

**FRAMING THE RDI PROJECT USING SOFT SYSTEMS METHODOLOGY**

One of the key perspectives of SSM is taking part in its practice in order to “understand and enjoy benefits” (Checkland, Poulter, 2006). SSM is about dealing with so-called problematical situations. These are complex settings of circumstances and actors who have different worldviews and try to act purposefully in a way that enquires about the problematical situation with the intention of identifying models
of purposeful activities within the context of certain worldviews. These may later serve as banks of meaningful questions that lead to a consensus of both feasible and desirable interventions:

“SSM is an action-oriented process of inquiry into problematical situations in the everyday world; users learn their way from finding out about the situation to defining / taking action to improve it. The learning emerges via an organised process in which the real situation is explored, using as intellectual devices – which serve to provide structure to discussion – models of purposeful activity built to encapsulate pure, stated worldviews” (Checkland, Poulter, 2006, p. 22)

In the case of designing educational programs the traditional approach is to define pedagogical aims and/or development goals, sometimes using participatory processes. The next step is to design the curriculum and to measure learning outcomes or other indicators connected to the success criteria originating from the pedagogical aims. Instead of this “clear approach” of designing a system based on pre-defined needs, the science education team in OFI chose a more dynamic approach. Based on experience from previous curriculum design and implementation processes, more effort and attention was put into defining needs before examining how elements of existing good practices and innovation that fit in the pedagogical framework could be integrated to the program. Finally the adaptation of various program elements in different settings was piloted and negotiated. This approach, similar to utilisation-focused evaluation (Patton, 2008) was already close to that of SSM, which translates into education as described below.

Although it might be an acceptable approach to construct a framework and then design a curriculum based on this framework, there is a risk that it might not respond to the cultural diversity of users and the systems dynamics of implementation (Kaufman and Herman, 1991). Usually this approach brings a danger of a deficit-policy, focusing on what is missing from the system at the time of creating the curriculum, and possibly neglecting some of the exiting needs and strengths of the actors in the system (ibid). In other words, curricula developed within this paradigm prove to be truly successful only provided that the system in every one of its elements corresponds to its initially supposed qualities - a lucky constellation of learning environments, student groups and teachers. Furthermore the deficit of knowledge-skills-competences should also consociate with challenges reflected by the development tasks in the curriculum.
In less fortunate cases when all these factors do not match properly, further efforts are required for implementation. Even provided that these are sufficient, cases may emerge when the culture of a learning community makes it difficult for the curriculum to work efficiently (Patton, 2011). Therefore, in a process that allows more flexibility for a curriculum and that includes practical approaches to tailor it to social and local aspects of the learning environment, the implementation of an educational program might mean fewer challenges. Additionally, in the case of sustainability, these aspects represent a substantial role in shaping an appropriate learning environment. On top of these, integrating sustainability as a priority area in an educational program involves future thinking, which by its own nature questions the relevance of pre-defined solutions.

SSM as a framework offers solutions to describe models through exploring the state-of-the-art and current practices, using divergent approaches to become suitably cohesive (Checkland, 1991). It also means that SSM does not offer one solution or the only solution that solves a challenge once and for all. Rather, it assesses possible solutions, the adaptation of which can lead to a continuous progression towards desired changes.

![Figure 3. Soft systems methodology translated to creating an educational program](image)

The overall learning journey taken by the project is shown in Figure 3 where the need for complex educational programs is represented as the real problematic situation. The purposeful activity models include good practices recognised in the system, together with elements such as didactics, teaching methods, useful contents
or project ideas that can be attained by teachers when adapting the modules of the educational program. Another element that can be included here is assessment.

The desired change is a flexible framework of teaching-learning sequences. In this case these are modules, individual units of learning cycles, ready to be adapted by teachers. Also included is a supporting framework for adaptation made up of a complete pedagogical concept and tools such as checklists, evaluation grids, assessment framework, and a set of tools guaranteeing a systemic approach of professional learning. These offer meaningful solutions to the extracurricular time in all-day schools and focus on inquiry-based science and sustainability learning in an inclusive manner.

**Methodology**

Peter Checkland described SSM as a process consisting of multiple iterative cycles (Checkland, 1972). Since this initial description, SSM has become a divergent concept and because, according to Poulter and Checkland (2006), a number of “misunderstandings and inaccuracies” (Poulter, Checkland, 2006) have crept into the process it was decided to use the original concept to guide the project. It was also decided to include a number of other research tools and techniques at points where more clarification or a more thorough investigation was needed in order to refine the results. This section gives a brief overview of how SSM was applied in this project, together with description of the other tools that enriched the inquiry journey. Four steps are described:

1. Explore a problem situation and existing activities, including influential factors such as cultural and political aspects. When engaging in SSM, the researcher facilitates the learning procedure of the groups constituting the system, while continuously and systematically observing and reflecting on the process, the progress and the dynamics. This can be summarised as a set of four main steps. It should be kept in mind that these steps are not linear, but are interconnected iterative cycles and in practice it might be needed to revisit a certain stage several times during the process. This was the experience of this project where steps 1 and 2 were revisited a number of times.

2. Define relevant activities and interventions and create intervention or activity models from these. Beyond making a root definition SSM uses different tools for establishing the model such as the PQR formula (do P by Q in order to contribute to achieving R), assessing CATWOE (Customers, Actors, Transformation process, Worldviews, Owners and Environmental constraints), and the 3E model (Efficacy,
Efficiency, Effectiveness). These serve as organising principals for a matrix of solutions.

3. Pose questions and test the model against the problematic situation. Detect answers and explore directions of development.

4. Establish feasible and desirable activities and interventions. As all of the above involve changes in the problematic situation itself, it also means that at this point it is possible to withdraw further work using SSM. This will not stop the process as an iterative cycle can start at this point.

In this project, in addition to applying traditional SSM tools, other research tools were also used. In a classical approach these can be seen as pre-intervention, process-embedded and post-intervention research activities. In the case of this project they all contributed to a more profound understanding and reflection on the SSM process.

Before starting the actual work in partner schools and in order to better explore the problematic situation, data available online was collected from 800 schools in Hungary, structured interviews with school principals were held and focus groups interviews with teachers were conducted. An environmental scan using Manninen et al.’s model of learning environments was also undertaken (Manninen, et al., 2007). The information gathered proved to be useful in the diagnostic phase of the participatory action research. This data was also used to establish different degrees of participation. Ten success criteria for science learning in primary schools in Hungary were also identified, using a public Delphi research. These criteria served as a reference point as well as a basis for reflective tools for teachers.

Partner schools were committed to participate in the collaboration and were provided with some financial support as well as professional guidance as part of their contract with the Hungarian Institute for Educational Research and Development. With the participatory action research (PAR), the Deakin model was used (Denzin, Lincoln, 2011), with the aim being to conduct at least two waves of research consisting of three cycles in each partner school. In some schools, where the organisational culture and former experience allowed, up to six waves of PAR were conducted, with up to five teachers participating in each. All in all, 22 teachers from 8 schools participated in the PAR, conducted by 4 researchers. In the planning phase of PAR, educational programming (Duit, 2005) was used as a framework for dialogue between researchers and teachers. It was also decided to use convergent interviews (Dick, 1990) in order to gain data about the changing culture and politics of the problematic situation and to gain an insight
to different the worldviews that effect those changes. PAR resulted in a rich set of data, which helped to revisit previous stages of the development (McIntyre, 2008), including reflections on (and refining modifications of) the pedagogical concept, the professional learning framework (concerning reflective tools, for example), the approach used for assessment and evaluation and the tools needed for successful adaptation (guidelines, checklists, hints and ideas) (McKernan, 1991, Reardon, Bradbury, 2008).

Meanwhile, teachers participated in a professional development course. Feedback from the course was provided using a set of reflective tools, an online questionnaire and deep interviews about the culture of professional learning they recognise and apply. After a year of fruitful collaboration with partner schools another research strand emerged: using grounded theory in which a team member explored teachers’ declared pedagogical aims.

All this information contributed to another phase of piloting involving 6 schools from the original 8. The main challenge for re-starting the SSM cycle was to provide meaningful reflections on the whole educational program and to further pilot, with opportunities to adapt the modules to specific educational settings in primary schools (grades 1-8). Revisiting the program led to a firmer basis of recommendations. (Patching, 1990)

**The learning journey of addressing sustainability via science education**

The main challenge in creating the educational program was therefore how it is possible to activate and build on existing elements of good practice professed by partner schools and which also corresponded to international trends, steering documents of educational policy, and last but not least the Ministry of Education’s expectations of such educational programs. Although the priorities remained unquestionably relevant, the first phase of SSM identified a number of tensions and gaps between these theoretical models and their representation in actual classroom practice. This called for many cycles of refining the desired interventions during the SSM process. These perceived tensions also led to a re-designing of the RDI framework with the participation of partner institutions.

This process itself modified the root definition of the problematic situation. The main challenge became, how the modules or the core elements of the educational program could be developed in collaboration with the teachers of the partner schools in a way that they refer to the success criteria and the six priorities of
the pedagogical concept: scientific literacy, inquiry based learning, ICT, inclusion, sustainability and international perspectives.

Figure 4 shows the process of SSM from sustainability learning aspect.

![Figure 4. Soft systems methodology translated to sustainability in the science educational program](image)

In each school the practical work started with a group discussion between the researchers and teachers involved in the collaboration, reflecting on the priorities and the overall approach presented by the educational program. Then the teachers decided on the topics they wanted to work with, and using a template called a target document, drafted the pedagogical aims, main development tasks, indicators and key steps of the inquiry cycle. This document was revisited by the group of researchers and teachers and as a result a lesson plan emerged. The teachers then piloted the lesson with one class, after which they reflected on their experiences with the guidance of two other templates. Based on this reflection as well as peer feedback from colleagues present at the pilot lesson, they finalised their lesson plan. In this way, 160 modules were prepared (each covering 3-5 lessons) during the year of collaboration. Out of these 160 modules, 34 were developed in PAR. In addition, each teacher was asked to pilot 10 modules prepared by a colleague from another school and use the same reflective templates.

The research team then assessed the reflective templates, which again led to a reconsideration of the problematic situation. During this process the points at
which further assistance or guidance was needed became increasingly clear. It also became apparent which were the most challenging aspects of such an educational programme for teachers.

As for sustainability learning, environmental awareness was strongly present in the modules as well in the reflections, while social responsibility and community learning were less emphasized. It also seemed that individual learning and affective elements of sustainability learning are clearly and strongly present in the first grades of primary schools, but after that they diminish and by grades 7-8 practically disappear. This might be due to the fact that in grades 1-4 an integrated, complex approach is taken to natural sciences that also includes elements from humanities, social studies and individual development, whilst in grades 5-6 there is a more specific focus on natural sciences, and in grades 7-8 students learn the distinct subjects of Biology, Chemistry and Physics.

Another challenge was opening to local communities. It seemed that some schools have already established a practice of inviting representatives of the local community to participate in and enhance the learning process of the students. In these cases, the regular practice served as a good basis for initiating collaborative learning linked to science education and sustainability. However, even in these cases, partners failed to recognise the potential of collaboration in creating mutual learning experiences for all partners involved. In other schools, where the link to local communities was not explicitly present, it seemed to be a question of transforming the school politics (of empowerment and responsibility) concerning efforts to initiate such learning occasions.

These examples illustrate some of the challenges faced during the learning journey. In the educational program these were addressed using assessment tools and checklists concerning the learning environment (especially the social and local aspects), the collaboration culture and the inclusion. In addition reflective tools were also offered to school principals and teachers in these areas. However, it was decided not to prescribe a specific degree of participation or collaboration in the teaching-learning program. Instead, a showcase of many possible levels in the 80 modules of the educational program was presented, leaving it to the schools and the teachers to opt for the ones that best served their needs and intentions. Moreover, empowerment and genuine learning experiences in the professional development and mentoring program were also offered.
In addition to creating inspiring learning environments, which extracurricular programs are especially capable of doing, even in regular formal school settings (Dumont et al., 2010), other issues emerged. One of the most important of these was the teachers’ diverse understanding of sustainability. An interesting aspect of this was, that while they are aware of the global context of the local problems observed, other aspects (such as regional, national or European) were not at all present in their declared teaching aims or reflections. Another aspect of sustainability involved addressing complexity. While teachers were well aware of different aspects of sustainability (such as economic, social, environmental and cultural), in the proposed activities usually only one, or in best cases two were explicitly present, usually with the intention of “not to confuse students”. It also seemed that in lower grades teachers had to put a considerable effort into understanding transdisciplinary issues due to lack of sufficient subject knowledge. This is in contrast with teachers of grades 6-8 who often possessed the necessary subject knowledge but lacked the intention to think in a transdisciplinary manner. These teachers often claimed that it was “the curriculum which prescribes this”, despite the fact that the Hungarian national core curriculum is organised around cultural domains, not in school subjects, and that in this project the aim was to develop an extracurricular program. Complexity also seemed to be a sensitive issue in terms of assessment, especially by subject teachers who were uncertain whether they were qualified and responsible for assessing aspects of learning other than those related to students’ learning outcomes in their subject areas.

An ongoing debate was generated about whether or not certain topics might qualify for both science and sustainability with often the claims being that they were not “scientific enough” (for example, in the case of transport) or that they fell into another related cluster of education, such as environmental education, social learning or global education. It seemed that these labels often disempower teachers. Therefore, it was decided not to use the originally intended “education for sustainability” label, but to propose leading questions to consider whether or not the teaching-learning material had this aspect.

It was also interesting to observe how the emphasis differs between the three aspects of sustainability in teaching-learning contexts: regular eco-school activities or science learning; regular classes or extracurricular activities; only school activities or school-community collaboration; different age groups; homogenous or heterogeneous (mixed) groups of students and classroom or situated learning. It seems that teachers have strong hidden curricula for these different educational settings. At
the same time it was found, that loosening the framework and settings helps teachers overcome these mental barriers. When working in out-of-school settings with external partners (including members of the local community such as experts of any kind or parents) and/or heterogeneous groups of students, teachers seem to be more open to complex issues, while being more able to tackle the transdisciplinary approaches and the assessment topics emerging from these.

**SUSTAINABILITY AS A PRIORITY IN A SCIENCE EDUCATION PROGRAM**

Through some of the results of this SSM research, a number of challenges linked to incorporating, integrating and implementing sustainability elements in a science education program have been highlighted. The team did not intend and never managed to provide a recipe for achieving this, however, the results have demonstrated the following:

1. Sustainability can be an integral element of a science education program.
2. Topics related to sustainability are not only relevant for science education but offer a new way for teachers to engage students in science learning.
3. An action-oriented approach offers ways to include a diversity of students, as well as the affective elements of sustainability learning. Based on student interviews and pre- and post-intervention tests it can be claimed, that low-achievers, students from disadvantaged backgrounds and those from minority groups engage in learning more effectively when sustainability aspects are present in science learning.
4. Students realise the relevance of science learning much more effectively if confronted with local sustainability issues. This experience becomes yet more relevant if they also have a chance to engage in problem solving.
5. Empowering teachers in experimenting with open learning experiences and diverse, non-conventional learning environments leads to a better addressing of sustainability learning issues.

With this three-year project only a few steps have been taken so far, but the research team is convinced that the topics and pedagogical approach present in education for sustainability and related pedagogies may offer renewal and a way of re-defining its role for science education in the future.

**ACKNOWLEDGEMENTS**

To my colleagues in the science education team (Judit Czuczor, András Lénárt, Anna Majer and Boglárka Vadas), in the project team (Edit Sinka and Attila Varga PhD),
all experts contributing to professional dialogues and negotiations and the 44 teachers and the 8 school principals sharing (enjoying and sometimes suffering) our three-year learning journey.

REFERENCES
és felhasználók kézikönyve. Budapest: Educatio (The pedagogical system. A handbook for developers and end-users.)


