adolescents

Article

An Early Beginning of Citizen Science: Adolescents Experiencing Urban Energy Usages and Air Pollution

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Abstract: Here, we report on the process and development of high school science projects, which were inspired by a citizen science program focused on urban monitoring. We gathered and discussed two 1980s projects' data, involving 2600 students, 80 teachers, 15 scientists and 20 stakeholders. We added recent survey data from speaking with the former participants. Our analysis revealed key findings: (1) the process of a student-driven science investigation engages students in the scientific practices; (2) it is important to bring together scientists, teachers and students, reflecting the importance of multi-dimensional learning; and (3) citizen science was born before the 1990s, when the term came into use. Our findings have implications for awareness of urban environmental issues and the links between the education system and society, young people working together with public and private managers and the science and technology sector instilling ideas on sustainability in the entire society.

Keywords: STEM; Italy; 1980's; science enthusiasts

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1. Introduction

Citizen science (CS) [1] is public participation in research with the aim of increasing scientific knowledge [2–5]. Early examples of citizen science include public participation and involvement in astronomy (e.g., the American Association of Variable Star Observers), entomology (e.g., the North American Butterfly Association), or ornithology (e.g., the Audubon Society) [6–8]. CS raises the transparency of science and empowers citizens to learn about specific topics of research (e.g., energy use or air quality) besides the research process awareness. This environmental awareness, when grounded, might also enable citizens to campaign for socio-political modifications [9,10].

However, until the late 1990s, the scientific research conducted by non-professional scientists was very sporadic. Citizen science gained traction under the Obama Administration in the United States. In 2015, the Administration announced measures to increase public participation in science through citizen science: members of the public could participate in the scientific process, including identifying research questions, making new discoveries, collecting and analyzing data, interpreting results, developing technologies and applications and solving complex problems [11].

Before, the general perception was not the same: the (urban) environment in which we lived declined progressively through the end uses of energy or the quality of the air but did not affect politics, the productive world and, paradoxically, not even training. The 1980s in Europe were totally engaged by the essence of the global bipolarity centered on the two blocs, the Soviet Union and the United States of America. Bipolarity and its innumerable ramifications absorbed the main interests of the society at large, down to the personal sphere. No cultural room was left for topics such as the environment in which we live.

Still, a small community of enthusiasts, teachers, scientists and students moved the first, but not shy, steps toward awareness, acquired through practice and study. The science enthusiasts were adolescent citizen scientists, trainers at large (professors and scientists) and stakeholders (public administrators, managers of energy companies) in two high school science fair projects on urban monitoring inspired by a citizen science program in the early 1980s.

The purpose of this work is re-examining old projects and rediscovering meaningful messages for current citizen science movement.

2. Theoretical Framework

Key challenges and opportunities facing CS can be summarized as: (i) recognition of scientific value, (ii) scientific rigor and data quality, (iii) citizen (scientist) involvement, (iv) political guarantees for action on findings, (v) timely data, (vi) environmental policy issues on public education and (vii) participatory democracy [12]. Forty years ago, none of these instances was perceived as a societal priority. Connections between scientists and experts, stakeholders, decision makers and citizens were not at all customary in those years. During the 1980s, thinking about the importance of encouraging an intellectual environment in which citizens bring their skills to bear on the resolution of common problems was not at all customary [13]: "through participation in the analysis of their vulnerability, ordinary citizens may regain their status as active subjects, rather than remain undifferentiated objects in yet another expert discourse". The link between CS and sustainability transitions is not automatic [14–17]. CS provides opportunities for connections among people; these circumstances generate a web of exchanges and new thinking on socio-economic–environmental circumstances [18]. Coupled with data gathering (i.e., both ecological and human dimensions data within a single community) today, CS is identified as public ecology projects, civic ecology, civic science or community-based management. These CS projects include working at the edges of fields and moving into each other's field of expertise (boundary crossings) [19]. Today, participants, who provide information through apps regarding CS projects, are often granted permission to mine back emerging databases as a reward for their commitment. Internet became a case and tool connecting the collective abilities of large numbers of people to accomplish tasks with unprecedented social mobilization: speed, accuracy and scale [20]. In the pre-digital era, feedback to citizenship was the active participation of citizen scientists only. This certainly made their task more difficult, less fast and accurate, but the result in social terms were more effective, even in the absence of a well-established methodological tool for assessing learning outcomes [20]. Today, the majority of CS projects are contributory [9,21–23]; an overview of the types of CS approaches and techniques have been listed by Dickinson and Bonney [24].

3. Methodology

3.1. Data Collection

We gathered two science projects discussing the outcomes from 2600 involved students, 80 teachers, 15 scientists, 20 stakeholders and 5600 analyzed point data. The universities were not involved; only some individual scientists were included in these activities managed directly by the secondary schools. Local public administrations and national energy companies financed the activities.

The first science project was based in Turin, the second in Rome (Figure 1). Interviews were conducted at the interviewees' homes, where the interview was 20 to 40 min in length. The interviews (Appendix A) were transcribed and examined separately (independently) by the researchers and school science teachers. Volunteers were identified using two approaches: suggestions from science teachers in the school and "snowball sampling", where students' families recruited future subjects from among their acquaintances.

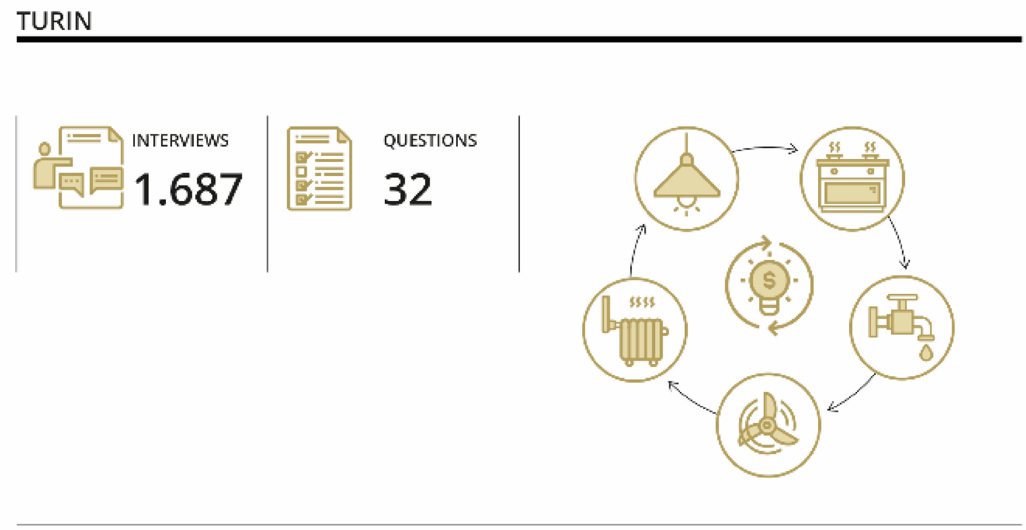

Figure 1. The rationale of this study is re-examining old projects and reliving significant messages for current CS activities. Project #1, analysis of the energy consumption of one urban district at family level. The Crocetta district of Turin, 12,000 inhabitants km^{-2}, was identified for its average social homogeneity and for the availability of preliminary data on the electricity and gas consumption.

3.1.1. Turin

A total number of 1687 interviews were conducted during the 1979/80 winter/spring period using a form of 32 questions (Figure 1).

The aim was to complete an analysis of the energy consumption of one urban district at the family level in order to obtain suitable recommendations for economic planning. The Crocetta district of Turin was identified for its average characteristics (social homogeneity) and for the availability of preliminary data on the electricity and gas consumption. Historically one of the most prestigious residential areas, the Crocetta district, peaked in the last century between the 1910s and 1930s, maintaining its reputation as a middle-class neighborhood. Since the 1950s, it has been known to host the current headquarters of the Polytechnic University of Turin. Here, population density progressively decreased from 14,000 inhabitants km^{-2} during 1980s to the current 12,000 (*source* Città di Torino).

The primary aim of this activity was the support provided by stakeholders in terms of data and means of processing, local authorities (Regione Piemonte and Municipality of Turin) and various industries (ENI, CNEN, Fiat SES, ltalgas, ENEL, AEM Turin, and Olivetti).

For the calculation of monetary revaluations based on the consumer price index for the families of workers and employees we referred to ISTAT (URL rivaluta.istat.it/Rivaluta).

The original version of the project is available (in Italian) at https://doi.org/10.5281/zenodo.3859388 (Accessed on 21 June 2021).

3.1.2. Rome

The research involved approximately 2500 16–19-year-old STEM (Science, Technology, Engineering and Mathematics) students, 50 STEM teachers and 15 principals from 15 senior high schools in Rome (I, III, V, IX and XI districts) and 1 at Pomezia. The size of the group (3 people, on average) was designed to standardize all activities, which had to take place in a total time between 20 and 30 min. The partitioning of the groups was optimized so that measurements could be made at all times and dates provided by the general calendar and that each group made no less than 4 observations. The students collected the samples and conducted the measurements.

The project #2 (“Ecology Project”) ran over the whole 1984/85 schoolyear. It analyzed two aspects: (i) the final uses of energy in private houses and (ii) urban pollution. The final uses of energy in private houses (i.e., familiar uses) meant final uses in the respective building types. Urban pollution meant monitoring gases (carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2) and particulate matter (PM)); rain (pH and PM type); and the health conditions of two key species of the urban vegetation, stone (*Pinus pinea* L.) and maritime pine (*Pinus pinaster* Aiton) and evergreen oak (*Quercus ilex* L.) (Figure 2).

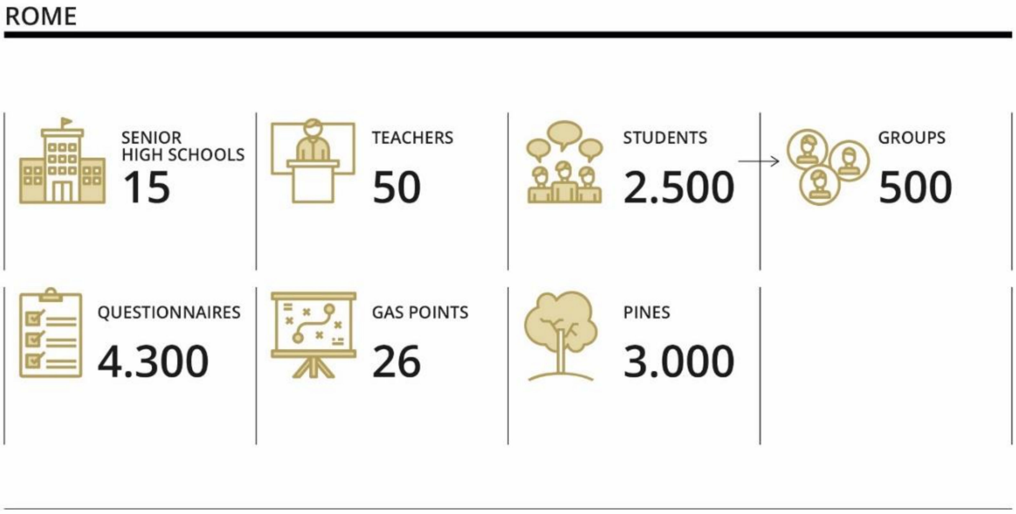

Figure 2. The rationale of this study is re-examining old projects and reliving significant messages for current CS activities. Project #2 was run in five districts of Rome and 1 at Pomezia over the 1984/85 school year. It analyzed two aspects of the industrial civilization: the final uses of energy in private houses that are familiar uses, including final uses in the respective building types, and urban pollution gases. (For ease of reading, groups of thousands are divided into digit groups using a dot delimiter).

The final uses of energy have been surveyed by means of 4000 interviews based on special questionnaires in sample city districts: (a) one 33-question inquiry form for final uses and (b) a 102-question survey for building types. These questionnaires were aimed at identifying the inhabitants' attitudes about change: 4000 questionnaires of type (a) and 300 of type (b) were collected. To train the students, 40 conferences with experts were organized. The interactive meetings were intended to focus on how much people knew about air pollution and how people made choices in their day-to-day lives, which affects their personal exposure to air pollution.

The first part on energy was completed at the beginning of January, when, concomitantly, the second part on urban ecology started, observing over 26 monitoring points (Figure 3). The students, organized in 500 groups, surveyed until mid-May samples of three gases that were collected three days per week (Monday, Friday and Sunday) at 7:30 am, 2:30 pm and 6:30 pm using a 100 cc manual Dräger sampling system equipped with single-gas vials (CO 5–100 mg m^{-3}, NO_x 50–3000 µg m^{-3}, SO_2 10–3000 µg m^{-3}) (Figure 4). The air quality monitoring network of the city of Rome was launched in 1993. For this reason, it was not possible to carry out an external calibration. Instead, an internal calibration was performed through bump tests, evaluating the response of gas detectors against standards (zero-point and span-point tests) with the aim to optimize accuracy.

At the same time, they were locating and checking the health conditions of approximately 3000 pines, located in the proximity of gas sampling points. At individual points, the students, in addition to the measurement of gases, completed 40-question survey sheets on the vegetation status, sampled dust (adhesive tape and Pantone color comparison) and, when possible, rain (Carlo Erba pH strips). Weekly, meteorological data, supplied by ITAV and UCEA, were collected and joined to the general database.

The original version of the project is available (in three languages) at https://doi.org/10.5281/zenodo.3859410 (Accessed on 21 June 2021).

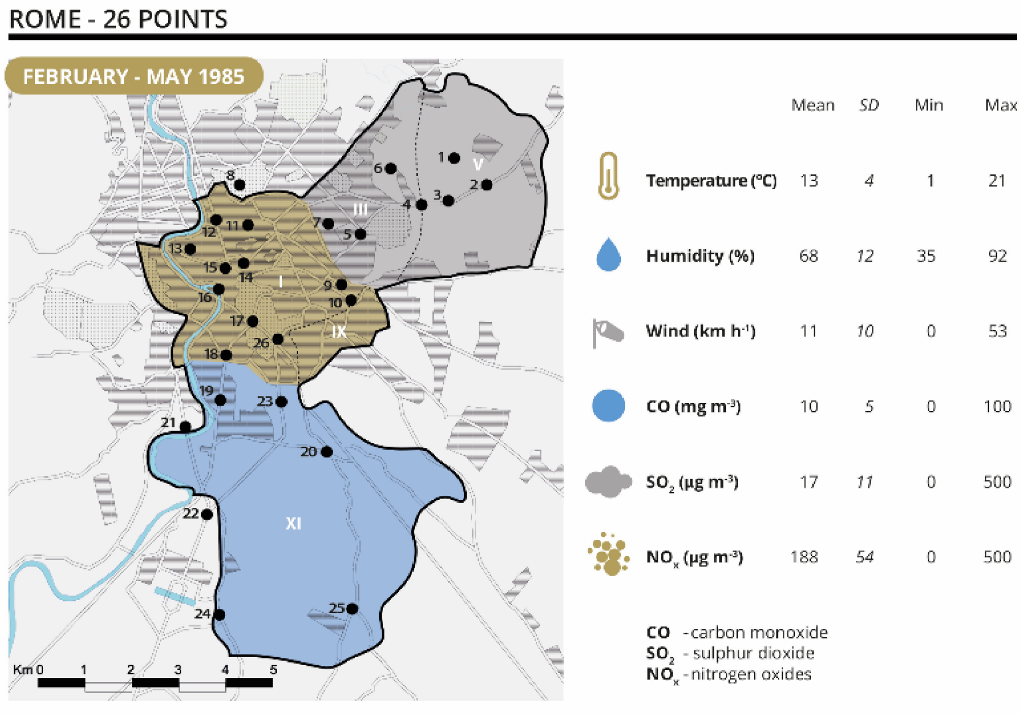

Figure 3. Air pollution monitoring: the map on the left shows the sampling points and the three areas of the City of Rome, which will be referred to later in order to report the averaged data. On the right, the descriptive statistics, referring to the entire city, of the main meteorological parameters and of the average of gases analyzed. Samples of three gases were collected three days per week (Monday, Friday and Sunday) at 7:30 am, 2:30 pm and 6:30 pm. At the same time, the students were locating and checking the health conditions of approximately 3000 pines, located in the proximity of gas sampling points.

Figure 4. Air pollution monitoring: adolescents, there as researchers, measuring the concentrations of polluting gases in the air of the city where they live. They used a hand-held tool (enlarged image on the right), a 100 cc manual Dräger sampling system equipped with single-gas vials.

3.2. Participants

When we refer to "participants", we mean the participants in the old projects. The same participants (a part of them) have been contacted today to obtain feedback.

It would have been optimal that participants for this study were drawn using a maximum variation sampling method to identify a diverse variety of participant experiences and to identify patterns and differences among participants. This has not been the case, since many years have passed. Therefore, with semi-structured interviews via Google Docs, we retrieved most of the participants from that time that we could find today. Our current audience consists of adults over 18 who would have been teenagers (16–19 years) at the time of the projects. The survey questions (Table 1) were intended to address our awareness objectives only. The intrinsic limit of this approach is given by the nature of the reasoned sample obtained. The advantage is the vocational consequences of participating in these extra-curricular activities. Major nodes of engagement were analyzed according to Phillips et al. [25].

Table 1. Former adolescents participating in 1980s projects interviewed today. These data are retrospective analysis of high school students' attitudes and understanding about their involvement in collecting data regarding energy use and air quality during the 1980s in Turin and Rome, Italy. The numbers refer to today's perception of the past participatory experience of former adolescents determined through questions that refer to the behavioral, cognitive and working spheres. Questionnaires completed in February 2021 by a sample of CS projects' former participants. Individuals who completed surveys (N = 34) were more likely to be female (55%), age 55 ± 4, education level (78% post-secondary), STEM education level (74% post-secondary). Answers as a percentage.

Dimension	Question	No
Behavioral dimension	Before participating in the research did you have the perception that the use of energy or the situation of the pollution of the cities were a potential danger?	20.0 [1]
	At the time of the project, were you aware that the use of fossil fuels was potentially dangerous to health?	13.4 [1]
Cognitive dimension	Have the results you obtained during the field experiment changed your way of thinking?	15.1
	Were the interviewed people aware, at that time, that energy could be used more effectively?	25.5
	Were you, yourself, aware that there were technologies that allowed a more efficient and rational use of energy?	11.8
	After the research work, has your experience, over the years, allowed you to adopt a more conscious behavior?	1.0
Working dimension	Has this experience changed your life in any way?	17.8
	Has the research experience influenced your choice of job or the jobs you have done in your life?	66.7
	Has it influenced personal choices in the family or in the professional sphere?	38.4 [2]

[1] a quarter of the responses focused on human health; [2] half of the positive responses focused on the professional sphere.

Initial criteria for participant selection into both programs included grade-point average, standardized test scores in STEM and level of responsibility. Our data included evaluation of the student display boards and oral interview excerpts using post hoc rubrics aligned with high school STEM practices and with an explanation rubric drawn, including question, hypotheses, methods, results and discussion based on those practices that, years later, will be considered acknowledged procedure of scientific investigations [26].

4. Results

The rationale of this study is re-examining old projects and reliving significant messages for current CS activities. Here, we describe here two bottom-up approaches to knowledge and scientific research projects inspired by the CS approach, which took place in 1979/80 and 1984/85, respectively, in the cities of Turin and Rome (Figure 5). These are subjective positions, as it is not universally agreed that CS can be said to be preferable, or at least complementary, to science done by professionals. This is partly for the reasons explained afterward in the conclusion section, but also because it is possible to arrive at non-replicable results that therefore have a limited cognitive value. However, CS represents an effective way to raise awareness of important issues, such as ecology and the environment, and, therefore, from this point of view, CS is a thought-provoking methodology.

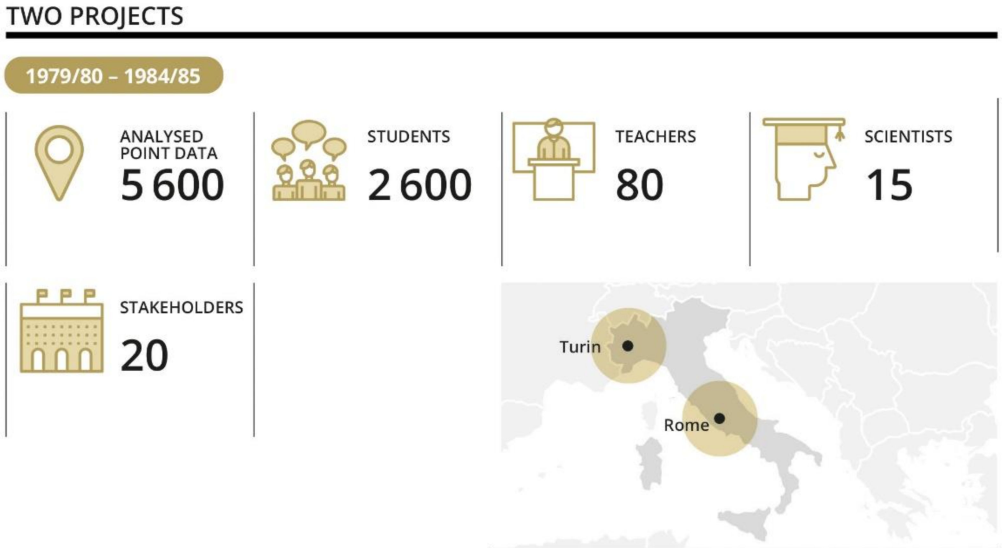

Figure 5. Re-examining a couple of old projects and rediscovering meaningful messages for the current citizen science movement is the goal for this study. Two high school science fair projects, inspired by a science program of citizen science monitoring started in the early 1980s with their classroom teachers and concerned stakeholders. The information was conveyed to a wide audience of students, with the participation of teachers. The most motivated students became "researchers" and provided the basic data to the scientists, who elaborated with interpretations, which were then discussed with students and teachers.

4.1. Turin

This investigation started from a point that seemed, in those times, of substantial importance: in Italy, numerous and qualified contributions addressed the problem of how new buildings should be designed and built in order to save money and energy. The key results (Appendix B) confirmed that the autonomous environmental heating, compared to centralized, had some advantages in terms of consumption for heated volumes, and showed the need for having some direct tool of control of heating consumption. Finally, a remarkable propensity for installation of solar water heaters was revealed, even in the face of significant projected spending levels.

The clear preference for gas or mixed cooking was confirmed, powered by mains gas, in a situation where the gas distribution was provided to practically all homes. The electric stove was not very diffused, on the other hand, throughout Italy. The mandatory electrical uses survey results allowed us to estimate about 600–700 and 1000–1200 kWh as the average annual consumption of washing machines and 1200 kWh for dishwashers. This result constitutes an important confirmation data specific to the Crocetta district, previously, estimated by proxies only. The washing machine was used for no more than two times a week, and mostly in the morning, in 70% of cases. The washing machine would make a significant contribution to the formation of the peak load in the morning. The dishwasher, on the other hand, did not seem to create similar problems, mainly used in off-peak times: especially after 19:00 and between 12:00 and 16:00. The iron was used, in most cases, not more twice a week, with a relative consumption in the order of 100–150 kWh year^{-1}.

The historical narrative of the student report (Appendix C), the Councilor of the Region, (Appendix D), and the scientist (Appendix E) describe for themselves the cultural status (including the use of time in the everyday life) and the societal hot topics of that time.

4.2. Rome

During the field activity (February–May 1985), about 1076 observations were made, three observations per day, for three days a week, on 25 points (Appendix F). Carbon monoxide did not exceed 10 mg m^{-3}, and sulfur dioxide, 10 µg m^{-3}, although there are sporadic observations all over the city with values ten times higher for both gases (Figure 6). Nitrogen oxides, particularly in the south and north of the city, reached very high values, 500 µg m^{-3}, in more than a third of the observations (mainly after 18:30, during Sunday, as well).

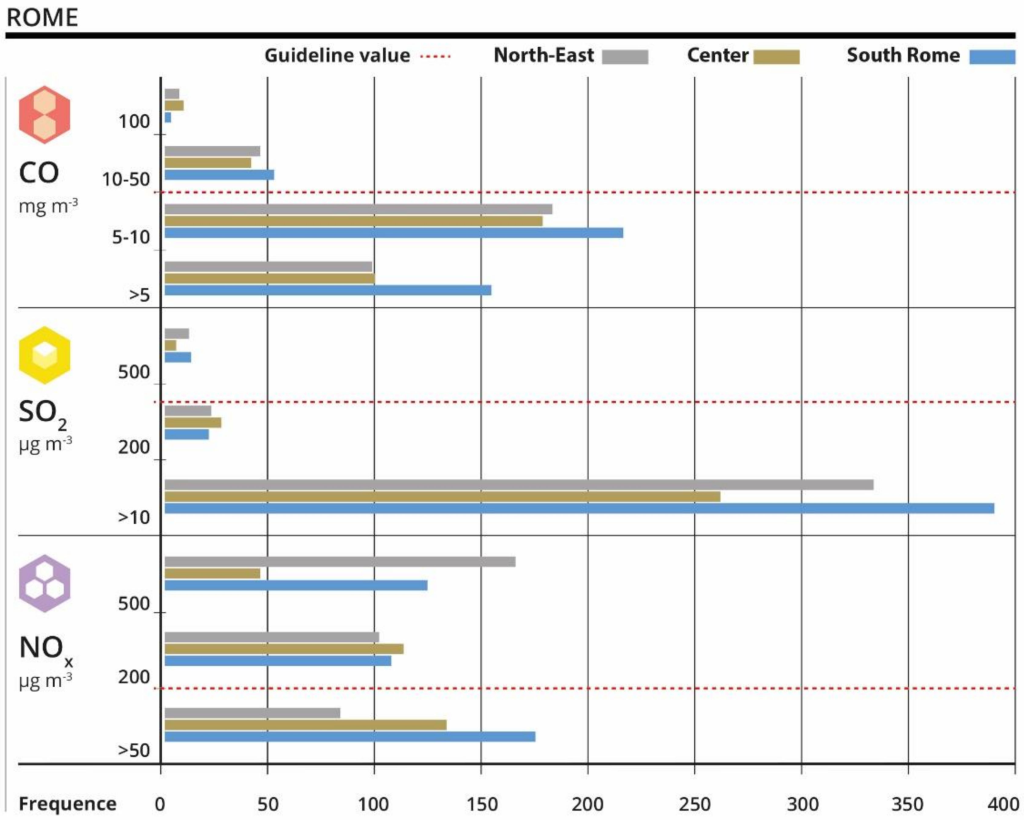

Figure 6. Frequency of the concentration classes of the three gases, CO, SO_2 and NO_x, grouped by geographic areas. The histograms indicate the gas concentrations averaged with respect to the areas of the City of Rome, gray for the Northeast, bronze for the Center, and blue for the South. The symbolism of the gases is that adopted by the European Environment Agency. The red lines indicate the guideline values suggested by EC [26] and WHO [27]: carbon monoxide (CO) 10 mg m^{-3} 8-h^{-1} daily mean; sulfur dioxide (SO_2) 20–125 µg m^{-3} 24-h^{-1}, 350 µg m^{-3} h^{-1}, 500 µg m^{-3} 10-min^{-1}; nitrogen dioxide (NO_2) 40 µg m^{-3} annual mean, 200 µg m^{-3} h^{-1}.

Today, the European regulations have promoted a decrease in air pollution emissions, courtesy of the conversion of the industry and the implementation by abatement technologies. Again, today, the fact that passive air pollution adversely affects trees by inducing tissue damage in vascular plants, damaging leaves and increasing leaf senescence rates and plant growth rates, reducing nutrient availability, is well-documented [26–33]. Our data, which refer to the past four decades (when there was no clear scientific evidence on the use of urban trees as bio-indicators), show that spatial analysis of leaf damages by pollutant concentrations did not reveal specific hotspots.

Alongside the presentation by the scientific world (Appendix F), the assessment statements by the President of Province of Rome, the Councilor for IP and Culture, and the Councilor for Health and the Environment (Appendix G), show how the complexity of society can be positively well exploited to improve its future. “This future, inevitably, must pivot on the younger generations throughout current industrial culture and environmental protection”; this is defined through the words of one of key stakeholders, the executive delegated to the Ecology Project by the Province of Rome (Appendix H). The most important feedbacks are those of the main actors, students (Appendix I) and teachers (Appendix J): the enthusiasm of active participation (e.g., one of the gas measurements was carried out at 7:30 in the morning, Sunday included) resulted in enhanced awareness and perspective.

4.3. Participation Outcomes

All interviewed stated that their former participation in science fair projects helped them develop their scientific literacy, their academic abilities and their understanding of the science and technology at large (Table 1). The main talked-about outcome (N = 27 of 34 semi-structured interviews) of the CS projects was personal growth, expressed in diverse behaviors related to professional prospects, technical training, personal competence, and flexibility. Another form of perceived personal growth was greater trust of scientists.

A broad conceptualization highlighted how former participants discussed environmental awareness, which included direct actions to conserve energy and to protect the environment at large (e.g., intra- and extra-family transfer of virtuous behavior) as well as more general environmentalism-associated behaviors (e.g., direct involvement in environmental organizations). Former CS projects associated these conservation-oriented attitudes to the CS project in which they were involved because of acquired greater knowledge.

The majority of former participants (N = 31) express today a (past) interest in CS projects (84% of students gave scores above 4 on a 1–5 point scale of interest) from the minimum average (3.7) up to the maximum (4.5) in students with good STEM background. The type of student was related to participation in the CS project, where students with good STEM scientific background had the highest rate of participation. The participation rate was not explained by the school performances, but the level of science education of the students influenced it.

5. Discussion

As other authors have done recently [33] we, then, focused on CS topics that are on the leading edge of environmental research, and disseminating articles from the primary literature allowed us to mature crucial background. The substantial knowledge transfer activities started from the scientists who provided the scientific information current at that time. The information was conveyed to a wide audience of students, with the participation of teachers. The most motivated students became “researchers” and provided the basic data to the scientists, who elaborated with interpretations, which were then discussed with students and teachers.

5.1. Specific Outcome Obtained by the Projects

In discussing the specific results of the two projects, we summarize the whole considerations on the energy and environmental aspects. On energy issues, it is interesting to highlight that to the question, “If the system was centralized, would you be available to install a system of heat-meter, and therefore to pay the heating as a function of the used heat, if the cost of installing the meters was between 200 and the 500 thousand Italian lire?”, a total of 64% of the interviewees declared that they were willing to face extraordinary spending (650–1640 EUR, 2020 prices, corresponding on average to a monthly wage of a worker in 1979). This early attitude was so true that, a couple of decades later, it became state law. In Italy, in fact, two legislative acts (Decreti Legislativi 19 August 2005, n. 192 and 29 December 2006, n. 311) impose mandatory thermostatic valves, correcting some of the parts contained in the specific law for the accounting of heat in buildings (Legge 9 gennaio 1991, n. 10). The thermostatic valve allows a considerable energy saving, less waste of energy based on the ambient temperature or the type of regulation: lower when leaving the house, or when a room is sunnier. The mandatory thermostatic valves automatically regulate the flow of hot water based on the pre-set and desired temperature, selected on a special graduated knob. This valve gradually closes as the room temperature—suitably detected by a sensor—approaches the desired one. When the temperature is reached, the hot water flow is diverted to the other radiators still open. On pollution issues, other authors report much lower average data than that measured in the 1985 study by Roman students. There was no permanent pollutant-monitoring network, and the measured values were decidedly high when compared with international guidelines [26,27]. Not to mention, the top concentrations we measured in at least a third of cases in the northeast area of Rome; for instance, the demonstrated existing correlation between Roman air pollution and respiratory diseases [33,34], or myocardial infarction [35], were obtained referring to mean values of CO, SO_2 and NO_x that were less than half of those measured ten years before their studies. In addition, similar conclusions on the effects on human health have been obtained in other Italian cities, referring to pollutant concentrations of the same order of magnitude [28–38]. The works of other authors are more recent and refer to a socio-political context in which pollution has already been the subject of legislation aimed at its reduction. In the 1970s and 1980s, in the Italian cities, there was no monitoring network, although the emissions of pollutants were extremely worrying. In particular, it was believed that the industrial cities of the north were the most polluted [39]. The results of the Rome project, on the other hand, show that air quality was also to be considered in non-industrial cities in other latitudes.

By examining the historical narrative in the stories of the various stakeholders, the word "peace" emerges (as opposed to the word "war"). In that historical period, strongly dominated by the logic of hegemonic blocks, people's daily attention was completely clouded by the fear of war (which ended in Italy only 40 years earlier). The energetic and ecological themes, as emerged from the activity of the citizen science projects operated by the students, were felt themes. Nevertheless, given the geopolitical situation, they could not yet be priority themes for the individual. The great merit of these "enthusiasts" was the seminal one, a sowing that produced fruit, even tangible, years later (Figure 7).

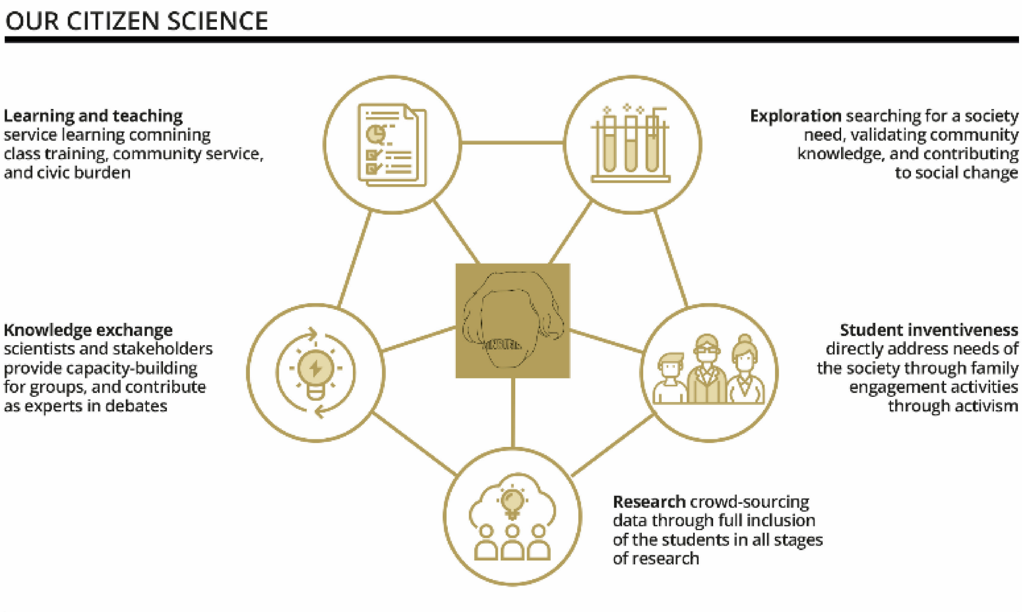

Figure 7. Engaging in the strategic activities of science is more than simply going through the motions. Engaging in the research provided a chance for students to graft within the explanation framework of statements and think through that practice, in particular when they discussed their labor to an audience. The great merit of those enthusiasts adolescents was the seminal one, a sowing that produced fruits years later. (In the center, the original logo of the Einstein Committee designed by the graphic designer Armando Testa).

5.2. Engagement/Learning/Cognitions

Engagement has been analyzed to define student dropout rates, school achievement or reform efforts, but engagement may refer merely to whether a CS participant finalizes a task or is paying attention [25]. Engaging in the strategic activities of science is more than simply going through the motions [40]. Engaging in the research provided a chance for students (Appendix K) to think through that practice, in particular when they discussed their labor to an audience [41]. These seminal CS projects allowed students to build an understanding of training and involved them in the epistemologies of that activity, so engaging in awareness [34]. Engagement is ductile, tangled to learning and precursor of learning [25,42–46], and cultural and ecological influences (experiences, friends, family and community structures) are quite important [47]. Today, we know that citizen scientists are particularly devoted persons who care about their own environment and the (quality of) data they collect [25]. They experience stimuli that influence emotional dispositions, which influence attitudes, values, behaviors, and overall experiences [25]. In the 1980s, these aspects were not known, but what emerges from our experiences evaluated over time is that the "fully engaged" participants developed an awareness of the issues addressed at the time in order to orient their professional or family life in a way that they could cultivate those issues.

5.3. Limitations

The most important limitations of the work reported here are both the spatial and temporal resolutions of the analyses.

Another limitation was that of not being able to make biunique the direction of the relations that began with the scientists, passing through the teachers, then the students, to get to society.

One barrier to the use of information produced through citizen science is the perception that the quality of research carried out by students does not have the same value as the methods used in research laboratories. In the described cases, we consider these claims as minor limitations that the monitoring data used in the analysis were subject to several uncertainties and biases. Furthermore, guidelines for the predictor variables were a priori, chosen based on expert judgment. There is manifestly some factor of uncertainty when restraining the directions of effects.

These studies, in analogy to those described by other authors [47–49], do not peculiarly aim to produce reproducible findings but look for lifting up topics for societal awareness, possible policy initiatives and, in any case, further advanced studies.

Moving CS toward coupled systems research requires: (i) standardization of a knowledge base, (ii) increased infrastructure support, (iii) quality data, (iv) effective tools of support, (v) analysis of feedback loops between participants and studied systems and (vi) the recruitment of participants [19]. In these seminal projects, we described the preliminary energies dedicated to move the first five issues forward, certainly not meeting the current needs of the CS projects. Regarding the recruitment of the participants, their preparation and the returns, in terms of social penetration of the topics examined, we do not think there is room for improvement compared to the approaches adopted at those times. The storage, in particular handling, and analysis of all data was the most critical part. To date, there is no complete (hard copy) copy of all individual surveys made.

While scholars in recent times have begun to discover the combination of outcomes at multiple scales, Jordan et al. [50] argue that this should be at the vanguard of future CS approaches.

6. Conclusions

Our conclusions must be considered as tentative only, as the information that we have discussed in this piece have been assembled serendipitously. The projects we described have shown multi-pronged citizen science approaches with perceptive discoveries. Open-mindedness can be taught [36]: those students (both their familiar and their school environments) revealed a progress in their awareness about energy management, urban ecology and air pollution [51]. Moreover, a bridge was built between professional scientists, stakeholders and the local communities. More than 30 years earlier, according to Mahajan et al. [49] and Cappa et al. [52], with the non-digital technology available, the projects involved a sensationally higher number of active participants. The results, now as then, are analogous.

Today, citizen science can be seen as a discipline per se [49–56], including gamified approaches [57,58]. The Citizen Cyberscience Center involving CERN, the UN Institute for Training and Research in Switzerland and Open Air Laboratories (OPAL) in the UK [12] are just a few examples. The United Nations Economic Commission for Europe (UN-ECE) adopted the Aarhus Convention, giving European citizens the right to participate in environmental decision-making; the European Commission and European Environment Agency recognized the value of citizen science for environmental research and monitoring [59], including policymaking, with the establishment of the European Citizen Science Association (ECSA) [60]. Furthermore, the citizen science community has been developing a data and metadata standard for Public Participation in Scientific Research (PPSR) in partnership with SciStarter.org and other partners. Today, CS comprehends a multiplicity of projects appealing to the general community in the training of science. With the opportunities that technology makes available to society today, they span from direct participatory research to large web-based actions (an up-to-date database at URL scistarter.com (Accessed on 21 June 2021)) [61,62]. However, we believe that today is also the son of the sporadic and seminal activities of the recent past. Moreover, this is especially true in Europe, and even more in Italy, where those students helped define and address future research questions and future citizen-led initiatives relevant to the society and their own local environment. Participation in the projects had the potential to deepen existing places attachment [62,63]. In the case of air pollution, CS allows the community to more clearly understand the fine-graded differences in pollution concentration, and this type of approach, if integrated with government-sponsored public information, might provide more timely and accurate air quality alerts [64]. Although different CS understandings were utilized [64–67], this has not permitted the definition from being taken up broadly and becoming extremely popular. These experiences show that the practices were already in use well before the Anglo–Saxon term was introduced.

On 9th May 1985, Alessandro Pertini, the President of the Italian Republic, hosted a delegation of 200 students, "veterans" from the activities of the Ecology Project, to obtain their first comments and feedback. This episode, per se, explains the social return of the activity of these adolescents, early pioneers of the participatory ecology, not acknowledged as example of citizen science, having arisen much before the term itself.

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Appendix A

End uses of energy ("Usi finali dell'energia", 1979)—Questionnaire form

House—Street __________ N. ___ Floor ____

Questionnaire number __________

(1) You have heard of the energy problem and the need to avoid it waste and contain consumption? (Yes/No question)

(2) If Yes, by which means? (multiple answers)

- radio
- television
- newspapers
- campaigns of various entities
- others

(3) Do you believe that the awareness initiatives implemented so far have been (closed question):

- useful
- not very useful
- unnecessary
- the product of a fashion
- the fruit of interest

(4) Is the energy problem (closed question):

- important
- not important for our country

(5) Have you adopted some measures to limit the so-called consumption to avoid wasting energy and money, or do you think your contribution cannot be useful? (Yes/No question)

A—Characteristics of the house

(6) The interviewee's home type is (closed question):

- single family
- two-family
- apartment in multi-family building

(7) Number of family members (open question)

(8) Number of floors above ground of the building where the apartment is located (open question)

(9) What floor is the interviewee's apartment on? (closed question)

- basement or basement
- ground floor
- 1st floor
- intermediate floors (between the second and the last)
- top floor

(10) What is the approximate area of the apartment in square meters? (open question)

(11) Number of windows or French windows communicating with the outside: (open question)

- of which with double glazing (or double window)

(12) Title of occupation of the apartment (closed question):

- in property
- for rent: by public body

from a private company

privately

- other
B—Heating
(13) Which type and fuel? (open question)
- autonomous system
- centralized system
- stove (number)
- fireplace (number)
- coal
- wood
- diesel fuel
- fuel oil
- kerosene
- methane
- liquid gas
- electricity
(14) Does this system also supply hot water? (Yes/No + question)
- yes
- yes, winter only
- no
(15) Type of centralized system management (closed question)
- management by the condominium
- outside firm
(16) What was the expenditure for heating in the 1978/79 season, in Italian lire per apartment? (open question)
(17) In the 1978/79 season, were any measures taken to save costs? (closed question)
- no
- yes, that is, it was:
- tightness of the fixtures improved
- isolation
- technical interventions carried out on the system
- maintenance and control of autonomous systems
- installation of thermostatic valves on radiators
- radiators, improved or turned off if not needed
- other
(18) How do you rate the temperature of the apartment? (closed question)
- excessive
- sufficient/adequate
- insufficient
- unbalanced (both excessive and insufficient, depending on the rooms)
C—Hot water
(19) Type (closed question)
- centralized system
- water heaters per individual apartment
(20) Which type and fuel? (open question)
- kitchen
- bathroom
- somewhere else
- electricity
- gas (immediate)
- gas (heat storage)
- other
(20b) The heaters are in the vicinity of points of use? (Yes/No question)
(21) What is the time slot of greater use of hot water? (closed question)
- 7:30–12:00

- 12:00–16:00
- 16:00–19:00
- after 19:00

(22) Would you be willing to turn off the water heater during the day? (Yes/No question)

(23) If the water heater(s) are electric, they are located: (closed question)

- external wall or draft, near
- external wall or draft, far

D—Cooking

(24) What type of cooker do you use? (closed question)

- electric
- gas
- mixed
- LPG
- other

E—Mandatory electrical uses

(25) Please tell us which of the following household appliances are present in this home, the weekly frequency of use and the time of use more frequent: (open question)

- washing machine
- dishwasher
- iron
- conditioner
- fluorescent tube lamp(s)

F—Attitude toward change

(26) If the interviewee has an electric water heater. If the replacement of the electric water heater with one of gas incurs savings at the current one's average consumption levels of an Italian family, would be willing to replace the current electric water heater with a gas one if the expense were between 200 and 400 thousand Italian lire and if it were recoverable in a period between 4 and 6 years? (Yes/No question)

(27) Replacing the electric or gas water heater with the solar one entails energy savings. Would you be willing to replace the current electric or gas water heater with a solar one if the expenditure were between 1 and 2 million Italian lire and if it were recoverable between 5 and 10 years? (Yes/No question)

(28) What if the above expense were deductible in three years from the personal income tax—would you be willing to replace it? (Yes/No question)

(29) What type of heating system would you choose in a newly built house? (closed question)

- independent
- centralized system, with independent regulation
- centralized system, with distribution of expenses according to use
- traditional centralized system

(30) If the system were centralized, would you be available to install a system of heat-meter and, therefore, to pay the heating as a function of the used heat, if the cost of installing the meters was between 200 and the 500 thousand Italian lire? (Yes/No question)

G—Gas and electricity consumption in the last year:

(31) What has been your gas consumption in the last year (from the last four paid bills), in cubic meters and Italian lire? (open question)

(32) What has been your electricity consumption in the last year (from the last four paid bills), in kWh and Italian lire? (open question)

Appendix B

End uses of energy ("Usi finali dell'energia", 1979)—Results.

A total number of 1684 questionnaires were collected.

1—Have you heard of the energy problem and necessity to avoid waste and limit consumption? In affirmative case by which medium? (as % of responses): 85 TV, 75 newspapers, 64 radio, 17 campaigns by various entities, 9 others.

2—Do you consider the energy problem (number of responses): 1647 actually important, 24 not essential to our country.

3—Have you taken some measures to limit consumption and avoid waste or believe that your contribution cannot be useful? (as % of responses): 77 yes, 23 no.

4—Type of home (number of responses): 7 single family, 7 semi-detached house, 1668 multi-family.

5—Housing by surface classes

Classes m^2	**Cases** N	**Average** m^2
<50	258	42
50–100	763	79
100–150	308	128
>150	236	204

6—Home ownership (number of responses): 572 property; 988 rental, of which: by 122 public body, 84 private company, 782 privately.

7—Owned and rented houses by surface classes (as %)

	<50 m^2	**50–100** m^2	**100–150** m^2	**>150** m^2
property	18	31	48	61
rent	82	69	52	39

8—Houses by type of heating system (number of responses): 1357 centralized, 106 autonomous, 224 other (stoves, fireplaces)

9—Housing provided with integrative system, Type (number of responses): 65 stoves, 14 chimney

10—Heating systems by type of fuel (number of responses)

	Wood or Coal	**Diesel Oil**	**Methane**	**Other**
independent		9	81	14
centralized	112	981	200	10
other	12	2	179	88

11—Heating costs in the 1978–1979 season, depending on the surface of the houses classes

Classes m^2	**Total Costs** Lit · 10^3	**Total Costs** EUR (2020 Prices)
<40	160	524
41–60	214	701
61–80	274	898
81–100	354	1160
101–120	424	1390
121–150	524	1718
151–200	618	2026
>200	773	2533

12—Expenditure per heated volumes (cubic meters) during the 1978–1979 season as a function of the housing surface

Classes m^2	**Cases** N	**Costs** Lit per m^3
<40	101	1681
41–60	231	1326
61–80	269	1257
81–100	265	1241
101–120	125	1238
121–150	136	1245
151–200	132	1136
>200	65	1037

13—Expenses per cubic heated meter during the 1978–1979 season, depending on the surface of the houses and the type of heating (Lit per m^3)

Classes m^2	**Autonomous**	**Centralized**	**Other**
<40	1253	1888	1600
41–60	1074	1423	1218
61–80	1107	1302	993
81–100	1019	1286	792
101–150	861	1267	-
>150	838	1114	-
average	1048	1293	1255

14—Expenses per cubic heated meter, during the 1978–1979 season, depending on type of fuel (Lit per m^3): 1420 wood and coal, 1295 oil, 1199 methane.

15—Specific cost and consumption of fuels in the 1978–1979 season

	Costs Lit $Mcal^{-1}$	**Consumption** Mcal m^{-3}
coal	23	61
oil	17	74
methane	17	68

16—Judgment on heating management, depending on type of heating (as % of responses)

Classes	**Autonomous**	**Centralized**	**Other**
excessive	4	11	2
sufficient/adequate	82	68	61
insufficient	9	15	24
unbalanced	6	6	13

17—Willingness to install heat meters on radiators, then pay for heating according to the energy used, with a one-off spending hypothesis of 200–500 thousand Italian lire (as % of responses): 64 favorable.

18—Measures taken in the last season to save heating costs (as % of responses): 61 none, 4 tightness of the fixtures improved, 4 thermal insulation works, 5 maintenance of heating systems, 3 heat meters on radiators, 8 adjustment of radiator potential, 7 selective shutdown of radiators, 14 other.

19—Type of hot water supply (as % of responses): 5 centralized system, 95 independent water heater.

20—Type of autonomous water heater (as % of responses): 73 electricity, 25 gas (immediate), 2 gas (heat storage), 0.4 other.

21—Location of autonomous water heater (number of responses)

Classes	Kitchen	Bathroom	Other
electricity	189	1079	15
gas (immediate)	226	212	2
gas (heat storage)	15	12	2
other	3	2	2

21—Proximity to points of use of autonomous water heater (% of responses): 85 close.

22—Time slots for greater withdrawal of hot water (% of responses): 63 7:30–12:30, 6 12:30–16:00, 7 16:00–19:00, 24 after 19:00.

22—Willingness to turn off the electric water heater in the daytime (% of responses): 85 favorable.

23—Willingness to replace the electric water heater with a gas model (% of responses): 46 favorable.

24—Willingness to replace the electric/gas water heater with a solar model (% of responses): 39 favorable.

25—Time frequency of use of the main appliances (% of responses):

	Weekly Frequency			Time Slot			
	1	2	>2	7–12	12–16	16–19	>19
Washing machine	40	30	30	62	10	13	15
Dishwasher	17	12	71	14	33	8	45
Iron	40	27	23	24	24	36	16
Conditioner/Fluorescence lamps	-	-	-	-	-	-	-

Appendix C

Final report by "Albert Einstein" high school students.

We students of the Einstein Committee, interested in the energetic problem, we have faced this new experience investigating one aspect of the matter and getting in touch with public opinion during the investigation carried out in a neighborhood of our city. The feedback is undoubtedly positive, first because it has allowed us to be interested in the "domestic" aspect of the energy, the end uses of energy. Secondly, we were in direct touch with "public opinion", concretizing a concept totally unknown to us as students. It was therefore a moment of communication and discussion with users, during which we practically applied our study, directly exposed to the actuality of our time. In addition, for the first time, we sent a message to be listened to and therefore to have a role of subjects entirely pro-active. For this reason, the results obtained, although, as there has been confirmed, they are valid and unpublished, they are affected by our inexperience in the role of researchers. The information was adequate to address the questions of the users; also to the positive effects of the research, we can add the completely experimental and new character of our work. It is necessary to note, for the record, that we have encountered some difficulties, mainly due, we think, to the distrust of public, because we were strangers; in any case, however the problem was resolved with our enthusiasm that involved our interlocutors. Most of the interviewees declared themselves theoretically favorable to the introduction of alternative elements for the partial solution of the energy problem. Many were inclined to accept the introduction of solar energy for "domestic" use, the use of measures for heat preservation and for a minor electricity consumption. In very rare cases, they have proven themselves.

The opposed to any means of saving energy and against energy alternatives. We think that based on this experience it is necessary increase information and in some cases even stimulate communication awareness of the energy problem.

Appendix D

Assessment statement by the Land planning and residential building Councilor of the Piedmont Region, Luigi Rivalta.

The energy problem, which from the carelessness in which it had been left has emerged in recent years manifestly in the eyes of all in its real range and gravity, if on the one hand it poses problems inherent in energy production. On the other hand is a problem inherent in its consumption: correct use of energy and energy resources, elimination of all waste, savings. In this respect, it is a matter of promoting the growth of one collective consciousness that recovers the deleterious effects of the (false) illusion, generated during the period of unbridled expansion consumerism, according to which resources would not place availability problems. On the other hand, the extraction costs of the raw materials and the costs for their transformation into energy they are increasingly burdened and increasingly exploited. This fact poses serious balance problems and environmental and natural protection. Economic, cultural and social reasons therefore dictate take savings as the basic cultural datum of being of our society. Such a conception must be reflected in the management proper to the various final energy consumption sectors, from industry to transport, to civil uses. Energy consumption for heating buildings, for hot water and for home appliances, has reached almost the same size as industrial consumption (excluding those of the material processing sectors raw in energy); in more developed countries they have also surpassed them. In our region, they now make up about 1/4 of all final consumption. In this sector, as in the others, irrationalities are relevant present and waste. With reference therefore to civil uses, a savings policy can obtain significant, certainly not marginal, results.

The investigation conducted on the initiative of the Einstein committee contributes to become aware of these problems by taking exemplary as a field of investigation that of the already existing neighborhoods, for which the problem of innovations tending to savings collides with the rigidity of structures. In addition, of habits, but which constitutes certainly the largest sphere for a policy of savings in the civil use sector. It constitutes an interesting contribution of knowledge and knowledge awareness; alongside other initiatives—exhibitions, conferences, debates—promoted by the Region. Say here, the interest of the regional administration to support this initiative. Add to this the value and importance that takes this example of integration of didactic activity to operational interventions of public bodies and live issues of general interest in society.

Appendix E

Einstein Committee President, Professor Tullio Regge (1980 and 1985 presentation).

The whole industrialized world is about to be hit by the energy crisis of vast proportions that poses serious problems to our economy. The shortage of fossil fuels makes us dependent, not only economically, but also politically from the exporting countries oil, coal and possibly also by those who they control uranium technology. We will have to contain and above all plan our energy consumption. The planning implies an initial diagnosis in such a way that identify wastes and indicate the solutions to avoid them, for this reason the Einstein Committee has thought of raising awareness public opinion through a series of initiatives aimed at the energy problem. Key point of this activity was the support provided by local authorities and various industries, (Regione Piemonte, ENI, CNEN, FIAT SES, ltalgas, ENEL, AEM Turin, Olivetti, Municipality of Turin), and in placing means at our disposal economic data. These circumstances allowed us to formulate a questionnaire that allowed us to make maximum use of the information. For house-to-house interviews, over 70 students of the state high school "Albert Einstein" volunteered; to them ours goes thanks. Beyond the work done, the educational side of the initiative must be underlined, aimed at sensitizing young people to important problems of our time. The work done and the results obtained went beyond our best expectations. The volume that we are presenting here provides accurate data and never so far collected on private energy consumption, data that will be needed for years to sector planning. We are also convinced that the initiative will not fail to have imitators to whom our encouragement goes. In order for this work not to remain useless an energy policy must be put in place that allows us to survive for the next two decades which are very critical for ours economy. Such a policy presupposes public education and continuous attention of the sectors concerned. We trust that the work done will serve as a stimulus for further initiatives and as a first basis for discussion of the problem energy. I conclude by warmly thanking all the stakeholders, and once again, the young people who lent themselves with enthusiasm to the experiment.

In 1980, the Einstein Committee carried out the first research project that saw high school students for the first time being researchers in collaboration with public and private bodies and companies. The project, carried out in Turin in the Crocetta district, with around 100 students from the Albert Einstein and Carlo Grassi schools who participated. The goal of contributing to knowledge and control of consumption energy had been widely achieved. The "Ecology Project" proposed by the Province of Rome, conceived, and created by the Einstein Committee in collaboration with major institutions energy five years later represents an ambitious goal achieved by the conjugation—public administration, companies public and private and high school students. The idea we proposed obviously has good legs on which to walk on.

The control on the end uses of energy in civil dwellings and by contrast environmental control through gaseous pollutants and their effects on natural indicators it represents a model that is as complex as it is overall significant for the problem analyzed. High school students are proving to represent one resource and for the construction of the new cultural model of our society. The search for a more balanced distribution of wealth is the search of a global balance, that is, peace also passes through them. The 2500 students involved in Rome, as those in Turin, are an example to imitate. Energy and the environment are resources whose a correct use determines the quality of life for the generations.

Besides, the school must always become a training area to the methodology of knowledge and research. Any type of programming they cannot ignore a cultural model possessed by the majority of young citizens.

Appendix F

Frequency of the concentration classes of the three gases, grouped by geographic areas: South Rome (A), Center (B) Northeast (C). Unit: CO mg m^{-3} NO_x μg m^{-3}, SO_2 μg m^{-3}.

CO					**SO_2**					**NO_x**				
Zone A	**Feb**	**Mar**	**Apr**	**May**		**Feb**	**Mar**	**Apr**	**May**		**Feb**	**Mar**	**Apr**	**May**
0	22	110	18	4	**0.0**	41	260	64	24	**0.0**	18	110	32	15
10	25	110	66	15	**0.1**	9	5	4		**0.1**	10	40	7	2
20	1	10	2	2	**0.2**			2		**0.2**	7	30	9	2
30	1	20	4	1	**0.3**			8		**0.3**	3	20	6	1
40		1	2	2	**0.4**			3		**0.4**	2	10	4	1
50	1	2	2		**0.5**					**0.5**	10	50	16	1
60														
70														
80		2												
90														
100														

Zone B	**Feb**	**Mar**	**Apr**	**May**		**Feb**	**Mar**	**Apr**	**May**		**Feb**	**Mar**	**April**	**May**
0	6	46	28	18	**0.0**	37	115	98	10	**0.0**	35	50	40	8
10	28	72	42	36	**0.1**		20		1	**0.1**	2	30	28	1
20		4	6	6	**0.2**		2	2		**0.2**		35	14	2
30		6	4		**0.3**		2			**0.3**		5	2	
40		2	2		**0.4**					**0.4**		2	4	
50	1	5	4		**0.5**			2		**0.5**		20	12	
60			2											
70		1												
80			2											
90			2											
100			1											
Zone C	**Feb**	**Mar**	**Apr**	**May**		**Feb**	**Mar**	**Apr**	**May**		**Feb**	**Mar**	**Apr**	**May**
0	28	55	14		**0.0**	50	176	60	46	**0.0**	19	40	14	10
10	20	117	38	7	**0.1**		12	4	2	**0.1**	4	20	12	8
20	2	10	4	1	**0.2**		3			**0.2**	8	30	8	12
30		11	8	3	**0.3**					**0.3**	3	20	6	6
40		1	3		**0.4**					**0.4**	2	15	2	2
50		1			**0.5**	2	3	2	3	**0.5**	14	60	26	10
60		1	2											
70														
80														
90		2												
100		1												

Appendix G

Assessment statements by the Province of Rome, Gian Roberto Lovari (President), Lina Di Rienzo Ciuffini (the Councilor for Public Education and Culture), and Giorgio Fregosi (the Councilor for Health and the Environment).

In the province of Rome 3,706,000 inhabitants live; of these just over 10% (to be exact 320,000 to 1981) are found in the age between 14 and 18, that is, in school age. The demographic projections indicate a decrease in this share of youth. Young people therefore become rarer and therefore more valuable. They represent our future and, in a demographic structure and social that goes through a transition phase and tends to grow old. They all need commitment and special attention. These contributions organized by the Einstein Committee and coming from the initiative of the Province, of the Bodies that deal with energy in our country and finally with something like that vast array of high schools in the Roman metropolitan area, testify to the quality and revitalization of our effort.

"Peace is the new frontier of the young people of current and future generations", so began a student who spoke on behalf of thousands of young people during the meeting "1945–1985 forty years later... to say peace" organized by the Province of Rome on 23 April at the EUR Palace of Sport. This student was one of the participants in the Ecology Project that had begun the previous autumn and would have ended at the end of May. Offer young people opportunities for knowledge make them familiar with energy and environmental issues; make them protagonists of research and proposals for change. This, in summary, the methodology of the project. The culture of peace, soil that we have privileged above all, I believe it represents the most fertile humus for the new generations by which to express the desire for participation and knowledge that young people, by the threshold of year 2000, they show that they have. A future of peace, and that in which the new Man, subject-protagonist and not object-victim of social changes that advanced technology determines, finally lives master of one's lifetime: finally, lives freed forever from the nightmare of total destruction.

In the 1960s, the writer witnessed and participated in the big one transformation of the model of life that takes place under the pressure of industrialization and low-cost energy.

There were lights and shadows. Certainly one of the most critical aspects was degradation of the natural environment, which has since experienced a deterioration progressive. Today energy is no longer cheap, and those who were young students in 1960, who became adults, find it difficult to face everyday life in the logic of saving energy. Those who are young today [in the mid-1980s] find it easier to combine their way of life with environmental protection and rational use of energy. Rather, they are the protagonists. In the Ecology Project, they expressed themselves as researchers demonstrating which resource of inventiveness and transformation is contained within our schools. Our thanks go to the students, their teachers and their families, to those who collaborated and participated.

Appendix H

Executive delegated to the Ecology Project by the Province of Rome, Paolo Trevisani.

When it was decided to launch a project in Rome focused on the conservation of energy, project born in Turin in the heart of the industrial society of our country, quite a few perplexities emerged. Stereotypes are hard to change. In the debate, the general tone ironed, once again, on the peaceful and accommodating nature of Roman citizens, challenged by uncongenial themes. On the other hand, the angularity of the piedmontese people was feared, whom solve everything through objectives, methods and implementation procedures. The success of the project has overwhelmed, in the experience of those who have had the good fortune to participate, this contrast of local masks. Is true that to accomplish the metamorphosis and appeals to a very valuable raw material: the students of the metropolitan area of Rome, which like all young people in the world, are more free from cultural influences. However, this explains many things, not all. One of the most recent currents of culture and research appears aimed to deepen the real peculiarities of the environment where the structures that allow the performance of human activities are located. Researchers, men of culture and gradually larger and larger layers of the population, they began to alarm. Faced with the effects of economic growth not from the 1960s onwards, the question arose wondering to what extent the environment would have governed the transformations induced by Man without irreversible compromise. The identification of the main culprits has been attempted. To the industrial system, and through its development, including to socio-economic and territorial effects that are derived from it, the major ones have been reserved debits. This critical point, and then it developed and organized until as sum up the characteristics of a relatively widespread "cultural attitude". The message that comes from these elaborations is the following: a weaker industrial system is a guarantee of a better conservation of the environment and protection of territorial resources. Would this message be said to be direct to a sense of alarm which comes from the industrial crisis that the country is experiencing, almost wanting to grasp positive aspects: since in the past the development of this sector occurred through the uncontrolled exploitation of natural resources (and therefore through the castigation of weak sectors, such as agriculture and forestry). Today it is (all) the "green" component that can find elements of recovery and support in the crisis of the industrial system. By pursuing this logic, however, we lose sight of the fact that the onset of imbalances took place mainly due to weakness or the absence of global government policies. Therefore, the search for responsibilities, by itself, is not enough, although it is our duty. Programming methods and tools must be relaunched, extending their influence to neglected sectors so far. Think of the transformation charge that comes from reading of environmental quantities, to the relative predictive systems, to the whole environmental impact issues and more. When, just above, I mentioned the "weakness or absence of global policies", I also meant to refer to the inadequacy of the school and professional training. Hundreds of thousands of young people know little or nothing about energy, despite being irresistible-mind directed toward new professions that in the energy node have the main reason for being. The idea that they have energy is connected to electric current, or to the atomic bomb. A vision too partial for people who, in everyday life, continuously enter into contact with different energy sectors, producing pollution and waste (i.e., dispersion of wealth) due to insufficient information neither. Through this passage, the energy problem can be easily grasped, mind in reference to the environment. The problem of protection can arise markedly in the presence of large concentrations of the population, although industry assumes a more predominant role among the activities of the population itself. This was the intuition of the Province of Rome (a geographical area that performs, however, in third place among the Italian industrial realities): reconstructing the identity of the pollution issue by reassembling the segments it is made of. With attention directed not only to its own territory but also to the entire national framework. The Einstein Committee and the students have brought this topic of discussion within the school; they enriched it with different contributions based on a broad debate. The result has been a boost to overcome the problem, a real and shared search for solutions. In particular, it emerged a net difference between the energy problem and the industrial culture associated to it, including the behavior of some connections of the industrial system. The attempt to unload every fault on the industrial system turned out to be an emotional reaction, aimed at obfuscating the problem of environmental protection rather than solving it. Abuse must be condemned and repressed. Dangerous processes must be eliminated or, at least, controlled and limited. Therefore, the environmental issue is electively placed within the energy question, and within the evolution of industrial and productive culture. Now, the results of the "Applied Ecology" project, carried out in the area of Rome, show that this connection is informally present in the experience of very large sections of the population and awaits to be recognized and valued. Students and citizens, who live, operate, and therefore formed in a socio-economic reality that wants to be extraneous to the problems of productivity, this connection is they acknowledged, probably with a sense of relief. A connection between the fraction of energy for personal use (for the use of groups, such as the family, business etc.) and the effect on the collective do exists. I believe there are connections between this great expression of sensibility, in some unexpected ways, and the extension, the deepening and revolution in Italy of culture around industrial production. This, in my opinion, ii signal that the Romans gave to students a wider range of ecological issues for the identification of forms of entrepreneurship and production of the future.

Appendix I

Sabrina Natali, IB class, student of the "L. Einaudi" school and Sergio Nico, III A class, student "F. Severi" school (Rome).

Many schools have agreed to participate because the use of energy and the quality of the environment are extremely important issues, and we students are very sensitive to these topics. The Ecology Project aimed to highlight the best ways of using energy resources, avoiding negative consequences. We noticed great difficulties in answering the related questions expenses and consumption of gas, electricity and heating; however, this fact made it difficult for the interviewees to reflect on the amount of their consumption. The operation made it difficult for us to contact unknown people by acquiring greater security in establishing relationships with them. The most important thing to notice is that we analyzed various pollutants present in the air of our city, and at thus, assess the seriousness of the question under consideration. Participation in the Ecology project has contributed to enriching our culture and our lexical knowledge, as well.

This experience led by young—with spanning age between 15 and 18 years—in my opinion, was useful because we acquired knowledge about problems not much considered by public opinion. For the majority of us it was a novelty to participate in this type of activity. We have gained an unrepeatable experience. Students from many city schools joined together, showing interest in social problems. The project had the support of families who stimulated us young people to participate. Often it was a useful moment of confrontation between generations.

Appendix J

State Industrial Technical Institute 'Francesco Severi teacher, Silvia Zorzenon (Rome).

It is a need felt by teachers to adapt continuously to improve the quality of their teaching, to renew itself in the methods and content to make a participating school to contemporary reality and more responsive to insertion needs in society by today's youth. For this reason, we are always looking for the new, new texts methodologies and new experiences that can enrich the baggage cultural background. Unfortunately, we often find ourselves in this constant research effort isolated, without support or collaboration especially from external environments to the school; for their part the students are bored and frustrated in one school in which they find few contacts with everyday reality. The 'Ecology Project' came to modify this situation: in fact, we teachers had the possibility to implement a method of different teaching, in contact with independent experts from outside the formal school. Students were informed, worked on a big issue of the actuality and felt protagonists of an investigation that had a real meaning. In short, the school, usually closed within itself, opens finally toward the environment that surrounds it and engages with reality. It is for these reasons that a large number of teachers and students, and attracted interest and attention by the parents and families themselves, welcomed research into energy end uses and urban pollution in. It should also be stressed that this research had a high content didactic as it allows the students to apply that inductive method to from which experience passes to data processing, hypotheses formulation, concerned laws, etc. . . . , and to implement a complete interdisciplinary approach on a real problem leading to an involvement of the teachers of all subjects. To give some examples, the compilation of end-use questionnaires energy, as well as informing and raising awareness among young people about the energy situation of our country, placed them in direct contact with the company, with their fellow citizens whose behaviour they learn about and reactions. Such behaviours and reactions could be discussed in class with teachers of letters; and again: the result of the investigation, a statistical survey, could be part of the maths program, such as research on gases and the effect of pollution on the green of the science and chemistry programs. I would also like to point out how the high participation in the project has shown that not a few teachers are available to do school differently, as long as their collaboration and means are provided, and to underline regret shown in this sense by the Public Education and Culture and Health and Environment Departments of the Province of Rome. In addition, to these Departments, to the Einstein Committee and to all the Bodies who collaborated that goes our solicitation for this collaboration between schools and Public Administration, which is only a beginning and does not constitute an isolated fact.

Appendix K

Society and energy—The future.

In June 2020, we had face-to-face interviews with some key people on the activities carried out by the Einstein Committee: two scientist co-founders of the committee, a former student currently senior manager of the Municipality of Turin and a current student engaged on environmental and energy issues. The greatest challenge for humans living on the planet Earth is to get a better life. This means that the challenge is connected to knowledge, and the strongest enemy is ignorance or lack of knowledge or any political movement that tries to limit knowledge, school, university, and freedom to acquire the living condition and ethic equity in wellness distribution. The limit of knowledge is one of the most interesting reports published by Cesare Marchetti, the scientist that first started to investigate on complexity founding a new discipline in studies and society behaviour investigation. Society needs knowledge in order to promoting equity in every field. When I suggested promoting scientific research with high school students, I was aware that: politicians were not able to investigate complexity (their knowledge was too limited) and society is a complex system and society's problems are complex. There are no simple solutions, so necessarily solutions have to be complex; Citizens have to be involved in finding what is good for society and must take part in approaching the path of solutions. Ethics or moral are something like a mood of understanding right solutions for society. The values of solutions that worth for citizens have to worth for every science solutions. Our students were committed to finding the right approach for society's solutions. The idea was to know how, for instance, energy must be used in a right way. It was not a solution but the way to approach a right solution. The approach adopted for the 1980 energy project "Indagine sugli Usi Finali dell'Energia" was the same adopted for the 1985 ecology project named "Progetto Ecologia" we managed in order to monitor the gas pollutions: by the mobility and the building heating system, of the city of Rome. It was the first time that pollutants gases were monitored for a long time and many times during the day. The results of these two projects we can read in the attached reports.

What can we do now? The pandemic is an accident but like many accidents it gave time to reflect and take some direction on our common future. We got helps, suggestions, inspirations, from some famous scientists that worked with us since the beginning, among them Mr. Mario Palazzetti; Mr. Cesare Marchetti I before mentioned; and many others from the majors of the Italian business companies. Right now in order to present our contributions into the domain of citizen science, we interviewed the above-mentioned scientists and among the new politics streams, Ms. Erika Trullo, a representative of FFF, Friday For Future, the movement on climate change founded by Greta Thunberg. Erika Trullo and the FFF are pushing the EU states governments and the EU parliament forward laws focused on technology that keeps the planet temperature below 1.5 °C. Mr. Luca Palese, one of the students taking part in the first project and now officials of the public body of Torino city. The line of the horizon of our future is crowded of great challenges: climate change, energy consumptions, energy sources, equity in wellness world distribution, just to mention some important. Mr. Cesare Marchetti, the prominent scientist that invented the model to foresee the future of our technological society and the greatest expert of H_2 is in favor in H_2 energy source. Mr. Mario Palazzetti, the versatile genius in the technology of cogeneration small scale, that among the others invented the anti-lock braking system (ABS), is looking the future electrics. Mr. Luca Palese, powerful officials of the society system is looking to the behaviour of the public bodies that now at the European level decided already to promote laws in favor of keeping under control the energy consumptions. The main idea seems that we, Einstein Committee, started to rally among the firsts in the world toward the path that now is the mainstream of the society behaviour. What is next?

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