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Nuclear weapons—a suitable topic for the classroom?

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Jerry Wellington's article on 'Teaching the unteachable—physics education and nuclear weapons' in *Physics Education* (Wellington 1982) started the debate about whether and how nuclear weapons should become a part of the physics or science curriculum in secondary schools. In our view the debate that has followed this article has concentrated on two points:

● The discussion about 'physics education and nuclear weapons' has widened into a discussion about whether to integrate the armaments problem into various existing school subjects or whether to put a new subject like 'peace studies' on the timetable (Bondi 1982, Wellington 1983).

● Since some people think it is difficult to teach the subject in an unbiased manner the fear exists that teaching materials and teachers' behaviour may (consciously or unconsciously) indoctrinate children into accepting a one-sided view of the nuclear arms issue (Bondi 1982).

It will not surprise the reader to learn that a similar discussion is going on in The Netherlands.

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Recent developments in the nuclear arms race have stimulated public debate, e.g. on the deployment of Cruise missiles, the nuclear tasks of the Dutch army and the validity and ethical acceptability of deterrence. As a result, teachers are expressing an increasing need for teaching materials and teaching methods suitable for dealing with questions on nuclear armament in the classroom. In recent years teaching materials have become available for use in physics lessons, in social studies and for school projects. From our experience in developing some of these teaching materials we shall try to express our view on the ways in which the subject of nuclear armament should and can be dealt with in secondary education.

The place of nuclear weapons in the curriculum

In agreement with Jerry Wellington (1983) we advocate dealing with the nuclear armament issue by integrating it into the existing (core) subjects and not by introducing a new subject such as 'peace education' into the timetable. Some of the arguments against the introduction of a separate subject are as follows:

● From a strategic point of view it is very hard to add a new subject to the existing timetable.

● As a separate subject peace education may become an isolated activity in school since each new subject starts off by defending its specific identity.

● A separate subject might provide teachers of existing core subjects with an excuse for not dealing with the issue.

Just as important as these negative arguments, however, are some positive arguments in favour of integration:

- Peace education has such wide ranging objectives that a school-level approach will be more appropriate with all subjects sharing responsibility for it.
- We are convinced that the emphasis in current education should change. It should shift from being rather academically oriented to being more functional and reality-bound. The scope of present school subjects should be broadened and the classification of individual subjects should become less rigid. Physics should also deal with technological and social matters (Eijkelhof and Kortland 1982).

The nuclear armaments issue should be dealt with in physics lessons, but not only in physics. It belongs to physics education in the sense that physics is not only a collection of laws and theories, but also a social activity, involving the study of technical applications and social consequences. Besides, if one adopts as an educational aim that schools should enable pupils to take part in democratic decision-making and to reach informed judgments, physics should contribute to that aim, certainly as far as the nuclear energy and the nuclear armament issue is concerned.

On the other hand, not all aspects of the complex nuclear issue need to be taught in physics lessons. First of all, important aspects of peace education are rooted in the social climate and social aims of a school: cooperation, conflict regulation, responsibility, etc. Secondly, the nuclear armament issue has so many aspects—technical, historical, geographical, economic—that the best way to teach it is through interdisciplinary cooperation. Then physics education can concentrate on the physical and technological aspects.

However, if for any reason other subjects do not join in, the accent should certainly remain on physical and technological aspects but some more attention could then be paid to historical, economic and social aspects.

Aims

During the development of curriculum materials on nuclear weapons as part of the physics curriculum we had long discussions on what goals we had in mind. What did we expect pupils to know afterwards? What attitudes did we wish to encourage? Should we impress on pupils the horrors of war, should we teach them just facts, should we try to recruit more people for the peace movement or encourage pupils to join the army, or should we force them to have an opinion on nuclear arms issues at the end of a series of lessons?

In our view the main goal of teaching about nuclear weapons in physics classes should be a better understanding of (aspects of) public discussions on the subject. Therefore pupils should:

- be familiar with the nuclear vocabulary,
- understand causes and effects of nuclear explosions,
- be able to identify links between different concepts,
- be able to recognise various viewpoints expressed in public discussions.

These aims are of a mainly cognitive nature. In the affective field we should like pupils to be able to express their personal feelings and views on the issue and to accept the fact that other people have different feelings and views.

What objectives can actually be achieved depends strongly on constraints such as the number of periods available and the age of the pupils.

For the sake of clarity we should also mention some of the goals we think should *not* be pursued:

'All students should personally recognise nuclear arms as a very important issue'—how important something is to someone is very much a personal matter and a teacher should not tell pupils what is important and what is not.

'All pupils should have an opinion—whatever it may be—on nuclear arms issues'—a teacher should not force a pupil to have an opinion at any moment.

'Pupils should have a specific opinion on the nuclear arms issue'—education should not allow itself to be used as a medium for indoctrination.

In our view it is not the teacher's job to preach values: the indirect ways in which this could be done should be carefully observed, e.g. pupils might be told 'Your teacher is not angry that you think nuclear arms promote peace but it makes him very sad'. The teacher should create conditions in which pupils are able to decide whether the issue is of long-lasting interest to them, to decide whether they are going to adopt a particular view on this issue and if so which one. These conditions have to do with the kind of learning experiences the teacher offers—in which both content and method are important—and the promotion of a class atmosphere in which pupils feel free to express their personal feelings and views. This is not to say that a teacher should not express his feelings and opinions. A certain aloofness however might be necessary as a teacher could unwillingly dominate a discussion.

What to teach

If the main objective is to enable students to get a better understanding of the nuclear arms debate, one can ask what knowledge and understanding is needed for this. In analysing a recent public debate

Peace demonstration in The Hague on 26 October 1983 *(photographs courtesy of Ina ten Wolde)*

in a Dutch newspaper we found that for an understanding of that debate one needed a lot of strategic and political information, but hardly any knowledge of physics. So it seems to be an exaggeration to say that physics is indispensable for understanding the nuclear armament issue. However, in our opinion physics has a specific contribution to make to a better understanding of the following three points.

(1) The difference between a conventional bomb and a nuclear bomb. Why is there such a fuss about nuclear weaponry: all weapons are horrible (Bondi 1982)? The effects of a nuclear explosion should therefore be clarified: the physical side (pressure, heat, radiation, fall-out); the somatic side (direct and long-term). Teaching about the effects of a nuclear explosion will also imply: the operation (physical. principles) of the bomb; the different types of bomb (A-, H-, N-bomb); means of protection against the bomb (types of radiation, half-life, half-value thickness).

(2) The relation between the civil and military application of nuclear energy (proliferation). Too often a nuclear plant is simply identified with nuclear bombs. Insight into the fission process (creation of plutonium) and the processes of enrichment and reprocessing is essential for understanding this relation.

(3) The relation between physical–technological developments and the arms race. For instance how the Los Alamos project started the nuclear arms race, how the black-box inspection, put forward by the Pugwash Conference, supported the Partial Test-Ban Treaty and how laser research may undermine any future Complete Test-Ban Treaty or the Non-Proliferation Treaty. In this context some strategic concepts such as strategic and tactical weapons, first and second strike capability, etc, should be taught. When dealing with these points we can pass on a lot of knowledge about physics, but we shall not be teaching physics in its own right but as a means of clarifying or structuring an aspect of the nuclear armament issue.

Teaching materials

In the insets we describe some practical examples of teaching materials from The Netherlands. They refer to work done in physics curriculum development. We have chosen them because we have been involved in the development of these materials ourselves and because they illustrate the various ways in which the issue of nuclear armament can become part of the physics curriculum in secondary education. Teaching materials on the nuclear issue can be used as:

- part of the separate STS unit (e.g. *Physics in Society*) in a traditional, academic curriculum,
- a separate unit in an STS curriculum (e.g. the PLON unit *Nuclear Arms and/or Security*),
- part of a unit in an STS curriculum (e.g. the PLON unit *Ionising Radiation*).

It will be clear from the short descriptions of the *Physics in Society* and PLON units that there are various ways in which the issue of nuclear armament can be dealt with in physics lessons. Use of the units can be adjusted to specific school conditions and it is possible to treat the issue in conjunction with other school subjects.

Experiences

Of course, it is very useful to argue about units to be written: views, strategies, content, etc. But it is even more useful to contribute to this debate some experiences with teaching materials on nuclear weapons. We shall deal here with reactions of policy makers, teachers and pupils to these teaching materials.

Administrators in the school system (civil servants, inspectors, school boards) in general do not want to see the nuclear arms issue as part of the physics curriculum. This was illustrated in the implementation of *Physics in Society* in the national examination syllabus. The proposed syllabus, which reflected the contents of the book, was changed on two points before it was officially accepted:

- 'Nuclear arms' was discarded as a separate topic and instead 'the nuclear bomb' was listed under the heading 'energy', among many other subtopics.
- The passage on 'social effects of the military application of physics (arms race, arms control, peace initiatives)' was scrapped.

Among the reasons given for this kind of action

Physics in Society

Physics in Society is an optional part of the national physics examination programme and originates from a book published by the Free University, Amsterdam. The unit is written for use in pre-university education for pupils aged 17–18. The book deals with various controversial issues like energy supply, noise, transport, nuclear arms, information systems and third world technology. The final chapter contains information about the development of the relation between science, technology and society.

In many schools the book is used mainly as a background reader. In that case the main pupil activity consists of writing an assignment on one specific point from the book (with nuclear armament as one of the options), based on information from a variety of external sources which the pupils themselves consult.

Since the unit is an optional part of a traditional curriculum, it is assumed that the pupils have the necessary physics background. So in the case of the sections on nuclear energy and armaments the book contains no 'pure' nuclear physics.

are the political nature of nuclear weapons and the fear of promoting 'doomsday' thinking among pupils.

At one school the PLON unit *Nuclear Weapons and/or Security* was banned by the school board: it was not considered to be physics and was thought to be too biased. However, in our view the various opinions in the unit are presented in a balanced way: views of Barnaby on arms control versus views of people in favour of strength through arms.

A second important group is that of *physics teachers*. So far not all teachers working with the PLON curriculum have chosen to include the unit *Nuclear Weapons and/or Security* in the physics curriculum. As reasons the teachers mention one of the following points: 'Too much politics, not enough physics', 'I don't know the answers to these problems myself', 'My personal involvement is so strong that I cannot participate objectively in class discussions'.

However, it should be pointed out that these were the reactions just after the unit was written. We expect teachers' reactions to become more favourable once we are able to clarify our aims, to give successful examples of teaching and to present a revised unit, based on class experience.

This brings us to the third (very important) group: the *pupils*. Evaluation studies have shown that *Physics in Society* is a very popular option among 17–18-year-old pupils, with weapons as one of the favourite topics. They find this topic very interesting and very important, and most of them are satisfied with what they learn. We cannot yet report conclusively on the PLON units as they have been published only recently in first versions.

Nuclear Arms and/or Security

Nuclear Arms and/or Security is a compulsory part of the experimental PLON curriculum for intermediate general secondary education, intended for pupils aged 15–16. The central theme of this unit is the dilemma of 'security through deterrence' versus 'security through disarmament'. The dilemma is introduced by two texts each supporting a different viewpoint. As a result the pupils come to realise that the word 'security' has a different meaning for different people depending on what they consider to be important. The following section of the unit deals with three aspects of the role of physics and technology in the nuclear arms race and the proliferation of nuclear arms. In this way pupils get some idea of the interaction of physics, technology and society in this field. In addition, pupils are given information about the nature and size of the effects of using nuclear arms compared with conventional arms. In the final stage of the unit pupils make an inventory of possible actions that people could take. They discuss the effectiveness of these actions.

'Pure' nuclear physics can be found as a separate part of the unit, and is to be used as a tool to understand previous parts of the unit. Pupil activities consist mainly of reading and analysing texts. The teachers guide offers suggestions for simple games, class discussions, etc.

Experiences so far with 15–16-year-old pupils show the following trends:

- About 90% of the pupils take the view that this topic should be dealt with at school, and 65% are also of the opinion that it should be part of the physics curriculum.
- Among pupils themselves there is a large variety of opinions about the desirability of nuclear weapons.
- Interest among pupils in the topic 'nuclear arms' itself is not altered by the unit.
- Pupils are interested mainly in aspects such as the effects of explosions and the possibilities of protection.
- Pupils are fairly satisfied with what they learn during the lessons.
- Pupils complain about the teaching methods: they miss the practicals that dominate other PLON units and would like to see more variation in working methods.

The opinion of the pupils on teaching methods should be taken very seriously. It is quite difficult to find suitable pupil activities in connection with this topic and for this age group. The topic does not lend itself to a lot of practicals. Of course reading a text is always a possibility and has been used all too often. But many pupils do not like a lot of reading, and they get easily bored by texts or have difficulty

Ionising Radiation

Ionising Radiation is a compulsory part of the experimental PLON STS curriculum for higher general secondary education, and is intended for pupils aged 17–18. 'How acceptable to you is the risk of ionising radiation' is the central question in this unit. To answer this rather difficult question, the unit is broken up into subquestions like: who takes advantage, who bears the risk, how large is the risk estimated to be, how could the risk be reduced or avoided?

Three fields of application have been chosen: nuclear energy, nuclear arms and radiation for medical purposes. Before working in groups on one of the applications, pupils are told about the physical and biological aspects of radiation which are useful in answering the subquestions mentioned above. In this unit, the part on nuclear arms is dealt with by part of the class. Pupils working on this part of the unit are expected to report their learning experiences to their fellow pupils who have studied nuclear energy and radiation for medical purposes. While working on the chosen subject of nuclear arms, pupils read and analyse texts and gather information from various external sources such as libraries, public and civil defence institutes, etc, to try and find an answer to the question of whether it will be possible or impossible to survive nuclear war in an underground shelter.

with the reading level. Possible pupil activities include:

- analysing texts (on arguments, facts, opinions),
- watching video-tapes,
- gathering information on subtopics,
- interviewing experts and lay persons,
- short simulation games,
- writing posters,
- class discussions on certain viewpoints.

We have learned from pupils' reactions that, especially at this age and level, we should not just think about *what* pupils should learn but also *how* they should learn: what do we expect pupils to *do* inside and outside the classroom. We hope that the discussion will continue and focus on this aspect too.

References

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Physics in Society (English edition) is available from SISCON, c/o Mrs Gillian Gibbons, 3 Beech Court, Macclesfield Road, Wilmslow, Cheshire. Price £2.50

The PLON units (in Dutch) *Nuclear Arms and/or Security* and *Ionising Radiation* are available on request from PLON, price £2

Thermodynamics—a practical subject

Hugh G Jones

Thermodynamics usually forms part (or should?) of any physics undergraduate's programme of studies. The amount of time devoted to it and the manner of its presentation varies from establishment to establishment. Sometimes its study is spread over two or three years or, with the advent of modular degree courses, over one semester. The 'flavour' of presentation can be along pure physics lines or sometimes an applied physics approach is developed (but rarely — this is generally left to mechanical engineering courses). Whichever 'flavour' is adopted it is generally accepted that a certain amount of mathematical expertise is required by the student. Indeed, looking through various thermodynamics texts and typical examination questions, it could be argued that much more than just a passing familiarity with certain branches of mathematics is required?

This can easily give students the impression that thermodynamics is a highly mathematical branch of physics and not a practical subject at all. This is further reinforced by the lack of what most physics students would regard as laboratory experiments in thermodynamics. Indeed a physicist would probably have to venture (with trepidation?) into a mechanical engineering department before finding a laboratory devoted entirely to thermodynamics.

It might seem reasonable to expect that students who have followed a course of lectures in macroscopic thermodynamics can, at the end of the lecture course, appreciate the following points about thermodynamics:

- It is inherently different to other areas of physics.
- The 'mathematical fiddling' involved is not merely a cerebral exercise in manipulating differentials.
- Even though there are few practicals as such that can be performed under laboratory conditions thermodynamics is a very practical area of physics.