A New Module Based on PARSEL Stages

— For PET bottles, is recycling all we need to do? —

Yukihiko UENO[1], Mónica Baptista[2], Teresa Conceiçáo[2], Cecília Galvão[2]

In recent times, science and technology have permeated our daily lives, especially in urban areas, although the commonplace nature of science-based systems has made us largely unaware of their presence. For example, although smartphones are a widely used convenience, their structural components are ill-understood by the mainstream populace. Most people know little about the structure of the battery, central processing unit (CPU), touch screen, and so on. Thus, there are many 'black boxes' around us. However, the foreseeable societal problems concerning science and technology, such as issues related to energy, human health, and information technology demand that we understand these matters as much as possible. For example, regarding the serious problem of whether nuclear power plants should be abolished, each of us has the responsibility as citizens to thoroughly analyse this matter. Such a decision is to be made by considering this question from the social aspect, such as the economics, as well as in terms of science and technology. Therefore, the importance of science literacy assumes paramount importance.

High school teachers recognize that for the majority of students, science is less interesting and science careers are not perceived as attractive, as also alluded to by European educators. However, the study of science is indispensable for all students as mentioned above; thus, students majoring in literature, arts, sports, economics, commerce, and various fields should acquire science literacy.

Thus, we planned to develop new teaching materials according to the "PARSEL" approach to increase the popularity of science and promote greater student interest in science by making students feel that understanding science is essential for life in general and is of importance for all careers. PARSEL, which serves our purpose, is a European Commission Project (1st Oct, 2007 – 31st May, 2009) under the Science and Society banner, which proposes an approach designed to raise the popularity and relevance of science teaching through a collection of modified, or created, teaching/learning modules. The modules cover a series of lessons at the basic and secondary level (grades 7 to 12) and are designed for use within mathematics, biology, chemistry, and physics classes. The main objectives of PARSEL are to develop, test, and disseminate science education modules that can be used to enhance scientific literacy.

We prepared a new module based on PARSEL stages, entitled "For PET bottles, is recycling all we need

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to do?" as a teaching material to stimulate students to think about the issue and significance of recycling PET bottles. This module is suitable for high school students because many of them are familiar with PET bottles. The module consists of an Abstract and 1) Students activities, 2) Teaching guide and Teacher's note, 3) Assessment, and 4) References.

The objectives/competencies are as follows. Students are expected to be able to:

* Accurately recognize the symbol indicating PET (polyethylene terephthalate).
* Describe the methods for synthesizing and decomposing PET.
* Write the chemical equation for complete combustion of PET.
* Cooperate as a member of a group in planning and carrying out experiments and in undertaking discussions on discarding PET bottles as responsible citizens.
* Communicate orally in an appropriately scientific manner and in writing by creating a report.
* Carry out tests on the toughness of PET, its deformation at high temperature, the combustion properties, and soot formation. Understand the toughness based on bending and stretching and the thermoplasticity of the PET film and the formation of soot upon combustion in air.
* Understand soot generated from burning PET bottles and its poisonous effects and health impact.
* Find information on the costs, the environmental impact, and energy and resource saving associated with PET recycling and reconfirm the importance of reducing the total volume of waste PET as well as recycling PET.

At the end of the study unit, students should be able to make an informed socio-scientific decision on the theme: For PET bottles, is recycling all we need to do?

Thus, in the modules based on PARSEL experiences and stages, scientific themes closely related to the society are studied and students approach the issue of PET use from both a purely scientific and a social perspective, and finally engage in socio-scientific decision making.

* This study was conducted in the University of Lisboa, Portugal and the article is stored in Waseda University Repository (https://waseda.repo.nii.ac.jp).

References:

* Schreiner, Camilla & Sjøberg, Svein, "*Sowing the seeds of ROSE : background, rationale, questionnaire development and data collection for ROSE (The Relevance of Science Education) : a comparative study of students' views of science and science education (pdf)*" (Acta Didactica 4/2004). Oslo: Dept. of Teacher Education and School Development, University of Oslo (2004).
* http://icaseonline.net/parsel/www.parsel.uni-kiel.de/cms/indexe435.html?id=home

For PET bottles, is recycling all we need to do?

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Subject: PET (polyethylene terephthalate), Material recycling, Chemical Recycling, Thermal Recycling, Combustion of plastics, Soot

Grade level: 10–12 chemistry module on recycling PET bottles

Curriculum content: Environmental chemistry, plastics, organic compounds

Kind of activity: Internet search for materials, laboratory investigation, and group discussion to make a socio-scientific decision

Anticipated time: 4 lessons (50 min × 4)

Prior knowledge expected: ester bond, hydrolysis, balancing chemical equations, complete combustion

Abstract: PET (polyethylene terephthalate) has gained widespread use in daily life and increasing emphasis has been placed on PET recycling as a means of conserving natural resources and for sustainable development. However, many students do not know the outcomes of the recycling process. Once they throw PET bottles into a rubbish bin, they have little interest in them. Here, we study the implications of PET recycling from the scientific and economic perspectives. We learn the SPI numbering system for plastics and investigate the ability of PET to withstand a pulling force and a bending force and evaluate the thermoplasticity and the poisonous characteristics based on combustion experiments. Using the internet or other materials, we find information about the percentage of PET bottles that is recycled in a selected city or country and consider how much recycling contributes to the sustainability of life.

Each group must submit the Handout to the teacher at the end of the last lesson and each student must submit a report on the theme “For PET bottles, is recycling all we need to do?” by the deadline.

The objectives/competencies are as follows:
Students are expected to be able to:

* Accurately recognize the symbol indicating PET (polyethylene terephthalate).
* Describe the methods for synthesizing PET and decomposing by hydrolysis.
* Write the chemical equation for complete combustion of PET.
* Cooperate as a member of a group in planning and carrying out experiments and in undertaking discussions on discarding PET bottles as responsible citizens.
* Communicate orally in an appropriately scientific manner and in writing by creating a report.
* Carry out tests on the toughness of PET, its deformation at high temperature, the combustion properties,

and soot formation. Understand the toughness based on bending and stretching and the thermoplasticity of the PET film and the formation of soot upon combustion in air.

* Understand soot generated from burning PET bottles and its poisonous effects and health impact.
* Find information on the costs, the environmental impact, and energy and resource saving associated with PET recycling and reconfirm the importance of reducing the total volume of waste PET as well as recycling PET.

(Attached files)

1. Students activities
2. Teaching guide and Teacher's notes
3. Assessment
4. References

For students

For PET bottles, is recycling all we need to do?

Student Guide

Scenario

Is it always true that recycling PET bottles benefits the economy and the environment? We know, of course, that PET bottles should not be thrown away along the path or burnt in the open air. If they are burnt, poisonous and irritating compounds and soot will be emitted. Thus, we dispose of PET bottles in a designated trash bin and they are conveyed to a facility for recycling. The disposed PET bottles are reused and recycled into fibers for clothes or new plastic commodities, which contributes to sustainable living.

Recycling of PET bottles has an associated cost and the process leads to the emission of heat and energy. Therefore, recycling PET bottles is influenced by a confluence of factors.

Here, we intend to study the factors that affect the recycling PET bottles, such as the cost and the environmental impact, and consider whether it is beneficial to recycle waste PET bottles.

Research problems

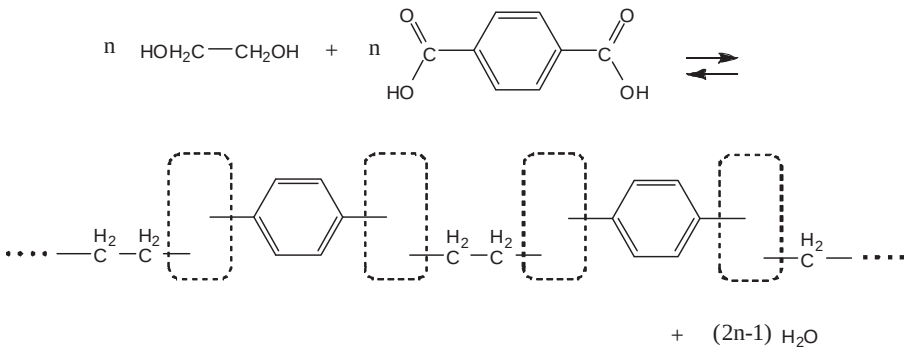
(1) What symbol is used to mark PET bottles? Which number is surrounded by the three cyclic arrows? What is the method for synthesizing PET? Can it be decomposed by hydrolysis for recycling?
(2) Can strings be formed from a PET bottle? Is PET flammable? When a PET bottle is burnt in the open air, what poisonous compounds are generated?
(3) What is material recycling, chemical recycling, and thermal recycling (burning)? What percentage of the consumed PET bottles is recycled in a specified city or country? Has the volume been growing or declining? What causes the loss or gain of momentum for recycling? (For example: what happens if the price of commodities produced from recycled PET is lowered.)
(4) What is the impact of recycling?

Student Tasks

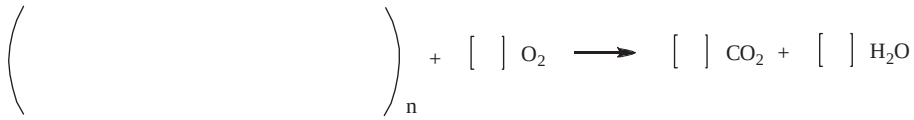
Phase 1

Form groups of 3–5 students in a class and count the total number of PET bottles consumed in a group per week. Prepare an empty plastic water bottle for each group and look for the mark on it, i.e., a ‘1’ surrounded by three cyclic arrows, ‘PETE’ or ‘PET’, and from the internet or other materials, find the meaning of the symbol.

Find the scheme for synthesizing PET from ethylene glycol and terephthalic acid. Fill in the blanks in the figure below to show the complete chemical equation. Based on this equation, comment on possible methods of PET decomposition?



The word ‘poly’ in the name ‘polyethylene terephthalate’ means ‘many’; thus, the name means many ‘ethylene terephthalates’. For example, ‘poly A’ means many ‘A’ bounded linearly, and is usually indicated as $(\text{-A-})_n$. Show the structure of PET in this style and balance the chemical equation for complete combustion (Eq. 1). Fill in each blank.



PET

(Eq.1)

Phase 2: Experiment

Investigate PET by experiments. Cut the PET bottle with scissors to obtain some chips of PET.

(a) Record the appearance of the chip and the ability to withstand a force by pulling and bending the PET specimen at room temperature.

(b) Make a plan to investigate whether the PET chip can be deformed easily into strings upon heating and whether it burns when placed in a burner flame to generate soot and record it in your notebook. Based on your plan, conduct the experiments and document the results and your observations in detail.

* (If the sample burns, put the fire out by immersing the sample in a beaker of water).

(c) When the PET chip is placed in the flame, is the combustion complete or incomplete? Answer this question based on the results of the experiments and Eq. 1.

Phase 3

From an internet search, explain what soot is and the deleterious effects on human health and the influence on the environment.

Example of reference: https://www.americanprogress.org/issues/green/news/2012/08/10/12007/soot-pollution-101/

Phase 4

With regards to recycling PET bottles, find information from the internet and answer the following questions:

* What is material recycling, chemical recycling, and thermal recycling (burning)? Which is the best way to recycle PET bottles?
* What percentage of the consumed PET bottles is recycled in a specified city or country?

Has the volume been growing or declining?

What causes the loss or gain of momentum for recycling? (For example: What is the impact if the price of commodities produced from recycled PET is lowered).

<Remarks> Waste PET bottles are generally sorted out at a material recovery facility, compressed into bales, washed, and cut into clean dried flakes. Contaminants must be absent for fiber or bottle applications as they lead to breakage and an unrefined appearance. For example, polyvinyl chloride (PVC) as a contaminant generates acidic compounds during recycling; these species catalyse the hydrolysis of PET. Thus, the recycled clean dried flakes of PET sometimes can not be used directly to produce commodities, and cost and energy requirements are associated with removing the contaminants from recycled PET.

Phase 5

Taking the investigation above and the observations into consideration, discuss in the group whether the recycling of PET bottles is effective from the viewpoint of science and economics and what steps must be taken for sustainable living.

Each student has to make his/her own decision and describe the process of reaching the decision on a sheet of A4 paper and submit it to the teacher as a final report by the deadline. The handouts should be gathered at the end of the experiment.

For teachers

For PET bottles, is recycling all we need to do?

Teacher guide

Some plastics are very flammable because they are made from petroleum. For example, caps for PET bottles burn well once they catch fire. Polyvinylchloride, which is often used for butter containers, is an inherently fire-resistant plastic, but it burns in a flame to generate hundreds of compounds and a lot of soot. Thus, if garbage containing plastics is burnt in a city, many kinds of toxic compounds will be generated, which is a very serious problem for humans and the environment. We should learn how to treat plastics, and we should not only dispose of PET bottles in a designated trash bin, but also reduce the total volume of waste PET bottles.

The present lesson is a group study for 4–6 persons.

Learning outcomes by lesson

Lesson 1

Students are expected to be able to:

In Student tasks–Phase (1)

- Understand the numbering system for plastics and its background and significance.
- Understand that PET consists of ester bonds of ethylene glycol and terephthalic acid and that the polymerization reaction is reversible. Thus, they should understand that the starting materials for PET can be recycled.
- Write the chemical equation for complete combustion of organic compounds ($C_xH_yO_z$).

Lesson 2

Students are expected to be able to:

In Student tasks–Phases (2) and (3)

- Plan experiments that are as safe as possible and do risky experiments in a draft chamber.
- Test the mechanical properties, thermoplasticity, and burning properties of PET.
- Cooperate as a member of a group in planning and carrying out experiments and in undertaking discussions on discarding PET bottles as responsible citizens.
- Communicate orally in an appropriately scientific manner and in writing to create a report.
- Be aware of the hazardous compounds generated from burning PET bottles.

Lesson 3

Students are expected to be able to:

In Student tasks–Phase (4)

Think about the contribution of PET recycling to creating an environment committed to sustainability as well as the economics of recycling.

Lesson 4
Students are expected to be able to:
In Student tasks–Phase (5)
Make a socio-scientific decision as a responsible citizen living with plastics and write a report on how this decision was reached.

Suggested Teaching Strategy

1. How many PET bottles do we use in a week?
   In a whole class discussion, lead students to be aware of how many PET bottles they use. The discussion leads to the assignment for students to count the total volume of PET bottles disposed by them in a class in a week.
2. Is PET suitable for reuse, material recycling, chemical recycling, or thermal recycling?
   From the results of the experiments (Phase 2), students confirm the hardness and the toughness of PET, and thus, they could suggest the best method of reuse. The equilibrium equation in Phase 1 suggests the possibility of chemical recycling for starting materials. The thermoplasticity of PET demonstrated in Phase 2 also shows the possibility of material recycling. PET can be deformed into strings and sheets to form various products. Thermal recycling is the last option.
3. Why should we separate waste PET bottles from other garbage and dispose of them in a designated rubbish bin?
   Guide students to consider the PET burning experiment in Phase 2 and the information on the poisonous compounds generated from burning PET.
4. Do recyclers make a profit?
   Lead students to find data on the internet regarding PET recycling and to determine what percentage of the consumed PET bottles is recycled in a city or a country. From this data, guide students to understand the situation of PET recycling and to pinpoint the factors that limit recycling.
5. What should we do for the creation of an environment committed to sustainable development?
   Teachers could suggest that it is impossible to create an environment committed to sustainability only by recycling PET and that reducing the total volume of waste PET bottles is inevitable. Small groups in a class could debate the issue of social responsibility, focusing on the reduction of PET usage.
   For the reduction of waste PET bottles, teachers could also highlight the overuse by consumers and the overproduction by the manufacturing industry.

For teachers

For PET bottles, is recycling all we need to do?

Teacher's notes

Student tasks–Phase (1)

For the numbering system for plastics, there are many websites with easily understood information[1]. The Resin Identification Code (RIC) system was introduced in 1988 by the Society of the Plastic Industry (SPI)[2] for recycling waste plastics. Nowadays, SPI is working to improve the system to make it easier for people to know what to recycle, and in some countries an improved RIC system has actually been implemented where complex plastics such as polymer alloys have been developed and used for many products.

There are four recycling methods: reuse, material recycling, chemical recycling, and thermal recycling. It is very important to separate our waste plastics because plastics are recycled according to the number. The best way to recycle is reuse, the next is material recycling, and the third is chemical recycling. Thermal recycling is the least desirable as it leads to the evolution of heat and carbon dioxide.

The synthesis of PET involves the bonding of ethylene glycol and terephthalic acid by ester bonds. The esterification reaction is reversible; therefore, PET can be decomposed by hydrolysis with acids or bases to recover the starting materials.

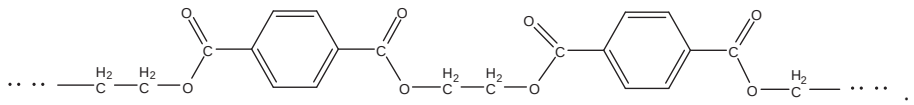
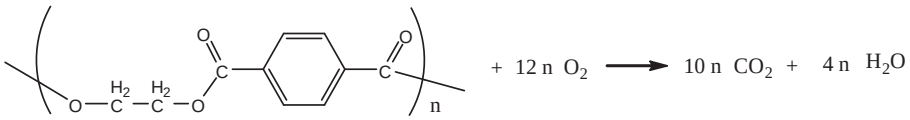


Figure. The structure of PET

According to Eq. 1, during the complete combustion of PET, only carbon dioxide and water are generated, without soot formation or generation of a pungent odor.



(eq.1)

PET

Figure. Equation for the complete combustion of PET.

Student tasks–Phase (2)

The teacher has to check the plan for safety.

Example of an experimental scheme:

In a draft chamber, pick up a sample (0.1–0.5 mg) of PET with tweezers and put it on a burner flame while pulling it with another pair of tweezers, then burn it in a burner flame. Observe the changes in the PET sample, the burner flame, and look for soot formation.

<Remarks> The most important thing is for the student to perform the experiment safely. The teachers should check the experimental plan and guide the students to conduct safe experiments. The burning test MUST be conducted in a draft chamber and the sample size should be small.

Student tasks–Phase (3)

The term "soot" has been used for both combustion products as a group and for a material with specific, defined properties, although Buseck et al.[3] defined soot as particles with grape-like morphologies that consist of nanospheres that possess distinct structures of concentrically wrapped, graphene-like layers of carbon. Thus, soot comprises many graphene-like layers, which are not planar layers though graphene has a plane structure with carbon rings and a conjugated structure, as shown below.

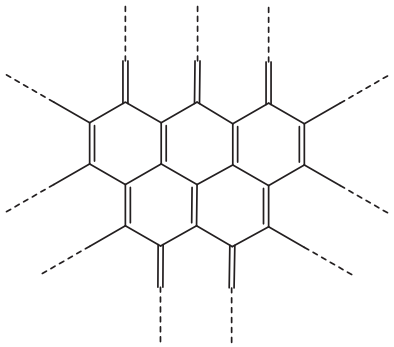


Figure. Structure of graphene.

Student tasks–Phase (4)

A reduction in the price of recycled PET resin is expected given that the price of virgin PET has declined. The price of virgin PET has been driven down by competition due to overcapacity, little increase in demand, pressure from lower-cost imports, and reduced raw material prices. If the cost of collection and processing by the recycler does not decrease and the price of virgin PET is comparable to the price of recycled PET, the price-based incentive to use recycled PET vanishes. Therefore, PET recycling has to contribute to creating an environment in which there is a commitment to sustainability.

Students need to study the energy consumption and the emission of heat and CO_2 associated with recycling. Therefore, they should take many factors into consideration.

This information can be obtained from proper websites, for example "*PET recycling rate reports*" [4], Napcor, or "*Plastics–The facts 2014/2015. An analysis of European plastics production, demand and waste data*" [5], Plastics Europe.

Student tasks–Phase (5)

Reducing the number of waste PET bottles is closely related to our lifestyle. If we consume a large volume of PET bottles, a sustainable society cannot be realized. The excessive commercialization, overproduction, and overuse of PET bottles should be curbed. It is doubtlessly good to recycle disposed PET bottles, but the most important thing is to conserve the natural resources on Earth and exercise caution with the scarce resources we have.

Student Handout; each group has to submit

STUDENT: Grade ( ) Class ( )
No. ( ) Name ( ), No. ( ) Name ( ),
No. ( ) Name ( ), No. ( ) Name ( ),
No. ( ) Name ( )

Phase 1
The number 1 in the numbering system refers to ( )
Give the chemical equation for PET synthesis:

Give the chemical equation for the complete combustion of PET:

Phase 2
(a)
Describe the following physical characteristics of PET:
Toughness of bending: ( )
Toughness of pulling: ( )
(b)
When the PET chip was heated:
Could the chip be deformed easily? ( )
Could it be deformed into strings by drawing? ( )
In a flame:
Does PET burn? ( )
Does it generate soot? ( )
Is the combustion complete or incomplete? Explain the reason.
( )
The reason:

Write your other observations:

Phase 3

What is soot:

Describe the poisonous effects of soot on health:

Describe the influence of soot on the environment.

Phase 4

What is material recycling:

What is chemical recycling:

What is thermal recycling:

Assessment

For PET bottles, is recycling all we need to do?

Criteria

Concerning Student Handout, we present an allotment of points.

Points in Handout:

Phase 1 (1 point for each *)

* The number 1 in the numbering system refers to (PET).
* The chemical equation for PET synthesis.
* The chemical equation for complete combustion of PET.

Phase 2

(a) (1 point for each *)

* The appearance: (clear and smooth surface).
* Toughness of bending: (hard to bend by hand).
* Toughness of pulling: (very hard to elongate by hand).

(b) (1 point for each *)

When the PET chip was heated:

* Could the chip be deformed easily? (Very easily).
* Could it be deformed into strings by drawing? (Very easily).

In a flame:

* Does PET burn? (Yes).
* Does it generate soot? (Generates soot).
* Is the combustion complete or incomplete? Explain the reason. (Incomplete).
* The reason: Because it generates soot and a pungent odor.

Write your other observations: (point is arbitrary)

Phase 3 (2 points for each *)

* What is soot:
* The poisonous effects of soot on health.
* The influence on the environment.

Phase 4 (1 point for each *)

* Material recycling.
* Chemical recycling.
* Thermal recycling.

Concerning the final report:

We present a list below (Table 1) with assessment criteria for the report.

Table 1 Assessment of the written report

Assessment criteria	Description	Score
Ideas and its development	Final report presents an extensive development of the ideas. Main idea is well-grounded with details	4
	Final report presents a fair development of ideas, with many well- grounded details.	3
	Final report presents an appropriate development of ideas, which are supported by some details.	2
	Final report presents a poor development of the ideas, which are supported by only few details or even none.	1
General organization	Final report presents good organization – the ideas follow a coherent line and are divided into themes.	4
	Final report presents fair organization, although there is no clear guidance line.	3
	Final report presents poor organization - there is no coherent line bridging each theme.	2
	Final report presents lacks organization ….	1
Data organization	Data is well organized, divided into categories of analysis and displayed in tables in ways that facilitate its reading.	4
	Data is displayed sometimes in tables, which are sometimes easy to read	3
	Some data are displayed in tables, but other is dispersed	2
	Data is badly displayed and of difficult reading	1
Vocabulary	Imaginative use of words. Correct use of scientific words.	4
	Good use of words, with a clear meaning. Correct use of scientific words.	3
	Fair use of words. Uses simple words. Correctly use of scientific words.	2
	Poor and sometimes incorrect use of words. Incorrect use of scientific words.	1
Language use	Excellent written text. No orthographic mistakes and sentences of different sizes.	4
	Good written text. Few orthographic mistakes and sentences somewhat varies in their sizes.	3
	Simple written text. Some orthographic mistakes and use of simple and small sentences.	2
	Poor written text. Many orthographic mistakes.	1

References

For PET bottles, is recycling all we need to do?

1) For example: “RECYCLING PLASTICS IS AS EASY AS ...1,2,3 (4,5,6,7)!”, http://www.dec.ny.gov/docs/materials_minerals_pdf/plasticpam.pdf
2) https://www.astm.org/newsroom/new-astm-standard-covers-society-plastic-industry’s-resin-identification-code
3) “Are Black Carbon and Soot the Same?”, Buseck, P.R. *et al*., Atmos. Chem. Phys. Discuss., **12**, 24821–24846 (2012).
4) https://napcor.com/reports-resources/
5) http://www.plasticseurope.org/documents/document/20150227150049-final_plastics_the_facts_20

PARSEL に基づく新しい授業材料の開発

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現在，都市の日常生活には，科学や科学技術が入り込んでいる。あまりに身近であるためにそれらの存在が意識されないことも多い。スマートフォンについて，使い方や情報伝達の方法につき熟知していても，その中に使われている電池や CPU，タッチパネルの仕組みや原理について何も知らない人も多い。このように私たちの身の回りには，ブラックボックスとして使い方のみ知っていれば良いとされるものが多くなった。しかし，将来はエネルギーや健康，情報通信などに関する科学と密接に関連した多くの社会問題が生じるであろう，そしてそれらについてできるだけ詳しく知る必要に迫られることになるであろう。そのような時に科学の基礎的な素養，科学リテラシー，は不可欠である。例えば，「原子力発電を進めるべきか，否か。」私たちはこのような重大問題について，市民として一人一人が考え，自分で判断しなくてはいけない。経済など社会的な問題点と純粋に自然科学的な問題点と，それらを良く考えて判断せざるを得ない。従って，市民に不可欠な素養として自然科学の重要性は増していると考えられる。

一方で，科学や科学技術に興味をもちこれらを将来の職業と考える学生や，教養の一つと考えて興味をもち続ける学生の割合が減少しているように思える。中学校や高等学校の理科の授業に興味をもてない生徒の割合が多いことは，ヨーロッパでも報告されている。前述したように科学リテラシーは，科学や科学技術とは直接関係ない学生にとっても必要な素養であり文学，芸術，スポーツ，経済や商学などの分野に進む学生にも是非，興味をもって学習して欲しい基礎教養である。

そこで，筆者たちはおおくの学生にとって科学が人気あるものとなり，彼らができるだけ興味をもち，その結果，科学はどのような生き方や職業の人にも必要であると感じられるような“PARSEL”に基づく新しい授業材料の開発を計画した。PARSEL は Popularity and Relevance of Science Education for Scientific Literacy を略したもので，ヨーロッパ委員会のプロジェクトであり，自然科学と日々の社会現象を結び付けることを旗印として，2007.10.1から2009.3.31まで行われた。これは，モジュールと呼ばれる専門家により練られた授業材料を用いて，学生の興味を引き出し身近に感じられるアプローチを押し進めるものである。モジュールにはいろいろな種類があり，中学生及び高校生を対象として，一般の自然科学，すなわち生物学，化学，物理を網羅している。PARSEL では，その主な目的を自然科学教育の科学リテラシーを推進するモジュールを開発し，テストし，普及することとしている。

ここで作成する材料の題目は，社会と関連が深く，私たちの周りのことで，しかも自然科学の問題を探した。その結果，廃棄プラスチックの問題が中学生，高校生になじみがあり，毎日のように触れるものであるので，これを題目とした。

作成したモジュールの題目は“For PET bottles, is recycling all we need to do?”で，PET ボトルリサイクルの問題とその回収の意義について考えるものである。それは，１）学生の活動，２）指導手引き，３）評価，４）教師用メモ　からなる。目的あるいは獲得すべき行動や思考の特性は以下のとおりである。

学生は次の事柄ができるように求められる。

＊ PET（Polyethylene terephthalate）の番号システムを正しく認識する。

＊ PET ボトルの曲げ強さ，引っ張り強さ，熱可塑性を知る。
＊ PET ボトルを燃やしたときに発生する毒性の化合物を知る。
＊ PET ボトルのリサイクルコストと環境負荷を考え，科学的工学的立場と経済的立場からリサイクルの効果を考える。

最後に自然科学的観点と経済的観点から，PET ボトルリサイクルについて，社会と深く結びついた自然科学的な意思決定をできるようにする。すなわち，PET ボトルリサイクルが本当に我々の社会に有益なものか否かの判断を下す。

このように PARSEL に基づくモジュールでは，社会と深く関係した自然科学の問題を研究し，学生はその純粋に自然科学的な面と社会的な面から探求を行い，自分たちで最終的な意思決定を行うように組み立てられている。PARSEL の言語は英語及びその他のヨーロッパ各国語が用いられるので，ここでは英語のモジュールを作成した。