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Improving the quality of innovative science teaching materials

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Abstract
An increasing number of scientists of different fields is working together in interdisciplinary subjects. For school science it is difficult to bring these interdisciplinary developments into the classroom. Pupils thus get an outdated view of science and of possibilities in science and technology for their future career. Also there are indications that interdisciplinary subjects are more attractive to pupils than classical science subjects, even more so for females.
In the Netherlands one remedy for this is the development of a new interdisciplinary subject: NLT (Natuur, Leven en Technologie). This subject is offered to science stream pupils in senior secondary schools in addition to the regular subjects physics, chemistry, biology and mathematics. A set of more than 50 modules is being developed as teaching materials for national use. Each module is developed by a team in which teachers of secondary schools and an expert of the subject work together. However this does not automatically lead to good teaching materials. For this reason a quality control procedure was developed for all NLT modules. In this procedure, teachers, pupils, scientists and science education experts all play a role in the evaluation of draft modules. The results of such a multi-perspective evaluation procedure are promising.

Introduction

Science is a discipline which is quickly developing by the contributions of a large number of researchers. Some of the research is taking place in specific sub disciplines of science, such as physics, chemistry, biology, mathematics, computer science and earth science but an increasing number of scientists are working in interdisciplinary groups on topics which cannot be tackled successfully from one specific perspective (Black and Atkin, 1996). Obvious examples are the fields of climate, environment, health, consumer products and ICT. Technology often plays an important role.
For school science it is no easy task to remain connected to developments in science and technology outside the classroom. Due to heavy teaching duties teachers have limited time for professional development and many science teachers are disconnected from the world of professional scientists. At the same time, scientists may have outdated views on education and often have no working relations with teachers in secondary schools. The risk of this situation is twofold: (a) pupils do not get an updated view on science and technology (Wong and

Hodson 2009) and consequently may not be encouraged to opt for a career in science and technology, and (b) the image of the teaching profession lacks dynamics which may prevent young scientists to join the teaching force. As some studies suggest, it does seem that interdisciplinarity could serve as a strong entry point into scientific studies for women (Rhoten and Pfirman 2007).
In the Netherlands this problem has been addressed by the development of a new advanced science subject, called "Natuur, Leven en Technologie" (NLT)[1]. Since 2007 this subject is offered to science stream pupils in senior secondary schools in addition to the regular subjects physics, chemistry, biology and mathematics. It is an optional subject, schools are not obliged to offer NLT to their pupils. It is assessed through school-based exams (Krüger & Michels 2007).
The main aims of NLT are:
(1) offer pupils a modern view on science and technology, which includes insight into current developments in a wide range of topics, the cooperation between various types of experts and the role of mathematics in science;
(2) challenge pupils to study developments in science and technology in depth;
(3) offer options in choosing topics according to the interest of pupils, the expertise of teachers and opportunities in the region of the school;
(4) assist pupils in their orientation on a career in science and technology;
(5) contribute to continuous innovation in science and mathematics education.
Development of teaching material in the form of modules started in 2006. In 2010 more than 50 modules will be available, each covering 40 student hours. Most modules are interdisciplinary and deal with topics in depth. Therefore NLT has to be taught by an interdisciplinary team of teachers, preferably with physics, chemistry, biology, mathematics and/or earth science backgrounds. As the whole subject NLT requires about 400 student hours schools have many options to make up an NLT curriculum. Currently about 40% of the Dutch schools are offering NLT.

From previous experiences with curriculum development in the Netherlands and elsewhere we learned that new subjects are vulnerable, especially when they are interdisciplinary. They have to compete with subjects with a long tradition and a national exam, curriculum innovations are often judged critically by both teachers and outside experts (Fensham 1993; Panwar and Hoddinott 1995; Eijkelhof and Kapteijn 2000), and in Dutch schools interdisciplinary activities are not common, so school organization is not adapted to such kind of teaching. Many conditions have to be fulfilled to make curriculum implementation successful (van den Akker 2003), but here we focus on the quality of the teaching materials. Textbooks have been criticized by reviewers for a variety of reasons: the range of topics covered (Aubrecht 1989; Chiapetta et al. 1993), treatment of specific topics and key ideas (Dall'Alba et al. 1993; Kesidou and Roseman, 2002; Stern and Roseman, 2004), scientific errors (Bohren 2009; King 2009), language use (Vachon and Haney 1991), application of illustrations (Holliday 1990), attention to student diversity (Bazler and Simonis 1991, Elgar 2004)) and the use of historic examples (e.g. Brown 2006). For new subjects such as NLT no adequate textbooks are available while in the traditional science subjects textbooks play a major role in teaching in the Netherlands.
Development of the modules requires good cooperation between science and mathematics teachers and external specialists. Teachers are not familiar with many of the topics and outside experts have little experience with teaching these topics to non-experts such as pupils.

[1] http://www.betavak-nlt.nl/English/

The specialists should provide an authentic view of their field and the teachers should focus on the feasibility of the modules in view of school conditions, teachers expertise, pupils potential and facilities. Therefore all writing teams include teachers and specialists. A good match between these types of expertise is not obvious and therefore it is important to safeguard the quality of the teaching materials.
For this reason a procedure was developed for all NLT-modules to be finally approved for use in schools by the national NLT Steering Committee. Steps in this procedure are: (a) developing a first draft of the module, (b) trialling the draft module in two schools collecting comments from teachers and pupils, (c) evaluation of the draft module by scientists and science education experts, (d) rewriting the draft module based on the various comments collected in steps (b) and (c), (e) final evaluation report and (f) approval by the Steering Committee. Steps are supervised by a national NLT-team consisting of six staff members from a variety of institutions: university, teacher training institute, school, national curriculum institute, and with expertise from various disciplines. The whole procedure takes 18 months, or more if major problems occur.
In this paper we will focus on steps (b) and (c) and address the following questions:

1. What types of comments are given by pupils, teachers, scientists and science education experts on the draft modules?
2. In which way do these comments correspond?
3. What are the strengths and weaknesses of this kind of quality control for innovative science teaching materials?

Methods
For 23 modules comments were collected from teachers, pupils, scientists and education experts (science and mathematics).
Trial schools were selected after a public announcement and were offered a fee for participation. The teachers completed a questionnaire, answered specific questions from the authors of the draft module, additionally commented on the teaching materials and some sent detailed lesson reports. Their pupils completed questionnaires and/or participated in focus interviews taken by their teacher and/or kept log books.
Scientists were selected by members of the national Steering Committee according to their expertise in the specific domain of the module. Most of them were employed by universities. They were not involved in the construction of the module and they received no compensation for their review. Their names were not released in order to allow them to comment freely. The scientists were asked to focus on the quality of the contents of the module (comments and suggestions) and were not given specific guidelines. Some answered with only main comments (one page), some used more than 4 pages for detailed remarks.
The science and mathematics education experts were part of the national NLT-team and used a list of pre-set criteria covering many quality aspects of the modules, such as theme, feasibility for the target group, interdisciplinary nature, pupil activities, teaching approach, coherence, assessment, relation with other school subjects and external cooperation.
The comments from these four perspectives were analyzed and for each group ordered according to rubrics which followed from the contents of the comments. Some rubrics were similar, others specific for a group.
The comments were compared to characterize similarities and differences across the four groups. Finally the strengths and weaknesses of this part of the procedure were assessed by the authors.

Results

A. Scientists

Comments of the scientists referred to a variety of aspects and have been ordered in 10 rubrics:

1. Attractiveness

70% of the modules received positive comments about:

- Contents: 'well informed', 'instructive', 'well chosen', 'good quality', 'complete story', 'multidisciplinary design is nice'.
- Pedagogy: 'stimulating approach', 'nice actual examples', 'well explained', 'I wish I was taught this way', 'relates science to pupils' perception of the environment'.
- General: 'fascinating', 'useful and interesting', I read the document with pleasure'.

2. Critical comments on wording

Most modules got comments about incorrect and inaccurate wording and suggestions for improvements were given:

- Incorrectness: 'wrong terms', 'incorrect', 'just the other way around', 'misleading', 'outdated', 'odd', 'peculiar', 'X has nothing to do with Y', 'this remark is really disappointing', 'too pretentious', 'figure is an example of an everlasting myth'.
- Inaccuracy: 'sloppy wording', 'unclear', 'ambiguous', 'inconsistent', 'imprecise', 'confusing', 'too popular', 'strange construction'.
- Language: 'spelling mistakes', 'bad grammar', 'too much repetition'.
- Suggestions for wording: clarify concepts', 'use different terms', 'rephrase', 'avoid confusing symbols', 'distinguish processes and mechanisms', 'improve definitions', 'use different classification', 'use official dimensions'.

3. Level of difficulty

Critical comments on the level of difficulty were given for 25% of the units:

- Too difficult: 'high density of information', 'too much depth', 'I wonder if pupils can understand this distinction', 'too formal for pupils', 'pupils might get lost by the explorative and divergent nature of the module'.
- Too superficial: 'module too wide and lack of depth: more focus on one topic required', 'rate of depth varies'.

4. Complexity of topics

The science experts were obviously aware of the complexity of the topics raised in the modules and made comments to clarify and improve explanations:

- Suggestions for improving explanations: 'give boundary conditions', 'mention simplifications', 'give comments on measurements', 'results given too simplistic', 'with exception of …', 'mention other causes', 'give more than one application', 'this is just an hypothesis', 'simplify but use correct descriptions', ' "is" should be "might be" ', 'too one-sided view presented'.

5. Coherence

A few modules should be made more coherent according to the experts:

- Incoherence: 'too disjointed parts', 'give more connections', 'inconsistent as a whole', 'transitions too abrupt'.

6. Activities

Although not required some experts made positive and critical remarks about the pupil activities:

- Quality of activities: ‘nice activities’, ‘extend/add/clarify assignments’, ‘activity could also be done as…’, ‘level of exercises too different’, ‘delete questions which are not related to the topic of the module’.

7. Suggestions for additions

For many modules suggestions were given for extension of the modules:

- Text additions: ‘too concise’ , ‘write more about…’, ‘give more background information’, ‘pay more attention to …’, ‘I miss …’, ‘too short’, ‘explain why’, ‘make a distinction between X and Y’, ‘describe the role of …’, ‘not only postulate, also explain’.
- Additional sources of information: suggestions for hardware, software, screen dumps, PowerPoint sheets, CD-ROMs, textbooks.

8. Other remarks

The experts commented incidentally also on figures, module titles, lay-out and privacy issues.

In summary: the experts were in general pleased with the attractiveness of the modules, noticed a large number of incorrect, imprecise and misleading information, were fully aware of the complexity of the topics raised in the modules, proposed to make modules either more profound or more shallow, and presented many suggestions for additions in content to be covered and sources to be used.

B. Education experts (science and mathematics)

Quality of the draft version of 23 modules was analyzed with reference to the aspects mentioned above and recorded in a formal report, which formed the basis for feed-back to the development group.

1. Interdisciplinary nature

This aspect was clearly appreciated in most modules:

- 'pupils will get a grasp of technique'.

2. Theme

The themes of the modules were considered interesting and up-to-date with developments in society and science:

- 'recognizable context', 'approach from relevant practise', 'imaginative', 'good potential for connection with modern research', 'at the frontier of new knowledge'.

3. Feasibility for target group

In about 25% of the reports the feasibility for the target group was deemed insufficient. Too low, too high or not consistent:

- 'level not consistent', 'more depth in biology', 'this is too simple for these pupils', 'don't overestimate the pupils'.

4. Pupil activities

The draft modules contained many and varying pupil activities:

- 'nice experiments and use of ICT', 'interesting problems', 'nice variety of activities', 'possibilities for choice', 'a good amount of varying practical work', 'nice combination of calculations and theoretical depth'.

5. Teaching approach

Many critical remarks were made on this aspect in about 75% of the draft modules:

- Incomplete instruction for open assignments: 'assignment too open', 'assignment not explicit', 'instruction incomplete'.
- No instruction for working in groups or instruction incomplete: 'more variation', this is an assignment for individual work', 'unclear', 'reference to Toolbox[2] is missing'.

6. Coherence

This was also judged to be insufficient in about 75% of the drafts. Often the central casus or main context was inconsistently used or even missing:

- ' the context is not clear/ not consistently used', 'coherence not explicit', 'too many loose ends', 'theory has nothing to do with the context used', 'theory should be logically connected to the main question'.

7. Assessment

Learning objectives were missing or it was unclear in which way they should be assessed:

- 'what should pupils know at the end of the module?', 'what should pupils be able to do at the end of the module and in which way will that be assessed?'.

8. Relation with other school subjects

In about 50 % of the reports there were remarks on the attention paid to prior knowledge, the overlap with existing science subjects and the role of mathematics:.

- 'expected prior knowledge not stated', 'in which way is difference in subject knowledge taken into account?', 'this might be a problem for pupils who don't take physics', 'too much similarity with physics / chemistry / biology / science for public understanding', 'mathematics is disconnected from the main text', 'mathematics should be more explicit / should get more attention'.

9. Wording

For about 75% of the draft modules the wording was deemed not suitable for the target group or the quality of the text was insufficient:

- 'bad use of language‘, 'mind spelling of names of plants', 'wording too difficult for target group', 'text is chaotic'.

10. External cooperation

Sometimes the role of the external expert had to be clarified. In general there were few problems noted with this aspect of the development process.

In summary: the education experts were in general pleased with the attractiveness of the themes, the interdisciplinary nature of modules and the variation in pupil activities. They were critical about the quality of instruction of assignments, the lack of coherence within the

[2] Toolbox is a separate handout for pupils. It contains instructions for a number of activities and skills which are common to many modules, such as how to design and execute an experiment, how to write a scientific report, how to present a report to a group, the design cycle, making a concept map, etc.

modules and the language used. Also the relation with other subjects gave some reason for concern.

C. Trial schools: teachers

Teachers reported on 23 modules. There were many appreciative remarks and even more constructively critical remarks. These last ones roughly fall into three categories: remarks on the quality of teaching material, on costs in time and money and on the need for teacher support.

1. Assignments

Teachers made critical remarks on several aspects..

- Lack of clarity and purpose: 'in practical work better instructions for pupils are necessary', 'the purpose of the questions is not clear'.
- Type of answers required: 'the answers to these questions are on the previous page', 'sometimes the answer is not to be found in the text and apparently you have to search for it on internet', 'the Sourcebook contains all the information the pupils need, there is no incentive to explore'.

Where applicable teachers appreciated possibilities for choice for pupils, variation in learning activities and clear instructions for pupils:

- 'many possibilities for the pupils to choose their own activities', ' the instructions for practical work are very well written and have a good lay-out; leave it as it is', 'very interesting topic and stimulating to teach', ' pupils not only learn about a particular subject but also how to cooperate in a group, to execute and report on practical work, technological design, etc.'.

2. Feasibility for target group

The majority of teachers who were critical about the feasibility thought the module they tested at least in some parts too difficult for their pupils, or at the wrong time in the curriculum. There were also remarks on the wording:

- Too difficult, at the wrong time: 'difficult to comprehend for pupils', 'they lack the necessary math skills', 'I had to introduce a lot of new concepts, this module belongs later in the curriculum', 'the module is very theoretical, certainly in the first part, we advise to start from a practical situation'.
- The language used: 'too many English words', 'some texts seem to be taken from Wikipedia', ' a lot of specialist language is used, hard to understand for pupils; try to explain more in simple language'.

There were also cases where the teachers were very positive on this aspect:

- 'the level is good, challenging for the pupils', 'this material gives pupils a good idea of the wide range of possibilities for a career in science and technology', 'an inspiring module, the subject is very popular with pupils and they learn quite a lot', 'I will certainly teach this module again in the years to come', ' these were my best lessons during the last months, partly because my pupils chose the topic, so they were very motivated'.

3. Coherence

Teachers remarked on the lack of coherence within the modules:

- 'no coherence between the chapters', 'it starts with an interesting story, but that has no continuation in the assignments', 'no continuity'.

Where coherence was present teachers showed appreciation:

- 'learning activities result naturally from the context'.

4. Assessment

Most remarks on this issue concerned summative assessment:

- Lack of tests and of clear guidelines: 'tests and criteria for assessment are insufficient', 'there are no alternative summative tests'.
- National guidelines: 'how do you assess pupils for this module and how do you compare assessments nationally?'.
- Abundance of assessment: 'there are too many tests in this module, which causes stress for pupils and teachers'.

5. Amount of time required

Teachers who remarked on this topic reported that more time was required for teaching and learning than the 40 hours which are indicated:

- '40 hours is not enough for this module', 'too long, please add possibilities for choices', 'the teacher guidelines are too optimistic on teaching hours required', 'this module seems to take more time than the previous one we tested'.

6. Cost (in material and time)

Teachers reported on cost in time and money:

- Cost in time: 'the practical work is very nice but organisation and preparation require a lot of time, also for lab assistants', 'you ought to have more teachers available at the same time, which is hard'.
- Cost in money: 'we skipped part of the experiments, the apparatus is not available in the region and too expensive to buy', 'the material looks very pretty in full-colour, but is expensive for schools'.

7. Teacher support

Teachers were confronted with many new topics, both in their own field and outside their specialisation. They expressed the need for more support:

- 'you may assume that for many teachers it is more than 20 years ago since they studied this subject, more explanation in the teacher guidelines would help', 'I missed suggestions on how to teach this', 'this module needs a sound basis in biology, which I don't have', 'organise for NLT teachers a relevant training and possibilities for continuous professional development, preferably within networks'.

8. Other remarks

Teachers offered many suggestions for improvement, sometimes quite detailed. They also appreciated the interdisciplinary aspects of the material:

- ‘very modern topic', 'very innovative, all these disciplines combined', 'module was well written, my colleagues became enthusiastic as well', 'the learning objectives at the start of the chapter worked very well'.

In summary: teachers showed their commitment in making a great number of constructive critical remarks and in providing suggestions for improvement. They also remarked on what they perceived as positive aspects of the subject and the material, which also was helpful. As was to be expected they often commented on practical aspects of the material: organisation, cost, time needed for preparation and teaching, etc. The need for teacher support on implementation of NLT was made very clear.

D. Trial schools: pupils

Pupil reports were collected for 21 modules. A large number of remarks concern to what extent they considered the material interesting, fun, challenging and/or varied. Other comments were on the level of difficulty, the language used, the assignments, relation with other school subjects, the practical work and learning objectives.

1. Level of difficulty

The meaning of pupils varied:

- Level too high: 'too difficult', 'too difficult for our year', 'in our form some pupils do not take physics, this module was too hard for them', 'more explanation is necessary'.
- Level all right: 'the level was OK for our form', not very difficult', 'theoretical part was fun'.

2. Wording

For more than 50% of the modules pupils complained about the texts:

- 'too many errors', 'make the text easier to read', 'too much text', we had to read too much to answer a question', 'too many words we do not know'.

Some made positive remarks: 'easy too understand'.

3. Assignments

Often these remarks are about lack of understanding what the assignment is about:

- 'less words, more explanations!', 'sharp questions, a pity they do not always relate to the text and illustrations', 'we don't understand what we have to do'.

4. Relation with other school subjects

These remarks are about missing knowledge or too much overlap:

- 'make it easier to understand for people who do not take biology', 'too much biology/ physics', 'repetition of physics', 'overlap with ANW (science for public understanding)'.

5. Practical work

This was appreciated, in 30% of the cases pupils asked for more practical work:

- 'practical work was fun', 'less theory, more practical assignments', 'more experiments and other practical work', 'more practice in research, less searching the internet', 'good challenging assignments'.

6. Learning objectives

- 'it is not clear what you have to learn, learning everything is complicated'.

7. General remarks

- 'we liked having police officers in the classroom', 'an interesting subject from present-day science', 'we learned a lot', 'the module is slightly / very boring', 'this chapter is more psychology, not a favourite topic for a science student like me', 'this chapter is more historical than scientific', 'I liked best that we had so much freedom to choose our assignments, that gave a lot of variation, great!', 'we had more than one teacher and they did not know what the others did, that was a problem', 'our teachers loved this subject too and showed it'.

In summary: pupils reacted very diverse on the various modules. Most negative reactions were about the level of difficulty, the large amount of text and the lack of clarity of instructions. The practical work was valued very much.

If the comments of the four groups are compared there are some similarities. Teachers, scientists and education experts are often positive about the choice of topics but critical about the lack of coherence in the modules. Pupils vary in appreciation of topics; within one group pupils might like or dislike a particular topic.
Scientists make more positive and critical comments about specific content of the modules, the correctness or incorrectness or bias of information and offer a large number of suggestions for changes and additions in contents. It is remarkable that these comments with respect to the content were given although in all of the writing groups (other) experts were involved.
Teachers tend to give more comments about the level of difficulty of modules, assessment and practical matters such as time required, cost and additional work load for teachers and lab assistants.
Education experts focus more than other groups on the relation to other subjects, level of difficulty, depth and ways to increase the coherence of the modules.
Pupils appreciate especially practical activities and possibilities for choice.
Pupils, scientists and education experts were critical more often on the wording (difficulty, suitability and spelling errors) than teachers.
Pupils and education experts were in many cases of the same opinion about insufficient or lacking instructions.

Conclusions and implications
What types of comments are given by pupils, teachers, scientists and education experts on the draft modules?
All groups commented extensively on the specific modules they were evaluating. There were many positive remarks and also, as described above, many constructively critical remarks on several aspects: content and structure (correctness, suitability for target group, coherence), implementation in the classroom (organisation, cost, time required), language (level, spelling, correct expressions), assignments (variation, quality of instruction, level) , assessment (formulation of learning objectives, summative tests, criteria for testing) and relation to other subjects (prior knowledge required, overlap or gap with other disciplines).
From the analysis of the comments may be concluded that input from these various groups is necessary as they each offer a specific perspective on the modules. Roughly, scientists mainly focus on content, teachers on the implications in the classroom, pupils on clarity and attractiveness of activities and language, and education experts on module structure and required knowledge of pupils. A combination of these comments proved necessary in order to improve the quality of the modules.
In which way do these comments correspond?
Positive, encouraging remarks were made on aspects one liked, often the theme, the interdisciplinary aspect and the possibilities for choice. Scientists, education experts and teachers often had suggestions for improvement. To some extent wording was criticized by all groups. Coherence or the lack of it also was an aspect mentioned by all groups, though mostly by education experts.

What are the strengths and weaknesses of this kind of quality control for innovative science teaching materials?
NLT aspires to bring modern developments in science and technology into the classroom. One might get the impression from the above critical comments that the writing groups

produced low quality materials and did not do their work properly. However, that would be unfair to the authors. Writing new teaching materials on modern topics is no easy task: unlike traditional topics hardly any prototype texts are available, many decisions have to be taken related to 'which content to include and which not' and there is no experience with the level at which these topics could be taught and assessed. Besides, cooperation between teachers of various subjects and science experts with their different background in knowledge and expertise is more complicated than in cases where materials have to be written on single discipline topics. At the same time, such cooperation is necessary in order to provide curriculum materials that are up to date in content and at the same time suitable for teachers and learners.

Bringing teachers and science experts together often was an enriching experience for both groups. As also is clear from literature (Panwar & Hoddison 1995) there may be tensions caused by difference in ideas and working methods of both groups. All the same the science experts were indispensable to reach a high quality of scientific information for these modern topics which are often not in the standard curriculum and so contributed to a fresh approach of content of teaching material (Bohren 2009; Wong & Hodson 2008). The teachers however, were much better at developing suitable activities and assignments for the pupils. During the testing in a real classroom situation many practical problems came to light, but also deficiencies in the text for the pupils.

However there are some pitfalls.

From the point of view of organisation the process is quite demanding. Writing groups of teachers and experts have to be formed and need some coaching. Clear guidelines, including deadlines are necessary. Some training for the writing groups may be required.

Science experts are not always easy to find, on some topics there are few experts available and most experts lack time as they are heavily occupied with their own work. Experts sometimes disagree on scientific matter, which is normal in science, but may be confusing for writing groups.

Testing conditions are not always as they are meant to be, which makes some comments from teachers and/or pupils less valuable. One has to keep an eye on testing conditions in order to be able to interpret those comments properly. Teachers sometimes don't have time to write down their comments in the format provided, or they communicate verbally.

Just dropping the different comments at the writing groups is not sufficient, as following all comments might make the unit too large or too demanding or comments may be contradictory.. So an important role is to be played by those who integrate the comments into an evaluation report which is the basis for the rewriting of the draft module (step (d)). The final evaluation report (step (e)) takes into account whether there is improvement on the aspects mentioned, usually there is no second round of trials.

In next studies it might be worthwhile to investigate in more detail in which way comments from the specific groups have been implemented in the final versions of the modules: which types of comments were useful and which have not been followed for which reasons Analysis of the texts on misconceptions would be interesting (King 2009).

Occasionally teachers comment on their experiences with the final versions, but not in a systematic way. In one case a scientific expert criticized the final version of a module, which was partly justified, partly misjudging the teaching situation. So after approval of the final version the discussion on the quality of modules might continue. For some very innovative modules it might be useful to collect comments on the final versions from another set of teachers, scientists, pupils and education experts.

It should also be worthwhile to investigate NLT-teachers' views on the nature of scientific work and its relationships with society, compared with teachers who do not teach NLT (Wong & Hodson 2008).

However for the present material there is no doubt that the final versions are very much an improvement on the draft versions.
We recommend the use of multi-perspective comments in the process of developing new science curriculum materials and sharing of experiences between similar curriculum projects.

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