SUPPLEMENTARY TEACHING MATERIALS

PROMOTING SCIENTIFIC AND TECHNOLOGICAL LITERACY

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Jack Holbrook and Miia Rannikmae

ICASE / UNESCO SUPPLEMENTARY TEACHING MATERIAL

PREFACE

This *collection of* exemplary teaching materials has been specially compiled to help teachers promote STL (scientific and technological literacy) among the students. As such, the materials are very much in line with Project 2000+ - an initiative by ICASR and UNESCO to encourage developments within countries to meet the challenges facing science and technology education for the 21st century.

The materials have been developed by teachers from Eastern European countries (Estonia, Czech Republic, Latvia, Lithuania, Poland, Russia, Slovakia, Ukraine). They have gone through several developmental stages during a one year period - beginning from the initial idea (during an ICASE-UNESCO writing workshop, May 1996), piloting in schools and then based on the results of trials - modification made to the structure for scripts. Assessment components, as well as the strategy for achieving the objectives, were added by the editors and follow the general philosophy for STL teaching The materials were not written for any curriculum in particular, but were created with secondary school teachers in mind.

The materials are designed to remind teachers that science education is part of EDUCATION and that science teachers (or biology, chemistry and physics teachers) are called upon to guide students in that education. The overriding intention is that students are EDUCATED. Science education has a responsibility in the education of students in the 21st century, that citizens arc to relate to the very considerable science and technology challenges of the future and cope with the ever increasing pace of change. This responsibility is seen as going beyond the acquisition of science concepts, or the scientific method. It is seen as embracing social values, cooperative learning, personal development and the acquisition of a range of communicative skills through the teaching of science.

The materials are intended to guide the teachers towards this more socially driven science education, in which students are expected to be fully involved in the planning, the problem solving and the decisions that need to be made. However, science concepts are not forgotten. They are also seen as being important. But scientists[4] science is displaced by citizen's science. The transference of educational skills, based on critical thinking in a science framework, provides the platform for further learning, not, as seems to be the present case, a collection of memorised scientific verifications and procedures.

These materials represent an accumulation of work, facilitated by a number of persons and organisations. Besides the initiators of the scripts, the following ICASE member associations and institutions helped in carrying out the trials: Estonian Association for Chemistry Teachers, Latvian Association for Chemistry Teachers, Lithuanian Assocation for Chemistry Teachers, Russian Association for Science Professors, Polish Association for Science and Technology Teachers, Polish Association of Physics Teachers, Czech PEDAGPROGRAM, University of Torun, Department for Teachers In-service of Herzen Pedagogical University of Saint Petersburg, Department of Science Didactics, University of Tartu.

Jack Holbrook

Miia Rannikmae

PART

INTRODUCTION

TO THE SCRIPTS AND THE PHILOSOPHY UNDER WHICH THEY HAVE BEEN DEVELOPED

PART I
INTRODUCTION

SECTION 1 INTRODUCTION

Dear Teacher,

Do you wish to have *science* teaching materials that you *can* use directly in your teaching? But not just any teaching materials! Teaching materials that are interesting for the students

- ✓ provide a learning challenge for the students
- ✓ are written in a manner that is supported by science education research
- ✓ *broaden teaching in line with modern science education philosophy*
- ✓ *specify the learning objectives for both students and teacher*
- ✓ arc ready to use!

— This set of teaching materials is designed to do all that It is intended as an additional resource, beyond the *text* book, for the teaching of science subjects. It is written to be used directly with students. The scripts are written for students at different age levels. In general all scripts are designed to be within the age range 11-17, but this is given i as a guideline only.

— The materials are very different from the textbook. First and foremost, the materials arc not simply for reading Each script puts forward activities that involve the students. This is one of the major goals of the scripts. The teacher does not need to talk for long periods of time. Students do not need to read text and try to memorise its content. Each script involves students in individual or group learning tasks.

— Other objectives include

- being a science learning exercise
- being enjoyable (for students and hence for the teacher)
- promoting cither problem solving or decision making skills
- putting emphasis on communication skills
- originating from the society, thus ensuring RELEVANCE of the science content

► This first section explains what the teaching package contains, why the scripts have been written and gives suggestions on how to use the scripts. Other sections explain the teaching approach being advocated. Interested teachers can read further and appreciate the philosophy behind the approach, the meaning of STL (scientific and technological literacy for all) and the need to move science teaching away from sterile, science content

An appendix gives information on Project 2000+, an ICASE and UNESCO initiative to promote STL and encourage Governments, non-Governmental organisations (such as professional Science Teacher Associations), teacher educators and teachers themselves, to rethink the purpose of science education in schools for the 21st century. Project 2000+ encourages all to get involved in teacher education and guide science teaching in a new direction. This of course is no easy task and cannot be achieved overnight. This teaching package is one attempt at stimulating teacher change.

Finally the materials in the teaching package are not written for any specific science curriculum. The scripts can be used by teachers whenever they feel it is appropriate.

PART I

INTRODUCTION

1. About this Teaching Package

The teaching package comprises this introduction to the scripts and t number of independent teaching scripts. The introduction to the scripts is designed to give the overall guidelines and thus assist the teacher in understanding this package, how it can be used and the purpose of using it. Teachers are strongly encouraged to read this before using the scripts.

The independent teaching scripts are ready to use in the classroom. The teacher needs to decide whether to use only one script, or many scripts. *Teachers are permitted to make multiple copies of the Student Handouts for use in the classroom without infringing the copyright*

Besides making available additional resources for the science teacher, the purpose of developing this teaching package is to help teachers to

1. embrace teaching and learning for scientific and technological literacy (STL)*;
2. increase the effectiveness of teaching by giving specific targets to be achieved;
3. increase student interest and thus make science teaching more enjoyable;
4. gear science teaching to the attainment of as many of the stipulated general educational goals as possible; and
5. if 1- 4 are achieved, this teaching package is designed to influence teachers to change their teaching style in other science lessons, and hence further promote STL learning

* See page 15 for an explanation of STL

2. Using the Scripts

Each script can be used by teachers within a teaching sequence of their own choosing. The scripts are designed to be independent of each other and comprise:

—— An Introduction
General for both Students and Teachers

——***A Students* Script***
Giving the Scenario plus Tasks to be undertaken

——***A Teacher's Guide***

PART I

INTRODUCTION

Assisting the teacher by suggesting Teaching Strategies, how the scripts sets about Achieving the Objectives, Assessment Ideas, and, if appropriate, additional Handouts for the Students.

Some scripts will have additional information. The additional information has been added to scripts to help the teacher, but there is no suggestion that this is folly adequate to undertake the activities. Teachers are advised to seek further information where they feel it appropriate.

The Introduction

This is intended to give some indication of what the script is about and the educational objectives* students are expected to achieve by undertaking the activities provided.

* The scripts arc about the teaching of science. The purpose in teaching science is to achieve the educational objectives.

The educational objectives are geared to the general education goaJs. These goals are specified within a country, as the rationale for attending school. They state what schooling is attempting to achieve These goals may change for different age levels and may not be explicitly stated in all countries. An example of general education goals is given in appendix. These goals are NOT subject specific.

Students' Script

This is the main document to be given to students. A scenario sets the scene for the tasks to be undertaken. The scenario is related to the society and points to an issue or concern on which the script draws. Besides the scenario» a number of individual or group tasks tit given which represent the learning activities. These ate geared heavily towards cooperative learning, promoting communication skills and either making societal decision» of solving societal problems. As it is important that the whole lesson is under the control of the teacher, the strategy for introducing the students' scripts, die manner in which they arc used and the way the lesson is conducted, is for the teacher to determine.

Teacher'* Guide

From the teacher's point of view, the guide needs to be considered as the main part of the script It gives guidance on how to use the script, *in the manner intended.* It assists the teacher by putting forward a teaching strategy, details how the *intended* educational objectives are to be achieved, suggests assessment approaches and includes any additional handouts for the students that the teacher may wish to give later in the lesson, |

The section on 'achieving the objectives' is very important. It links the student tasks to the objectivci These objectives are the intention. The next section on 'assessment' is very much related to the achievement of the objectives. It outlines the manner in which feedback from the students can be obtained fin a formative and/or sumrnative manner) and hence help the teacher determine whether the tasks have enabled the students lo actually achieve the objectives put forward.

3. How to Use the Scripts

The following procedure is suggested:

1.Select a script that is on a topic of interest.
2.Read through the script, noting (a) its objectives (i.e. the introductory part) and (b) the equipment needed (given in the teacher's guide).
3. If the script is suitable for the lesson, decide how many student scripts is sufficient. (Teachers may feel that each student should have their own copy of the script, so that a record can be kept alongside written/graphical/tabular reports produced by the student).
1.Plan the lesson (decide whether to follow the teaching strategy suggested, with or without modifications. It is stressed that the guidelines are only suggestions and that teachers are free, and even encouraged, to make modifications whenever they feel it appropriate).
2.Ensure students have time to complete the script.
3.Check that the objectives can be achieved (see - achieving the objectives section).
4.Prepare the formative and sumrnative assessment components you will include within die tesson.

5.In case of difficulties, consult this introduction to the scripts again.

4. Why Use the Approach in these Scripts?

The approach being suggested is very different from that in most teaching material It marks a serious attempt to link science education to the purpose of education. The following summarises the major points.

1. *1. It is not just a teaching idea.*

It is a teaching idea with specific objectives to be achieved, accompanied by student tasks and teaching strategies

2. *It is not simply something to do*

It is designed to be enjoyable, but it has also serious educational objectives The objectives tie made known to students and the teacher, and the teacher is guided as to how they can be achieved.

3. *It begins from the society.*

This is a major change. Usually teaching materials begin with, and relate to, the science. The link to the society is not given (or if it if mentioned, it is not stressed) These scripts always begin from the societal issues or concern and attempt to 'solve the problem* making use of scientific principles, or facts in this way they show science in the service of man.

4. *It involves students.*

Many teaching scripts do this, but care is taken to ensure that an activity does not equal a 'recipe* experiment, to be followed without understanding its purpose. [If a recipe is included for students to follow, it is to enable students to achieve goals beyond the carrying out of the experiment itself].

5. *//promotes the acquisition of scientific» higher order thinking.*

A laudable target, often neglected by teaching materials The importance of requiring the students to acquire concepts is stressed. It is to be noted that concepts cannot, in themselves, be taught. Rather guidance is given to students to enable them to acquire scientific skills and abilities - an important aspect of science lessons.

6. *It is emphasises communication skills.*

This is not new, but by paying attention to this area, the scripts encourage greater interdisciplinary learning and the bringing of student involvement processes from other lessons to bear on scientific issues.

7. *It encourages cooperative working.*

Again this is not new. But the material relates this to societal needs and hence integrates cooperative work into the learning schedule.

i. **Suggested Assessment Procedures**

Each script includes a table to illustrate to the teacher how the educational objectives relate to the student tasks. Whether the objectives are actually achieved is determined by carrying out assessment procedures (Many teachers will recognise these as methods to obtain feedback).

The meaning and purpose of assessment, as stated here, is to determine how far students have attained the educational objectives specified for a particular script. This refers to all objectives and the skills related to them. The objectives are given as explicitly as possible so that it is possible for the teacher to undertake formative assessment..

Formative Assessment

In many cases the assessment procedure can be carried out within the class. This is very useful, as remedial action can be taken immediately should the need arise. Classroom assessment is often referred to as formative assessment It takes place during the teaching process and can be used to guide or inform students of their progress. (It can also guide the teacher to determine whether their teaching approach is successful). Teacher observation, whereby the teacher watches student groups at work and the manner in which they interact with one another, is one important formative assessment technique that some teachers find hard to carry out. They prefer to get involved and ask the student groups probing questions. This is also important, although the teacher must take care that they do not stereotype the responses towards 'the solution* as preferred by the teacher (Further ideas on teaching strategies for formative assessment exist in the literature).

Summative Assessment

Summative assessment (assessment after the teaching) can also take- place. This is often undertaken written format by students it individuals.lts advantage is that it can lead to the assignment of student marks* Its disadvantage is that it is limited in its coverage of the educational objectives, especially those involving groupwork or social skills.

The table below illustrates the manner in which formative and summative assessment may he carried out, related to specific student tasks. Further ideas on the assessment philosophy are

	ASSESSMENT STRATEGY by the teacher	
STUDENT TASK	*FORMATIVE*	*SUMMATIVE*

Oral		
Brainstorm ideas	observe	-
Group discussion	observe ask questions see written summary	Mark Written summary
Participating in a debate	observe	-
Participate in	observe	-

a tole playing exercise		
PRESENTATION ID the class	Observe see written summary	Mark Written summary
Manipulative (and written)		
Undertaking an investigation	Observe see written observations see written inferences	Mark Written Observation Mark Written inference
Undertaking a project	discuss see written plan see written observa ions	Mark written report

	see written inferences	
Written (graphical/tabular/drawing)		
Writing an essay	observe sec written script	**Mark finished essay**
Writing a letter	discuss sec written script	Mark finished letter
Devising a questionnaire	discuss see written script	Mark questionnaire
Planning investigations	discuss see written draft	Mark written plan
Recording information or ideas	see written draft	Mark written record
Calculating	see draft calculations	Mark calculations
Creating a poster	discuss see draft design	Mark finished poster

Developing a class display	discuss see prototype display	Mark finished display
Oral or written		
Making a decision	observe see written record	Mark written record
Justifying a decision	observe see written record	Mark written record
Predicting a consequence	observe see written record	Mark written record

Teachers are used to given marks such as 9/10 or 8/10. But what do these marks mean? If there are 10 questions to answer or 10 calculations to make, than it is understandable (but only if each questions or calculations has equal weighting!). Giving students' work a mark of 9/10 is not by itself, helpful. The criteria for determining this are not known. Does it mean 9 correct points are given and one aspect is missing? If so, are all the 9 points given unit weighting? And finally, are marks awarded for judgements of social skills as well as scientific knowledge or an important section of the education objectives omitted? If it is omitted, what is the point of doing that? Assessing student work, particularly in a formative sense needs to be developed against specific criteria. Criteria based from assessment provides a measure indicating whether a student can, or cannot, meet the criteria. In the scripts, the criteria are set by the educational objectives. The assessment can thus judge whether a student has or has not met the objectives and can be used to guide the student and the teacher on future developments and the progress made.

The criteria can be set bearing in mind the age level and abilities of the students. The criteria should not be seen as a constant. With this in mind, it is possible for students to achieve the objective? well above the level expected, la the scripts, therefore, a 3 point grade level is proposed -

level A where the achievements is **not at the** level expected;

level B where the achievement does meet the criteria set a level considered satisfactory; and

level C where the achievement is well beyond the level expected and clearly exhibits a much higher standard..

Wherever possible, achievement levels Me indicated to each script for an objective being measured by t given task. However the tasks often covet multiple objectives and where separation of skills ~~becomes~~ artificial (e.g. social, personal and career related skills), they are assessed together. likewise achievement on scientific method and science knowledge objectives may be **assessed** together.

6. Summary

These scripts

1) are designed to supplement ordinary reaching.
The teacher can select one idea and use ft where it is felt most appropriate.

2) are designed to be student participatory.
The teacher may use the ma rem! when more student involvement is desired.

3) meet educational objectives that go beyond those geared to academic science. The teacher may wish to use the materials when introducing a wider array of teaching objectives.

4) are designed to be challenging and to promote higher order thinking skills. The teacher any wish to introduce such teaching material when students are encouraged to dunk beyond simple recall or interpretation of observations.

5) lend themselves to formative assessment.
The teacher may wish to use supplementary teaching materials in order to gain feedback from students on their progress and acquisition of science skills.

PART 1

INTRODUCTION

THE FOLLOWING SECTION DETAILS THE PHILOSOPHY BEHIND THE TEACHING PACKAGE FOR THOSE WHO ARE INTERESTED IN UNDERSTANDING MORE ABOUT THE EDUCATIONAL VALUE

Each script has a teacher's guide, plus material to hand out to the students. **The** students material gives the scenario for the script and the tasks to be performed. **When |he** teacher feels the students ate ready, there may be additional student handout material which the teacher can give to the student groups. The additional information may not be fully adequate to undertake the activities. Teachers are advised to add **further** information where they feel it appropriate.

The material is designed such that it can be used in more than one science topic It |S left to the teacher to decide on the most appropriate time to use any script and to time its use such that the students maximise their learning experience.

SECTION 2 ILLUSTRATING THE STL PHILOSOPHY

"Teachers steach students,not science"

The STL (scientific and technological literacy) teaching approach proposed in this teaching package is very different from the uncontextualised emphasis on scientific principles and concepts used in most textbooks. The relevance of the science for the student is stressed. The science learning is put into a contextual framework, which is directly related to the society. The philosophy is based on the belief that, *if the science does not have a societal context, then that science is irrelevant to the students' learning needs.* The societal link provides the framework for the choice of content.

But as the science and technology in use within society is often very complicated and demanding in conceptual understanding, the STL science taught in schools needs to find ways to meet this challenge. Students are definitely required to think (minds-on), but the depth of treatment reflects the 'need to know' required for the learning being promoted. The inclusion of scientific principles and scientific concepts in these scripts is seen as pointing to a strong demarcation between social science materials and these science teaching materials. The demarcation is NOT made, as is often the case where teaching rigidly follows the textbook, by the addition, or absence, of values education. Values education is seen as a crucial aspect of STL science teaching and the thinking skills involved in decision making are firmly based on this. Science education is not value free. The development of students' opinions, beliefs and values form an important component of STL teaching.

The concept of STL is being promoted through Project 2000+, an initiative of ICASE and UNESCO. Further information on Project 2000+ is given the section III.

To explain the teaching being advocated in more detail, this section

- sets out an example of a usual curriculum and teaching scenario
- suggests to need for change
- suggests what is involved in enacting the reforms
- indicates the need for STL supplementary teaching material;

- shows a process for the assessment of student achievement through the use of STL resource materials
- details the role of ICASE and science teacher associations (STAs)

1. The Usual Science Education Scenario

To illustrate a typical scenario, let us consider, first, a standard curriculum sequencing and secondly, a common teaching approach. In both cases the ineffectiveness is pointed out and the suggestion is made that there must be something better.

A Common Science Curriculum Sequencing Practice

To illustrate a typical sequence, based on scientific principles and concepts, consider a curriculum section for the teaching of the topic of the halogens. This is not intended to be prescriptive, but to illustrate what a typical science curriculum that includes a study of halogens may contain.

Curriculum Outline *for* Halogens (traditional approach based on common textbook sequences; suggested time allocation: 8 periods)

The halogens *Trends* **in** *physicalproperties of* **the halogens** *as a familv of* **elements.**

Family trends to be emphasised where **appropriate e**.*g.* **physical states**

Methods of preparation of the halogens.

Preparation of chlorine by oxidation of HCl or **NaCl.**

Chemical properties **of** *chlorine.*

Manufacture and uses **of chlorine.**

Chemcal ***properties of other halogens should*** *be related to the* ***family*** *trend.*

Halides Tests for the halide ions (excluding fluorine), Relative ease of oxidation of hydrogen halides.

of curriculum L **that is** needed for students to acquire STL for the 21st century? **Perhaps** there **are** 1 **dements** of interest for the learners, but much of the content is **neither** useful, **nor** 1 **modern. It** reflects outdated science. Surely we can do better.

And what about the type of common teaching approach used in science? The follow-1 ing **tries to** illustrate this for another segment of the curriculum and at a different age | level, apologising where it exaggerates the actual situation.

A Commonly Used Science Teaching Approach

Consider the following classroom scenario

Good morning class.

In your textbook you will find the next chapter entitled 'the particulate nature of I matter'. Matter is made up of very small particles. These small particles are too small to be seen by the naked eye, but no matter what material you examine, j they are all made up of particles.

We can show that matter is particulate by looking at a number of experiments. Watch the following demonstrations that illustrate this. (Students are called upon to observe. They know the observations expected - they are in the textbook!), j The first demonstration is the dilution of potassium permanganate solution. Note j that the solution is very dark purple at present. Let me pour most of the liquid away and refill with plain water. Notice the colour now. It is much lighter, but it is still coloured. Some potassium permanganate is present. The particles of permanganate have spread out throughout the liquid and coloured it. As there are less particles now, the colour is less intense. Let us dilute again and see that the colour becomes even more light.

Although condensed, this episode illustrates a possible typical science lesson at the upper primary/junior secondary level. Yet it is hardly fair to call it science. And you can almost hear the comments of the students within the class. Would you agree the students are likely to think:

Another boring lesson. First the teacher tells us to open the textbook to the next chapter and then tells us what it says. Looking at the chapter we see it is headed the particulate nature of matter. What is the point of knowing about that ? What i has it to do with our lives ? The teacher shows us an experiment from the text book on diluting potassium permanganate. The teacher didn't ask our opinion whether the experiment was worthwhile, or tell us why that substance was cho-sen. What has dilution got to do with the particulate nature of matter ? The teacher adds water to a coloured substance and it goes paler . We all know that. It is obvious. Who needs to hear about the particulate nature of matter. Will it (help us dilute better ?

Who, outside the school laboratory, fills balloons with hydrogen ? What is hydrogen ? If anyone leaves a balloon long enough it will deflate. We are know that. We I have done it many times. This is because the gas comes out. Why is linking this to the particulate nature of matter mentioned in the textbook ?'

What have the students achieved ? They know, by rote memory, that matter is particulate. It docs not relate to anything meaningful and whether they absorb this fact will probably depend on their background knowledge and how this information fits with that. To suggest that the lesson covered the concept is hardly realistic. Basically the teacher has done little to justify his/her salary. The students could almost learn as much simply by looking at the textbook.

Had the students been involved in carrying out the experiments themselves, there would have been an opportunity to undertake manipulations and make observations. The learning could be widened. But even then, the point of the experiment is not given and the situation is like many experimental sessions at this level - students following a 'recipe' as given in the textbook, or workbook. No justification for the experiment is specified. **Surely we can do better !**

1. The Need for Change

The need for change is based on the belief that Science Education is called upon to meet new goals, based on the changing needs of the society. With the vast and ever increasing developments in science and technology, this need is great and goes beyond simple changes in content. It encompasses new concerns and issues confronting the society. Science education, in fact, needs to address a new concept in education - that of scientific and technological literacy for all (STL).

What is STL ?

STL is usually taken to mean developing the ability to creatively utilise science knowledge in everyday life to solve problems, make decisions and hence improve the quality of life. This is based on acquiring educational skills at the intellectual, attitudinal, societal and interdisciplinary levels.

If the above represents the target, then STL within formal schooling can be defined as 'that science which is intended within the school curriculum such that science education can maximise its role in aiding students to acquire the goals of general education, as stipulated by society within a country*. In other words, science is taught in schools, because it is seen as an important part of general education. The *purpose of education is stipulated by the society*. Science taught in schools, therefore, is to enable students to acquire the educational objectives within a science context. It needs to enable students to acquire societal values, personal skills as well an understanding of the scientific method and science knowledge as these relate to the stated goals of education. In addition, because this approach frames science in a societal context, the interaction between science and technology, leading to scientific and technological literacy, is crucial. After all technology that we see and with which we interact. The science only becomes evident when we need to solve a problem or made a societal decision.

In the past it ha» been suggested that there are two major types of science education and hence two different curricula:

a) That which provides a background for further study, especially when specialising;

and

b) That which enables a person to operate within a scientific and technological society

STL teaching, as defined above, does NOT subscribe to this division. All science teaching is geared to the educational objectives (but, of course, these objectives change in iicL[r]rcc5 of expectations at different stages of schooling). How far science education emphasises any specific general education goals will obviously depend on the overall learning environment, and especially the range of learning situations offered in addjtion science lessons. This in turn depends on the range of subjects offered within the total curriculum, the age of the students and the amount of teaching time allocated to science subjects.

The previous paragraph suggests that STL is not a constant target, but differs dependent on the education received and the educational objectives stipulated at a given educational level within a specific country. This is a very important point to note in striving towards STL. In fact, it is important to realise that ALL students do achieve some degree of STL But in putting forward STL as the teaching goal, it is the STL that enables students to acquire educational objectives, to the degree intended by society, that is important. And this can be expected to be more demanding the longer students remain in school. BSCS (1993), referring to biological literacy, suggests there are 4 levels of STL operadng in schools, but only the 4th is seen as the real target.

Nominal STL literacy

Students identify terms and concepts as being scientific in nature, but that they have misconceptions and can only provide naive explanations of scientific concepts.

Functional STL literacy

Students can describe a concept but have a limited understanding of it. School examinations are renown for testing this level.

Structural STL literacy

Students (a) develop personal relevance and are interested in the study of a scientific concept and (b) construct appropriate meaning of the concept from experiences.

Multi-dimensional STL literacy

Students understand the place of science among other disciplines, know the history and nature of science, and understand the interactions between science and society. The multidimensional level of literacy cultivates and reinforces life-long learning in which individuals develop and retain the need to know, and have acquired the skills to ask and answer appropriate questions.

Notice it is only the multi-dimensional STL level that enables students to appreciate the place of science in their daily lives. It is at this level that students begin to see meaning in any formal science education. The goal is thus to raise the level of STL above the structural level and empower all students to lead productive lives by striving towards multi-**dimensional STL.**

Objectives of Science Education

The objectives of science education that guide the development of multi-dimensional STL and which enables science education to play a full part in the achievement of general educational goals, can be expressed in terms of five major components that

underline the organisation of curriculum and instruction (Bybce, 1993):

1. Social development or achieving the aspirations of society.
2. Scientific methods of investigation.
3. Personal development of the student.

4. Career awareness.
5. Empirical knowledge of chemical, physical and biological systems.

The first component illustrates that education is a societal demand and that science education has a role to play in the development of persons able to integrate into the society and gain skills to function within the society, as society would intend *e.g.* science education in relation to cultural, environmental, political and societal understanding, awarenesses and values.

The second component encompasses the techniques of investigation, the required skills and activities of inquiry (observation, data collection, formulation of hypotheses, experimentation, etc.) and scientific attitudes (e.g. openness, recognition of errors). As this component exists among all sciences, it has been taken as fundamental for the integration of the different subject areas.

Components 3 and 4 recognise that students are individuals and that science education needs to play its part in helping the individual aspire to a general education that is relevant to their development and in the awareness of career opportunities.

The last component includes facts, concepts, generalisations and conceptual schemes generated by scientists. It also includes abstract ways knowledge may be organised and the functional applications of knowledge. This has all too often been taken as a major aim of science teaching with the canonical knowledge taught associated with the specific subjects areas (chemistry, physics, biology).

Together, the second and last components encompass the main content areas of science teaching and, sadly, in courses where objectives are poorly explain, often form the sole components of science education in the eyes of teachers. Also, as textbooks are largely geared to these areas, slavishly following the textbook, seriously inhibits the acquisition of STL. In such teaching, multi-dimensional STL is not taken as a serious target.

All five components are essential for the teaching of science subjects geared to relating education to a changing society. Neglecting the development of the intellectual, emotional, physical and social components of education as requisites for the assimilation of knowledge and a scientific method, leads to science being taught as an sterile, unmotivational subject unrelated to the needs of society. Meeting the social needs of students is important, to be promoted by preparing them to solve problems perceived within the society and make responsible decisions concerning science related to social issues and career awareness. This teaching package is specifically geared to promoting this aspect of science education.

Specifying the Educational Objectives

Goals and objectives are not only important for the teacher. Research carried out by Melton (1978) showed that 64% of students, who were aware of the education objectives, achieved better results on acquiring teaching material essential to these objectives, and the remaining 36% did not suffer, neither achieving better results, nor doing badly. He explained that students achieve better results when

— the objectives are explained
— an understanding of the objectives is considered essential by some teachers
— the objectives are not too difficult to understand, or achieve
— the objectives relate to personal interests
— prior motivation in other directions is not too strong to allow students to meet the objectives

PART I

ILLUSTRATING THE STL RHILOSOPY

3. Enacting the Reform

A Review of the Curriculum Sequense

Let us revisit the curriculum squense and teaching approach ullistraited carlier and refleet on a STL orrientation in line with the teaching materials being prometed.

An STL *Curriculum* Sequence **Some chemicast** for Health end **for Use in the Home (sugested teaching allocation 12 periods)**

An investigation **of bleach** as **a decotouriser of dyes end e killer of germs.** A consderation **of how** much **to use end** the **dangers of fumes from** excees.

An introduction to cMonne e dangerous gas.

The strength of e bleach measured by amount of 'available chlorine'

liberated on adding Mid.

6) **Making Bleach - understanding the electrolysis process. Electrolysis of a chloride solution (e.g. aq sodium chloride).**
A consideration of the chlor-elkali industry, its main products and the relative importance of bleach

Role-playing exercise **geared to siting of the industry and** balancing the demand for the various **products,**

7) How bleach functions - an introduction to oxidation and reduction. Explanation of bleaching action **of OCI** (aq) **and the instability of** HOCl(aq). An introduction to oxidation **numbers to show bleaching is an** oxidation; process.
Explanation of germ **killing action is by oxidation. Chlorine purifying** drinking water. A look at the **water treatment industry.**

Bleaching by reduction **- the $S0_2$ story.**

8) **Swimming pools - are they healthy?**
Purification of swimming pool **water by chlorine, but under controlled** pH **conditions.** Convenient chlorine **supplies for swimming pools.**

Determination of the chlorine **concentration - a comparison of the** reactiv**ity of chlorine,** bromine and iodide **and their salts.**

9) Fluorides, **chlorides,** bromides and iodides for our health. Fluoridation **of water** and toothpaste. Why ?
Fluoridation **of drinking** water - is it necessary ? Should we have the right to choose?

lodinatîon **of table salt.** Why ? Should this be debated also ?

Effects of **sunlight on halogen compounds** e.g. silver chloride. Tests **for**

halogens **in the laboratory.**

What are **x-ray plates/ photographic papers ?**

10) **Halogen compounds in general - are they friend or foe ? A debate**
The **good -** inflammability, compounds relatively stable, **compounds** of low molecular mass are volatile, high relative density in relation to number of carbon atoms in the molecule, as liquids form good solvents for greases, poisons as herbicides and pesticides, antiseptic qualities
j The bad - liable to form free radicals thus carcinogens, destroyer of ozone, not decomposed in soils leading to residues build up.

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The content it similar to that for the halogen sequence givenearlier in part 1but the context, and certainty the teaching approach, are very different.The emphasisis no longer on content only; but enhancing a range of skills through invoulving students in variety of activities. It is much more geared to enabling students to strive for multimensional STL.

A Review of the Science Teaching Approach — the particulate nature of matter revisited

What it I useful way to approach this topic for multi-dimensional Sit? Bearing in mind that there is no one answer and that the situation, the culture and the background of the students may not lend themselves to this approach, a possible scenario is given below Note that there is no intention of a heading on the blackboard (or elsewhere) mentioning matter or its particulate nature. This is done on purpose and sets the trend advocated for teaching science in a social context.

¡ Good morning class.

May I draw your attention to a comment Johnnie made last time. We said we • would consider this today. Johnnie's problem« if I understood it correctly« was he wanted to add ice to a jug full of water without spilling any. He had observed | that his big sister added sugar to a jug full of water and none of the water | spilled. Have I got the problem correct Johnnie ?

Let us explore this problem and see if we can help Johnnie. Let us first consider i why Johnnie wanted to add ice to the water and why did his big sister add the sugar to water ? Do you want to start us off Johnnie ?

Students work in groups of 4 to consider the rationale for putting the substances into water and begin to appreciate the very different reasoning for the two scenarios. The teacher will try to direct the lesson towards the sugar in water situation as this will test understanding of the particulate nature of matter. How much this is possible will be dependent on the background of the students and of course their realisation, at an early stage, that ice is the solid form of water.

Let's assume the students are quickly guided, in their groups — the teacher going around the groups - to realise that the ice cools the water (the purpose of adding to the water), but floats on the water and displaces some of the water. Also if the ice melts it forms water and thus adds more water to the jug. Attention now focuses on the sugar and on the problem - why does the water not overflow?

Let us have a brainstorming session. I want you to tell me any idea you have and I will put it on the blackboard. We will not decide whether it is useful or not - we will collect everything and later we will see what is useful. The more ideas we j have the better. Let's see if we can collect ideas from everyone.

The teacher is now getting the students involved in defining the problem and thus making it more clear how their problem can be tackled. The teacher obviously wants them to do an experiment to see that the solid spreads out throughout the liquid. Following this, the teacher can then guide the students to think about how this can be possible i.e. is it possible for matter to be continuous or must it be made up of particles for this to happen?

In your groups I now want you to put forward any idea you have why adding the sugar to the water does not spill any of the water. 1 want you to suggest an experiment that will support your idea.

If the students can answer this then the idea of particulate nature of matter is already familiar to the students and there is little need to reinforce. The teacher can move to another topic

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Assuming howewer that the task is too difficut for the groop, then this is now necessary for the teacher the break the problem down with the students. One possible way to the this would be to get the student to try out an experiment (instruction given) using marbiles in a meassuring cylender and than adding rice. It would be important for the students to make to connection between this experimwnt and the problem at hand. Assuming this to be the case, than the teacher can now play 'devil's advocate' take on a non-particulate stance. The purpoce of this is to help students think out their suggestion and gain confidence in their own ability to put forward reasonable suggestions.

4. The Need for STL Supplemantary Teaching Materials

The major resources used by teachers and students is undoubtedly the curriculum mfa (the syllabus) and the textbook, especially in developing countries. Changes in the a* riculum and textbook can help to reflect new tendencies to some degree. The earfiet curriculum illustration is an example of this. The textbook can change to follow this sequence. Also, by moving from academic to thematic titles and by presenting the material through storylines rather than factual text, textbooks can reorientate the maa- ner in which the learning material is viewed.

BUT, course outlines, curriculum guides and most textbooks cause problems in promoting STL. For a start, they are out-of-date, having been produced before the latest advances and before the latest issues or concerns have emerged within the society Neither can they relate to a specific area, a specific school district or to the issues and concerns that reflect immediate school environments. And none can take advantage of 'connections' that may be unique to each person, school, science centre, local industry, or the community.

The textbook is even more limiting by its desire to impart knowledge. By stating tfe case and providing the necessary background, the textbook heavily inhibits the promotion of problem solving and decision making skills. And, of course, it has already decided on the communication approach i.e. the written text, perhaps supported by diagrams ' tables/graphs. By placing too much reliance on the centralised curriculum and on curriculum developers, the most meaningful context for relevant learning, that can only be exploited by the teacher, is being undermined. Teaching becomes stereotyped and in danger of being divorced from meaningful learning

The Need for Supplementary Teaching Materials

One resource which can guide science education towards greater relevancy for the 21st ccmury is the use of STL supplementary teaching materials. These materials arc not extensions of the textbook, but are additional resources for the teacher to call upon g required. As such they are optional materials and can be used as and when the readier feds it appropriate. If the materials allow students to engage in activities relevant td STL» they enhance the learning situation and hence guide students to achieve $$J§§ tended educational objectives.

Criteria for Recognising STL materials

a) education objectives are stipulated and form the major focus of the material H students are participating in the process of educational learning appropriate tor B the country and their intellectual development;

b) material is societally related i.e. students are familiar with the situation and can thus appreciate its relevance;

c) material is a learning exercise i.e. it provides an intellectual challenge and utilises constructivist principles - moving from the information and under-ftaikding already in the possession of students to the new;

d) the activity is student participatory i.e. the student is involved either individually or in groups for a considerable amount (>60%) of the teaching time;
c) consideration is given to enhancing a wide range of communication skills.

5. Assessment of Student Achievement through the Use of STL Teaching Materials

The educational objectives put forward in each script need to be achieved. The teacher's guide indicates how this can be attempted. But are they achieved ? This is the purpose of assessment suggested in this teaching package.

Earlier in this introductory booklet, it was suggested that the teacher assesses the students on the various tasks put forward in the scripts. After all, the tasks were introduced to help students achieve the educational objectives. However it is not quite that simple, because

a) a task can be given to students to achieve more than one educational objective;

b) achievement of an objective can be partial. A decision needs to be made whether this partial achievement is sufficient to meet the passing criteria;
c) the stated educational objectives are specific to the script - assessment is geared to the attainment of the general education goals from which the educational objectives derive.

The achievement of an objective can be specified by whether certain criteria have been reached. However criteria can be considered at a number of levels. For example, a student mav not exhibit achievement in the direction demanded. This student needs help to raise the educational level. Another student may illustrate an acceptable level of performance, whilst another may be achieving far higher than the standard expected and can be challenged to reach a higher level of literacy. Formative assessment takes place during the teaching process and gives the teacher a picture of the various levels of achievement in each criteria by each student. Achievement of criteria can also be undertaken as a summative form of assessment (i.e. after the teaching).Written, tabular or graphical data usually form the summative assessment components, but verbal presentations supplemented by visual aids can also be considered.

Irrespective of whether a formative or summative assessment approach is adopted, the following is a suggested General Strategy for Assessment *based on a 3 point achievement scale*

Scale A represents an unacceptable standard and more practice in this area is required

Scale B represents an acceptable standard for the particular students in question, taking into account their age, experiences andprevious background. This standard represents the target expected of A.I J. students in the class. Scale C represents an achievement above the standard and is the challenge posedfor those students able to go beyond the standard level of achievement.

The objectives given in the scripts relate to the five components of science education put forward earlier (pages 16-17). However the components are too vague to indicate criteria. Below an attempt is made to describe facets within each component and indicate the scale of achievement geared to criteria met.

Social values involves

Justifying a decision, taking into account social values, political considerations, environmental concerns and science and technology information.

Scale A Decision not made, or if made not justified, or justified based on a single criterion.

Scale B Value position justified, but biased towards a predetermined point of view. Scale C A well balanced justification taking into account the assessment of risk, the consequences of the decision and the sensitivities of the local people.

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Scientific Method İnvolves

Recognition of the problem and putting forward i suitable plan to solve the problem.

Scale A Problem poorly conceived Planning very vague or no plan.

Scale B Planning is simple, sampling considerations arc simple and one off; repcating

for authenting data not induded.

Scale C Planning complete, detailed so taht it is easy to follow. The instructions and the apparatus needed are specified. Factors such as controlling variables are specified.

Personal skills involves

1. Exhibiting perseverance, creativity, initiative or ingenuity leadership skills.

2. Behaves cooperatively.

3. Handling materials/apparatus safety; aware of and appropriately assesses the risks involved.

4. Relating to ethical issues (takes **a** stance).

Scale A Little attempt to participate in a cooperative activity and not able to take on a leadership role. Few signs of creativity exhibited.

Scale B Willing to participate in group work and to play a significant role. Whilst leadership skills may not be highly developed, the student is willing to perse-verc and put forward ideas that show some creativity and ingenuity. The student is able to handle materials as guided and show some attempt at assessing risks involved. The student is able to take a stance on ethics! issues when specifically called upon to do so (may not exhibit this quality without being specifically requested).

Scale C Willing to participate in groupwork and take on a leadership role. Abie to put forward ideas that exhibits both creativity and ingenuity. The student is able to handle materials and apparatus in a safe manner and be clear on the risks involved. The student takes a stance on ethical issues and persuades others of its virtue.

Communication invokes

The communication of ideas orally, in written, tabular, graphical or pictorial formats or by utilising technology e.g. the computet.

Scale A Does not participate, or the contribution is poor, lacking in clarity.

Scale B Participates and puts forward ideas, but is easily persuaded by others and adopts their ideas.

Scale C Actively participates, putting forward ideas dearly, logically, emphasising the main points and being persuasive.

Careers Awareness involves

1. Recognising skills involved in a given scientifically oriented or scientifically associated career opportunity.

2. Being aware of educational achievement level needed for scientifically oriented or

scientifically associated career opportunities.

3.Appreciating the job specification for different scientifically oriented or scientifically associated careers.

Scale A Not able to hnk school work to career possibilities.

Scale B Aware of educational achievement necessary for a range of career opportunities and sets sights on specific targets with this in mind.

Scale C Very mte of fob specifications for a range of careers, the qualifications needed for acquiring such employment and the value that school work can have ki meeting these targets.

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Knowledge skills involves

Factual information, understanding of scientific principles, applications of scientific ideas and higher order thinking skills (analysis, synthesis, evalution).

Scale A Gives factual information with explanations copied or based on the text –book. Little evidence of higher order scientific thinking. Is only able to undertake experimantal work when specific instructions are given.

Scale B Is capable of analysing synthesising or evaluating a situation with guidance. Can undertake experimantal work following plans devoloped during groupwork or suppleid by the teacher.

Scale C Shows evidence of being able to analyse synthesise and avaluate a situation with full understanding of the scientific principles involves and an ability to retrieve additional information from secondary sources. Is able to plan and carry out experimantal work in a safe secure manner.

6. The Role of ICASE and STAs

ICASE (International Council of Associations for Sciense Educations)

ICASE has as its aim to assist sciense and technolgy teachers worldwide through its member organitons (STAs; instutues sciense centres, etc). ICASE is ran by a voluntary group of professionals, elected by its member STAs, and recognises the need for more enlightened approaches to sciense teaching. ICASE persuaded UNESCO to cointly promote scientific and technological literacy for all through project 2000+. This project was launched with a target that by the year 2001 there would be structures an activities in place within each country to promote STL.

ICASE sees Project 2000+ as a mobilising movement to encourage all to rethink what science education is about. Whilst UNESCO concentrates on Governments, ICASE | links with its member non-Governmental organisations (NGOs), especially STAs, ICASE through it journal, symposia and workshops is dedicated to helping STAs promote STL by first changing the teacher outlook and teaching practices and then see ondlv; changing the curriculum and assessment strategies.

lb this end, ICASE has introduced, largely with the help of UNESCO), regional training workshops for the creation of STL supplementary teaching materials (The scripts in this package originated from such a workshop), materials are created in the work- shop, are extensively edited and developed using ICASE expertise to make them ready for classroom trials. The trialiing is carried out in the country of the original authors and the script modified based on feedback. The scripts in this package have gone through this process.

STAs (Professional Science Teacher Associations)

The role **of STAs is** crucial not only for the process of creating STL teaching materials, but also for getting them publicised and known within the country.

The ICASE envisaged role of STAs is to follow up ICASE regional workshops by hosting workshops of their own within their own country, thus creating local STL teaching materials» These materials, disseminated to teachers in the STA, can be used in schools and feedback received. Adoption of the scripts as acceptable teaching material by a large number of teachers then leads to a consideration of curriculum and assessment changes.

The role of ICASE and STAs is in line with the ICASE belief that:

1st There is a need to change the teaching; and then

2st It is possible to successfully change the curriculum and examination practices.

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SECTION 3 APPENDIX

1. Educational Goals

Given below is an example of the educational goals stipulated for the 11-16 age range from one country:

1. help pupils to cultivate their moral and social values, to make critical value judgements and to develop an ability to solve value conflicts;

2. promote pupils' mental and physical health and to encourage worthy use of leisure;

3. nurture pupils' creativity and to promote their aesthetic development;

4. help pupils to develop their ability to think logically and independently and to make rational decisions;

5. help pupils to develop a positive attitude towards life and a sente of responsibility for their roles in the family and the community;

6. help pupils to develop their ability to communicate effectively in the national and an international language in relation to the different roles that each language plays in the community;

7. provide pupils with a basis of mathematical, scientific, technical and commercial knowledge and skills to prepare them for the fast-changing, highly technological society in which they live and work;

8. help pupils to develop their potential for further study or work according to their ability and aptitude;

9. help pupils to acquire an appreciation of the national culture and develop respect for all peoples, their cultures» values and ways of life;

10. encourage pupils to develop a respect, awareness and concern for the local environment, their society; and the world; and

11. help pupils to understand and adapt to the local cultural, social, economic and political characteristics.

2. Glosary of Therms

ICASE

International Council of Associations for Science Education; a worldwide umbrella body linking national and regional science teacher associations and other bodies involved with science teachers and science teacher educators for the primary and secondary education levels.

STL

Scientific and Technological Literacy (or scientific and technological culture as it may be more aptly translated into other languages) - the knowledge, skills, attitudes and values related to science and technology that are inculcated within school science teaching so as to enable a student to function at a multidimensional level in the society of today and in the future.

* STL also refers to education beyond the school and hence to non-formal and informal education, but for the purposes of the teaching materials, it is restricted to formal education,

UNESCO

United National Education, Science and Cultural Organisation; A United National Organisation, with headquarters in Paris, France, supported by member States. It deals directly with the Government within in a country, but forms links with other organisations including non-Governmental organisations such as ICASE.

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2. Student Participatory Strategies

Groupwork

By this term is meant approximately 2-5 students working together on a common task. Students share the work based on the students own decision making.

The teacher's role is to provide the groups with the initial stimulus and then guide the students in their task. As part of the guidance the teacher gains feedback from the groups, rather than 'interfering' with specific or isolated instructions given to the class as a whole (without reference to the progress made within the groups and often without requesting the groups to temporarily stop their activity so that they can concentrate on the teacher instructions).

Groupwork is applicable to experimental work in the laboratory and to such actions as - discussions of tasks or for making decisions, role playing exercises, playing games, participating in a debate and preparing for presentation of work to the whole class.

Individual work

This is applicable to the development of individual problem solving or decision making strategies and to all forms of written communication.

Brainstorming

In this activity the students present ideas related to the topic under discussion. All ideas are collected and recorded, irrespective of their worth or correctness and without comment. This activity is designed to stimulate thought and to call on students background knowledge (and maybe their misconceptions).

A common approach is for the teacher to write student suggestions on the black-board.

Role Playing

In this, students (or a group of students) undertake to play a specific role within a group debate or enactment of a scene. The student undertaking the role tries to act according to the role assigned, putting forward points of view in line with the expected belief. The role playing exercises lends itself to decision making whereby decisions can be made by a judge, a panel, or by a referendum of many people, based on the value placed on the various aspects within the scenario indicated.

Public Inquiry

This is similar to a role playing exercise. In this students create a courtroom and allow individual students to play the role of various figures in the enactment of a public inquiry. The bulk of the class act as the jury and vote on the final decision. The teacher plays the role of the judge advising the 'jury' as necessary.

Debate

In this a panel is set up (often of 3 speakers) that speak for the motion that is to be debated and are opposed by a similar number of speakers. Starting with the speaker for the motion and followed by a speaker from the opposition, the panel takes it in turns to present the points as forcefully as possible without duplicating a previous speaker, yet carefully refuting points put forward by the other side. The audience (or a panel) decide the winning team.

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4. Creating Teacher Produced STL Supplementary Teaching Material

Its suggested that the teacher starts from an issue or concern arising in the students* societal perspective. This could arise from a student question (often a situation at the primary school level) to a topical concern being expressed in the media (the newspaper* television, radio). Thus 'how to save energy in the home*, rather than 'energy in the home", or 'how do we clean clothes', rather than 'oxidation by chlorine'.

Then the skill is to determine an activity (or activities) that can best help students to appreciate the concern or issues in an educational perspective, gain the necessary scientific background and give appropriate feedback to show their grasp of the situation and their command of a communication skill relevant to the teaching situation.

Who identifies the concern or issue ?

1. Best choice - the students.

2. Teacher, taking from a secondary source e.g. newspaper, TV.

3. Teacher, initiating artificially e.g. from the textbook.

Student Motivation

Students need to be aware of the objectives of science education. Students need to recognise these objectives are important to them (relevance). The objectives need to be explicitly stated in the script.

Student motivation will be enhanced gready by the teaching style adopted by the teacher. The teacher needs to:

a) stress what the learning is and its purpose;
b) relate the learning to students' needs.

5. Understanding the Education Components

A major recognition in STL education is that science teaching is about educating students. Teaching facts or even guiding students to acquire isolated scientific concepts is not enough. Science teaching must aspire to helping students gain the total range of educational objectives put forward for schooling at the given age level.

These educational objectives have been arbitrarily sub-divided into four areas as to highlight different areas, but there is no suggestion that theses areas can be taught in isolation or that the descriptors given below are unique and clearly reflect only one attribute. The descriptors merely try to point out there are different aspects which STL teaching materials should recognise and give some direction for tackling the attribute involved.

Social Skills

Although not unique to science teaching, the ability to recognise and discuss societal problems and issues and put forward informed options that relate science concepts to economic, environmental, political and social considerations is very important for STL. The social skills also relate to being able to cooperate in a group or team, put forward points of view or procedures, but being willing to reach consensus as a group. In being able to put forward opinions, students are guided to develop values for attributes and thus social skills include the ability to communicate a point of view that reflects the values placed on factors involved. In formulating values, STL teaching emphasises the need to substantiate points of view with evidence as appropriate and recognise tolerance in moral views is crucial for social harmony. The goal must be to produce informed citizens prepared to deal responsibility with science and technology related issues.

Scientific Method

Whitin society, our concern is with the ability to ible to solve problems connected with our daily life and alto the abbility to make decision.

Solving problems requires a scientific background and a knowledge of the scientific method. It is thus very fitting that sciense teaching should paly an important thurust in this arca alongside other subject areas such as technology(where is exists in the curriculum) and mathematics. Solving problems begin from a recognition of the problem and ussually the abbility to transform the problem into one that can be answered scientifically. This is than followed by suggesting a way in which the problem can be tackled the material required for an investigation and the manner in which than can be carried out for meaningful resulst and then an interpretation of the findings to see whether the problem has been solved.

The scientific method requires backgrounds in handling process skills geared to scientific investigations. Such skills as absorving hypothsising experimenting analysin and drawing conclusions are important for sciense education as are handling equipment controlling varriables meassuring calculating and planning procedures.

‘Recipe following’ in carring out experimental procedures is not regarted as a major taeget for scientific method.

Personel Skills

The need to educate the person is aho of importance m science education. Students need to be ibic to utilise aoence for improving their own Jives or health and coping with the changes taking place tn our technologically developing world. The ability to be creative, to exhibit ingenuity, initiative and perseverance, as weH *u* the ability to com- munitate orally, in writing and by mews of symbols, graphs, tables, chartf and diagrams, etc., a-te major personal skilk Abo of importance is die attitude of the individual, especially towards science and science education:. Developing an interest in sti- encc and the role it can play within society has much to do in aiding scicnce learning in school

The ability to understand scientific concepts, to recognise problems and to suggest methods of resolving such problems also relate to persona! skilk and of course on forming an interest in the subject.

Finally personal skills gained from science teaching should enable students to more aware of the range of cuter possibilities that match their aptitude and interests.

Sciense Learning (geared to Bloom's Taxonomy)

In this context, knowledge covers the whole range of acquisition of science, from the simple factual aspects, undctstaa&ig. eaabBag application of the knowledge, to higher order thinking skills. A conceptual error by many teachers is to assume that teaching must follow the sequence from simple knowledge, through understanding before the higher ability teaching can take placc, (if it can be attained at a!). STL teaching does not recognise such linearity. It recognises that the real challenges are the higher order skills and that these should be introduced as soon as possible. Such skills are as much part of primary school teaching as they are in die upper levels of the secondary school.

Higher Order Thinking Skills (Analysis, Synthesis, Evoulations)

These are a major target for science learning. These are geared to knowledge but can also apply to societal problem solving/ decision making. Higher Order thinking skills in science teaching have, in the past, tended to relate to 19th century science (abstract academic principles). Or perhaps even more serious, higher order thinking skills have

|been omitted totally by teachers, partly

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6. Project 2000+

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The Target

By the year 2001 there should be in place appropriate structures and activities to foster

scientific literacy and technological literacy for all, in all countries.

The Project 2000+ targets for basic education are

a) Promoting the teaching of science and technology linked to relevancy in society.

b) Encouraging positive attitudes towards science and technology.

c) Increasing skills in decision making, problem solving communication achieved through science and technology teaching.
d) Development of a greater degree of teaching resource packages.
e) Reinforcing the use of interactive teaching methods as the mainstay of science and technology education.
f) Development of more relevant curricula in science and technology for scientific and technological literacy for all.
g) Enhancing teacher education programmes.
h) Encouraging a greater involvement of teachers and NGOs in the development, dissemination and evaluation of programmes.
i) Development of more relevant assessment programmes.
j) Implementation of effective evaluation strategies.

The Role of the Ministry of Education

The local part of Project 2000+ arc NATIONAL PROGRAMMES operating at the Governmental, non-Governmental, or both levels. These programmes are planned locally, directly locally, implemented locally and evaluated locally.

The role of the Ministry of Education is seen as receiving, and seeking ways to implement, project suggestions from the national task force. At the same time the Ministry of Education is seen as encouraging non-Governmental developments, particularly by educational institutions and professional teacher associations that initiate national projects by providing data, material and support for national task forces.

NATIONAL PROGRAMMES could be:

1. adapting, equipping or restructuring existing centres or facilities for supporting the improvement of science and technology education throughout the country, or if necessary creating new ones;

2. providing support for the establishment or reinforcement of professional associations for science and technology' teachers which will make important contributions to achieving both the qualitative and the quantitative goals of Project 2000+;

3. providing support for groups or institutions working or willing to engage in the popularisation of science and technology (museums, exhibitions, the media, etc) particularly to help them to focus on people's needs and to establish good links with the educational system;

4. publicising the need among the general public for greater scientific and technological literacy for all;

5. promoting of the status of science and technology education within the community using the formal school sector, the media, and greater community involvement;

6. undertaking a rethink of policy for science and technology education;

7. designing new curricula, implementational strategies, resource materials, assessment techniques for supporting formal, informal and non-formal learning

8. encouraging more valid assessment instruments to use with students and greater attention to the evaluation of programmes for scientific and technological awareness and literacy.

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Ride of Professional Teacher Associations

Major ways in which teachcr associations can be involved in promoting Project 2000*

and hencc in enhancing scientific and technological literacy; are by

(a) persuading teachers to support the new direction and helping them realise its educational potential;

(b) developing materials and other resources to help teachers prepare for a new direction and encouraging teachers to trial them in their classrooms;

(c) providing in-service support for teachers through seminars and workshops to introduce* plan trials and evaluate strategies and materials related to the new direction;

(d) providing resources which teachers may find useful for updating;

(e) lobbying the Ministry of Education to take joint action to encourage the ideas and allaying the concerns of teachers;

(f) playing a leading role as a member of a national task force in initiating and implementing projects.

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PART I

PART II

TEACHİNG MATERIALS

Section 1 Maintaining a Metal Bridge

Jack Halbreak

Section 2 Can Vegatable Oils be Used as A Fuel ?

Jack Halbreak

Section 3 Discovering Old Settlement Sites

İnitiated by Elma Hanba

Section 4 Wood a Potential Fuel for Tomorrow ?

İnitiated by Volga Kokse, Andrea Zhesis, Mihalis Gorskis and Andrea Rainbokle

Section 5 Is Oremulsion Suitable as an Alternative Fuel?

İnitiated by Regina Jerriamene, Rita Damberakinne, Laima duyburuime and Valeri Davydeskho

Section 6 Saving Cultural Monuments From Corrosion

İnitiaed by Andrei Zhegis and Irina Tutina

Section 7 Which Medicine is Better Black or White ?

Helina Ouisnik and Mila Raimiksate

Section 8 How to Avoid Biycle Accidents ?

İnitiaed by Ludisha Kalcer, Lastisker Barsik, Helina Pieta, Alina Domgala and Haxna Norakata

Section 9 Radon in Our Homes- is the Rick Acceptable ?

İnitiated by Hanna Osiscks and Bozyna Madro

Section 10 An Astronomical Clock ?

Jack Helbrook

PART II

MAINTAINING A METAL BRIDGE

SECTION 1 MAINTAINING A METAL BRIDGE

A decision making exercise for students

Jack Holbrook

Introduction

This exercise builds on knowledge gained concerning ways to protect steel from rusting. It incorporates societal factors which can influence the choice of method to use to maintain a bridge and thus ensure a metal bridge is an important right-of-way between a housing estate and the local school for at least 18 years.

This script is designed to be used as a latter part of a study of rusting and a knowledge of rusting is assumed. It concentrates on a number of educational objectives.

Educational Objectives

This script includes the following educational objectives:

1. Appreciating that 'most appropriate' can apply to a particular situation and can change if circumstances change.

2. Ability to use previously acquired background knowledge to solve a societal problem.

3. Utilising information presented in tabular format.

4. Cooperating as a member of a group.

5. Communicating orally through participation in groupwork.

6. Understanding methods used for the prevention of rusting.

Scientific concepts involved

Rusting (an example of redox)

Metal reactivity series

Teaching/learning resources needed

Diagram illustrating the scenario

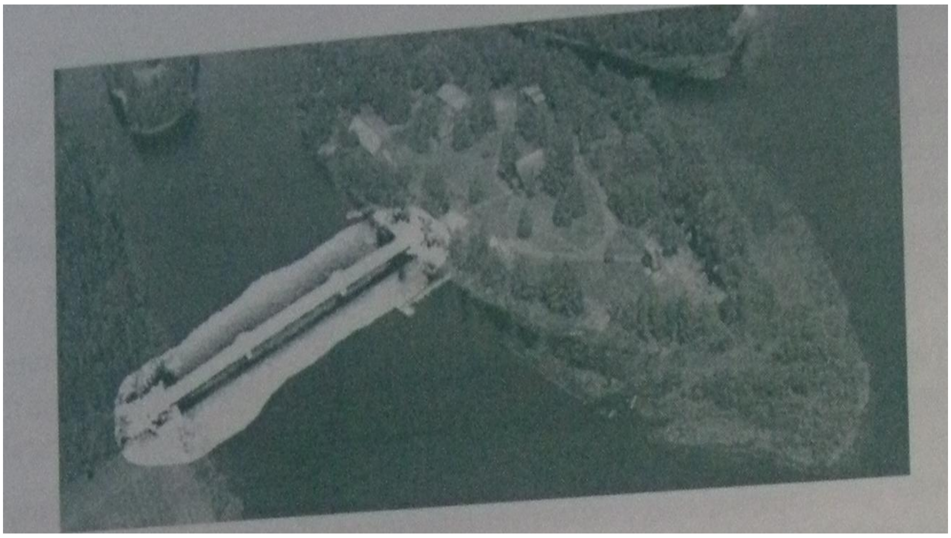
Table giving cost data

Table illustrating interest payments

MAIN TAINING

The Scenario

The diagram shows a newly built housing estate separated from the community school by a river. To gain access to the school a bridge has been built over the river. As this is only a pedestrian access and it is estimated the bridge will only be needed for 18 years (a new school will then be built on a different location), it has been decided that the bridge should be constructed of steel.



From your previous school studies you are aware that iron rusts. You are also aware that iron and steel are very similar and both are very strong building materials. In this exercise you are asked:

a) to suggest how the steel can be protected so that the bridge can last a long time;

b) hat form of protection, if any, is the *most appropriate* in this situation;
c) explain what is meant by *most appropriate* for these circumstances.

Your teacher will guide you how you should undertake the above tasks.

Your Task

1. Brainstorm possible ways to stop iron from rusting.

2. Select, in a group, approximately 4 possible approaches.

3. Discuss which method is the most appropriate for maintaining the bridge.

4. Present your decisions on the most appropriate method of maintaining the bridge.

PART 61

MAINTAINING A METAL BRIDGE

Teacher's Guide This activity relates to:

a) reinforcing previous knowledge of rusting;

b) making a decision on the best way to prevent rust;

c) realising that 'best' does not solely depend on the scientific process, but is also influenced by social factor which may change from place to place.

Teaching Strategy

1. Although the decision making component is the mainstay of the lesson, the teacher will need to reinforce early ideas on rust prevention. It is suggested that this part is achieved by a brainstorming exercise. In this students put forward their ideas on how steel can be protected and these are written on the blackboard. All ideas are accepted (even if they are incorrect) and as many suggested as possible are solicited.

2. If necessary the teacher may guide the brainstorming to ensure the students suggestions are not confined to earlier school work, but can widen to encompass areas such as painting, plastic coating, using stainless steel, or, using alloys.

3. The next stage is for students to eliminate inappropriate (wrong, impracticable or perhaps very expensive) suggestions. This can be done as a whole class discussion so that valuable time is not wasted and the teachers can get feedback on how far earlier work undertaken, on rust prevention has been consolidated.

4. Also as a whole class, discussion is the next stage, narrowing down the possibilities to a mraage&ble 3 or 4. Here the teacher may need to inject ideas. One important ded at this stage is that the bridge should last for 18 years and that if the bridge is allowed to rust (i.e. no action is taken), the bridge will need replacing after 6 years. Nevertheless this could be a viable option, although safety considerations may eliminate this because it can never be certain that the bridge will rust at an even rate each year and that weather conditions do not promote accelerated rusting.

5. The data in the student hand-out is based on the following possibilities being chosen. If this is not the case then the teacher may need to obtain additional information for the remaining parts of the lesson.

6. In their groups, students are then asked to consider which method is the most appropriate for maintaining this important right-of-way ? It is important for the teacher to go around the groups and determine whether the students have a clear grasp of the problem and are considering a wide range of possibilities (there is a strong tendency, especially with weaker students to consider the science answer and possibly the economic answers only). If necessary it is appropriate to stop the group discussion after 5-10 minutes to hear the possible solutions. Where choices are very different, this by itself may stimulate further discussion in the groups and encour- age greater in-depth

thinking. If choices are very similar (usually because the range of options students have considered is low), then the teachers will need to inject other considerations e.g. the aesthetic aspect - that it is important what the bridge looks like), societal factors (the need to provide unskilled employment opportunities because of mass unemployment) or simply asking the students to consider the use of metal within the society and to reflect on how this is actually being protected (it is inappropriate for students to put forward unrealistic decisions).

7. Following the group discussion, the teacher needs to ask each group to present their choice and its reasons. This can then lead to a general discussion session to see if consensus can be obtained for the whole class (if this is not possible, it is worth reminding the class that in a real community, ways need to be found to overcome such a situation otherwise it could lead to violent confrontation. It is necessary to understand the points of views of others and this is only possible by considering all aspects of a problem.)

PART 63

MAINTAINING A METAL BRIDGE

OBJECTIVE	This is achieved by
1.Appreciating that 'most appropriate' can apply to a particular situation and can change if circumstances change.	students appreciating that besides economic and scientific factors, there could be societal factors that are important (employment needed as many persons out-of-work), that finding the initial money to do the work is a problem (and hence the cheapest now involves a calculation of interest repayments) or initially, the cheapest way to build the bridge is chosen (i.e. no protection given to the metal bridge) even though it is not the cheapest overall.
2.Ability to use previously acquired background knowledge to solve a societal problem.	students utilising knowledge gained about rusting and ways to prevent steel from rusting are tested and consolidated through a brainstorming session in which students put forward their suggestions to prevent a metal bridge from rusting. Then they eliminate methods that would be inappropriate (in this case a concrete bridge would not be appropriate because, being on soft soil, a concrete bridge would need extensive foundations to take the much greater weight).
3.Utilising information presented in tabular format.	students interpreting the data from the tables in developing their choice.
4.Cooperating as a member of a group.	discussing in groups the most appropriate method of protecting a bridge from rusting.
5. Communicating orally through groupwork.	students being encouraged to discuss the 'most appropriate [c] through group-work and to realise that the 'most appro priate' is not an absolute answer, but dependent on choice and circumstances. In such a situation the students realise that communication about preferences is important, if the general public are to be involved in the decision making.
	students being called upon to give their understanding of the use of more reactive metals for rust prevention during the brainstorming session, or the elimination of air and water from being in contact with steel.

Assessment

Using the script as indicated, only an assessment of achievement of the objectives by using formative methods is appropriate. As no written record is requested, summative assessment based on post session marking is not possible. Formative assessment, however, can occur at all stages of the development of the script.

PART 65

MAINTAINING A METAL BRIDGE

Formative assessment strategies

▼ Award a social value grade (objective 1)

The teachcr listens to the discussions of the various groups.

A Not able to make a meaningful contribution to the discussions. Unable to suggest a choice other than based on economic grounds i.e. cheapest

B Able to participate in the discussion and recognise that a choice can be made on scientific as well as economic grounds. Can consider other factors e.g. environmental or social but only when guided by the teacher

C Able to play a significant role in the discussions and reflect on the many viewpoints from which a discussion could be made. Able to select an appropriate choice based on social as well as environmental, economic and scientific grounds.

▼ Able to award a scientific method grade (objective 2 and 3)

The teacher listens to the discussions of the various groups. The teacher asks questions for clarity where appropriate.

A Not able to comprehend the data presented in the tables. Able to use little of previous scientific knowledge in suggesting ways to prevent rusting.

B Able to interpret the data in the tables and determine the various costs. Able to suggest ways of preventing rust based on previous knowledge of reactivity of metals and on oxidation/reduction.

C Able to interpret the data and understand how the figures in the tables were derived. Able to utilise previous knowledge to suggest ways of preventing rusting and utilise a deep understanding about their reactivity properties and their ability to inhibit moisture or oxygen from forming on the metal and hence preventing redox from occurring.

▼ Able to award a personal skills grade (objectives 4 and 5)

The teacher observes the group during its discussions

A Does not take part in the discussion or show interest in the topic Does not help the group towards a decision. Ability to communicate scientifically is not illustrated.

B Able to participate in the discussion, helping the group to eliminate non helpful choices from those put forward during the brainstorming session. Able to communicate with the group to derive a 'best method' using suitable scientific language. Able to present to others if points reinforced by the teacher.

C Eager to participate and help others to join in. Leads the group to make choices ensuring all members of the group are permitted to make a contribution. Able to communicate both within the group and as a presentation in clear and scientific language.

▼ Able to award a science concept grade (objective 6)

The teacher observes the various groups during their discussions. The teacher asks questions for clarity of understanding where appropriate

A Not able to eliminate inappropriate choices put forward during brainstorming on scientific grounds.

B Able to eliminate inappropriate choices from the brainstorming session based on the reactivity of metals and on the need to prevent redox reactions

C In addition are able to recognise that some metals although suitable from the reactivity series point of view, are not usable on the basis of costs, too reactive or in the metals such as aluminium, protected by an oxide layer.

MAINTAINING A METAL BRIDGE

Student Handout Possibilities for Maintaining the Bridge

11) Do nothing. The bridge will rust and will need replacing after 6 years.

12) Once the bridge is built, give the bridge 2 costs of paint. As the painting is affected by weather, it is predicted that repainting will be necessary every 3 years.

13) Once the bridge is erected, carefully remove all signs of rust by sandblasting and then applying a primer paint and 2 coats of ordinary paint. It is predicted this will last for 6 years and the process will need to be repeated.

14) Before the bridge is erected, sandblast and galvanise the metal. It is predicted the bridge will last for at least 20 years without further attention.

Supporting data that may be useful

Costs at 1994 prices (in US$)

Metal for the bridge =	80000
Construction cost =	10000
Paint for the bridge =	6000
Sandblasting charge =	4000
Galvanising cost +labour =	21000
Cost of the scrap metal =	2000

Cost of labour for painting = 1000

Calculations

A. Cost (in thousands of US$) of maintaining the bridge, with time, for each of the four possibilities

	Option			
	1	2	3	4
Initial cost	90	97	102	123
After 3 yrs	90	104	102	123
After 6 yrs	178	111	114	123
After 9 yrs	178	118	114	123
After 12 yrs	266	125	126	123
After 15 yrs	266	132	126	123

B. Costs (in thousands of US$) if the initial cost is borrowed, and interest repayments are made yearly

Initial cost	90	97	102	123
After 3 yrs	108	124	123	149
After 6 yrs	196	151	156	175
After 9 yrs	214	178	177	201
After 12 yrs	338	205	210	227
After 15 yrs	256	132	231	253

SECTION 2 **CAN VEGETABLE OILS BE USED AS A FUEL ?**

A laboratory based science project

Jack Holbrook

Introduction

This script introduces a project to examine whether vegetable oils can be used a fuel for vehicles. It is designed to be used as part of the topic on fuels

Conventional diesel causes much pollution in the form of hydrocarbon and sulphur compound emissions. This is a problem associated with most fossil fuels. There is strong environmental pressure to eliminate, or at last greatly reduce these emissions, especially in areas of environmental sensitivity such as lakes and inland waterways and in inner city areas.

This script involves students in a project to explore alternatives to diesel as a fuel.

Educational Objectives

This script includes the following educational objectives:

1.Formulating a value for using vegetable oils as fuels.

2.Suggesting parameters for deciding on the 'best' hiodiesel.

3.Devising procedures for testing the biodieseL

4.Cooperating as part of a team.

5.Communicating orally through discussion and in written format.

6.Producing a biodiesel fuel.

7.Understanding the importance of flammability, suitability of flame,

viscosity and calorific value of a fuel.

Science Concepts involved

Esters

Catalysis

Separation of non-miscible layers (decanting or use of a separating funnel)

Flammability and suitability of flame

Viscosity

Calorific value

PART II

CAN VEGETABLE OILS BE USED AS A FUEL ?

Student's Guide **The Scenario**

The fuel for many vehicles, especially those used commercially, is diesel. Normal diesel is obtained from the distillation of crude petroleum, which is usually regarded as a non-renewable resource. Any limitation in the supply of petroleum can thus have dramatic effects on the commercial life of a country.

If alternative ways could be found to produce diesel, this could help countries plan into the future, ensure that supplies of fuel can be obtained and hopefully providing a cheaper alternative than replacing the diesel engine with other mechanisms.

(If an alternative to diesel from crude petroleum could be found that was more environmentally friendly both in production and in use, this could be an added incentive.)

Fuels based on vegetable oils produce much less hydrocarbon emissions and practically no sulphur compound emissions. However, direct use of the oil itself is possible only with modification to existing diesel engines. This is not a viable proposition.

Your Task

1. Embark on a project to develop and test an alternative fuel to diesel made from crude petroleum. In particular you are as&eci to consider a fuel from vegetable oils.

2. Discuss the use of vegetable oils as alternative fuels for vehicles.

3. Suggest which vegetable oil is 'best'.

4. Put forward a point of view on whether biodiesel fuels made from vegetable oils should replace conventional diesel, considering the following factors:

   a) Are they viable alternatives (perhaps by being converted to a better product) ? (They are viable if vegetable oils are easily obtained, are cheap and are usable in a diesel engine directly, or with simple or cheap modifications — modifications to the diesel engine itself, or the conversion of vegetable oils to products usable in diesel engines.)

   b) Would it be ethical ? (Vegetable oils are a source of food for both humans and animals. To use vegetable oils for fuel, land for growing needs to be set aside. This land is thus not available for growing foodstuffs. If land is plentiful, setting aside some land is not a problem, but when the land needed for the generation of fuel is at a premium, this becomes a question of ethics.)

PART II

CAN VEGETABLE OILS BE USED AS A FUEL ?

Teacher's Guide This project relates to biodiesel and the process of transesterification. Neither are usual topics within a science (chemistry) curriculum. However an understanding of the process and the development of the skills in making the actual product are secondary to the educational skills of devising procedures to measure ease of burning, viscosity, suitability of flame and calorific value. It is also secondary to the values component introduced with respect to the acceptability of using biodiesel fuels.

This project is thus related to:

a)making biodiesel;

b)developing procedures for testing properties of different biodiesel fuels;

c)formulating an opinion as to whether biodiesel is a viable, ethically suitable alternative fuel.

Teaching Strategy

1. This topic can be introduced by the teacher drawing attention to the environmental concern produced by road vehicles, and in particular diesel vehicles. Students can be encouraged to put forward their comments. The teacher guides the discussion towards what would be considered a good fuel.
2. The teacher initiates a short group discussion in which students write down what factors should be considered in developing a good fuel. This is followed up by each group quickly reporting on their considerations.
3. The teacher introduces the possibility of utilising vegetable oils rather than mineral oils as a fuel. Students, in groups, are asked to investigate the burning of a vegetable oil to confirm that it is a potential fuel and to discuss, in their groups, the feasibility of using vegetable oil as a fuel.
4. Following a class discussion when the teacher ensures students recognise the inap- propriateness of vegetable oil in its present state, the teacher

guides students to suggest that a less viscous fuel needs to be created in an economically viable way. (This leads to the project which is to try to break down vegetable oil and produce a fuel with acceptable properties. To prepare a number of samples of different biodiesels by one group of students is obviously a time consuming process. It is thus recommended for this project that different groups of students work with different vegetable oils and results are compared between groups.)

5. The procedure to break down the vegetable oil is given to the students as a worksheet to be followed (the transesterification process is not something about which the students need have a detailed knowledge). The students work in groups and follow the instructions given in the handout.

6. Having prepared a sample of biodiesel, student groups are challenged to test the biodiesel and compare it with diesel. This is the major component of the project. The tests suggested to the groups are —

a) Determine Flammability.

b) Suitability of flame.

c) Viscosity.

d) Calorific value.

7. The groups will need to devise their own procedures and then discuss these with die teacher. When the teacher is satisfied on the feasibility of their experimental ideas and that safety rules have been observed, the groups embark on their investigations.

8. Student record the results of their investigations. They prepare a short report for a presentation to the rest of the class.

9. The class presentations need to kept short (less than 2-3 minutes) as it is intended to lead to a class consideration of the 'best' biodiesel.

10. The students are asked to complete their group project report such that it contains their experimental results, a discussion on the *best' biodiesel, plus a final section on (a) the viability of using a vegetable oil as a fuel and (b) the ethical aspects associated with this.

Achieving the objectives

OBJECTİVE	This can be achieved by
1. Formulating a value for using vegetable oils as fuels.	students reflecting on the viability and ethics of using biodiesel as a fuel.
2. Suggesting parameters for deciding on the "best' biodiesel.	students putting forward their ideas on which biodiesel is best after they have tested a number of biodiesel fuels.
3. Devising procedures for testing the biodiesel.	by students being called upon to devise their own tests for flammability, suitability of flame, viscosity and calorific value.
4. Cooperating as part of a team.	students undertaking the production and testing of biodiesel fuels. It is expected that different groups of students will test different vegetable oils and that within groups, students will cooperate as a team in the production of the biodiesel and in its subsequent testing.
5. Communicating orally through discussion and in written format.	discussing within the group on planning experimental procedures and deciding of the 'best' fuel. Creation of a written report
6. Producing a biodiesel.	following the instructions given in the handout and preparing a sample of biodiesel.
7. Understanding the importance of flammability, suitability of flame. Viscosity and calorific value of a fuel	students considering these factors in determining the "best* fuel and in presenting their findings.

Assessment

This project can be assessed by both formative and summative methods.

Formative Assessment stratgies

▼ Able to award a social value grade (objective 1)

The teacher observes and listens to the students in their groups.

A Not able to play a positive role in the discussions and suggest the best biodiesel. Not able to put forward an opinion on the appropriateness of using biodiesel as a fuel.

B Able to put forward an opinion on which biodiesel is best, but not necessarily using all factors in making the decision. Able to formulate an opinion on whether biodiesel should be used as a fuel as an alternative to conventional diesel backed by rationale argument.

C Able to express an opinion on the best biodiesel to act as a fuel based on all factors available. Able to formulate an opinion on the suitability of biodiesel as a fuel incorporating factors beyond ethical and economic consideration.

▼ Able to award a scientific method grade (objective 2 and 3)

The teacher observes the students in their groups. The teacher consults th plans being developed by the group.

A Only able to put forward an appropriate plan for testing the biodiesel in one or two cases. Not able to interpret the test outcomes with respect to determining the 'best' fuel

B For the most part, able to suggest suitable tests and suitable apparatus toJ determine which is the ''best' fuel and from the results of the tests undertak* I forward suggestions.

C Able to put forward suitable and even unique methods for testing the suitability of the product for flammability, sootiness, viscosity and calorific value. The apparat^ suggested is well within that available in the standard school laboratory. Able suggest the relative importance of the various tests.

▼ Able to award a personal skills grade (objectives 4 and 5)

The teacher observes the group during its discussions.

A Does not take part in the discussion, or show interest in the topic. Does not help the group towards suggesting apparatus or tests to undertake. Ability to communicate

scientific is not illustrated.

B Willing to participate in the discussion, helping the group to put forward factors important in a good fuel. Able to work with the group to create a biodiesel and to discuss how the product should be tested, showing some ingenuity in the manner in which the product should be tested. Willing to contribute to a discussion on the 'best* biodiesel.

C Eager to participate and help others to join in. Leads the group in experimentation and in developing procedures for testing the product, has original ideas but ensures all members of the group are permitted to make a contribution. Able to communicate both within the group and as a presentation in clear and scientific language.

▼ Able to award a scientific understanding grade (objective 6)

The teacher observes the students performing the experiment. The teacher asks questions of the group where appropriate.

A Not able to carry out the experiment by following the instructions given without assistance from the teacher. Unable to appreciate the various stages of the experimentation. Not able to obtain a viable product.

B Able to follow the instructions as a group in a reasonable and coherent manner, to produce the product without drying, paying attention to standard safety procedures. Drying procedure were not successfully completed. I

C Able to produce the product in an efficient manner and dry the product as per the instructions.

▼ Able to award a scientific concept learning grade (objective 7)

The teacher listens to the group and asks individuals questions to test understanding

A Does not exhibit more than minimal understanding of flammability, why sootugjs occurs, viscosity or the meaning of calorific value. Thus not able to suggest tests on the product to determine its suitability as a fuel.

B Able to suggest meaning for flammability, sootiness, viscosity and calorific value o a fuel, but often lacks details or scientific expressions until guided by the teacher.

C Able, unaided, to explain the meaning of the various tests using appropriate sceintinc terminology and thus is able to detail procedures to determine the suitability of a fuel by testing for flammability, ease of burning, viscosity and calorific value.

Summative Assessment Strategies

▼ Able to award a social value grade (objective 1)

The teacher reads the description given in the report

A Report does not mention the viability of biodiesel or give any reference to whether it would be ethical to use such a fuel.

B The report refers to both viability and the ethics of using biodiesel, but the discussion is limited in its scope and basically suggests biodiesels are viable if they are cheap and they are ethically appropriate if they do not take up land that could be used for food..

C The report gives viewpoints for a number of different perspectives in determining whether the use of a biodiesel is viable and ethical.. The report leads to the suggestion that no clearcut answer is possible, but gives a specific view by taking a specific situation.

▼Able to award a science method grade (objective 2 and 3)

The teacher reads the description of solving the problems of the project in the report.

A The description of procedures is basic and there is litde flair in the manner in which the various tests on the products are performed. The report shows little insight into the meaning of a 'good' fuel.

B The report accurately describes the making of biodiesel. The report puts forward suitable tests on the product and describes these tests in a logical and accurate manner. The report gives the outcomes of the tests and infers the 'best'fuel.

C The report gives an attractive account of the making of biodiesel. It accurately and concisely reports on the tests devised for determine the 'besf fuel and reports the results and interpretation in a very suitable mannt r. The report enters in to a discussion on the meaning of "best fuel* based on the various weightings that can be applied to the tests performed.

▼Able to award a personal skills grade (objective 5)

The teacher assesses the communication skill illustrated by consulting the report.

A Report poor giving minimal information with respect to the development of the project and the results obtained. Little discussion on the interpretation of the results or on the appropriateness of biodiesel as a fuel.

B Report clearly sets out the experimental procedures to follow in undertaking tests on the biodiesel product and the results that were obtained. The report compare the results with the results from tests undertaken by other students and suggest the best' product. Some discussion on the appropriateness of biodiesel as a fuel included.

C Report clearly sets out the experimental procedures and the interpretation of the results. The choice of "best' biodiesel is clearly explained. An extensive discussion is given on the appropriateness of using biodiesel as a fuel clearly indicated the advantages and disadvantages.

▼ Able to awards a science concept grade (objective 7)

The teacher reads the report for understanding of the science concepts involved.

A Little understanding expressed on what constitutes diesel or the meaning of fuel.

B Shows understanding of the term 'diesel' and why the term biodiesel can be applied to the product formed by the preparative experiment. Expresses an understanding of flammability, sootiness, viscisity and calorific value in the maner in which the report is written.

C Report well written given a clear indication that the science concepts are understood and this meaning is expressd in suitable scientific language.

PART II

CAN VEGETABLE OILS BE USED AS A FUEL ?

Teacher Notes for the Introduction

1. Vegetable oils

One property of vegetable oils is that they burn.

But vegetable oils, without modification, are not consider suitable as fuels for

diesel engines, because of their high viscosities.

A suggestion is to break down the oil in some way to create smaller molecules that will be Jess viscous, but still flammable. If these molecules are similar in size to the hydrocarbons used in diesel, then it will be possible to utilise them in standard diesel engines. (Students could be asked to explain this statement).

2. Breaking Down Vegetable Oils

We are familiar with breaking down vegetable oils using an acid or an alkali.

But by reacting the oil with an aqueous substance, we have a problem of extracting the flammable part. How great a problem is this ? Do you have a simple solution to extracting a flammable product (If the solution is not simple, the cost of extraction will stop the process from being viable)?

One cheap and simple method of breaking down vegetable oils is known as transesterification. This means making one ester from another. Vegetable oils are triglycerides (they are based on the alcohol, glycerol, which has three OH groups). It is possible, by transesterification, to replace the long hydrocarbon chain by methyl or ethyl and thus create simpler esters.

Simplified equation:

$XR_3 + 3Et\,OH \rightarrow 3ROEt + XH$

veg. oil ester   less viscous ester   glycerol

where X is $CH_20(CH0)CH_20$,

R is $[C_xHy]CO$ and

Et is C_2H_5

3.The best vegetable oil can depend on many factors such as cost, appearance, calorific value, viscosity, stability, ease of burning, smell, or not being used for another purposes. Very often the weighting placed on the various factors is a societal choice and hence the best vegetable oil can vary from country to country. 'Best' is thus very difficult to define. The manner in which best is interpreted is left for students to determine.

4.The use of vegetable oils is viable if vegetable oils are easily obtained, are cheap and are usable in a diesel engine directly, or with simple or cheap modifications - modifications to the diesel engine itself, or the conversion of vegetable oils to products usable in diesel engines directly.

5. Vegetable oils are a source of food for both humans and animals. To use vegetable oils for fuel, land needs to be set aside for this purpose. This land is thus not available for growing foodstuffs. If land is plentiful, setting aside some land is not a generate fuel is at a premium, it becomes a question of ethics.

PART II

CAN VEGETABLE OILS BE USED AS A FUEL ?

Teacher Notes for the Investigations

Preparing the biodiesel

It is possible to carry out the experiment with a reduction in chemicals xlO. Measuring the volume of potassium hydroxide solution is then more problematic and a small syringe or pipette is needed. The product obtained will be too little to wash, but the experiment can easily be carried out by student groups. Leaving the product to settle overnight (or for a few days) will overcome problems of slow separation of the product.

Experimental procedures students are called upon to develop for their project.

a)Determine flammability

Intended here is a simple test of how easy it is to burn the product. Putting a match or burning splint to a little of the sample on a metal bottle top or watch glass is perhaps the simplest manner in which this test can be performed. The biodiesel usually does not burn without a little warming (but care — any unreacted alcohol does!). The warming can be achieved by putting the bottle top/watch glass on a guaze and heating gently from below with a suitable flame.

If this does not lead to a noticeable difference between the various biodiesels or between a biodiesel and ordinary diesel, then more sophisticated tests can be devised.

[Industrially the temperature at which a biodiesel burns after ignition by an electric spark is obtained. Also measured is the flash point ~~ the tern perature at which the fuel self ignites. THESE TESTS ARE NOT SUGGESTED.]

b)Suitability of flame

By burning a little of the product as in (a), the 'sootiness* of the flame can be compared also. A sooty flame indicates incomplete combustion and gives a measure of whether the fuel will be efficient and whether it leads to greater pollution of the atmosphere.

c)Viscosity

Again the emphasis is on a simple test such as the time it takes a weight (ball bearing) to fall through the biodiesel for a given length. This test will demand a greater quantity of product, unless the apparatus can be devised on a very small scale.

A test tube is not really long enough but a length of wide bore glass tubing is good. Should this not be available, a 1 litre plastic bottle can be used but the quantity of oil needed is obviously much greater. Other substitutes can be used to show that something like a marble or ball bearing will take different times to fall through the liquid is dependent on the viscosity.

d)Calorific value

The emphasis is on simple apparatus and, if necessary, students can devise ways to minimise heat losses by draughts, etc.

The suggestion is to burn a known quantity of fuel in a bottle top or spirit burner and to use this to heat a tin can containing a known quantity of water. The quantity of fuel needed to raise the temperature of the water by a standard temperature rise (5°C) is determined and used as a measure of the calorific value. (Whether students undertake the actual calculation depends on the level of the students.)

PART II

CAN VEGETABLE OILS BE USED AS A FUEL ?

Student Handout **Preparation of Biodiesel**

100 cm^3 Vegetable Oil

15 cm^3 95% Ethanol

1 cm^3 9 mol dm-^{3} aq. Potassium Hydroxide Solution

0.5 g anhydrous Sodium Sulphate

1.Pour the vegetable oil and ethanol into a 250 cm^3 beaker.

2.Slowly add the potassium hydroxide solution from a 1 cm^3 plastic syringcjJ small dropping pipette, over about 1 minute.

3.Stir continuously for a further 2—3 minutes and then stir occasionally (5-{j seconds every 2-3 minutes) for 2—3 hours or until 2 layers are formed settling. Do not stir too vigorously as this may lead to emulsification.

4.Pour into a separating funnel and allow to settle for 1 hour.

5.Run off the lower layer. This layer contains most of the glycerol which b released during the reaction. The lower layer is discarded.

6.Add 10 cm^3 of distilled water to the crude product and mix well (shakmgl not advisable since an emulsion can form which will take a long time tosepi rate). Leave to stand for 1 hour.

7.Run off and discard the lower layer. (This washing procedure can be repeals if the product is not clear.)

8.Add 0.5 g anhydrous sodium sulphate. Stir for about 15 minutes.

9.Allow the sodium sulphate to settle.

10.Decant the biodiesel into a sample bottle.

Devise your own procedure for the following and compare with diesel.

Test the product for:

a)flammability;

b)viscosity;

c)calorific value; and

d)suitability of flame.

PART II

DISCOVERING OLD SETTLEMENTS SITES

SECTION 3 DISCOVERING OLD SETTLEMENT SITES

A planning and experimental investigation

Initiated by Ulna Haiba

Introduction This unit considers how an analysis of phosphates can lead to planning an archeologi- cal investigation.

Educational Objectives

This script includes the following educational objectives:

1.Indicating a sense of value related to the search for and excavation of archeological sites.

2.Preparing a plan of work for investigating a possible site.

3.Understanding the sampling technique skill involved m examining a possible site.

4.Cooperating in carrying out the investigation in groups.

5.Communicating in appropriate formats on values, procedures and results obtained.

6.Carrying out the phosphate test and appreciate its value in identifying archeological sites.

7.Analysing data and predicting where to start archeological work.

Science Concepts

Testing for phosphates

Sampling data

Teaching/learning resources

Filter paper 6 cm diam, dropping pipette, 2 x volumetric flask 100 cm^3. Solution

1.

5g ammonium molybdate and 35 cm^3 5M nitric acid (1:1) added to a volumetric flask. Made up to the mark with distilled water.

Solution 2.

0.5g ascorbic acid (vitamin C) made up in a 100 cm^3 volumetric flask using distilled water.

PART II

DISCOVERING OLD SETTLEMENTS SITES

Students' Guide The Scenario

Where people were living many thousands of years ago, phosphates were formed in the soil. These formed important archeological sites providing information about how our ancestors lived thousands of years ago. Unfortunately with the increasing pressure for development, these sites can become inaccessible and thus lost for future exploration. For example, near Narva in Estonia a new road to St. Petersburg is to be built through fields where it is suspected people lived 5-6 thousand years ago. These potential settlement sites may become buried under the road. And if this happens, the history associated with these settlement sites will be lost and there will be no possibility to learn more about our ancestors. It is thus helpful to be able to detect such sites. This can be done by carrying out a phosphate content analysis of the soil.

Your Task

1.Discuss the importance of determining and excavating archaeological sites.

2.Decide which samples of soil to analyse for phosphate content based on the map of the area provided. You will note from the map that some analyses have already been undertaken. You do not need to repeat these. You may start your analysis in any area and you are at liberty to choose whether to analyse all areas, or to concentrate On a few.

3.Determine the amount of phosphate in soil samples. Details for this are given in a the separate handout.

4.Record your results in the form of a table showing samples taken, quantity ot soil used, results of the analysis, percentage of phosphate in the soil, suitability for archaeological investigation.

5.Determine how to interpret the data you obtain and hence indicate M archaeological work should begin. It may be easier to indicate the position[0] where to commence archaeological work by use of a map.

PART II

DISCOVERING OLD SETTLEMENTS SITES

Teacher's Guide

This project relates to the amount of phosphate in soil due to historical human activities. By detecting the phosphate content of the soil, it is possible to locate archeological sites. Samples are normally taken at a depth of 5 cm. As the search area is large, it is first necessary to randomly sample the soil from different places and build up a map of the phosphate content of the soil. Where a place of higher phosphate content is indicated, sampling can be intensified and the extent of the potential site determined. Digging can begin in the most favourable sites to look for comb-marked pottery and to take samples.

This script indicates that:

a) a determination of the phosphate content of soil can give a possible indication of previous human settlement;

b) how the phosphate test can be carried out;

c) reflects on the value of determining archeological sites.

Teaching Strategy

This is a simulation exercise in which students determine soil samples to analyse based on their understanding of the general archeological area. The site is indicated on a map.The area on the map is divided into grids and samples can be taken from each grid area.

1. The lesson can begin by a group discussion on archeology and the value of archeology to society.

2.This can be followed up by a class interpretation of the discussion, followed by a consideration of how one finds out where an archeological site might exist.

3.The teacher can then introduce the script and point out that it is a simulation exercise whereby the students will analyse soil samples according to the map grid area they have selected. Students thus plan their investigation and suggest which samples they will examine and in which sequence.

4.As the area is large, the teacher needs to explain that some analytical data concerning phosphate content has already been included. (Students are given the map of the area.) The student task is to test samples from various regions and build up a more complete picture of the area. Promising areas will need thorough testing of the phosphate content of the soil. The students will need guidance to undertake the minimum of samples but at the same time they need to find the changes in phosphate content. The teachers should recognise two major approaches to this. Either the students cover the whole area in a general way and then look at specific areas. Or they explore promising areas as soon as they identify them.

5.The teacher will need to give the students the experimental details for determining the phosphate content. There is no need for the students to be familiar with the chemistry of the test apart from the fact that the test works on the phosphate ion. The teachers will need to give the student groups soil samples related to various positions on the map grid. (Details for preparing soil samples is given in the teacher's notes.)

6.Student groups undertake the experimental investigation. The teacher goes around the groups and guides them, as necessary, to share out the work among the members so that the repetitive testing can be speeded up. (This also encourages cooperation among the students in the group to work towards a common standard.)

7.As a result of their testing, the student groups put together their results and determine how best to present the data in an interesting manner. The teacher should guide the students to make use of appropriate graphs, but the teacher should not tell the students how far apart to space the points. The students should think this out for themselves, with help from the teacher as necessary.

PART **II**

DISCOVERING OLD SETTLEMENTS SITES

8. Students groups take on the role of archeologists and make decisions about where excavations should begin. These predictions are at the heart of the whole simulation exercise. The rationale for making the predictions needs to be understood.The predictions need to be based on the understanding that phosphate content of soils increases where there were human settlements and hence archeological findings are much more likely in these areas. It is likely that the phosphate content will increase around a settlement area reaching a peak at the centre, before falling away to background levels *as* further analyses are undertaken away from the settlement area. (If the simulation *is* based on an actual excavation area, photographs and other indications can be shown of findings in the various areas of the map and from this students can compare (and hopefully confirm) their predictions.)

9. This information is shared across groups by each group presenting there data and conclusions to the rest of the class. Any discrepancies in predicting possible sites are dealt with by class discussion.

Achieving the Objectives

OBJECTİVE	**This can be achieved by**
14. Indicate a sense of value involves in searching for and excavating	archeological sites

14. Understanding the sampling technique skill involved in examining a possible site.

discussing among group members, expressing personal opinions on the value of undertaking archeological work and trying to appreciate the societal value.

14. Cooperate in carrying out the investigation in groups.

14. Communicate in appropriate formats on values, procedures and results obtained.

14. Prepare a plan of work for investigating a possible site.

teamwork and allows the team to be involved in a problem solving situation in which they can either undertake a methodical analysis of the whole area and be sure to cover any unexpected findings (the path often chosen by archeologists), or they can follow their intuition and analyse areas based on a hunch The latter could be a much faster approach to uncovering potentially useful archeological sites and allow excavation to begin ahead of the complete analysis being undertaken.

Deciding, in groups, how to proceed. Later by comparing data with other groups, determine the success of the sampling procedures adopted.

teamwork in planning the exercise and in carrying out the experimental investigation.

discussing within a group and presenting

the results in graphs, tables, maps and through making archeological predictions.

14. Analyse data and predict where to start archeological work.

14. Carry out the phosphate test

and appreciate its value in identifying archeological sites.

.

interpreting the data obtained and predicting where excavations should begin

undertaking experimental work and determining the conclusion to which the experimental work leads.

Assessment

Assessment of Groupwork

The tasks that make up this activity are based on group work. The teacher should thus look for evidence that the objectives are being achieved through the groupwork. The teacher should also attempt to ascertain whether each student in the group is participating and acquiring the objectives or whether the group learning is through a few members of the group only.

Formative Assessment Strategies

▼ Able to award a social value grade (objective 1)

The teacher goes around the groups during the initial discussion and observe 1 or 2 students per group (these are preselected so that different students are assessed on other occasions.) Award a social values grade of A, B, or C based on the following:

A No value position taken, but willing to accept the values put forward by the rest of the group without any form of challenge. Takes little part in the communication.

B Has values and is willing to put them forward. The values are justified. Willing to discuss these with the other students.

C Has strong views and is able to put these forward in a very convincing manner. The other students in the group are persuaded to adopt this value position by the justifications put forward.

▼ Able to award a scientific method grade '(to groups or individuals) (objectives 2 and 3)

The teacher observes the groups, asks comprehension questions to members of various groups, and notes the written sampling plan and recorded observations. The teacher decides whether to assess the group as a whole, or by putting emphasis on the questioning and observation of individual written work, assess individuals within the group.

A Sampling plan very arbitrary, no understanding of how to sample logically.

B An empirical systematic sampling plan put forward and different students allocated to carry out the tests in various areas.

C A systematic plan is put forward based on a theoretical assumption. The testing procedure is carefully planned so that different student reinforce the results of others (by testing in a grid area adjacent to other students, rather than the same grid) and carefully example any discrepancies.

▼ Able to give a personal skills grade (to individuals) (objectives 4 and 5)

The teacher observes the groups, asks comprehension questions to members of various groups, and notes the written observations.

A Tends to be a passenger and lets others in the group to do the experiments. May take part in the recording of results, but usually by copying from others. Has little idea of why the various steps in the procedure are being followed.

B Carries out the tests diligently and carefully as a member of group. Records the results systematically. Able to answer teacher questions on general procedures

C Not only carries out the tests diligently and carefully, but acts as group leader and guides the standard of experimentation and recording of results. Able to answer teacher questions on the purpose of the experiment and suggest how the analysis will be tackled at a later stage.

▼ Able to award a science concept grade (objectives 6 and 7)

The teacher can gives a group mark based on the analysis and findings of the during the presentation session

A Carries out the phosphate test, but analysis put forward is not in agreement with the experiment results. (All members of the group are awarded at level A.)

B Analysis presented in a logical manner following on from the recorded results.A clear recommendation of where to begin the excavation is given (Students decide whether all members of the group are awarded at level B or whether some will only receive level A.)

C Analysis is very logical and follows the results obtained. The presentation is very well produced and shows understanding of the scientific principles. (Level C is only awarded when it applies to all students in the group.)

This can be based on individual work, or the group as a whole can be assessed on a single submission from the group. The areas that can be assessed are:

▼ Able to award a personal skills grade (objectives 5)

The teacher reads the recorded results and analysis of the phosphate tests

A List of results is not compete (it fails to include results of all members of the group) or if complete is not recorded systematically or without the minimum of labelling needed. Little indication of interest in the work.

B The list of results is complete and recorded systematically with clear labelling. Possible archeological sites are indicated.

C The results are very well presented and a note (with possible explanations) is included where any results show discrepancies. The analysis is carefully communicated using appropriate scientific terminology leading to possible archeological sites.

▼Able to award a science method grade (objectives 6)

The teacher reads the result and analyses materials produced e.g. graphs and the conclusions made on the excavations sites

A Graphs and other presentation data do not relate to the results obtained. Or materials presented without clear explanations. Or no conclusion made.

B Graphs and other presentation data do relate to the results obtained, the materials are explained and a conclusion is given.

C The information is well presented, related to results obtained and give clear conclusions as to excavation sites. The analysis shows clear signs of methodical working following a well thought out plan.

PART **II**

DISCOVERING OLD SETTLEMENTS SITES

Additional information

History of the stone age

Living in Europe became possible once the glaciers from the ice age had rescinded. These early dwellers were hunters and mainly lived on the coast catching fish, etc. Later, as they mastered the art of tools around 2-3000 B.C. , the stone age people moved inland and started to cultivate the land, rear cattle etc. Rather than being nomads, they started to form settlements. It is these settlements that can be found by establishing an increase in phosphate content in the soil. The phosphate comes mainly from the bones of humans and their animals and hence the amount of increase of phosphate in the ground depends on the length of time the period the village lasted, the number of people and whether they were mainly agricultural or whether they also caught fish, seals etc. The phosphate content of the soil increases towards the centre of the village and the depth of the phosphate increase in the soil largely depends on the age of the village

Phosphates

The "cultural layer", soil which has formed after the stone age or bronze and iron ages, is between 20 to 40 cm deep. The phosphates are thus discovered at this depth. How deep shows the age.
The analyses is based on the supposition that at earlier settlement sites

-the phosphate content is 10—100 times higher than in the forest, fields, garden;

-the phosphate has formed because of earlier human life in the area;

-the phosphates, derived from organic substances, have not decomposed, (that's why chemical tests are possible);

-the percentage of phosphates is different in different places of the settlement — the human activity has been different (usually it is more intensive in the middle (central) part of the settlement);

-the percentage of phosphates is influenced by

-the time the settlement was in existence,

-what the people were doing (in hunting, fishing areas, the phosphate content is higher than in agricultural areas).

How to take samples?

A typical area occupied by a stone age settlements is some thousands of square metres. Samples can be taken from squares grids 2x2, 3x3, 4x4 or 5x5 m^2, etc. Pits (holes) are made where the squares cross. (The archeologists use a special "bore" for taking the samples. This special bore gives a sample up to a depth of 60 cm with the possibility of making the test after each 10 cm.) Samples are usually taken at each 10 cm depth.

Using a spade, make a hole, diameter 30 cm, depth, 60 cm (using a sharp spade to clean one spot in the hole and take samples using a spoon).

The chemical test for phosphates

Phosphates, in the presence of ammonium ions, react with molybdate ions to form a yellow precipitate.

In the test the Mo (oxidation number +6) is reduced from +6 through +3 to +2. The complex that is formed is blue in colour. This is the colouration for the test.

Phosphate Analysis of Soil

The phosphate content is determined in relationship to the number of mg of P_2O_s present in 1 kg soil. Three to five tests should be conducted per area, taking samples from different places. Reference samples should be taken from areas near forests, sampling the soil at a shallow depth.

PART **II**

DISCOVERING OLD SETTLEMENTS SITES

Student	**Apparatus and solutions required**
Handout	Filter paper 6 cm diam, dropping pipette, 2 x volumetric

flask 100 cm^3.

Solution 1.

5g ammonium molybdate ($NH_4Mo_7O_{24}$ and 35 cm^3 $5MHN0_3$ (1:1) added to a volumetric flask. Make up to the mark with distilled water.

Solution 2.

0.5 gr ascorbic acid (vitamin C) made up in a 100 cm^3 volumetric flask using distilled water.

Procedure

1 Put about 50 mg (approximately the amount obtain with a knife tip) of the soil to be tested in the centre of a piece of filter paper.

14. Add 2 drops of solution 1.

14. After approximately 30 seconds, add 2 drops of solution 2.

14. After a further 30 seconds, observe the size of the resulting blue ring and whether there are striations.

14. Preserve the result by washing the filter paper after 2 minutes with sodium citrate solution (2%).

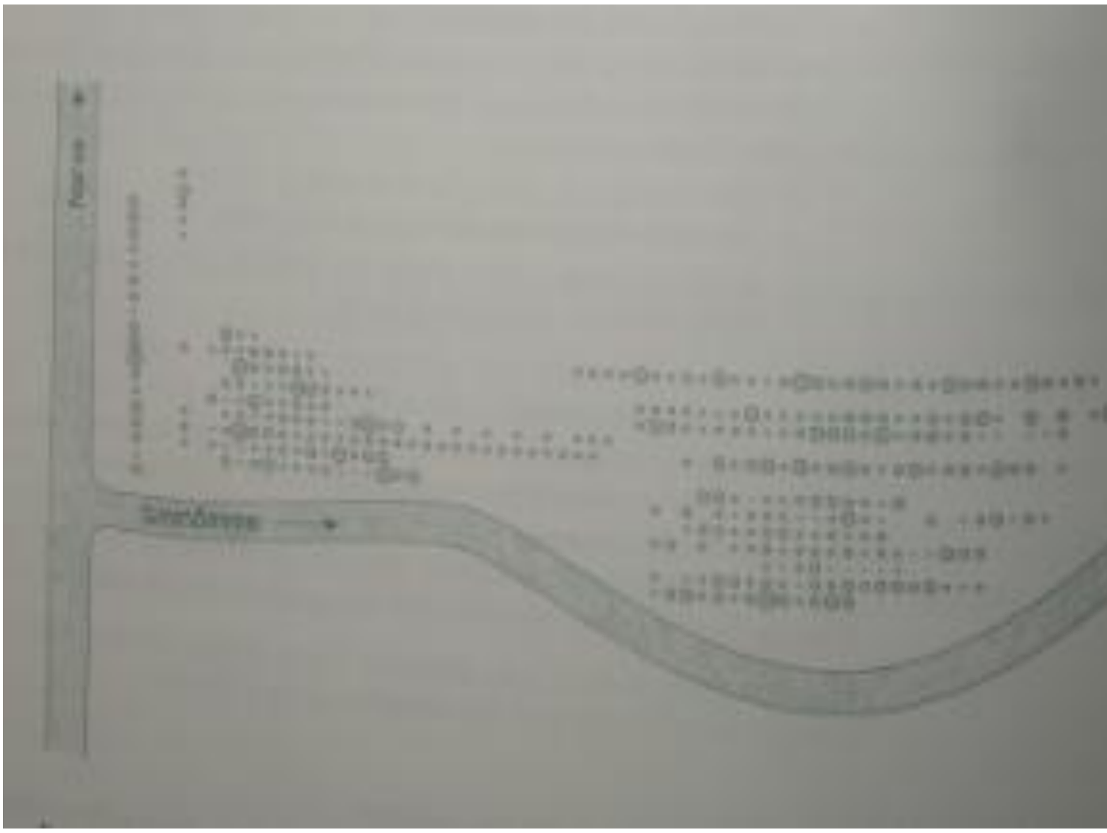


Diagram indicating where sampling occurred.

Interpretation of Results

Different soil has different content of phosphates. Not all the phosphates have come into the soil after human activity. In some places the natural level is quite high, so all interpretations should be done in comparison with a background phosphate level. This is soil tested from a place where there is no sign of previous human activity. The sampling starts in places suspected of archeological activity, or from places where some sign has been already found.

*level No blue ring around the soil. This shows the usual natural phosphate content of soil with no human influence.

!*level Very little, light blue colour. This indicates a possible archeological site - increasing levels of human activity This might be also as natural zone. For 1 and 2 level the content of phosphate (given as $P_20_{5)}$ is less than 12 mg in l00g soil i.e. around 0.12%.

3*level More blue and darker blue striations. HERE is an indication of human influence. Level of phosphate (as P_2O_s) is 20 mg/l00g soil i.e. 0.2 %.

4*level After 2 drops of the first solution, a yellow colouration is observed. After the second solution is added, a blue colouration with deeper blue striations. 20-25 mg/l00g soil 0.2- 0.25% phosphate (as P_2O_3)

level After the second solution added, very intense blue striations. 25—35 mg/ l00g soil i.e. 0.25-0.35 % P_2O_s Indication of strong human influence.

As much as possible, the soil samples should come from an actual site. (See the diagram, where archeologists have marked where sampling took place.) Otherwise it is necessary to create samples according to the table below (the natural zone should be indicated).

Soil Sample	**% of phosphate as P_2O_5**
1	0
2	0.12
3	0.20
4	0.20-0.25
5	0.25-0.35

PART II

WOOD - A POTENTIAL FUEL FOR TOMORROW ?

Section 4 WOOD - A POTENTIAL FUEL FOR TO MORROW?

An experimental based project

Initiated by Velga Kakse, Andrei Zhegin, Mihails Gorskis and Andra Keinholde

PART II

WOOD - A POTENTIAL FUEL FOR TOMORROW ?

Table 1 Evaluation table for different woods

Aspects \ evaluation	**grade 1**	**grade 2**	**grade 3**
Science and technology	**progressive**	**average**	**not progressive**
Economics	**cheap**	**average**	**expensive**
Environmental	**friendly**	**average**	**dangerous**
Social	**useful**		**useless**

Table 2 Application of the evaluation table

Raw material	**Science and technology grade**	**Economical grade**	**Environmental grade**	**Social grade**	**Combined grade**

Oil Coal					
Birch Wood Pine Wood Aspen Wood					

To answer aspects such as those indicated above, it may be necessary to consult the literature in the library or from other sources. In addition you will need to consider

15) Cost of different kinds of wood.
16) How much time it takes to reproduce a new forest for each type of wood.
17) Comparative cost analysis of using oil, coal and wood in your region.
18) A description of wood resources in your region.
19) How using oil coal and wood affects the environment (types of pollution, etc.).
20) Can changes to the environment caused by pollution be observed ?
21) What do you think of wood as an alternative fuel material and source of energy in the future ?

PART
IS OREMULSION SUITABLE AS AN ALTERNATIVE FUEL

A role playing exercise

Initiated by Kegina Jasiuniene, Rita Dambrauskiene, hatma Dybriene and Valeri Davydenko

This script is a role playing exercise in which students consider factors related to the use of oremulsion as a fuel.

Educational objectives

This script includes the following educational objectives:

1. Considering a social problem and putting forward suggestions based on rational thought

2 Suggesting how society can be guided to appreciate the choice of fuel being made.

1. **Cooperating as a member of a group.**
2. **Communicating orally.**
3. **Understanding the heat capacity of a fuel and why sulphur dioxide, carbon monoxide, oxides of nitrogen and vanadium compounds are considered pollutants.**

Science Concepts Fuel
Gaseous pollutants

Teaching/learning resources The role playing scripts

IS OREMULSION SUITABLE AS AN ALTERNATIVE FUEL ?

Students* Guide The Scenario

Imagine, there is a beautiful, tranquil place in your country. There are small lakes with crystal clear water full of fish, fine forest with wild animals and very diverse flora. Then one day somebody builds a thermoelectric power station in this area. The landscape is broken by the site of a large man-made construction. The soil is disturbed and in place of greenery are areas of concrete and asphalt. The chimneys begin to smoke. What is happening ? What is modern society doing ?

At the very heart of development of a country today is scientific and technological progress and for this a major requirement is more usable energy. As a country develops it becomes more industrialised and its energy needs increase. The cheaper the new energy, the easier it is for development to occur. Energy is largely required in the form of electricity as this is very convenient and versatile and its availability can encourage a range of diverse developments from mechanical farming to industrial estates for the manufacture of processed foodstuffs, clothing, pharmaceuticals, building materials, furniture and the like.

But power stations need fuel and the products of combustion pollute the atmosphere. Power stations need land to operate and methods by which the energy (electricity) can be **distributed.**

If we cannot hinder such **development and are required to live with the creation of additional** power **stations, perhaps it is important to consider what type of fuel to use** in power stations.

Your task

1. **Suggest the requirements of a power station fuel in terms of**
   1) **energy produced**
   2) **economics**
   3) **transportability**
   4) **health risk to workers, to the public**
   5) **availability from more than one source**
   6) **combustion products**

2. **After discussing these points in groups, develop a group response in the form of a newspaper article that promotes the importance of a new power station in the countryside where before there was nothing but green countryside.**
3. **Participate in a role playing exercise in which you decide whether a new fuel (oremulsion) should be imported and used as an alternative to conventional fuel oil.**

In the role playing exercise, one member of the group represents each of the roles given in the student handout.

PART II
IS OREMULSION SUITABLE AS AN ALTERNATIVE FUEL

Teachers guide This activity relates to

1. **appreciating the requirements needed of a fuel and that different combustion products from fuel poison the atmosphere;**
2. **appreciating the energy demands of modern society and hence the need to balance energy needs against environmental concerns;**
3. **choosing a suitable fuel for a power station.**

Teaching strategy

1) **The lesson can begin by students reflecting on the scenario and brainstorming ideas about whether the building of a power station should be allowed.**
2) **The lesson can continue by student groups discussing the requirements needed of a fuel and to understand that technological developments need energy supplied by power stations. These power stations need to be built somewhere! Where ?**
3) **The various groups can present there discussion outcomes and a general class discussion can follow.**
4) **Students make a decision that is real to society through par exercise in which different students attempt to view th perspectives and the group as a whole come up with a :**
5) **The student's decision making discussion concerning tions allows students to appreciate the energy demand need to balance societal choices of which the scientific : is probably not acceptable for society to choose the fuel value unless other conditions such as cost, environment*] are also favourable.**
6) **In the role playing exercise students should realise their can change should there be a change in any of the concern where a power station is built with a life of 20-30 years and poor decision! made at die time of construction could lead to lack of options in later years.**

Achieving the Objectives OBJECTIVE

ipating in **a role playing** problem from **different ¿need** solution, building of **power sta-** modern society **and the ion** is but one **choice, it , :h** the highest **calorific** impact and **convenience**

solution[9] is **tentative and** ters. This is **of particular**

This is **achieved by**

1 Considering a social problem and putting forward suggestions based on rational thought

1) **Suggesting how society can be guided to appreciate the choice of fuel being made.**
2) **G joperating as a member of a group.**

3) **Communicating orally.**

4) **Understanding the heat capacity of a fuel and why sulphur dioxide, carbon monoxide» oxides of nitrogen and vanadium compounds arc considered pollutants»**

students taking part in discussions **about the** value in building **a** new **power** station **and in** the role **playing** exercise **about the** important choice of **a** fuel.

students participating in the role playing exercise and highlighting the scientific ad* vantages of various procedures*

participating in the role playing excrcise and encouraging studenta to respect the views of others whilst putting forward their position as forcefully as possible.

students participating in the group discussions and in the role playing excrcise

students discussing the mcaningof the term fuel and the chemical process involved in burning a fuel plus forming pollutants. 2HH|dents also discuss **the heat ***

Assessment

The achievement of the objectives for this script can be assessed using formative assessment techniques. Based on the newspaper article, summative assessment is possible.

Formative Assessment Strategies

▼ **Able to award a social values grade (objective 1)**

The teacher observes the groups during their discussions.

A Unable to make suggestions concerning the type or position of a power station. B Able to suggest factors influencing the position of a power station in terms of economics and the environment, but not able to fully appreciate social factors (e.g. transport of raw materials, aesthetics of the area). C Able to appreciate the concept of risk assessment and the various risks associated with the type of fuel. Recognises the range of factors associated with the siting of a power station.

▼ **Able to award a science method grade (objective 2)**

A Able to produce a newspaper article but not able to portray the scientific aspects in any great detail.

B Able to positive project the scientific advances in the burning of fuels and the control of pollutants in developing a newspaper article. Can decide on the importation of a new fuel based on scientific evidence.

C Able to promote positive aspects of constructing a power station beyond the scientific advantages to **encompass environmental and social factors. Is able to support the importation** >t new **fuel based on scientific, environmental and social grounds.**

skills grade (objectives 3 and 4)

P A R T I I

IS OREMULSION SUITABLE AS AN ALTERNATIVE FUEL ?

▼ Able to aware

z role playing activity.

b role of an assigned person to discuss the power station **issue, uficant contributions to the role playing exercise, k tribution during the role playing exercise and** put **forward a arguments given, however, although scientifically** correct **are Incing, or given very forcefully.**

C Able to make a significant contribution to the role playing activity and exercise considerable influence over the type **of fuel chosen. Plays the** role **assigned very affirmatively.**

▼ Able to award a science concept grade (objective 5)

The teacher listens to the group discusion and the role playing activities.

À Unable to **indicate pollutants associated with** the combustion of **fossil fuels such as** acid **rain,** carbon dioxide **build**-up and dust particles. Little **understanding of heat** capacity of a fuel.

B Aware of pollutant* caused by the combustion **of fossils fuels and the potential dangers** of nuclcar fuels. **Can** give **a simple meaning of the heat capacity of a fuel and how this can be determined. Aware of the need for a power station as the standard of** living **of the society grows.**

C Recognises factors related with the siting of a power station and the scientific concepts associated with the use of fuels and the formation of pollutants, or greenhouse gases. Can explain the manner in which pollutants operate with respect to the **environment and endanger animal and human life.**

The teacher listen* A Unable to take or« Not able to make B Makes **a posttiv** choke **of** fuel. **The not made very convi**

PART II
IS OREMULSION SUITABLE AS AN ALTERNATIVE FUEL ?

Summative Assessment Strategies **V Able to award a social values grade (objective 1) The teacher reads the newspaper article submissions.**

A Able to develop a newspaper article that describes the power station project, but not able to support the advantages to the general public to any significant degree. B Able to take a positive attitude towards the development of a new power station and put forward arguments based on scientific, environmental and social grounds as well as economic factors. C Able to take a positive attitude toward the new power station and reflect although scientifically correct the disadvantages politically and environmentally as well as socially if the project is not permitted to go ahead.

Additional information

Information on Oremulsion ?

Oremulsion in an emulsion of natural bitumen and water. Oremulsion contains 30% of H_2Q Large deposits of bitumen are known in Venezuela (Orinoko river basin). It is extracted by pumping steam into a well. The steam dilutes **the bitumen and it can then be easily pumped out of the well.**

Heat capacities of fuel oil and oremulsion are:

oremulsion - 27.300 J kg"[1]

fuel oil - 40.068 J kg"[1]

Oremulsion proportions (compared to **fuel** oil):

sulphur content - 27% (equal to fuel oil) **ash content - 0,25 % (fuel oil - 0,1 %) vanadium - 0,03 %** (fiiel **oil - 0,01 %)**

Control of acid emissions

Using modern technology it is possible to use hydrofiners to reduce sulphur dioxide emissions to any level compatible with Governmental legislation

Prices

Oremulsion price on the Rotterdam goods exchange was 4.5 US$ ton[1], including delivery and was stable. The prices of fuel oil varied up to 8 US$ ton"[1]. v Comparable analysis of oremulsion and fuel combustion products is based on data of Dalhaus power plant (Canada).

For getting equal amounts of heat energy, we have to produce:

Pollutant	**Oremulsion**	**Fuel oil**
so_2	**1 1 4 %**	**100 %**
NO_x	**140%**	**100 %**
CO	**100 %**	**100 %**
Vanadium*	**444%**	**100 %**

** possible to diminish 17 times using filters*

Notes for the teacher

Different combustion products from fuels poison the atmosphere by releasing harmful gases like: SO , NO , CO etc. These cause acid rain which has a harmful influence on vegetation and animals. With this in mind, the question of fuel preference is very real although it depends on economical, ethical and political as well as ecological grounds. Countries that do not have their own sources of energy need to import large quantities of fuel and the choice of which fuel to use is an important decision for the ecology ot the country.

PART II
RADON IN OUR HOMES - IS THE RISK ACCEPTABLE ?

SECTION 9 RADON IN OUR HOMES - IS THE RISK ACCEPTABLE?

Initiated by Hanna Osica and Boena Madro

Introduction **This unit is an investigation into whether the risk associated with radon gas concentration in the home is acceptable ? In cases where this is not the case, the script considers steps that can be taken to make the risk acceptable.**

Students are guided to realize that there are probable correlations between the concentration of radon in homes and cancer diseases.

Educational Objectives
This script includes the following educational objectives:

1) **Recognising an acceptable risk and appreciating the value of greater publicity on the dangers of radon gas.**
2) **Developing skills in making individual science investigations.**
3) **Cooperating as a member of a group and with medicine and environmental centres in town.**
4) **Communicating using information presented in different forms (tables, diagrams etc.) and from different sources.**
5) **Understanding radiactive breakdown of radon and the integration of knowledge and skills of physics, chemistry,**

biology, medicine and health education as an aid to make rational decisions.

1 TASTRAK plate (freshly removed from its metallised protection bag) 1 empty clean yoghurt pot — 70 mm high, 50 mm diameter 1 small piece of plasticine type material e.g. Blu-tack 1 piece of clingfilm
1 elastic band to fit around the top of the yoghurt pot

RADON IN OUR HOMES - IS THE RISK ACCEPTABLE ?

Students* Guide The Scenario

The city of Torun in Poland has the highest lung cancer mortality rates in Poland, but its source is not known yet. The origin of this situation seems to be linked, among others, to the presence of radon. Radon — related lung disease among miners has been documented for more than 400 years, but since the 1950s there has been increasing awareness of elevated radon levels in above-ground buildings, particularly in homes and schools. In most countries (see Table 1 in the appendix) the greatest contribution to collective effective radioactive dose arises from radon in the home, and there is increasing evidence that this is a significant cause of lung cancer.

Your Task

*

1) Take part in a discussion on radioactivity. Since the phenomenon of radioactivity has been discovered we know that the ionizing radiation is around us - in the air, water, sands, food and in our bodies. It can be a stream of particles of various kinds - alpha, beta or protons, or a stream of high energy X or gamma rays,

Some discussion points:

— where does this radiation come from, and what percent is from each source? A

— how long does it live ?

— is it dangerous to the human body ?

— can we measure its amount and behaviour and so on ?

2. Through group discussion, put forward a plan to investigate the radon level in the home and compare this with results from other homes. Through presentation of each group's plan arrive at a consensus arrangement for a comparative study.
3. Determine the radon concentration levels in the home and compare this with data obtained from the literature.
4. Based on this knowledge (and published acceptable limits), determine the microrisk and put forward suggestions as to whether this risk is acceptable.
5. Comment on actions that can be taken where the risk is not acceptable.
6. Also comment on the fact that people choose to tolerate the substantial risks posed by radon but take action to reduce other risks that are not so great.

PART *II*
RADON **IN OUR HOMES - IS THE RISK ACCEPTABLE ?**

Teacher's *Guide* *This activity relates* to

1) *determining the radon concentration in the* ***home;***

2) *attempts to associate this* ***with the risk involved and comparing this risk with other risks*** *associated with our lives;*

3) *a consideration of acceptable levels of risk* ***and why some risks (exposure to radioactive radon*** *gas) are ignored even though the level of* ***risk may be quite high.***

Teaching Strategy

1. The *lesson* **begins with a brainstorming session on the causes of cancer in places such as Torun. Students are encouraged to put forward ideas. The teacher accepts** *all* **ideas although the expectation is that students will concentrate on the effects of radiacti vity.**

1) **After a variety of ideas have been solicited, the teacher draws attention to radioctivity and asks students in their groups to write down their understanding of radioactive decay and why this might be considered dangerous.**

2) **The groupwork is followed by class discussion in which the meaning of radioactivity is consolidated from presentations by student leaders. The source and emission of alpha particles is emphasised and the teacher suggests this can be detected using TASTRAK plates.**

3) **Groups are introduced to the TASTRAK plates by the teacher. Groups discuss where in the classroom the plate should be exposed for it to be a place of possible build up of alpha particle radiation. This discussion is extended to develop a plan of where to test in the home.**

4) **The teacher introduces exposed and processed plates. Student groups are invited to analyse the plates and undertake the necessary calculations.**

5) **At the end of the lesson, each group is given a fresh TASTRAK plate to expose in a home in an appropriate position.**

6) After exposure of the plates as per instructions, it is returned to school for processing. After processing it is now ready for analysis by the student groups in a similar manner to that introduced earlier. This is undertaken in the classroom and completed (if necessary) for homework.

7) The groups compare the analysis of their plates against stanadrd plates and determine the radiation level.

8) Students discuss the radiation levels in their groups and put forward actions that can be taken to reduce this. Students also indicate the microrisk associated with radiation in given instances and discuss whether the public can be educated to reduce their exposure to the risk or whether it is the responsibility for Government to enact legislation to assist the public (and possibly introduce measures in some circumstances — for example, all cellars must install a fan).

PART II

RADON IN OUR HOMES - IS THE RISK ACCEPTABLE ?

Achieving the objectives OBJECTIVES

1) **Recognising an acceptable risk and appreciating the need for greater publicity on the dangers of radon gas.**

2) **Developing skills in making individual science investigations.**

3. Cooperating as a member of a group and with medicine and environmental centres in town.

1) **Communicating using information presented in different forms (tables, diagrams etc.) and from different sources.**

2) **Understanding radiactive breakdown of radon and the integration of knowledge and skills of physics, chemistry, biology, medicine and health education as an aid to make rational decisions.**

This is achieved by

students discussing in their groups whether the microrisk is acceptable and how the risk about radon can be publicised to the general public.

planning their testing in the classroom followed by the students being asked to undertake an analysis in their own home. Carrying out the experiment and ensuring that it is legitimate as an important aspect of the investigation.

students putting forward their point of view, but for an investigation to be carried out where all variables are controlled it is important that students cooperate together in this respect.

obtaining data from **other sources. This** involves looking up **information from other** sources and relating **this** to **the task in hand.**

group discussion **on the radioactive decay of radon and on the health risk. Arriving at decisions based on an interpretation of the results involves higher order thinking skills and weighing up the evidence.**

Assessment

Students can be assessed by formative methods. As there are no written records, summative assessment is not suggested.

Formative Assessment Strategies

— Able to award a social values grade (objective 1)

The teacher listens the student groups during the discussions.

A Has difficulty understanding the radon problem in terms of microrisk. Not able to suggest whether the risk is acceptable and whether Government should interfere in taking measures by law to counteract the radon problem.

B Able to appreciate the risk and the difficulty the general public face in dealing with the radon gas emission problem. Able to suggest social actions to counteract the problem and comment on the need for Governmental legislation.

C Understands microrisk and can relate this to various aspects of life. Able to indicate the effectiveness of various preventive measures and recommend to the general public the action to take in a particular instance. Able to recommend to Government the type of education or action that would be most appropriate.

—— Able to award a science method grade (objective 2)

The teacher listens to the group discussions.

A Not able to plan the experiment with respect to potential radon build up. Experi**mental procedure simply followed according to instructions.**

B Able to select a position to expose the TASTRAK plate with respect to suspected radon buildup. Able to follow the experimental procedure.

PART **II**

RADON IN OUR HOMES - IS THE RISK ACCEPTABLE ?

Achieving the objectives **<u>OBJECTIVES</u>**

1) **Recognising an acceptable risk and appreciating the need for greater publicity on the dangers of radon gas.**

2) **Developing skills in making individual science investigations.**

3. Cooperating as a member of a group and with medicine and environmental centres in town.

Communicating using information presented in different forms (tables, diagrams etc.) and from different sources.

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RADON IN OUR HOMES - IS THE RISK ACCEPTABLE ?

tigations. (Students are expected to analyze same exemplary plates from their home **investigations, once they have been developed. This is a repeat of the procedure taught in die first lesson.)**

This analyses should be continued as a homework. NOTE: assuming 30 students in the classroom, it will not be possible to analyze all students' samples.

The third and most crucial lesson, discusses the results of the investigation, the microrisk for their area and other areas (in Europe and around the world) and through a debate discusses the need, and the manner in which this should be enacted, for Government intervention to minimize the exposure to radon.

Tasks for the Teacher

L To get acquainted with the problems of ionizing radiation and radon.

22) To **interest students in problems related to the radioactive** gas **— radon.**

23) **To organize and supervise the experiment performance (the instructions for use of TASTRAK detectors is given).**

NOTE: **if the number of** TASTRAK plastcs arc **sufficient, you can also examine the radon concentration** changes according **to such factors as:**

- **time (short and long-term of measurement)**
- **site of dwelling**
- **place in dwelling**
- **type of ventilation (aeration, air conditioning, etc)**

2. **To collect students' data, compare the results and draw the conclusions.**
3. **To discuss the results (suggested questions for discussion arc given).**
4. **To realize the risks of radon penetration to the human body and possibility of diseases caused by the high radioactivity doses — during the short and long term of exposure (see reference [3]).**
5. **To talk over the possibilities to solve problems connected with risk caused by the high radon concentration in homes (use the data given and that from the literature).**

Meaning of Risk

Everyday we take risks. We risk getting poisoned from the food we eat and suffering respiration problems from the contaminated air we breathe. Wc take a risk whenever we cross the road, ride a bicycle or travel in a car. We risk being harmed by exhaust fumes from diesel vehicles, being attacked in the street or being engulfed in a fire.

The mathematical definition of risk can be expressed as [5]:

where R is the risk; P is the probability **of occurrence, and C is the seriousness of the consequence. (In the case of certainty, P ~ 1. In case of death, C 1.)**

The concept *o f* microrisk is the risk through which 1 in million people exposed may be killed Based on B, Cohen's estimation, 1 microrisk/year shortens life expectancy by about t day.

International experience indicates that one microrisk is incurred when travelling

2500 km by train flying 2000 km by plane travelling 80 km by bus driving a
car for 65 km bicycling for 12 km smoking I cigarette living 2 weeks with a smoker
dfmkmg Naif a tore of wine breathing in polluted city Ukc Oacow for J days

PART II

RADON IN OUR HOMES - IS THE RISK ACCEPTABLE ?

The estimation obtained by subtracting the normal mortality and by extrapolation, assuming a linear proportionality between risk and dose. A dose equivalent of 1 mSv of Radon increases the risk of lethal leukemia and cancer by about 50 microrisks.

NOTE: We can assume the radioactive dose of 1 mSv is equivalent to the mean radon concentration value of 40 Bq/m^3 (if we are spending about 80% of our time in buildings).

Radiation

Exposure

Table I
The different contributors to the radiation exposure of the Polish population

Source of ioni2ing radiation	Radon gas	g rays from ground and buildings	Medical	Cosmic rays	Food and drink

%	43	18	18	12	9 HI

Radon

Radioactive radon gas ^{222}Rn is a decay product from Uranium and seeps into homes from uranium rocks and soils, even when found in trace quantities. It decays with a half-life time of 3.8 days according to the equation:

S H ^{218}Po I alpha

and emitting ionizing radiation alpha, which is the most active during interaction with matter, including the human body. Radon, when inhaled, exposes the lungs to alpha radiation and increases the risk of developing lung cancer. This risk rises as the level of radon and the duration of exposure increases. For example, radon levels indoors varies from season to season, from day to day, from the behaviour of family members, during the time of day and of course, the geographical location.

Calibration of the Radon detector

The yoghurt pot has been calibrated by the National Radiological Protection Board in the UK as giving

Radon concentration = 6 x count per cm^2 / exposure time in days

Radon levels are measured in Becquerels per cubic metre or Bqm^3 (One becquerel represents one nuclear decay per second).

Thus for a count made in 1 cm^2 over and exposure of 6 days, the Radon concentration ($Bqm*^3$) - equals the count.

Questions for discussion

What are the sources of ionizing radiation around you ?

What can you say about the properties of radon ? Which radon isotope is dangerous for our lives and why ? How do the radioactivity penetrate your body ? What are the ways of radon entry into houses ?

How can your local data be interpreted and what conclusion can you draw from them ? How you can protect yourself from influences of radon on your health ? How can levels of indoor radon be reduced ?

Why do dosage limits of radon concentration in buildings differs across countries ?

Why do people choose to tolerate the substantial risks posed by radon ?
While taking action to reduce other risks that are not as great ?
Why have only such a few houses across the country been tested for radon ?

ICASE / UNESCO
SUPPLEMENTARY TEACHING
MATERIALS

Student Handout

Using a TASTRAK plate, test the radon level in your home over a 6 day period as follows.

Apparatus required

1 TASTRAK plate (freshly removed from its metallised protection bag) 1 empty clean yoghurt pot - 70 mm high, 50 mm diameter 1 small piece of plasticine type material e.g. Blu-tack 1 piece of clingfilm
1 elastic band to fit around the top of the yoghurt pot

Immediate Procedure

1) **Ensure your hands are clean.**
2) **Record the number visible on the TASTRAK surface so that you will recognize your plate after processing.**
3) **Place the TASTRAK in the bottom of the yoghurt pot on a piece of Blu-tack. (The name TASTRAK must face uppermost — this is the surface to be exposed).**
4) **Cover the mouth of the yoghurt pot with clingfilm and hold in place with the elastic band.**
5) **Place the yoghurt pot in the selected place in your home and leave it there for 6 days.**

After 6 days

6) **Dismantle the detector and carefully place the TASTRAK plate into the metallised bag. (This will be sent for processing).**

After processing of the TASTRAK plate

7) **Mount the plate between photographic slide mounts.**

8) **Place the slide in a projector and project onto a screen so that the name TASTRAK, the inscribed 1 cm square and the number face towards you. (It is important to focus the projector on this surface of the plastic).**

9) **Look at the track left by the alpha particles (note they have the appearance of small dots with clear centres or miniature craters as opposed to faint, out- of- focus marks. As a rough guide of the projected square is 50 cm across then the craters will be about 3 mm diameter, although some may be a litde smaller.**

10) **Count the number of tracks inside the square on the TASTRAK plate (Correct focussing is important as there will be some tracks on the back of the plastic that should not be counted).**

11) **Analyze the data of your group and compare this with the results obtained by other groups and that published in the literature**

SAVING CULTURAL MONUMENTS 1-KUM

Additional Information

Bronze is made from mixing copper and tin (or copper and zinc as is preferred today) in a furnace, melting the metals and, on cooling, forming sheets of a fairly soft metal that can be hammered into shapes or carved with a sharp instrument. It is a dark brown/black colour on the surface, but on scratching reveals a bright orange/brown colour similar to copper. Bronze is typically 80% copper.

The reactivity of metals can be expressed in a table, the most reactive metals given first. Such a table is given below.

Ca Mg A1 Zn Fe Sn Pb H Cu Ag Au (K and Na have been omitted as their reactivity is too great to be considered for sculptures).

Although not a metal, hydrogen is included as a reference. With this, the same table can be used as an electrochemical series; metals above H establishing a negative potential compared to hydrogen and those below H, a positive potential.

Additional educational problems

24) The statue of Marcus Aurelius had been on the top of Capital Hill in Rome for 2000 years decorating this place. This is the only one of numerous riding cavalier statues which exists now. Others were destroyed by early Christians. At the end of the seventies it was moved to the laboratory. Detailes of bronze

monuments have been destroyed and the monument looks like a sieve with many holes. Ancient gold cover existed only in the form of small islands.
What do you think, besides time, caused the bronze destruction ?

25) Why is modern bronze, containing Zn, less stable than ancient bronze containing Sn? Why is the surface of statues made from bronze containing very little amount of Sn covered with white dots ?

26) What do you think was the reason of the Callosus of Rhodos destruction, taking into consideration that this statue was made of bronze sheets, which where clamped on an iron bearing construction ?

27) Sometimes to protect bronze sculptures they are covered by special films, consists of oxides and hydrosalts of copper. Why does the sulphate and nitrate, but not hydrogencarbonate of copper(I) and (II) get used in cities with highly developed industry for producing protection films ?

Statue of Marcus Aurelius

Over time little cracks appeared in the gilt. Water accumulated in the cracks. This water, together with substances in the air, formed a conducting medium and allowed an electrochemical process to occur between the gold and the bronze. As a consequence the statue became an enormous battery. The metal corroded and little holes appeared in the statue.

Patinas

The surface of every monument made of metal has a natural or protective-decoration cover which prevents the metal from further oxidation. These are called patinas. Patina is I more or less stable coloured film, formed as a result of complicated and multistage interactions of the upper layer of the sculpture material with acids, salts and gases in the atmosphere.

Non-natural cover are usually combinations of non-natural patinas and organic compounds, such as compositions from natural and synthetic wax, natural and synthetic drying oil, polybutylmethacryl varnish and others. It is known that some monuments were painted with drying oils and covered with a black pigment. Of course in these cases the surface of the monument loses its characteristic glitter of bronze and gains a varnish-like structure.

PART II

SAVING CULTURAL MONUMENTS FROM CORROSION

Some types of patinas used in the restoration of monuments around the world are made from the following chemical composition - (a) basic copper oxides (I) and (II), (b) basic copper sulphates (I) and (II), Sb(II), Bi(III) and (c) basic salts of copper (carbonates, sulphates, nitrates, chlorides).

Oxide films on the surface of small bronze objects are obtained by heating in a flame, leading to the formation of black copper oxide by oxidation by the atmosphere. Larger objects are heated in special furnaces. Making patinas is an usual operation which is made after sculptures have been cast. Sulphate films are stable only in conditions of low atmospheric humidity. Non natural patinas made on the basis of basic salts are very similar to natural patinas but they are less mechanically stable. However the quality of films influence by atmospheric conditions gets better with time, if the patina composition and way of making have been chosen correcdy. It is not recommended to use non-natural patinas, containing carbonate ions in towns which are situated on the sea coast and industrial centres, because carbonate ions can be easily replaced with sulphate ions (contained in the air). In these cases, it would be better to use films, containing basic copper sulphate or nitrate (strong acid salts).

To protect monuments in coastal areas chloride ions are introduced into the composition of the patinas. Because chloride ions could be corroding agents when we have a water film (on the bronze surface), copper in the presence of chloride ions oxidises in the air to form a thin and considerably stable light green film which protects the inner bronze layers from further oxidation. This film $CuCl_2$ $3Cu(OH)_2$ is called atakamit.

Carbon dioxide gas causes a transformation of atakamit to the green coloured malachite $CuC0_3$ $Cu(OH)_2$. Green patina is hardly formed on the bronze surface, but it shows old age of the monument. If in the air there is a. lot of sulphur compounds, this could lead to the formation of the green coloured film containing $Cu(OH)_2$ $S0_4$. Climate conditions greatly influence the physical chemical processes occurring on the surface of the sculptures. The most important factors are compounds polluting the atmosphere and the humidity.

Possible additional tasks

28) Bronze sculptures were created in very ancient times. In the 19th century cast iron was introduced in tothe practice of making sculptures. In the 20th century sculptures began to use steel and titanium. What metal is least likely to corrode ?

29) The famous monument of the bronze cavalier in St. Petersburg is constructed on an iron arc like a horseshoe, which is connected to the bronze sculpture with the help of bronze braces. During restoration in 1978, a steel framework was not only very carefully cleaned from dirt and rust, but was painted with red lead. It was very difficult to work inside the sculpture. Infrared lamps were used to make the drying process of the paint faster. However, restorers painted the inside of the sculpture several times.

Why was this done ?

Answer: it is necessary to isolate the iron framework from the bronze sculpture material.

30) Usually bronze sculptures have thin walls (1.5 mm up to several millimetres in thickness). They are usually fixed on the pedestal of the monument with the help of a special iron or steel framework. Unfortunately, due to the influence of accumulating water surrounding the sculpture, the bronze is being destroyed.

How can you explain that in the horse sculpture, the most noticeable destruction (even holes) is on the lower part of the legs ? Answer: The iron framework is rusting. This is more rapid where it is in contact with the bronze. The oxidation product (rust) has a largely volume than the iron and cracks appear in the very narrow places (for example the lower parts of the legs).

PART II _
SAVING CULTURAL MONUMENTS FROM CORROSION

4. Cracks in bronze sculptures are often sealed with an alloy of lead and tin.

What properties of these materials make them suitable for this process ? Why is their usage not the most convenient way to restore bronze sculptures ?

Answer: Lead and its alloys are fusable materials and it is thus easy to use them to restore cracks in the bronze sculptures. However, in using them we break the principle of not using different metals in contact and this leads to electrochemical corrosion.

Teacher Notes on the Experiment Ferroxyl solution

Agar + [10cm^3 3% salt (sodium chloride) solution, 3 drops of 10% potassium hexacynaoferate(III) solution and 1 drop of phenolphthalein indicator] for every 10cm^3 solution. The solution is formed by warming to dissolve the agar. Students use the solution warm. On cooling the solution sets to a gel.

And alternative to using agar is to use tissue or filter paper.

Soak the paper in a solution of 10cm 3% salt solution, 3 drops 10% $K_3Fe(CN)_6$, and 2 drops of phenolphthalein.
Wrap the strips and nails in the paper. Leave for '1-2 hours.

The main comparisons for this experiment are between the results in petri dish A with C and also between C with D.

31) The A/C comparison shows the problem for bronze when there are 2 dissimilar metals in contact.

32) The C/D comparison shows the acceleration of the corrosion in the presence of salt (seawater)

It is possible to include a further experiment to show what happens in the presence of acid (i.e. acid rain) ? The salt solution in the agar can be replaced by very dil. hydrochloric acid (the pink colour wouldn't form of course and the experiment would not need to run for long, otherwise the blue will be everywhere as the iron reacts with the acid).

SAVING CULTURAL MONUMENTS FROM CORROSION

Materials needed 4 petri dishes

33) *strips of copper foil 5cm x 0.5 cm*

34) x 5cm nail

100 cm^3 'ferroxyl' solution

25 cm^3 agar solution with indicator, but no salt solution added

Experimental instructions

34. **Select 4 petri dishes and label them A, B, C, D.**

34. **Into petri dish A, put a 5 cm x 0.5 cm strip of copper.**

34. **Into petri dish B, put a 5 cm iron nail.**

34. **Into petri dishes C and D, put a 5 cm nail with a 5 cm x 1 cm strip of copper wrapped, in one position, tightly around it (or tied to it with a cotton thread).**

34. **Pour a solution warm 'ferroxyl' indicator into the first 3 petri dishes (A,B,C), covering the nail and copper strips. In the 4th petri dishes (D), pour the separate agar solution which contains no salt solution (but does have the indicators). Place lids on all the petri dishes and leave for a few hours (how long the reaction takes will depend on the temperature. It is possible to leave for a few days).**

After leaving

34. **Remove the lids and examine the colourations in the petri dishes.**

34. **Draw sketches to show the colour development in each dish.**

34. **Note, in particular, where the pink colouration occurs which illustrates the presence of OH" ions (because the phenolphthalein indicator in the solution turns pink when the pH rises above 8.4) This is an area where reduction is occurring.**

34. **Note also the presence of a blue colouration which occurs when Fe^{2+} ions are present (an area where oxidation is occurring).**

34. **Try to interpret your observations by comparing the results in petri dishes A and C and between petri dishes C and D. The experiment in petri dish A is used as a control.**

PART II
WHICH MEDICINE IS BETTER -

WHICH MEDICINE IS BETTER BLACK OR WHITE ?

An experimental based decision making exercise *He/in a Otsnik and Mita Kannikmae*

BLACK OR WHITE ?

SECTION 7

This exercise involves students in an experimental planning task. The outcome is a decision on which substance adsorbs better in the digestive system so as to appreciate why certain medicines are suggested for indigestion problems.

Educational objectives

This script includes the following educational objectives:

1. **Indicating a sense of value related to the "sensible" treatment at home.**
2. **Preparing a plan for experimental investigation of charcoal and starch.**
3. **Cooperating in carrying out the investigation within the group.**
4. **Communication orally, in tabular format and in writing a report.**
5. **Understanding the interpretation of compari; »s rider real life conditions.**
6. **Developing an understanding of adsorption ; dissipation of gases during digestion.**

Human digestive system

Teaching/learning resources

Charcoal tablets

Starch powder

Cans of Soft drinks

Ink solution (coloured)

Filter paper

Beakers (any size)

Funnels

Spirit lamp

Thermometer (0-110°Q

Stop-watch

WHICH MEDICINE IS BETTER - BLACK OR WHITE ?

The Scenario

T\vc) days ago, Joey and Kim went to a birthday party. It was good, very good. The food was excellent. There was a very rich, fruity birthday cake and all kinds of fizzy drinks to sample.

Yesterday, however, the story was very different. Joey was unwell. He had stomach ache. His mother prescribed some fruit jelly drink. It tasted good. But Joey was not too sure he wanted to take it. Kim was also ill. Her mother decided that it was better to take her to see the doctor. The doctor suggested charcoal tablets. Kim did not like the appearance of these black tablets, but she was persuaded to take them.

Luckily, today both Joey and Kim are fine. Both recovered well. It seems the treatments worked.

Your task

1. **Discuss, in groups, possible reasons for the stomach ache experienced by both Joey and Kim ? You will need to explain what happens during digestion, where in the body the food is assimilated and what happens in cases where assimilation is not possible.**
2. **Discuss the treatments used on Joey and K?m a -\d why they worked. Put forward a point of view as to whether treatmen : without a doctor is socially wise and acceptable.**
3. **In your groups, develop a project to test the adsorption properties for starch (a white substance in jelly) and charcoal (a black substance in charcoal tablets), taking into account possible variations in conditions.**

4. **Record your project results in the form of table showing how different conditions (parameters) influence the speed and completeness of adsorption.**
5. **Conclude whether 'black or white' is a better adsorbent and make suggestions for their conditions of use in the body.**

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WHICH MEDICINE IS BETTER - BLACK OR WHITE ?

h r's Guide This material relates to understanding of adsorption, the **same phenomenon being** [cacnc **relevant in** both biology and physical sciencc. By planning an **experiment** for **testing** adsorption properties of starch and charcoal, students develop their **investigation skills** This exercise points to the need to consider variables before decision **making**

This activity relates to

a) reinforcing previous knowledge about metabolic processes and dissipation;
b) realising that adsorption has practical utilisation in everyday life;
c) introduction factors influencing the speed and completeness of adsorption;
d) making a decision whether it is better to use charcoal or starch in treating indigestion.

Teaching strategy

1 The lesson can begin with group discussions in which students are asked to put forward ideas about what might be the causes of the stomach ache for Joey and Kim. Students will need to explain the process by which food is digested and what happens with food that is not assimilated. This can be undertaken by completing a worksheet.

2 The groups should discuss why charcoal and starch (jelly) can be used as treatment for indigestion as people have done from earlier times.

3 Each group can be asked to present their answers to the questions on the worksheet This activity should be kept as short as possible and the teacher should try to ensure groups do not repeat answers that have already been given by other groups. This can be done by groups ticking their response where it is the same (or very similar) to that already reported by another group. When their turn comes to present they only present non-ticked parts.

Groups are next asked to plan experiments which will help to decide which of the treatments is better and under what conditions.

Students should create a project to test the adsorption properties. The teacher will need to help the groups to stipulate the variables to measure (e.g. timing how fast coloured liquid or soft drink will run through the charcoal, or starch; the influence of temperature, of the particle size, etc.).

The groups present their results in tabular form which they have devised.

Each group writes a report that describes the plan undertaken, the results and the conclusion reached which includes a decision as to whether they feel 'black[1] or 'white is a better medicine for indigestion. The report needs also to consider the social issue of whether doctors should be consulted on all medical problems or whether it is appropriate to use 'local remedies'.

Comparison table of adsorption properties for charcoal and starch

Aspects	Charcoal	Starch
Adsorption rate completeness		
Food value		
Ease/liking of use for children adults		
Possible side effects		

PART II

WHICH MEDICINE IS BETTER - BLACK OR WHITE ?

Achieving the Educational Objectives OBJECTIVE

1. **Indicating a sense of value related to the decision on whether 'sensible' treatment at home is acceptable**
2. **Preparing a plan for experimental investigation of charcoal and starch.**

3. **Cooperating in carrying out the investigation within the group.**

4. **Communication orally, in tabular format and in writing a report.**

5. **Understanding the interpretation of comparisons under real life conditions.**

6. **Developing an understanding of adsorption and dissipation of gases during digestion.**

This is achieved by

discussing in groups and making a decision on the value of local remedies and actions.

discussing and answering the worksheet.

sharing the experimental tasks and developing the table and report.

discussing within the groups, creating a table of results and preparing a report of the project.

formulating a decision as to which remedy is best under real life situations.

answering the worksheet and answering additional questions posed by the teacher to the groups.

Assessment

This project can be assessed by both formative and **summative methods.**

Formative Assessment Strategies

— Able **to award a social value grade** (objective 1)

The teacher observes the groups at work.

A **Not able to reach a decision or the decision is very stereotyped and impracticable.**

B Able to make a decision on whether to consult a doctor or whether the use of local remedies is acceptable.

C Able to suggest that common sense actions should prevail in deciding action to take in the case of illness and hence there is no absolute to deciding whether to consult a doctor or take local action. Appreciates that legislation by Governments will not be helpful.

— Able to award a science method grade (objective 2)

The teacher observes the worksheets being completed by the students and asks questions as necessary.

A **Unable to develop a plan for a project.**

B Able to develop a plan to test whether the 'black' or 'white ' remedy but the plan produced has not considered the controlling of variables such as particle size, temperature or amount.

C Able to develop a plan to test whether the 'black' or 'white ' remedy and include controlling of variables such as particle size, temperature "or amount; the plan involves testing under a number of conditions.

—— Able to award a personal skills grade (objectives 3 and 4)

The teacher observes the groups and listens to the discussions.

A Not interested in the work and unwilling to cooperate with the group. Does not show communication skills needed to create a table and prepare a report.

B Able to cooperate with the group in answering the worksheet, developing a project plan carrying out the project and creating the table and report.

C Very interested in the work and plays a leading role in guiding the work of the group and involving members of the group in undertaking tasks. The tables produced are very appropriate.

PART II
WHICH MEDICINE IS BETTER - BLACK OR WHITE ?

T Able to award a science concept grade (objectives 5 and 6)

The teacher discusses with each group.

A Unable to answer questions posed by the teacher related to the need for standard conditions for the experiments, or in understanding adsorption.

B Able to answer questions posed by the teacher on the need for standard conditions and in understand adsorption.

C Able to suggest standard conditions that are best suited to what happens in the body and is able to relate adsorption to processes within the digestive system.

Summative Assessment Strategies

1. **Able to award a personal skills award (objective 4)**

The teacher marks the table and the report.

A Report is poor or incomplete. The table of results is poor.

B Able to present a well planned report with the experimental procedures and the table of results complete. The report gives a ccDelusion as to the best remedy.

C The report produced is well planned and indu : - an introduction to the problem, the social issues involved as well as the planning o the experiment, the results and a well formulated conclusion based on conditions of the experiments.

2. **Able to award a science concept grade (objectives 5 and 6)**

The teacher marks the worksheets and the report.

A The descriptions give a poor understanding of adsorption.

B Adsorption is understood and the need for standard conditions is explained.

C The worksheet and report give a very good description of the meaning of adsorption in the context of the digestive system and includes a good description of how the conditions of the experiments are carefully controlled.

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WHICH MEDICINE IS BETTER - BLACK OR WHITE ?

1. **Give suggestions as to why you think Joey and Kim were feeling unwell.**
2. **Explain what happens to food when eaten. In your explanation describe how and where food is assimilated. Also explain what happens to food not assimilated and problems that could arise leading to indigestion.**
3. **What are the remedies that were suggested in the case of Joey and Kim ? What do you suggest is the purpose of taking the substances ?**
4. **Discuss and put forward a point of view as to whether it is appropriate to use 'local remedies' or whether it is important to consult a doctor when someone is unwell.**
5. **Plan experiments to decide which remedy is best. For this, take the white substance to be starch and the black, charcoal. You will need to be careful about controlling variables so that you use the same conditions in each case. Your plan should consider what happens if conditions are changed. Does this affect the choice of substance as being considered best ?**
6. **When given permission by the teacher to do so, undertake the experiments. Record the results in a tabular format. Write a report that covers the project and the conclusion reached.**

Carbon adsorption

The fermenting of sugars and sometimes the digestion of proteins creates gases in the intestines. Excess gas is usually caused by foods rich in sugars, as well in proteins (potatoes, cabbage, peas, bread, candies, beer, cheese etc).

Fermentation is caused by bacteria. Usually, formation of gases caused by fermentation takes place in the small and large intestine. There is no formation of gases by bacteria in the stomach, because of the acidic environment. The gases which have, for some reason, entered the stomach leave it through mouth. Gases from the small and large intestine exit the body through the anus.

The type and amount of different gases depends on the food eaten. For instance, eating eggs, curd and pea soup results in the formation of H_2S. The formation of gases in an organism is individual, depending on the content of the microbes. However, the main gases are $C0_2$, CH_4, H_2S, H_2, NH_3. Formation of excess gases often result from heart diseases, neutral system disorders, obeisity, constipation, or even too much sitting. Sometimes, gases are not let out because of mechanical obstructions.

To cure stomach gases one must take less sugar-rich food. In cases of food poisoning and/or indigestion, carbon is widely used as a remedy for removing the gases formed. The carbon, a tasteless, odourless, black powder, adsorbs the phlegm and toxins as well. Starch, another adsorbant, decomposes in the organism because of enzyme action (amylase and glycosidase). The remaining substance from the strach acts as the adsorbant. However, it does not absrob gases. Other adsorbants are milk and egg-white.

Adsorption refers to the collecting of one substance on the surface of another. In other words, adsorption in an physical-chemistry phenomenon in which some chemical substances have the property to adsorb, and keep on the surface, different liquids or gases. The adsorbing intensity depends on the surface area — the larger the surface area, the faster the adsorption. Most of the adsorbing substance do not dissolve in water or other liquids.

PART II

HOW TO AVOID BICYCLE ACCIDENTS ?

SECTION 8 HOW TO AVOID BICYCLE ACCIDENT ?

An experimental, problem solving exercise

Initiated by Ladislav Kulcar; Rastislav Banik, Halina Pieta, Alina Domgala and Hanna Novakova

Introduction This script investigates the problem of fast moving vehicles, especially lorries/**trucks** causing accidents to bicycle riders even though the lorry/truck is not actually in contact with the rider.

The investigation involves three steps

1. Undertaking a number of simple experiments to determine whether any interpretation is possible between a fast moving fluid and any subsequent pressure changes.
2. Devising an experiment to show the effect on a bicycle rider of a lorry/truck overtaking the rider and how this varies with distance between the lorry/truck and the rider when the lorry/truck moves at different speeds.
3. Suggesting steps that can be taken to reduce accidents caused by fast moving lorries/ trucks overtaking bicycle riders.

Educational Objectives
This script includes the following educational objectives

3. Putting forward practical suggestions for action based on scientific findings.
3. Planning an investigation.
3. Cooperating as a member of a group.
3. Communicating orally and by means of a poster.
3. Interpreting experimental observations based on the Bernoulli principle.

Science concepts pressure
Teaching /leraning resources
Table tennis balls x 3
Cotton thread
Empty audio cassette box x 2
Sheet of A4 paper
Bernouilli's principle

Cardboard cut-out of aeroplane wing
Glass tube (as per diagram in the student handout)

HOW TO AVOID BICYCLE ACCIDENTS ?

' Guide The Scenario

Your class is called upon to help reduce road accidents by carrying out laboratory investigations and then suggesting actions that might be possible to publicize how to appreciate better ways to avoid accidents to bicycle riders.

Bicycle riders are gready affected by conditions such as changes in road surface, wind direction, wind speed and of course the slope of the land.

Imagine a bicycle rider travelling along an open road and being overtaken by a long, very tall, truck. Although this truck goes quite fast, it take quite a few seconds to pass a bicycle rider. During this time the bicycle rider cannot turn otherwise he or she will either go off the road, or ride into the truck.

There seems to be a particular problem for many riders when the truck is going fast and is very close to the rider. Is it possible to find out more about the situation and suggest ways to avoid accidents ?

Your task

In a group of no more than 4 students

1. **Carry our the experiments given on the worksheet. Record your observations and interpretations in the space provided,**
2. **Use your knowledge from undertaking these experiments to devise an experiment of your own to show to other students the effect of a large truck overtaking at various distances from the rider and at various speeds. Record your results in the form of a graph.**
3. **Suggest ways and create any materials needed, to help the general public appreciate better the ways in which accidents can be avoided. You may wish to target bicycle riders or truck drivers with your suggestions, or you may gear everything to the public in general.**

part II
HOW TO AVOID BICYCLE ACCIDENTS ?

a) showing the reduction of pressure with fast moving fluids;
b) relating the reduction of pressure with bicycle accidents; b) providing ideas for increasing safety when riding a bicyclc.

For this reason, the earlier the unit can be introduced in the teaching schedule, the better.

Teaching Strategy

1. **The students can be asked to predict how objects will be affected by moving air, but often their prediction differs from that shown by the experiments. The experiments may illustrate discrepant events in their eyes. It is thus important to allow students to undertake the series of little experiments and to appreciate that fast moving air/ liquid causes a reduction in pressure and thus objects will move in the directions of the pressure reduction. This is the very^essence of aircraft takeoff.**
2. **Once this is established (and for a very able class this could be within 5 minutes, although an average class might need closer to 20 minutes) then the students can begin to think about the reduction of pressure caused on the bicycle rider and how they can devise an experiment to determine its effect depending on the speed of the truck and the distance of the rider from the lorry/truck.**
3. **For their simulation experiment, objects such as empty audiocassettes (to represent the lorry/truck) are likely to be needed. The bicycle rider can be represented in many ways, but one possible idea is to use a table tennis ball.**
4. **Obtaining quantitative data is problematic and thus the plotting of a graph of pressure reduction (or distance from the vehicle) against the square of the vehicle velocity is difficult Such a plot however can be utilised to illustrate the Bernoulli law in which pressure varies with the square of the velocity.**
5. **To simulate a fast moving vehicle is not easy and d . ; best solution is usually to blow air between the model of the truck and the bicycle. The variation can be shown by blowing by mouth, by using a bicycle pump or by using a hairdryer (or other blowing device). It will probably suffice if 3 different speeds are simulated (as in table 1) with the middle being used as the constant in table 2.**

Table 1.

No.	distance	speed	result of observation

—	constant	low
—	constant	middle
—	constant	high

Table 2.

No.	distance	speed	result of observation
-	3 cm	constant	
-	2 cm	constant	
-	0.5 cm	constant	

6. **A suggested manner in which the students can make the public more aware (of the dangers of fast moving air causing a reduction in pressure) is to design an educational poster which focusses on keeping a safe distance between the bicycle rider and the truck. The poster could be entided 'Drivers, the life of bicycle riders is in your hands'.**

HOW TO AVOID BICYCLE ACCIDENTS ?

Achieving the Objectives

OBJECTIVE

1. **Putting forward practical suggestions for action based on scientific findings.**
2. **Planning an investigation.**

3. **Cooperating as a member of a group.**

4. Communicating orally and by means of a poster.

5. Interpreting experimental observations based on the idea that increasing the velocity causes a reduction in pressure.

This is achieved by

the discussions following the experimentation related to bicycle accidents

devise an experiment to show the effect of increasing the velocity on pressure reduction and the effect of pressure reduction with distance.

group work and thus the functioning of the group will depend on all the members being involved in a positive manner.

discussing in the groups and suggesting ways to educate the public of the dangers of large vehicles overtaking bicycles through designing a poster.

undertaking a number of simple experiments in the laboratory and interpreting the obser-vartions made.

Assessment

Students can be assessed by both formative and summative assessment methods

Formative Assessment Strategies

── Able to award a social values grade (objective 1)

The teacher listens to the discssuion in the groups and notes the development of the poster.

A Not very aware of what can be done to solve this social problem. Poster not very creative.

B Recognises the problem and has ideas on how action can be taken to avoid the accidents. The poster is interesting and conveys a message for truck drivers that is useful.

C Full of idea on actions that could be taken. The poster is interesting and original. It not only conveys as message to truck drivers but also to the general public

── Able to award a science method grade (objective 2)

The teacher observes the groups. The teacher asks questions as necessary.

A Unable to suggest an experiment that could be carried out

B Able to put forward ideas but for the most part they require apparatus that is not easily found in the laboratory. Able to suggest the graph to be plotted.

C Able to put forward an experiment that can be carried out using usual laboratory apparatus and indicate the necessary measurements that should be made.

── Able to award a personal skills grade (objectives 3 and 4)

The teacher observes the students during the experiments and in the discussion groups

A Tends to allow others to do the experiments and is simply an observer most of the time. v

B Shows interest in undertaking the experiments and is able to relate this to the problem being investigated. Is able to discuss the results with other in the group and derive a joint interpretation. Able to suggest ideas for the poster and willingly cooperates with others in its design.

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MOW TO AVOID BICYCLE ACCIDENTS ?

C Very kern to undertake the experiments. Tends to lead the **discusión** on **the inter**pretation of the results and how the social problem can be tackled. Tends to **take** the lead in designing the poster and guiding others in the group to play their role.

▼ Able to award a science concept grade (objective 5)

The teacher listens to the discussions in the groups and asks questions as appropriate. A Able to perform experiments, but has little idea of what they indicate. B Plays a positive role in undertaking the experiments and is able to interpret the

findings related to a reduction in pressure. C Plays a positive role, understand the interpretation and is able to suggest modifications to the experiments to improve the outcomes. Able to relate the experiments to the social problem of bicycle accidents and apply it to other situations e.g. the carborettor in a car.

Summative Assessment Strategies

1. Able to award a social values grade (objective 1)

The teacher marks the submitted, finished poster. A Poster not very creative, and does not convey a clear social message. B Poster is interesting and conveys a values message for truck drivers that is practicable. C Poster is interesting and original. It not only conveys a values message to truck drivers, but also to the general public

2. Able to award a science method grade (objective

The teacher reads the written plan of the **suggested experiment.**

A Unable to suggest an experiment that could be carried out.

B Able to put forward ideas but for the most part they require apparatus that is not easily found in the laboratory. Able to suggest the graph to be plotted. C Able to put forward an experiment that can be carried out using usual laboratory apparatus and indicate the necessary measurements that should be made.

Additional Information

Percentage (Slovakia, in 1995)

Poor driving (high speed, dangerous overtaking)
Driving under the influence of alcohol
Bad technical state of cars
Pedestrians and children
Others

Children and adults as bicycle-riders cover approximately 20 % of total traffic accidents.

Reasons for accidents

25 **22** 22 **28** 3

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1 table tennis balls by a cot ton thread. Blow between the balls.

2. Stand an empty audiocassette box vertically. Place a table tennis ball on the table. Prohibit the table tennis ball from moving parallel to the box by another empty cassette lying on the table. Blow between the ball and the vertical cassette.

3. Hold a sheet of A4 paper at the corners of one end. Blow over the paper.

4 Mount a cardboard shape, build like an I aeroplane wing, in a horizontal
that allows for vertical movement Blow
at the wing using a blowing device.

I Run water through

Teaching a vertical glass tube to measure pressure.

PART II

IS OREMULSION SUITABLE AS AN ALTERNATIVE FUEL ?

Roles of student's groups

Chemists group

You get an order to investigate the properties of oremulsion and the products **of** its burning. You have a well-equipped laboratory where you can do **all** experiments you need. According to your conclusions, decisions will be made on the use of oremulsion as a fuel.

Technologists group

Your thermoelectric power station currently burns fuel oil. Now you have a suggestion to burn oremulsion. Is it possible and if so what changes are needed in the technological process? What expenditures are involved ? How will you meet societal demands for reducing pollution of the environment, yet meet energy production demands ?

A new sort of fuel (oremulsion) is being proposed for use. The impact of the combustion products on the environment is unknown. However the expected products of burning and the possible concentrations are known. Research the influence of these products on the environment and predict their likely impact. Be prepared to comment on topics such as acid rain, carbon particulates in the air and the need for sustainable development.

Business (entrepreneur) group

According to political considerations, we should refuse the provision of a monopolitical fuel providing from one country to another. But there are also economic and feasibility considerations. Oremulsion was proposed as an alternate fuel. You must determine the possibilities to supply this product to your region (cost, traffic cost, the cost of complementary equipment, use of alternate sources, etc) and determine its economic viability.

Housewife group

You know a new kind of fuel will change the demand for fuel oil within the country and there could thus be an increase the price of home fuel. This is particularly because of large seasonal fluctuations that are likely to arise in the future from the uneven need for heating and hot water in the home. You are afraid that next year fuel will cost you more. Besides you live near a thermoelectric power station where oremulsion would be burned. Will it be acceptable for you ?

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PART II

IS OREMULSION SUITABLE AS AN ALTERNATIVE FUEL ?

Guidelines for the role playing discussion

Chemist

What compounds will appear in the process of burning oremulsion? Compare this with the products from burning fuel oil.

What pollution compounds will appear in the environment from burnilfB products?

Ecologist

What effect will these compounds have on the environment and on people ? What influence will heavy metals have ?

Technologist

How much will the new equipment cost ?

How much will the adaptation of old equipment cost ?

What measures will be necessary for production control ?

Business Man

What is the cost of transportation ?

Housewife

What are the benefits in using oremulsion : Would orelmusion be cheaper or more expensive ?

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PART II

SAVING CULTURAL MONUMENTS FROM CORROSION

An experimental, problem solving exercise *Initiated by Andrei Zhegin and Irina Titova*

Introduction Many sculptures around the world have a special significance in history and form animportant part of our cultural heritage. Their preservation is important if this heritage is to be passed on to future generations. Unfortunately many sculptures today are showing signs of decay. The statue of Marcus Aurelius, previously at the top of Capitol Hill in Rome has had to be moved to the laboratory for restoration. Many bronze statues have lost valuable detail and in places, are beginning to look like a sieve with many holes. What is the problem with these bronze statues ? Can we do anything to save this important cultural heritage ? Can science come to the rescue ?

Educational objectives

This script includes the following educational objectives:

1. Illustrating to students the value of scientific knowledge in solving practical and social problems.
2. Solving a problem of how to save and protect cultural monuments.
3. Cooperating as a member of a group.
4. Communicating orally and in written format.
5. Developing students' knowledge on chemical and electrochemical corrosion based on a consideration of examples of sculpture destruction in cities

Sciense concepts

Reactivty series
Corrosion (redox)

Alloys such as bronze

Teaching/learning resources

Strips of copper metal

Iron nails

Agar agar (or gelatine)

Salt solutions

Petri dish x 4

Phenolphthalein indicator

Iron(III) hexacyanoferrate(III)

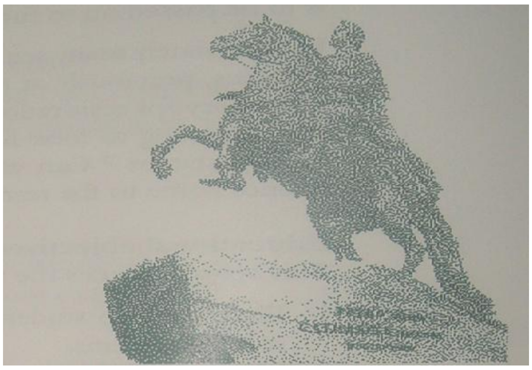
PART II

SAVING CULTURAL MONUMENTS FROM CORROSION

Students' Guide The Scenario

Bronze is a very good metal for creating sculptures. It is not as soft as copper, nor as hard as iron. Intricate artwork can be developed both by carving and the use of light and dark, the dark being the oxide of copper (copper(II) oxide is black).

It is thus not surprising that many very fine bronze sculptures exist and decorate many towns and villages in Eastern Europe. Many excellent bronze sculptures can be seen in St. Petersburg, a city of 4 million people and a major trading centre in North-East Europe. St. Petersburg has a strong cultural history and the city's sculptures are a reminder of its grandeur in past ages.



But problems occur with bronze sculptures exposed to the atmosphere and these prob- lems are particularly prevalent in St. Petersburg. There the sculpture are becoming pitted with small holes, particularly near the bottom. Sculptures are also covered in an uneven green/white film hiding the original bronze colour and much of the intricate artwork.

Your Task

In groups of 3-4

1. Brainstorm the possible reasons for sculptures showing signs of decay.

2. Discuss how this situation can be investigated in the laboratory and possible solutions illustrated.

3. Carry out experiments to investigate the effects of iron and of acid on copper (bronze).

4.Interpret the results of the experiments and consider possible solutions to the problem of decaying monuments.

Presentation of results in groups

Questions for the final discussion:

- What changes of the environment are the most dangerous for metal monuments?
- Why is the problem of the protection of monuments very important for everyone?

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PART II

SAVING CULTURAL MONUMENTS FROM CORROSION

Teacher's Guide This script indicates that:

a) the corrosion of sculptures can be considered as a problem solving exercise;

b)students can carry out investigations related to the problem in the laboratory;

c)students can put forward possible solutions to the problem.

The problems of the decay of sculptures is used to create a problem — solving situation to develop students' chemical knowledge and to show its importance for solving practical problems. It is hoped this will promote the students' motivation to study chemistry and skills to use knowledge in non-standard situations, and to participate in discussion.

Teaching Strategy

1. The lesson can begin with a brainstorming session in which students put forward their ideas on the causes of corrosion of monuments. In so doing their illustrate their knowledge of monuments and of the corrosion of metals. It is important at this stage that the teacher accepts all answers and does not pre-judge any response. The responses can be collected on the blackboard by writing the title in the middle of the board and linking each response to this by a line or arrow, thus creating a chart of thoughts related to the problem.

2. This can be followed by group discussion on ways in which the problem can be investigated in the laboratory. The teacher will need to suggest that copper is used in place of bronze and that experiments need to be set up that duplicate that in nature. But added to this there need to be experiments that look at possible solutions, or ways in which the problem can be minimised.

3. Based on the discussion, students *now* set up experiments investigating corrosion. The experiments will take time to complete and hence it is necessary to set them up in one lesson and the observations made and interpretations undertaken in a subsequent lesson.

4. Students will need to follow experimental instructions as it is suggested that agar solution is used to 'set' the experiments involving iron and copper. This will make it easier to observe the results. The corrosion of copper by acid (or acid in the presence of salt) is more straightforward and can follow student suggestions if deemed appropriate.

5. After setting up the experiments, they need to be left for a few days. After this time students, in their groups, can observe the results of their experiments and attempt an interpretation. The teacher needs to ensure that this discussion then focuses on a solution to the monument problem.

6. Groups can present their solutions to the rest of the class, including any theoretical explanations that may be required.

Notes for the class discussion

1. Study the literature from the library or by the use of other sources;

2. In preparing the group presentation on corrosion protection, include the following topics:

- Protection of corrosion dates back to very early times (Rhodos collosus destruction, ways of protection of sculpture in ancient Greece, corrosion of Knight's ammunition).
- Modern technologies of corrosion protection (spraying, painting films of oxides, sulphides, natural and synthetic wax, polybutylmetacryl and others).

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PART II

SAVING CULTURAL MONUMENTS FROM CORROSION

Achieving the objectives

OBJECTIVE

1.Illustrating to students the value of scientific knowledge in solving practical and social problems.
2.Solving a problem of how to save and protect cultural monuments.
3.Cooperating as a member of a group.
4.Communicating orally and in written format.
5.Developing students' knowledge on chemical and electrochemical corrosion based on a consideration of examples of sculpture destruction in cities.

This is achieved by

1. discussing the problem of the corrosion of monuments having carrying out practical investigation to better understand the theoretical background.

2. suggesting experiments to undertake and interpreting the results obtained.

3. discussing in groups and in carry out experiments on corrosion.

4. discussing in groups and presenting outcomes of the discussion to the rest of the class.

5. students discussing and then presenting their solutions to the corrosion problem of monuments.

Assessment

An assessment of achievement of the objectives of this script can be assessed by both formative and summative methods. Formative assessment can occur at all stages of the development of the script. Summative assessment can apply to the observations and explanations of the experimentation and to the solving of the monument problem.

Formative Assessment Strategy

- Able to award a social value grade (objective 1)

The teacher observes the group discussions.

A Unable to appreciate the problem.

B Recognises that the corrosion of monuments is a problem and that action should

be taken to stop the corrosion.

C Appreciates the cultural importance of preserving monuments. Willing to support restoration once a solution has been found to the corrosion problem.

- Able to award a science method grade (objective 2)

The teacher listens to the group discussions. The teacher asks questions in the group as appropriate.

A Students can put forward few ideas of how to investigate the problem, but able to

follow experimental instructions.

B Students can make suggestions to investigate the corrosion problem based on ideas of redox.

C Students appreciate that the problem is linked to an electrochemical process and can suggest a range of experiments to be undertaken to investigate the problem.

• Able to award a personal skills grade (objectives 3 and 4)
The teacher observes the students in their groups.

A Group cooperation was not well organised. At best only partial interest in carrying out the investigation.

B Able to follow the experimental instructions and set up the experiments. Group willing to cooperate together, but the cooperation is not efficient, as measured by the time involved in setting up the range of experiments.

C The group work well together and are able to carry out all planning and experimental stages smoothly and efficiendy.

PART II

SAVING CULTURAL MONUMENTS FROM CORROSION

▼ Able to award a science concept grade (objective 5)

The teacher observes the groupwork and the group presentation. The teacher asks

questions as appropriate.

A Poor interpretation of the experimental results. Very superficial suggestions for solving the problem.

B Able to interpret the results obtained for the experiments and recognise the corrosion problem when copper is in contact with iron and the role played by salt in the corrosion of copper.

C Able to interpret the experiments, appreciate the role of salt in aiding corrosion and put forward a range of interesting and novel ways of solving the problem.

Summative Assessment Strategies

▼ Able to award a social value grade (objective 1)

The teacher reads the answers to the questions posed.

A Only superficial reasons are put forward as to why protect the monuments i.e. to make them look nice.

B Able to suggest why the protection of monuments are important from a societal viewpoint.

C Able to consider the protection of monuments from a number of viewpoints and suggest the importance of protection the monuments from these positions.

▼ Able to award a science method **grade** (objective 2)

The teacher reads the solutions given in **the** presentation by the group.

A Few recommendations offered and presented in a very vague manner.

B At least one recommendation is given for the iron-copper corrosion problem and the corrosion of the copper in the air, but the solutions tend to overlap.

C A number of interesting and diverse recommendations are given that could have practical application.

▼ Able to award personal skills grade (objective 4)

The teachers reads the material used of the presentation by the group.

A Materials not logically presented. Observations not systematically recorded. Explanations missing. Not able to comment on possible changes in the environment that are dangerous for monuments.

B Material presented well, with observations given systematically and explanations offered. Able to suggest what changes in the environment are dangerous for monuments.

C Use of communication approaches beyond the written word included to aid comprehension of the material. Very clearly able to indicate the environmental dangers to monuments and how these are created.

▼ Able to award a science conceptual grade (objective 5)

The teacher reads the observations and explanations offered in the presentation by the

group.

A Poor recording of the observations. No explanations offered for the observations made.

B Observations recorded well. Explanations offered in each case for the corrosion, but the role of the salt is not fully understood.

C Good recording of the observations and the explanations. Good understanding shown for the role played by the salt in the reactions.

PART II

AN ASTRONOMICAL CLOCK ?

Student's Guide The Scenario

In the 17th Century governments were pressing astronomers to think up more and more accurate ways of telling the time. They wanted to set up trade routes across the oceans. For this it was necessary to tell the time at a reference point such as Paris irrespective of where you were in the world. As each hour difference in time represents 15° difference in longitude, knowing the time difference from a reference point would give the longitude.

Ole Roemer, a Danish astronomer, was interested in observing Jupiter and its moons. He considers it might be possible to see the moons of Jupiter, note the time of their eclipse and then, using a book of tables based on a reference point e.g. Paris, to work out the time there.

Your task

1. Suggest why knowing the time in Paris from on board ship was useful ?
2. Decide whether you think Ole Roemer was correct about this astronomical clock*

3. Determine the speed of light.

- The questions and sub-tasks given in the handout are intended to guide your thinking for task 2 and task 3.

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PART II

AN ASTRONOMICAL CLOCK ?.

Teacher’s guide The activity relates to

a) a consideration of the need to measure longitude;

b)deciding whether Roemer's ideas were appropriate;

c)understanding a method to calculate the speed of light.

Teaching strategy

1.The lesson can begin by a brainstorming session in which students put forward their ideas about longitude and its determination.

2.Students can be asked to consult the scenario and then, in groups, attempt to complete the tasks and sub-tasks given. The finding should be recorded in the form of a report.

3.The teacher can stop the group activities at any stage where there are general misunderstandings about any particular task.
Achieving the objectives

OBJECTIVE **This is achieved by**

1.Appreciating the problem facing the brainstorming session and- Governments in the 17th century. appreciating the scenario.

2.Solving the problem of the difference undertaking the activities suggested in between prediction and observation, the groupwork.

3.Cooperation as a member of a group, carrying the groupwork and answering

the questions given.

4.Communicating orally and by means undertaking the task given as a group, of diagrams.

5.Understanding the use of Jupiter and answering the questions and undertaking its moon Io to show longitude, why the calculations given in the worksheet, this was not possible and the implication of this finding.

Assessment

.''*Formative Assessment Strategies*

▼Able to award a societal values grade (objective 1)

The teacher observes the groupwork and asks questions as appropriate to follow up on viewpoints being taken.

A Not understanding the concern expressed by Governments in the 17th century. B Appreciates the need to be aware of the longitude on a ship and the problems

person on board ship faced in keeping the time in the 17th century. C Appreciates the 17th century Governmental concerns and why Paris was being consider as the reference point. Appreciates the value in considering concerns of history even though they are no longer a concern today.

▼ Able to award a science method grade (objective 2)

The teacher observes the group at work and asks questions as appropriate. A Needs help from the teacher to undertake the tasks. B Able to undertake the tasks given without help from the teacher. C Able to undertake the tasks given unaided and to work diligently in a logical manner to make efficient use of time.

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PART II

AN ASTRONOMICAL CLOCK ?

▼Able to award a personal skills grade (objectives 3 and 4)

The teacher observes the group.

A Not interested in the activities and unwilling to cooperate with members of the group.

B Interested in the tasks and willing to cooperate with other members of the group and work together.

C Works well with others and guides the group to undertake the task cooperatively and efficiently.

▼Able to award a science concept grade (objective :

The teacher observes the group and consults the written reword.

A Unable to perform the calculations without help.

B Able to undertake the calculations unaided, able to understand the cause of the difference between predicted and actual times and able to calculate the speed of light

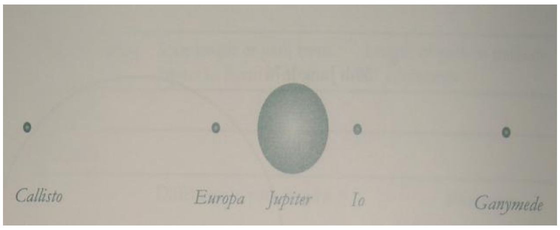
C Able to explain all calculations and procedures, recording data with an appropriate degree of significant figures and ensuring the use of correct units.

AN ASTRONOMICAL CLOCK ?

Answer the questions and complete the sub-tasks below

Understanding Roemer's basic idea

1. Why does Io appear to move more than the other moons of **Jupiter ?**
Diagram of Jupiter and its 4 moons



2. Why might Ole Roemer have suggested that Jupiter and its moons could be used to determine longitude?

Sub-tasks

3. Draw a diagram to show the position of the Sun, Jupiter and Io when Io is eclipsed.

4. Would the eclipse of Io always be visible from the Earth ? Give reasons for your answer.

5. Complete the table and find the average time for one orbit.

Date	Time of eclipse	Time since last reading	Number of orbits	Time for one orbit (in days)
15.05.1676	02.09			
07.06.1676	02.04	22d 23h 55m	13	1.76896
23.06.1676	00.11	15d 22h 7m	9	
30.06.1676	02.00	7d lh 49m	4	

Prediction versus observation

6. Complete the table to show your predictions of the dates and times of the next 4 eclipses of Io.

Eclipse Number	Number x Period of Io 1.769 Days	Time to next eclipse in days and hours	Peridicted observation time	date
86	152.134	152d 3.216h	05.13	
87	153.903	153d 21.672h		1.12.1676
88	155.672	155d 16.128h		2.12.1676
89	157.441	157d 10.584h	12.35	

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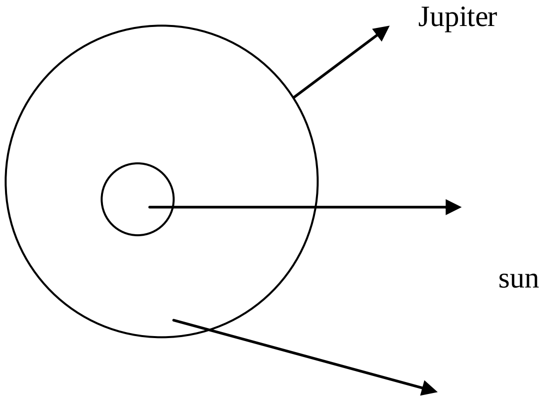
PART II

AN ASTRONOMICAL CLOCK ?

1. From the times predicted in 6, which eclipse willbe the most suitable to observe?
2. Study the diagrams which show the positions of the Earht and Jupiter in their orbits around the Sun, the times of your observations of Io. How have they moved in the intervening 5 months.

30th June 1676

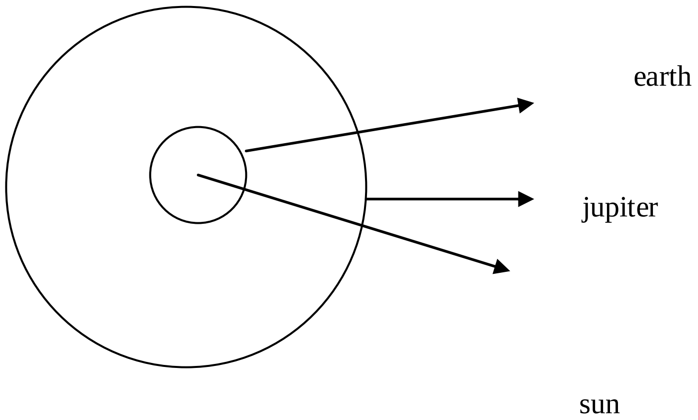


earth

0 200 400 600 800 1000

Millions of kilometres

1st December 1676



AN ASTRONOMICAL CLOCK ?.

9.How might this help to explain the fact that your obervations of the eclipse of Io in December to not occur at exactly your prediced times ?

Calculating the speed of light

10. Measure the diagrams to find the distances trevelled by light from Jupiter to the Earht, and use the scale to convert these distances into millions of kilometres.

Date of Reading	Scale length of path from Jupiter to Earth in mm	Lenght of path in millions of kilometres
30.6.1676		
1.12.1676		

Difference in path lenght = kilometres

11. Knowing that the difference between observed and predicted eclipte times is 20 minutes, calculate a value for the speed of light.

Speed (in m s^{-1}) = distance (in m)/time (in s)

Clock in space. Fact or fiction ?

12. Discuss whether you think Roemer was right about the possibility ofusing Jupiter and its moons as an astronomic clock.

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