"Solar Energy - Awareness & Action": Describing the developments of the 1st year of a Comenius school partnership project.

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Abstract. *The "Solar Energy – Awareness & Action"[SEAA] is a Comenius 1 project with 5 partner schools from Portugal, Spain, Italy, Malta & Greece [(Escola Antré Soares (PT), Colexio de Educación Infantil e Primaria Froebel (ES), Scuola Secondaria di 1° Grado C.B. Cavour (IT), Stella Maris College Junior School (MT) & 9th Primary School of Rethymno (EL)]. All project participants have become associated members of the "Hands-on Science" Network and the activities of this project also enroll in the activities of the network. The main aim of the project is to sensitise the pupils on issues and aspects of solar energy, within a framework of sustainable development and environmental and ecological awareness, both at conceptual and at practical-experiential level. Furthermore, the pupils are encouraged to act as conscious citizens, construct their own devices which work with solar energy and present them to local communities within open Science Fair procedures and activities, in an attempt to inform and sensitise the general public. A thematic approach to solar energy has been planned to include or even interweave formal, non-formal and informal teaching and learning approaches. These include investigations, hands-on activities and project work within formal and non-formal educational contexts, but also within a free-choice learning environment involving outside classroom activities (e.g. on site visits and science fairs). Shared project activities have been planned and undertaken by groups of children in each school, encouraging pupils to learn from the experience of working on a contributed set of ideas and projects from all participating countries.*

Keywords. Solar energy, school partnership projects, Socrates-Comenius 1 project, school based projects and activities, hands-on science activities, thematic-holistic approaches.

1. Setting the framework of SEAA project activities

Two meetings have been conducted during the first year of the SEAA Project. Members of the participating schools first met at the *9th Primary School of Rethymno*, Crete in November 2005 and then they met again at the *Escola Antré Soares*, Braga in May 2006.

Photo 1: SEAA group in front of *Escola Antré Soares*, 2006

In both meetings project issues have been discussed, whereas ideas and activities have been proposed and developed within a framework of prospective classroom approaches and/or applications. Discussion regarding the selection of particular activities and/or applications to be implemented as project tasks appears to be an open on-going process, based on a plethora of available activities and resources retrieved and distributed by the coordinator in an electronic form. Of course, these may be complemented with others to be found on the course. Some of these resources are being progressively uploaded as links on the project site (cf. URL:< http://9dim-rethymn.reth.sch.gr/contents_en/project_resources.htm >). Nevertheless, as part of our policy orientation, we have discussed and decided the variety of activities to focus on the 1st and later during the 2nd and 3rd year of the project. We have agreed to

work on all possible categories of solar energy applications and constructions, but on particular distinct designs for each project year. In this sense, different groups of pupils and different classes will deal with a similar, but differentiated, set of solar energy applications and constructions every year throughout the project years.

Furthermore, by the end of the 3 year-period of the project we will have accumulated a broader set of solar energy applications and constructions tried out and tested within classroom practice, which can be delivered as a final outcome of the whole project. In this sense, we believe that a broader range and number of future citizens will become aware and activated on solar energy issues. This appears more likely to establish a tendency in local citizens' communities for a considerate decision making process and future actions regarding alternative energy policies and a sustainable development, within a framework of environmental sensitivity and care.

Collaborating teachers have exchanged ideas on experiments and investigations regarding aspects of solar energy to be treated with pupils. Information on applications and/or constructions about *passive* (e.g. solar houses and solar architecture, greenhouses, solar cookers, solar dehydrators etc.) and *active solar systems* (e.g. solar water heaters, solar heating/cooling for homes, solar power stations with reflectors etc.) as well as *photovoltaic systems* (e.g. solar cells and arrays, solar cars and solar toys with PV cells and motors etc.) has been shared and discussed. A particular set of six activities on solar energy applications has been developed and put forward as a basis for the first year approach to solar energy applications. In more detail, two activities, one simple and one more advanced, for each of the three categories of solar energy applications (*passive*, *active* and *photovoltaic*) have been designed as follows (cf. URL: < http://9dim-rethymn.reth.sch.gr/contents_en/downloads.htm >):

1. **A simple pizza box solar cooker** with investigations on "hot boxes" and "heat traps".
2. **A more advanced solar box cooker** with one reflector and without a top lid.
3. **Simple solar collectors to heat up water** made out of plastic bags affixed on black and white cartons, providing the foreground for relevant experimentation activities.
4. **A solar water heater** with a collector with an "**S**" tube arrangement and a plastic bottle tank, setting the scene for an investigation on the *thermosiphon effect*.
5. **Experiments with a photovoltaic cell** and the performance of a motor after shading the cell or covering it with transparent, semi-transparent and non transparent materials.
6. **A solar toy car with a PV cell and a motor** in an attempt to sensitise pupils about the potential of photovoltaic systems in a rather familiar and playful way.

Thus, project work has been done in each participating school based on the above indicative activities for the current year, although partners have also developed their own projects within a broader thematic framework including other subjects apart from science such as language, mathematics, environmental education, theatre and drama, music, crafts and technology, geography, ICT, etc. An indicative list of such activities is as follows:

- text production by pupils related to the Sun and solar energy in the form of leaflets, narrations and poems
- collecting and rewriting stories and tales about the Sun in various cultures and civilizations throughout history
- the story of the sunflower and its products, presenting tales about the sunflower in various cultures and creating a collective piece of art with sunflower craftwork
- technological interventions and/or improvements on solar energy applications like solar cookers, solar water heaters and solar toys, based on problems needed to be resolved in terms of better construction and performance of the devices
- construction of horizontal sundials with simple materials, their orientation and calibration through principles of mathematics and geography
- dancing and singing songs related to the Sun in various languages
- role playing and theatre performances with a "Sun" or "solar energy" topic.

There has also been an attempt to actively develop a communication amongst participating pupils from different schools through an

exchange of letters and postcards organised in pairs, groups and/or classes. This has proven to be a difficult task mainly due to language difficulties and adequate combination of interests and age groups, but it has been considered essential in building up a warm atmosphere of friendship amongst participants to function as a solid basis for future joint experimentation and project development.

An electronic mailing list has been developed, involving all participating colleagues from the partner schools, providing *in vitro* communication with first hand and updated information about the developments of the project for everyone. Moreover, a web site of the project has been launched under the site of the coordinating school, the 9th Primary School of Rethymno, accessible at the URL: < http://9dim-rethymn.reth.sch.gr/contents_en/Comenius.htm>, which provides information about the project to partners and the general public.

2. Indicative project activities conducted during the 1st year

Teachers and pupils have been involved in a variety of project activities throughout the 1st year, 2005-2006. A more precise view of the number of pupils and teachers participating in the project is presented in the table below.

SEAA School Partners	Pupils		Teachers	
	F	M	F	M
Escola Antré Soares (PT)	58	54	6	1
Colexio de Educación Infantil e Primaria Froebel (ES)	25	28	5	1
Scuola Secondaria di 1° Grado C.B. Cavour (IT)	148	62	10	5
Stella Maris College Junior School (MT)	0	90	5	5
9th Primary School of Rethymno (EL)	75	70	5	5
semi-total	**306**	**304**	**31**	**17**
Total	**610**		**48**	

Table 1: Numbers of pupils & teachers participating in project work per school and in total numbers.

Although, it more likely appears that a greater number of pupils and teachers have participated explicitly or implicitly in project activities, than those initially declared. Some indicative project activities have been selected and grouped in terms of subject areas involved, within a thematic approach and are presented below.

2.1. Language, literature, history & culture related project activities

The revival of myths, tales and stories, which deal with the Sun in one way or another, has been conducted through classroom activities and text production. For example, the myth of *Phaeton* ("the shining one"), the son of the Sun-god Helios, who when finally learned who his father was, went east to meet him. He induced his father to allow him to drive the chariot of the Sun across the heavens for one day. The horses, feeling their reins held by a weaker hand, ran wildly out of their course and came close to the earth, threatening to burn it. Zeus noticed the danger and with a thunderbolt he destroyed Phaeton. He fell down into the legendary river *Eridanus* where he was found by the river nymphs who mourned him and buried him. The tears of these nymphs turned into amber. For the Ethiopians, however, it was already too late. They were scorched by the heat and their skins had turned black.

Another interesting tale is that of *Dedalus* and *Icarus*, where Dedalus was a famous Athenian architect/engineer that Minos had invited to Crete to build him a Labyrinth. When Dedalus finished, Minos jailed him in the Labyrinth. Dedalus however, build two sets of wings using wax and feathers, one for himself and one for his son Icarus, and they flew off Crete. During the flight to Athens Icarus, happy and excited from flying, decided to challenge the Sun. He flew too high and the Sun melted the wax that kept his wings together. Icarus fell in the Aegean and died. The island *Icaria* is named after him.

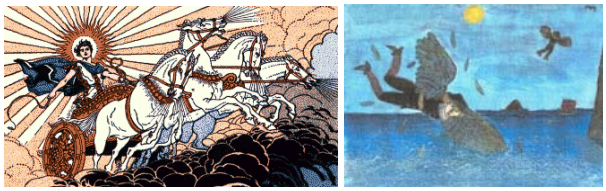


Figure 1: Pictorial representations of the tales of *Phaeton* & *Dedalus and Icarus.*

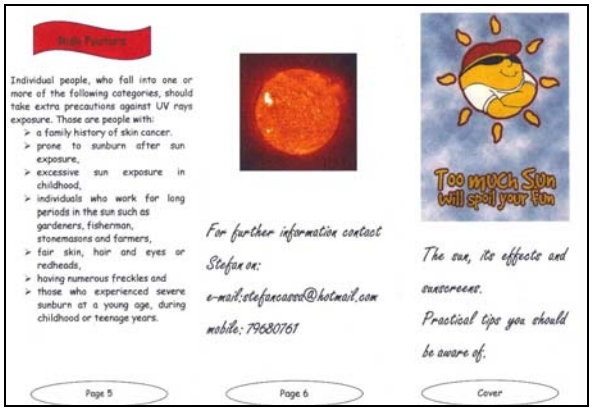
Both of these tales, alongside with other local myths and stories related with the Sun have been discussed and rewritten with children in class. In some cases, they have even "come into being" through dramatization.

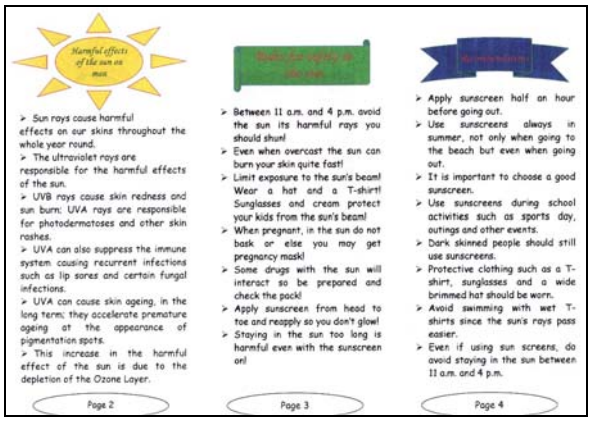
Furthermore, the legendary story of *Archimedes'* (287-211 BC) *"burning mirrors"* against Marcellus ships, perhaps the first known application of solar energy, has been thoroughly

examined by the pupils of *Scuola Secondaria di 1° Grado C.B. Cavour*, since Catania is just a short distance away from Syracuse, in Sicily, where the legend is said to have taken place. As *John Tzetes* (circa 12th century AD) contends *"when Marcellus withdrew them [his ships] a bow-shot, the old man [Archimedes] constructed a kind of hexagonal mirror, and at an interval proportionate to the size of the mirror he set similar small mirrors with four edges, moved by links and by a form of hinge, and made it the centre of the sun's beams - its noon-tide beam, whether in summer or in mid-winter. Afterwards, when the beams were reflected in the mirror, a fearful kindling of fire was raised in the ships, and at the distance of a bow-shot he turned them into ashes. In this way did the old man prevail over Marcellus with his weapons"*, [*Greek Mthematical Works* (1941), Ivor Thomas (tr.), Loeb Classical Library, Cambridge: Harvard University Press, Vol. II, p. 19].

Figure 2: A wall painting representing Archimedes' "burning mirrors", painted by *Giulio Parigi* (1571-1635).

Text production in the forms of creative writing (personal letter writing) and persuasive writing e.g. newspaper articles and leaflets have been developed in schools and especially by language teachers like the colleague *Claudia Caruana Anastasi* from the *Stella Maris College* in Malta. One example of a leaflet dealing with the harmful aspects of solar radiation to peoples' health is presented below (see Fig. 3 & 4).





Figures 3 & 4: A leaflet explaining how … "too much Sun will spoil your fun" *(Stella Maris College, MT).*

Another interesting language activity from the same colleague has been the revelation and etymology of "Sun related words", under an educative scenario that went on like this: *"just to prove once again how influential the Sun has been to mankind we looked up some things that had the word "Sun" in their names"* (such as: sunshine, sunrise, sunset, Sunday etc.).

Story writing and poetry have been two more text production techniques used by colleagues in *Scuola Secondaria di 1° Grado C.B. Cavour* in Italy (*Ketty Bufardeci, Antonella Piccin, Andrea Pantellaro* and collaborating teachers). What follows is a poem about the Sun, written by *Irene Napoli* from l° G class of this school, together with a nice drawing.

Il sole nasce al mattino
Illumina i fiori del giardino,
Colora tutte le cose
Risveglia tutte le rose,
La sera va a nanna e si addormenta
Tutti gli uccelli giocano con le foglie di menta.

Figure 5: The original text of the poem embedded in the pupil's drawing *(Scuola Secondaria di 1° Grado C.B. Cavour, IT).*

2.2. Science and environmental education related project activities

All partner schools have set up experiments and investigations on *solar thermal energy and active solar systems*, such as: a) solar water heating in various aluminium containers and/or plastic bags, b) observe the melting of ice cubes on carton papers of various colours, c) construct a small model of a solar water heater out of a plastic soda bottle to be used as a tank and a small black box collector with a rubber tube etc. In order to understand how solar heaters work, the *"thermosiphon effect"* has been discussed and analysed. Later, pupils did some project work on solar water heaters by constructing a serpentine solar water heater and/or a spiral solar water heater to be presented in a final science fair.

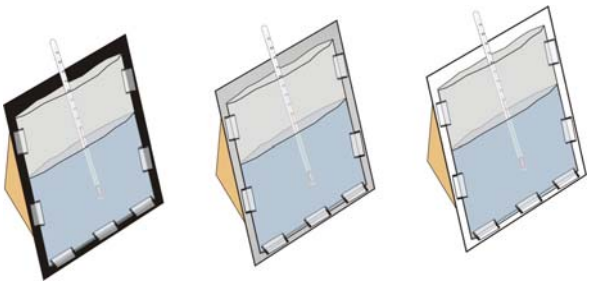


Figure 6: An experiment with a "simple solar collector" made out of a plastic bag filled with water, affixed on cartons of various colours, e.g. black, white, aluminium covered etc. *(9th Primary School of Rethymno, Crete, EL).*

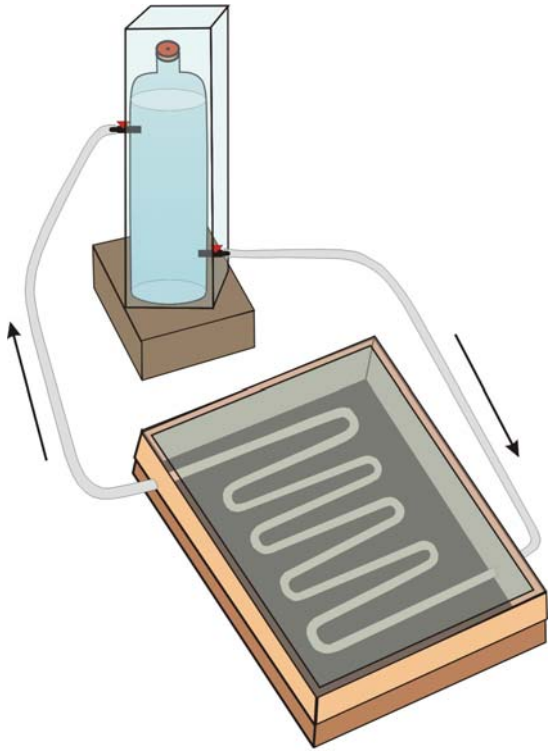


Figure 7: A drawing of a simple solar water heater out of a plastic bottle and a collector with a serpentine tube arrangement *(9th Primary School of Rethymno, Crete, EL).*

Photos 2 & 3: The preparation and construction of a serpentine solar water heater *(Scuola Secondaria di 1° Grado C.B. Cavour, IT).*

All participating schools have also set up experiments and investigations on *solar thermal energy* and *passive solar systems*, such as: a) make greenhouse models out of boxes with plastic glazing, b) experiments with "hot boxes", c) a simple pizza box solar cooker etc. In order to understand how solar cookers work, the *"greenhouse effect"* has been discussed and analysed. After that the pupils undertook project work and constructed *box solar cookers* with or without a top lid and a simple *solar dehydrator* out of a box in order to experiment with the drying of herbs, fruits and vegetables, which could also be presented at science fair activities. The pupils and teachers have been encouraged to record measurements and exchange data and information with their pen pals at all times.

This has not been achieved, in terms of the exchange, but several experimental recordings have been made by pupils at partner schools involving data representations in tables and charts. In this sense, mathematics have also been involved in the experimental processes, providing some quantitative or semi-quantitative approaches to a more general qualitative

observation and interpretation of phenomena under study, within the framework of hands-on science activities.

Photo 4: Pupils experimenting with hot boxes and the construction of solar box cookers *(Scuola Secondaria di 1° Grado C.B. Cavour, IT).*

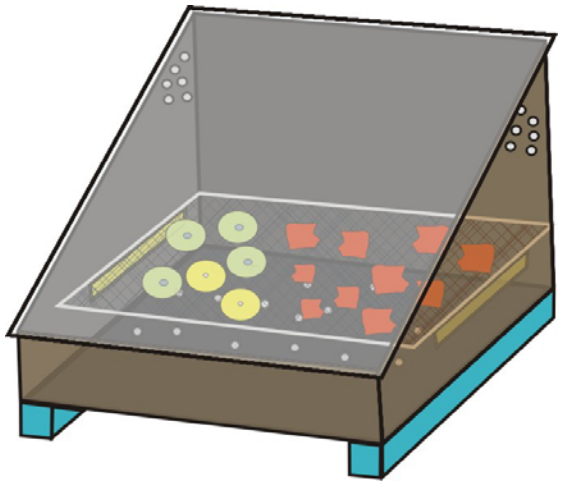


Figure 8: A drawing of a "solar dehydrator" (Sun dryer) out of a cardboard box, for drying out fruits and vegetables *(9th Primary School of Rethymno, Crete, EL).*

Photo 5: Two models of solar dehydrators and a box solar cooker presented at a primary science projects contest organized by Elinogermaniki Agogi in Athens *(9th Primary School of Rethymno, Crete, EL,* a distinction received*).*

The Italian colleagues and pupils of the *Scuola Secondaria di 1° Grado C.B. Cavour*, worked on the construction of a "*greenhouse-tunnel"*, where they grew seeds and plants. Through guide cards they analysed the different families of angiosperms, in order to select the most suitable to be grown in a greenhouse like monocotyledons and plants belonging to the family of *gramineae*. After the theoretical stage a group of students assembled the parts of the greenhouse made up by metal poles that we had fixed together.

The work was divided to different groups: The first had to cover the structure with plastic film. After that they began to plant narcissus and tulip bulbs, having prepared the ground adding a little of mould in order to make it softer. Other groups spread the seeds of broad beans and peas at a side of the greenhouse. They used some farm tools such as rakes, small and big hoes for digging holes, not very deep and 10 cm far one another. They often visited the garden and the greenhouse to take care and water the plants with a pump or with a pail. This greenhouse project is to be continued next year.

Photos 6 & 7: Pupils building the "greenhouse-tunnel" and planting the plants inside *(Scuola Secondaria di 1° Grado C.B. Cavour, IT).*

Moreover, the Spanish colleagues and pupils of the *Colexio de Educación Infantil e Primaria Froebel* have worked on the growing of plants and conducted experiments in their garden (*Teresa Couto, Manuel Carpintero Vázquez, Ana Lorenzo Bello* and collaborating teachers). They have looked at plants as self feeding organisms and they have discussed the process of photosynthesis and the role of solar energy in the growth of plants etc. After all, it was *Friedrich Froebel* (1782-1852) who contended that *"the garden is a place to learn the consequences of one's actions in a very direct way."*

Photos 8 & 9: Young pupils growing plants in raised wooden containers and in pots *(Colexio de Educación Infantil e Primaria Froebel, ES).*

The colleague *John Lahnidakis* from the *9th Primary School of Rethymno, Crete* has worked on sundials with pupils from the 6th grade of the school. They discussed how sundials work revisiting the Sun-Earth systems of motion (orbit and spin) and they created basic horizontal sundials out of simple materials like plywood and cardboard, which they oriented and calibrated out in the school yard.

Photos 10 & 11: Pupils of the 6th grade constructing and testing their sundials *(9th Primary School of Rethymno, Crete, EL).*

All school partners have also dealt with a third set *solar energy experiments* using *photovoltaic cells* such as: a) measure the rounds per minute of a circular piece of carton with a dot drawn on it, which is attached to the shaft of a motor operating with electrical energy coming from a solar cell, studying its performance under different conditions b) experiment with the performance of motors after orienting the solar cells at different angles towards the Sun, c) use transparent and non transparent materials on top of the solar cells and study their behaviour with motors etc. Pupils have undertaken project work in constructing solar toys with photovoltaic cells and motors (e.g. toy cars and/or boats).

Photo 12: A "big toy car" with a PV cell and a battery, which can carry a child *(Escola Antré Soares, Braga, PT* with *Maria da Graça Martins Pereira de Moura, Esperança Fernandes, Avelino Garrido* and collaborating teachers*).*

All schools worked on the solar energy projects and prepared the set up of science fairs, which have also been incorporated in the final events of the school year. Pupils and teachers have exchanged ideas and information amongst the partner countries and the coordinating school has provided advice and hints for the development of solar energy projects and constructions, eventually presented in science fair activities.

Photo 13: Explaining to science fair visitors how a solar water heater works *(Stella Maris College, MT)*.

Photos 14 & 15: Two science fair exhibits, a solar boat (left) & a solar carousel (right) *(Stella Maris College, MT* with *Ivan Misfud Bons* & collaborating teachers*)*.

2.3. Crafts, music and theatre related project activities

Some groups of pupils have worked to present other project related activities such as: theatrical plays, songs, craft work and happenings as well as paintings.

The colleague *Dafni Tsombanidou* from the *9th Primary School of Rethymno* has worked with children of the 3rd grade on a theatrical play *"The Sun-dropped lady"*, which has given several performances receiving a warm welcome and the compliments of the spectators. In its story, the Sun helps a good woman, who cannot have children, by giving her a child, the Sun-dropped lady. But, the Sun makes an agreement with the woman that she is to bring the child back to him when she becomes 12 years old. The mother takes care of the Sun-dropped lady, but when she reached the age of 12, the mother no longer wanted to keep the agreement. Then the Sun finds a way to take her to his palace, where the child has a nice and rich life, but feeling nostalgic, she wants to go back to her mother. She finally convinces the Sun to let her go back to her mother and they lived happily thereafter.

Photo 16: Pupils of the 3rd grade with their teacher on stage after the final performance of "Sun-dropped lady" *(9th Primary School of Rethymno, Crete, EL,)*.

Photo 17: Primary school children performing a Sun related story *(Colexio de Educación Infantil e Primaria Froebel, ES).*

Drama and role playing has been used in many cases amongst teachers and pupils in order to introduce and highlight aspects of solar energy and its applications. Even shadow theatre, for instance the Greek *Karagiozis*, has been used to play with light and its effects.

Pupils have sung and danced several songs like the "I'm walking on sunshine" and the "Here comes the Sun" by the Beatles. But, they have also created their own songs like the one from *Stella Maris College* in Malta, the *"Thank you Brother Sun"* song (Music: *Alfred Camilleri* & Lyrics: *Frank O'Neill*).

Come on let's use our energy.
To work as one in harmony.
We can do wonders, and have fun.
Just look above and watch the sky.
Fill with a glow that blinds the eye.
Move clouds away, here comes the sun.

Shining bright - what a sight.
Wonderful, powerful, beautiful
Dazzling light, radiant white
Energy, all for free –Powerhouse.

Bring in the sunshine (x2)
Bring in the light (x2)
One giant battery (x2)
Super energy.

Thank you, brother sun
(God Bless you)
You're my number one
(God bless you)
Shine on in the sky forever more (x2)

Figure 9: The *"Thank you brother Sun"* song *(Stella Maris College, MT).*

Pupils have worked with simple, common materials and have constructed several pieces of craftwork and paintings. They have been constructed either individually and/or collectively, sometimes accompanied with depicted texts like stories or even speech balloons and comics.

Photos 18 & 19: Collective craftwork by young children (18) and by primary pupils combined with story telling (19) *(Colexio de Educación Infantil e Primaria Froebel, ES).*

Several pupils have also prepared power point presentations to share their work with other fellow pupils and teachers. Those presentations deal with a variety of topics related to solar energy, alternative forms of energy, energy crisis, sustainable development etc. They are to be uploaded on the project web site soon (cf. URL: < http://9dim-rethymn.reth.sch.gr/contents_en/downloads.htm >).

3. Concluding remarks

A variety of solar energy activities, solar applications and constructions, which took place during the first year of the SEAA Comenius 1 project, have been presented and documented. It appears that there has been a thematic and rather holistic approach, not only restricting itself to a conceptual and practical level (cf. CAT, 1999; GSP, 2000), but also posing emphasis on social and cultural perspectives related to the issues tackled, at least for the majority of the activities (cf. Madanjeet & UNESCO, 1998).

During the two project meetings, we discussed the possibility for the establishment of an "e-twinning network" (cf. URL:< http://www.etwinning.net/ww/en/pub/etwinning/index2005.htm >) amongst school partners, in order to use the services and the *"TwinSpace"* for communication and exchange of project information. This seems to be an interesting idea under elaboration for the following project year.

Finally, we would like to thank all pupils and teachers of the collaborating schools, who have done such a wonderful work on the first year of the project, which credits a valuable asset for the future.

Photo 20: Pupils with logo T-shirts and an SEAA poster *(Scuola Secondaria di 1° Grado C.B. Cavour, IT).*

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[3] **Madanjeet Singh & UNESCO** (1998). *The timeless energy of the Sun for life and peace with nature*, San Francisco: Siera Club Books.