TEACHING SUSTAINABLE ENERGY IN PRIMARY SCHOOL: A GLOBAL LEARNING APPROACH

M. Carli, C. Luisetto, O. Pantano

University of Padova (ITALY)

Abstract

Safeguarding the environment represents a challenge no longer avoidable for present and future generations. This work presents an educational intervention in a fifth grade classroom with the aim of making students aware of problems related to the consumption of energy, adopting a global-local perspective. Among the different possible approaches, reference was made to the Global Learning framework, that emphasises how the actions of the individual have an effect both locally and globally, as he/she is part of an interconnected system. To evaluate the intervention, data were collected through multiple tools, in considerations of the multiple dimensions involved (cognitive, reflective, metacognitive, self-regulating). Specifically, an observation checklist was used to evaluate the behaviour and attitudes assumed by the children during the activities, while an objective test was used to assess knowledge and skills. Finally, a qualitative analysis was made on some aspects of the children’s personal logbook, a semi-structured instrument that accompanied the children’s reflection. The results suggest that the children participated actively in the proposed activities and were able to discuss and reflect on relevant sustainability issues, transiting from a global perspective to a personal perspective, and back to a global one. They became aware that individual choices and behaviours have a relevant impact on the Planet Earth, and showed willingness to act.

Keywords: sustainable energy, electricity, sustainable development, global learning, primary school.

1 INTRODUCTION

Environmental problems have been considered at the political level since 1988, when the Intergovernmental Panel on Climate Change (IPCC) was established. In 1992, the first Conference of the Parties (COP1) was held in Rio de Janiero. Since then, many conferences were held on an annual basis, some of which produced milestone international agreements [1-3]. These global actions are necessary, but not sufficient: real change requires the action of each individual, who needs to reflect on his/her habits in order to understand how they can be improved in a more sustainable perspective. This is where education comes into the play. The term “environmental education” was first introduced in 1969 by W.B. Stapp as “aimed at producing a citizenry that is knowledgeable concerning the biophysical environment and its associated problems, aware of how to help solve these problems, and motivated to work toward their solution” [4]. In 1977, the Tbilisi Declaration [5] stated that environmental education should be global, multidisciplinary, provided for all ages and levels of education, and addressed to the whole community; it should have the purpose of linking knowledge to action, through a process of assumption of responsibility and individual awareness, while not neglecting the interdependence between national communities. The Tbilisi Declaration was the basis of the educational component in Agenda 21, the framework for action adopted in 1992 by the United Nations Conference on Environment and Development [6]. In September 2015, the United Nations approved the 2030 Agenda for Sustainable Development [7] containing 17 Sustainable Development Goals and reaffirming the importance of education for their achievement. It is in this framework that didactic interventions on environmental education are designed and conducted, with the school acting as the main educational agency that has the task of training future citizens of the world.

2 METHODOLOGY

2.1 Background

2.1.1 Environmental education

Since the concept of environmental education has been clarified, many programs on this topic have been proposed [8]. As outlined above, one of the purposes of environmental education is "linking knowledge to action": however, the relationship between the two is not obvious. Most interventions
have been based on improving people's knowledge, believing that people are poorly informed about environmental issues, and that they would adopt more positive behaviours if they were more informed [9, 10]. However, Jensen [11] claims that “knowledge” should not be limited to content knowledge: in fact, this kind of knowledge alone is unlikely to lead to action, and can even produce a sense of resignation and powerlessness if not supported by an analysis of the causes and strategies for change. The author claims that action-oriented knowledge should be developed on four dimensions:

- Knowledge about effects: What kind of problem is it?
- Knowledge about causes: Why do we have the problems we have?
- Knowledge about strategies for change: How do we change things?
- Knowledge about alternatives and visions: Where do we want to go?

Frick [12], identifies three types of knowledge to assess environmental knowledge, that partially overlap with those identified by Jensen: system knowledge, related to how ecosystems operate (“knowing what”); action-related knowledge, i.e. the knowledge of behavioural options and possible action (“knowing how”); and effectiveness knowledge, that investigates the impact of a particular behaviour. Liefländer et al. [13] implemented these three dimensions together in an educational programme on water issues, observing a positive learning gain in each knowledge dimension and in terms of integration of the dimensions. Tasquier and Pongiglione [14] focussed on the influence of causal knowledge on the willingness to change attitude towards climate change, based on the hypothesis that the individual does not understand his/her role as causal agent and therefore doesn’t know how to take action. However, many studies suggest that the factors underlying sustainable behaviour involve more domains besides that of knowledge. O’Connor and Pooley [9] claim that an individual’s action towards the environment is based on three dimensions: affective, cognitive and behavioural, all of which have to be taken into account when designing an environmental education programme. Boyes and Stanisstreet [15] investigated the relationship between students’ beliefs about the usefulness of specific actions and their willingness to adopt them, finding that, in some cases, altering a student’s belief has little effect on their willingness to act. Another aspect in this regard was highlighted by Aarnio-Linnanvuori [16], who states that emphasising individual behaviour may result in feelings of guilt and a focus on ineffective activities. Finally, Carmi et al. [17] showed that environmental knowledge can drive environmental behaviour only if it arouses emotions.

2.1.2 The Global Leaning framework

Among the possible approaches to environmental education, we focused on the Global Learning framework. This approach recognises and integrates all the aspects underlined by research on environmental education, highlighting the fact each man or woman is part of an interconnected system, in which global issues are linked to the local ones [18]. Specifically, the Global Learning framework focuses on the following eight key concepts [19]:

- **Global Citizenship**: gaining the knowledge, skills and understanding of concepts and institutions necessary to become informed, active, responsible citizens.

- **Conflict resolution**: understanding the nature of conflicts, their impact on development and why there is a need for their resolution and the promotion of harmony.

- **Diversity**: understanding and respecting differences and relating these to our common humanity.

- **Human rights**: knowing about human rights including the UN Convention on the Rights of the Child.

- **Interdependence**: understanding how people, places, economies and environments are all inextricably interrelated, and that choices and events have repercussions on a global scale.

- **Social justice**: understanding the importance of social justice as an element in both sustainable development and the improved welfare of all people.

- **Sustainable development**: understanding the need to maintain and improve the quality of life now without damaging the planet for future generations.

- **Values and perceptions**: developing a critical evaluation of representations of global issues and an appreciation of the effect these have on people’s attitudes and values.
The Global Learning approach takes into account the entire human society and the context where the students live, placing the emphasis on the future, on the dynamics of human society and on the ability of the individual to choose and shape their own future. Furthermore, it invites teachers to promote cooperative learning aimed at action and shared responsibility in order to develop positive and responsible values and attitudes and active participation. This perspective resonates with the concepts of Global Citizenship used by Oxfam [20] and the EU Global Education Guidelines [21].

2.1.3 The concept of energy

When talking about environmental issues, energy is one of the topics that immediately emerges. The concept of energy is central in physics and physics education. In fact, energy has been recognised as one of the four core ideas for the Physical Sciences by the K-12 Framework of Science Education [22]. Also in the Italian National Standards [23], energy is recognised as one of the central content organisers even for kindergarten and primary school. Despite its keynote importance, this concept is one of the most difficult to understand [24] and there is lack of consensus among experts in physics education about its definition and what aspects should be emphasised at each school level [25]. This confusion is related to the abstract nature of the construct of energy itself [26] and to the fact that the word “energy” is used and understood differently in science and in everyday language [27]. Traditional definitions based on the capacity of producing work have been recognised as inadequate [28], and different alternative approaches have been proposed [29, 30]. In a perspective of a trans-disciplinary approach, Poggi, Miceli and Testa [31] identified six basic aspects of energy (forms, transfer, transformation, conservation, degradation, and entropy). However, in their definition and validation of a learning progression on energy, Neumann et al. [32] concluded that students should first develop an understanding of energy forms and sources, and only later of transformation and degradation, while energy conservation should be treated even later.

2.2 Research design

Moving from this background, we designed a learning unit based on the Global Learning approach. The main educational goal was to reach the awareness that even the action of a single individual can have an impact for the whole planet.

Our research addressed the following questions: (1) How can we design a learning unit on sustainable energy using the Global Learning approach? (2) What are the outcomes of such an intervention, in terms of the different dimensions of environmental education?

To answer these questions, we designed a learning unit paying attention to the development of all the four dimensions of knowledge outlined by Jensen [11]. We tried to construct a complex discourse with the children, where the effects were related to the causes and to the opportunities of action. At the level of the eight European Competence for Lifelong learning [33], the unit referred to the development of Social and Civic competence, about which it is stated that “sustainability is linked with the civic competence in order to stress the learner’s role in deciding and contributing to the development of peaceful, inclusive and sustainable world”. The choice of the topic also meets the Italian National Standards [23], where it is specified that, at the end of primary education, children should be able to “observe and interpret environmental transformations, including the global ones, in particular those that are consequences of the modifying action of the humankind”. Concerning the contents, the unit includes the core idea “Energy” [22], focussing on energy sources and energy transformations.

2.3 Participants

The research has been conducted in a fifth grade classroom belonging to a primary school in Castelfranco Veneto, province of Treviso, Italy. The classroom is composed of 20 pupils (10 girls and 10 boys), including two girls having non-Italian origin and two children (one boy and one girl) certified for disability.

2.4 Assessment

Given the polymorphic nature of the intervention and the different dimensions considered (cognitive, reflective, metacognitive, self-regulating), we adopted a multiple-perspective evaluation. Specifically, the following instruments were designed and administered, linked to the different foci of the evaluation:

- An observation checklist, aimed at detecting the behaviours and attitudes assumed by the children during the intervention.
• An objective test to verify the acquired knowledge and skills, covering the three main topics of the intervention: global issues, energy, good practices for energy saving.

• A logbook that accompanied the children throughout the intervention, aimed at tracing the learning process of each child and at detecting the metacognitive and reflective processes going on during the lessons. Guiding questions were designed for each lesson, in order to promote reflection. For the evaluation of the research, we focussed on some elements of the logbook that were particularly meaningful for giving insights on the children’s learning and reflective processes.

In addition to these instruments, a pre-test was administered to the children in the form of a survey on personal habits about energy saving. The survey contained 10 multiple-choice questions about the children’s habits in situations where energy consumption is involved (house lighting, use of the television/computer, use of household and electronic devices).

3 DESCRIPTION OF THE LEARNING UNIT

The intervention started from a global perspective, then gradually shifted to a personal perspective, and finally went back to a global one. Double-faced coloured cardboard glasses (red/blue) were built for each child, with the purpose of distinguishing the moments when they were adopting a global perspective from those when they were adopting a local one. The activity plan is described in Table 1.

<table>
<thead>
<tr>
<th>Phase/focus</th>
<th>Lesson no.</th>
<th>Learning outcomes</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal habits</td>
<td>1</td>
<td>• Become aware of personal habits</td>
<td>• Survey on personal habits</td>
</tr>
<tr>
<td>Phase 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The global scale</td>
<td>2, 3</td>
<td>• Reflect on energy issues on a global scale</td>
<td>• Different sources of energy (renewable/non-renewable), their use and impact</td>
</tr>
<tr>
<td>Phase 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Where does our energy come from?</td>
<td>4, 5, 6</td>
<td>• Recognise the importance of energy for everyday life</td>
<td>• The importance of energy in our society</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Outline the scheme of a power plant</td>
<td>• The journey of electricity (how electricity get to our homes)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Know the units of energy and power</td>
<td>• How the domestic energy consumption is measured</td>
</tr>
<tr>
<td>Phase 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The energy we use... the energy we waste</td>
<td>7, 8</td>
<td>• Estimate the amount of domestic energy use</td>
<td>• Power, energy and the price of energy</td>
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<tr>
<td></td>
<td></td>
<td>• Estimate the price of domestic energy use</td>
<td>• The importance of saving energy</td>
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<td></td>
<td>• Recognise the importance of saving energy</td>
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<tr>
<td>Phase 4</td>
<td></td>
<td></td>
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<tr>
<td>Let's save energy</td>
<td>9</td>
<td>• Identify good practices to be adopted today and in the future in order to save energy</td>
<td>• Good practices for energy saving</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• The energy label</td>
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<tr>
<td>Phase 5</td>
<td></td>
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<tr>
<td>I can make the difference</td>
<td>10</td>
<td>• Recognise that even the action of the individual can make the difference on a global scale</td>
<td>• The impact of personal choices on a global scale</td>
</tr>
</tbody>
</table>

In the following we provide a more detailed description of the activities.

*Phase 0: Personal habits*

• *Lesson 1.* A survey on personal habits concerning energy saving was administered to the children.
Phase 1: The global scale

- **Lesson 2.** The initial knowledge about energy consumption was surveyed using two open questions: "How is energy used?", "Can you make any examples where energy is wasted?". Starting from this activity, a shared cognitive matrix was constructed. Then a discussion was started about the finite nature of the resources of the planet Earth.

- **Lesson 3.** The main sources of energy were introduced and divided into renewable and non-renewable ones. The children listed the sources they already knew and those that were new to them. A reflection was then made on the energy sources that are mostly used in the planet, their use and their impact on the environment. At the end, each child was asked to search for an image summarizing his/her reflections during Phase 1, motivating his/her choice.

Phase 2: Where does electricity come from?

- **Lesson 4.** A reflection was made on what would happen if energy was no more available in our society. The children then discussed how electricity arrives in their houses and they agreed that it must be transformed from other energy sources. Finally, a self-made device called the "Dimobike" was presented, consisting of the rear-end of a bike (wheel, pedals and chain), with a dynamo and a light bulb connected to the wheel (Fig. 1). The purpose of the device was to illustrate energy transformation. The children observed the device and formulated hypotheses about its functioning.

- **Lesson 5.** The children tested their hypotheses about the functioning of the Dimobike. Then the energy transformations occurring in the Dimobike were outlined in a scheme. The same scheme and the concept of energy transformations were used to outline the functioning of power plants and the journey of electricity from each of the primary sources of energy to the houses.

- **Lesson 6.** An electricity bill was analysed, paying attention to the amount of energy that was used, its cost, and the total price. The Wh emerged as a possible unit for energy, the one typically used for domestic energy use. The children then analysed some household devices (hair drier, light bulb, television, …) to see if they could estimate the energy consumed by each one. The children realised that there was an indication of “power” rather than of energy: the concept of power and its unit of measurement (the W) was introduced and linked to the concept and units of energy.

![Figure 1. Children examining the Dimobike while wearing the glasses.](image)

Phase 3: The energy we use… the energy we waste

- **Lesson 7.** The children completed a table on the use of energy in their homes. They selected household devices from a list and estimated their typical daily energy use, based on the power and the duration of use, and summed up data for all the devices to calculate the daily energy use of their family. They then estimated the energy use in one month and one year, and the corresponding price.

- **Lesson 8.** The children compared their results. Then the values obtained by each child were added together, in order to obtain the total energy use of the entire class.
Phase 4: Let’s save energy

- Lesson 9. The children analysed different types of light bulbs, comparing the information reported on their energy label, and tested the bulbs on the Dimobike. Recalling the pre-test, the children were then invited to make a small personal commitment for one week, trying to change at least one of the “bad” personal habits that emerged in the pre-test.

Phase 5: I can make the difference

- Lesson 10. The children completed a second table, hypothesising the adoption of good practices for energy saving and revising the amount of energy consumption accordingly. The revised amount was compared with the actual one, both for each child and for the entire class, highlighting the (energy and money) saving that could be achieved. The count was then extended to a larger sample (town, region, country), in order to estimate how much energy could be saved if everybody adopted good practices.

4 RESULTS

4.1 Observation checklist

The observation checklist focussed on three main dimensions: participation, self-regulation, and reflections on a global perspective. Participation referred to the level of engagement and interaction of students. For 19 children out of 20, evidence of engagement in the discussions was observed; 12 children contributed to the construction of knowledge actively by intervening in the conversation, and 8 proposed new questions consistent with the topic. Self-regulation described the quality of discourse about good practices. All the children talked about their energy-related habits; for 13 children, evidence of a process of reflection on their habits was observed, and 7 were able to hypothesise improvements. Reflections on a global perspective regarded the quality of the discourse about global issues. Most of the children (16) recognised the problems concerning energy on a global scale; 11 of them were able to relate the actions with their consequences and effects, and to envisage solutions.

4.2 Objective test

The box plots for the scores distribution of the test are reported in Fig. 2, both for the whole test ("Total") and for the three areas composing the test: Area A (Knowledge on energy on a global perspective), included items on renewable and non-renewable sources and related topics treated in Phase 1; Area B (Energy) included items on the operation of a power plant, energy transformations, energy saving, the units of power and energy, and energy labels; Area C (Good practices) contained a “challenging task” on good practices for energy saving. The overall score was satisfactory (positive for 18 students out of 20); the area in which pupils performed better was Area A, while the one in which they encountered most difficulties was Area B.

Figure 2. Box plots of the scores of the objective test.
4.3 Logbook

4.3.1 The global perspective: from a visual stimulus to a reflective process

Children were asked to search for a meaningful image representing their views on the topics covered during Phase 1. In the motivations, some children reported a reasoning (linking the causes to the effects), while others privileged the affective-emotional area by expressing their feelings or emotions about the image. The purpose of this activity was to evaluate the quality of reflection of the children about energy-related issues on a global perspective. A qualitative analysis of the themes chosen by the children revealed that most children (8) chose the theme of energy sources, followed by pollution (4) and the effects of environment-unfriendly behaviours on the planet Earth (4). A sample image and the explanation provided by the child who chose it is reported in Fig. 3.

Figure 3. The image chosen by one of the children and its explanation.

4.3.2 The local perspective: a change is possible

In order to highlight the process of acquiring positive habits, we compared the “bad” habits that emerged from the pre-test to the personal commitments made by the children during Phase 4. The bad habits were grouped in eight categories: sleeping with a night light; leaving the TV on stand-by; leaving the TV on when not watching; leaving the PC on stand-by; leaving electronic devices on when unnecessary; leaving the lights on then leaving a room; leaving the refrigerator open; and turning the lights on even when there is sunlight. They were then compared with the corresponding “good habits” reflected by the commitments. For each commitment, the children reported whether they were able to fulfil it (“yes”), if they managed to respect it “sometimes”, or if they could not respect it (“no”). In Fig. 4 we compare the bad habits with the commitments, highlighting the degree of fulfilment.

Figure 4. Comparison between the children’s bad habits and personal commitments.
The graph shows that the most frequent "bad habit" was "leaving the TV on stand-by" (19 children), followed by "sleeping with a night light" (14), "leaving electronic devices on" and "leaving the lights on" (13 children). "Leaving the PC on stand-by" was also declared by a relevant number of children (7), while the group revealed good enough personal habits for the other categories. Comparing these results with the commitments chosen by the children, we notice that most of the pupils decided to modify the behaviour "leaving the lights on" (10 children): 7 of these children stated they managed to fulfill this commitment completely, while 3 said they respected it "sometimes". The two children that used to leave the TV on when not watching decided to modify this behaviour and succeeded in that, and so did the ones who used to turn on the lights even with sunlight. Apparently, "turning off the TV completely" rather than leaving it on stand-by was perceived as a less relevant - or more difficult - task, as it was chosen by only a small fraction of the children that admitted this bad habit (4 over 19). Despite its high frequency, "sleeping with a night light" turned out to be the most difficult habit to modify. In fact, only 3 of the 14 children that admitted this habit tried to modify it, and 2 of them stated they could not do that. This is probably a complex task for children, involving deeper emotional aspects than remembering to turn off the lights when leaving a room. In general, all the children made at least one personal commitment and 17 of them managed to respect it (11 "yes", 6 "sometimes"). Considering that the children had to choose only one commitment related to their bad habits, these results are overall satisfactory and suggest that the intervention triggered not only positive beliefs, but also willingness to act in favour of sustainable development.

4.3.3 The "glocal" perspective: is it possible to make a difference?

We analysed the answers to the logbook question "Do you think you can make a difference with your actions, in order to save the Planet Earth?". Most students recognised that their personal action can make the difference, motivating their statement with reasons such as:

"Yes, because if we all did small actions at home, there would be a better world."

"Yes, because if I tell all my relatives to save electricity […] then they can tell the same to their friends and it would be like a chain".

"Yes, because if I do, I can inspire others."

However, four children answered negatively, motivating their answer with the fact that their impact would be limited and "the adults won’t listen to us". It therefore appears that additional work is required regarding the perception of personal relevance.

5 CONCLUSIONS

The didactic intervention described here allowed the children to move from a global perspective to a local/personal perspective, and back to the global one, concerning the topic of sustainable energy. After becoming aware of sustainability issues on a global scale, the children were able to undertake a reflective process on themselves and their actions. Reflection, metacognition and self-regulation are complex tasks for children, but our results suggest that this intervention was effective in triggering these processes. Finally, the goal of becoming aware that individual choices and behaviours have a relevant impact on the Planet Earth was substantially met. In this regard, the children have consciously decided to try to modify their habits, recognising the ones that were most negative and deciding to act on them. The challenge now is to verify if these habits and behaviours will be maintained over time.

REFERENCES


