Evaluation of the *Time for critical thought* resource

Final report

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Executive summary

In 2003 the Royal Society of New Zealand, the New Zealand Association of Science Educators (NZASE), and Agcarm Inc. (the New Zealand Association for Animal Health and Crop Protection) sponsored the production of a teaching resource called *Entering the debate on Genetic Modification, by developing a critical thinking response* (hereafter *Time for critical thought*). Two copies of the resource were sent to all New Zealand secondary schools. In 2003/2004 the Royal Society and the NZASE implemented a regional programme of workshops to introduce the resource to teachers and to explore its potential use with their Year 10 pupils.

The resource aims to help teachers and students to develop critical thinking in the classroom. It was developed primarily for use by teachers of Year 10 science or English, but could potentially be used with any students above level 3 of the National Curriculum Framework (that is, students in senior primary or above). *Time for critical thought* uses the controversy surrounding the introduction of genetically modified (GM) crops as a context for the development of students' critical thinking skills.

In 2003 the New Zealand Council for Educational Research (NZCER) was contracted to carry out an evaluation of *Time for critical thought*. The aim of this evaluation was to enhance the usefulness of the resource, and to inform future development of materials to support the teaching and learning of critical thinking in secondary schools. With this in mind, the following research questions were developed:

1. Do participating teachers currently include the exploration of socio-scientific issues in their planned science programmes? If so, at which year level(s)?
2. What are science teachers' initial opinions of the resource?
3. Do they see the resource being useful for their science teaching?
4. What factors influence their stated intention to use the resource (or not)?
5. How is the resource used in different classroom settings?
6. Does the resource support the development of students' critical thinking skills concerning socio-scientific issues?
7. What barriers (if any) actually constrain the effective use of the resource?
8. What further developments of this type of resource, if any, would teachers like to see?

The research had three parts: 1) a survey of 58 teachers who attended regional workshops about the resource, 2) a case study of the use of the resource with four Year 10 classes in one secondary school, and 3) interviews with a workshop facilitator and two science HODs who attended *Time for critical thought* workshops but were *not* using the resource with Year 10 students at their school.

Key findings from the survey of teachers who attended workshops

- Most teachers who attended *Time for critical thought* workshops were science teachers. Many held positions of responsibility within their school (for example, as HOD or dean), or were responsible for providing professional development for other staff in their department.
- Most teachers said they taught socio-scientific topics in at least one of the classes they taught. The two most common topics (as described by teachers) were GM/GE/genetics, and environmental issues. Teaching of GM/GE/genetics was most often mentioned at Year 11 and Year 13, although some teachers said genetics was taught at Year 10.
- Most teachers who attended the workshops had not yet used the resource in their teaching and most were not familiar with the resource. However, most thought that the resource was "extremely relevant" or "possibly relevant" for their teaching. Teachers suggested they could use the resource with a range of year levels, although some thought it was too advanced for Year 10 students.
- The most common useful aspects of the resource commented on by teachers were the materials and templates it provided for use in the classroom. Teachers also commented on the value of the resource as a tool for developing students' critical thinking.
- Many teachers thought the resource was too difficult or "too advanced" for Year 9/10 students. Although some teachers specifically referred to the language level of the resource, other comments suggested that teachers felt the resource was too advanced in terms of Year 10 students' skills, needs, abilities, or interests.

Findings from the case study

- The way the resource was adapted and used in the case study school was heavily influenced by staff perceptions of the learning needs, interests, and abilities of the Year 10 students they taught, as well as the general characteristics and dynamics of these classes.
- The school's resource teacher for learning and behaviour (RTLB) was a critical factor in explaining why the resource was used with Year 10 students. The RTLB spent time adapting and modifying the resource into a series of lessons and activities for Year 10 students.
- The RTLB and the science teachers all supported the idea of a critical thinking skills approach, and thought the context of GM was relevant and appropriate for Year 10 students. However, staff also felt Year 10 students may not necessarily see how GM was relevant to them, nor have much existing knowledge or awareness of this area.
- The lessons developed in the case study school were intended to scaffold students' entry into the topic of GM, and the kinds of activities included in the resource. This included the use of literacy strategies to help students become familiar with some of the language and vocabulary associated with GM, and some of the important ideas and issues usually associated with the debate about GM.
- Teachers noted that it took a lot of time to prepare to teach using these kinds of approaches, and also expressed a desire for more support and ideas about how to be effective in this style of teaching.

- It was difficult to gauge, through classroom observation, how interested and engaged students were in the activities in the observed classes. However, focus group students said they were enjoying the activities, and preferred this unit to other science units they had done.
- Students preferred the GM unit because it was "more relevant" or "more interesting", and because there was the opportunity to include their own ideas and opinions, and they were doing different kinds of activities, rather than just copying down information.
- Students thought it was important to learn how to make choices and decisions for themselves, but felt that school was not always helpful in supporting them to do this.

Interviews about the use and non-use of the resource

- NZCER's attempts to identify schools to participate in the case study component of the research suggested there was limited uptake and use of the resource in schools.
- Interviews with a workshop facilitator and two science HODs who were not using the resource suggested that teachers who attended the workshops liked the idea of the critical thinking skills approach, and thought GM was a relevant topic for Year 10 science teaching. However, teachers identified two obstacles to the use of the resource in their teaching. First, they felt the resource in its current form was not appropriate to the learning needs of their students and would need to be adapted or modified. Second, they were uncertain about how the topic/unit would be fitted into their existing Year 10 departmental teaching schemes.
- Interview participants felt that the workshop approach was a useful way of introducing and familiarising teachers with the resource. However, the workshop facilitator and at least one teacher felt that more sustained support was needed to help teachers to become familiar and confident with the kinds of science teaching approaches that the resource could stimulate.
- Some of the existing practices and structures of secondary science teaching were identified as constraints on teachers' abilities to bring such teaching approaches into their practice. These included the nature and structure of the yearly departmental teaching schemes, the structure of the school timetable, and teachers' and students' existing expectations about what secondary science teaching and learning should be like.

Suggested modifications to the resource

- Frequently suggested modifications and adaptations to the resource included:
  - a reduction of the level of reading difficulty of the resource;
  - simplification of the activity pages, with a reduction in the amount of text on each page;
  - making the pages more attractive to Year 10 students by including cartoons, images, and stories and articles likely to interest Year 10 readers; and
  - providing more guidance for teachers about how to put activities from the resource together into a teaching unit (for example, by providing a suggested unit plan).

Challenges and barriers to using the resource

In addition to modifications to the resource, teachers identified school-level challenges for bringing a critical thinking approach to teaching science. These included:

- the amount of time needed for teachers to "unpack" the resource, and modify or adapt it into a series of lessons for their own classroom;
- teachers' lack of experience or confidence teaching in this way, particularly with students of this age;
- the structure of the school timetable (in particular, the 1-hour blocks for each subject which constrained the depth of discussion that could go on); and
- the number of topics, or amount of content to cover, in the school's Year 10 teaching schemes.

This evaluation demonstrates the considerable challenges that face developers of innovative resources like *Time for critical thought* which aim to support change in science teaching practice. The evaluation suggests more professional development will be needed if teachers are to make the many changes necessary to accommodate a forward-looking resource such as *Time for critical thought* in their teaching programmes.

1. Introduction

In 2003 the Royal Society of New Zealand, the New Zealand Association of Science Educators (NZASE), and Agcarm Inc. sponsored the production of a teaching resource called *Entering the debate on Genetic Modification, by developing a critical thinking response* (hereafter *Time for critical thought*). The resource was developed primarily for use by teachers of Year 10 science or English but could potentially be used with any students above level 3 of the National Curriculum Framework (that is, students in senior primary or above).

New Zealand and international research shows that many science teachers do not have the necessary background in the teaching of critical thinking, or the experience of teaching issues-related topics to their students (Dawson, Lock, Brickhouse, & Crosthwaite, 2002b; Levinson, R. & Turner, S., 2001b). In 2003/2004 the Royal Society and the New Zealand Association of Science Educators (NZASE) implemented a regional programme of workshops to introduce the resource to teachers and to explore its potential use with their Year 10 pupils. The workshops particularly targeted science teachers, although it was also suggested that teachers of other subjects could find the resource and the workshops useful.

"Critical thinking" in the New Zealand curriculum

The *Time for critical thought* resource uses the controversy surrounding the introduction of genetically modified (GM) crops as a starting point for developing critical thinking skills. The author of the resource suggests (p. 2) that "the skills that are modelled by working within the GM context are readily transferable to any issue requiring critical thought".

The *New Zealand Curriculum Framework* (Ministry of Education, 1993a) identifies critical thinking as an essential skill that all students should develop through their schooling.[1] The intent of the *Framework* is that the eight essential skills[2] be integrated and developed across all the

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[1] This appears in *New Zealand Curriculum Framework* as "Problem solving skills. Students will: think critically, creatively, reflectively, and logically; exercise imagination, initiative, and flexibility; identify, describe, and redefine a problem; analyse problems from a variety of different perspectives; make connections and establish relationships; inquire and research, and explore, generate, and develop ideas; try out innovative and original ideas; design and make; test ideas and solutions, and make decisions on the basis of experience and supporting evidence; and evaluate processes and solutions" (Ministry of Education, 1993, p. 19).

[2] The other essential skills are: Communication skills, numeracy skills, information skills, self-management and co-operative skills, physical skills, and work and study skills.

seven essential learning areas of the curriculum.[3] However, at present, it is not clear where or how students' critical thinking skills should be developed in New Zealand secondary science education. Development of critical thinking is alluded to in the two integrating strands[4] of *Science in the New Zealand Curriculum* (Ministry of Education, 1993b). However, the major focus of the science curriculum is the four science content strands: making sense of the living world, making sense of the physical world, making sense of the material world, and making sense of planet Earth and beyond.

Evaluation of *Time for critical thought*

In 2003 the New Zealand Council for Educational Research (NZCER) was contracted to carry out an evaluation of *Time for critical thought*. The aim of this evaluation was to enhance the usefulness of the resource, and to inform future development of materials to support the teaching and learning of critical thinking in secondary schools. With this in mind, the following research questions were developed:

1. Do participating teachers currently include the exploration of socio-scientific issues in their planned science programmes? If so, at which year level(s)?
2. What are science teachers' initial opinions of the resource?
3. Do they see the resource being useful for their science teaching?
4. What factors influence their stated intention to use the resource (or not)?
5. How is the resource used in different classroom settings?
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7. What barriers (if any) actually constrain the effective use of the resource?
8. What further developments of this type of resource, if any, would teachers like to see?

Research methods

The research methods included a survey of teachers who attended the regional *Time for critical thought* workshops, a case study of the use of the resource in one school, and interviews with a workshop facilitator and two teachers who were not currently using the resource.

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[3] These are: Science, mathematics, English, social studies, the arts, technology, and health and physical education.

[4] These strands are: "Making sense of the nature of science and its relationship to technology", and "developing scientific skills and attitudes".

Teacher surveys

In term 4 2003 and term 1 2004, the NZASE co-ordinated a series of half-day regional workshops to familiarise secondary teachers with the resource. Teachers who attended the workshops were asked to complete a short survey form (*see* Appendix 1). The surveys were administered and collected by the workshop facilitators and returned to NZCER by mail. Workshops were conducted in Auckland, Christchurch, Nelson, Wellington, Whangarei, Kaitaia, Kerikeri, and Dargaville. As time for teachers to complete the surveys was limited to about 10 minutes, and the resource was new to most teachers in the workshops, the survey questions primarily addressed research questions 1–4 above.

Interviews and a case study of one secondary school

Research questions 5–8 were addressed using qualitative interviews, and through a case study of the use of the *Time for critical thought* resource in one secondary school. The original evaluation plan was for NZCER to carry out case studies of the resource in use in three schools, using the *Time for critical thought* workshop facilitators to help identify suitable schools. However, it proved difficult to identify schools in which the resource was being used. Conversations with the NZASE, workshop facilitators, and science teachers we encountered in other professional networks, suggested that use of the resource in schools was low.

In mid-2004 we established contact with the science HOD of one school who informed us that the school planned to use the resource with several Year 10 classes in term 3. A 3-day case study research visit to this school was arranged. In addition, we identified and interviewed three other people about the use and non-use of the resource in secondary schools. These people were:

- one of the *Time for critical thought* workshop facilitators; and
- two science HODs who attended *Time for critical thought* workshops, but were not yet using the resource with Year 10 students.

Structure of this report

This report discusses the findings of the evaluation in five sections. Section 2 reports findings from the survey of teachers who attended the *Time for critical thought* workshops. Section 3 provides an in-depth case study of the use of the resource with four Year 10 science classes in one secondary school. Section 4 reports findings from interviews with two HODs and a workshop facilitator about non-use of the resource in secondary schools. Finally, Section 5 reviews the evaluation findings, and discusses the implications of these for the developers of this and other similar resources.

2. Findings from the teacher surveys

The NZASE contracted school support advisers based at TEAM solutions (Whangarei), Multiserve (Auckland and Wellington), and the Christchurch College of Education, to facilitate the teacher workshops. The workshop facilitators arranged and advertised workshops to schools in Auckland, Christchurch, Nelson, Wellington, Whangarei, Kaitaia, Kerikeri, and Dargaville. Although the NZASE initially intended more workshops would be carried out in other regions, these proved difficult to organise, and did not eventuate.

Characteristics of teachers who attended the workshops

A total of 58 survey responses were returned. According to the NZASE and the workshop facilitators, this figure represented most of the teachers who attended workshops.

Many of the respondents were senior teachers or held positions of responsibility within their school. Just under half had been teaching for over 15 years. Sixty percent indicated they held a middle management role in their school, such as HOD, dean, or curriculum or syndicate leader. Teachers were asked to indicate any other professional responsibilities or background experiences they felt were relevant to the workshop. Six teachers said they were responsible for departmental professional development, or for designing departmental teaching schemes:

> As a HoF—I will introduce 'bits' of this resource into PD sessions with my faculty.

Three teachers said that they had a role in developing thinking skills within the school:

> Lead teacher – thinking skills.
>
> I am a thinking skills co-ordinator and gifted and talented co-ordinator. My background is philosophy. I have written several philosophy books for schools.
>
> In charge of Year 10 subject 'creative & critical thinking'.

Two science teachers indicated their involvement or interest in promoting science debate inside or outside the classroom:

> I was involved in putting this [resource] together in 2001. I also give talks to Rotary etc. on genetic engineering trying to help the layman understand it more.
>
> As a science teacher I make science debate by our citizens more enlightened!!!!!

Two teachers mentioned roles as co-ordinators for literacy development:

As an English teacher I have a particular interest in reading – reading skills and teach remedial reading but see reading skills and text analysis as an area which needs to be more carefully and purposefully taught to all levels of students.

Co-ordination of literacy in science.

Subjects taught

Table 1 shows all the subjects and year levels taught by teachers who attended the workshops. Most of the teachers were science teachers (44 out of 58 taught at least one science subject). Thirty-eight of the 58 teachers taught Year 10 science. Seventeen teachers taught one or more non-science subjects. Five teachers taught English, and two teachers taught maths. Thirteen teachers taught "other" subjects, listed in Table 2.

Table 1 **Subjects and year levels taught**

Subject	Number of responses (n=58)					
	Year 9	Year 10	Year 11	Year 12	Year 13	Other year level
Science	31	38	31	2	1	2
Biology	-	-	6	16	15	-
Chemistry	-	-	-	4	4	-
Physics	-	-	-	3	3	-
English	3	5	5	5	3	-
Mathematics	2	2				-
Other subject	4	7	6	5	3	-

Table 2 **"Other" subjects taught (one teacher each)**

Year 7, 8 Science
Year 7, 8 Biotechnology
Year 9, 10 Health
Year 9, 10 Social studies
Year 10 Creative and critical thinking
Year 10 Gifted and talented
Year 10 Electrotechnology
Year 11, 12 Horticulture
Year 12, 13 Careers/Gateway
All years – Critical thinking, philosophy, religious education, classics, and citizenship
Year 9, 10, 11, 12 Reading and language enrichment

Current teaching of socio—scientific topics or issues

Nearly three-quarters (72 percent) of the teachers said they currently covered socio-scientific topics or issues in at least one of the classes they taught. Table 3 shows which socio-scientific topics were taught in science classes (including biology, chemistry, and physics). The most

common topics were GM/GE/genetics, and issues relating to the environment (examples include marine parks, horticulture, human impacts on ecosystem, sustainability, pollution, acid rain, and recycling). GM/GE/genetics was most often taught at Year 11 and Year 13, although there were seven cases where this was taught at Years 9 or 10.

The higher numbers of instances of GM/GE/genetics at Years 11 and 13 may reflect the presence of NCEA achievement standards in these areas. The same may apply for the frequent coverage of "environmental issues" topics at Year 12. (*See* Appendix 2 for examples of achievement standards that may be relevant.)

Table 3 **Socio-scientific topics or issues taught in science, biology, or chemistry classes (as identified by teacher)**

Topic	Number of responses					
	Year 9	Year 10	Year 11	Year 12	Year 13	Other
GM/GE/genetics	1	6	13	4	13	
Environmental issues	2	9	1	10	2	1
Energy (e.g. energy conservation or production, nuclear energy)	3	1	1			1
Cloning		1	4		1	
Biotechnology			1	1	2	
Ethics/bioethics			2		1	
Reproductive technologies		1		2	1	
Other health/medicines	1	1	2	2		
Space research	3					
Other	2	2	2	2	3	1

Examples were also given of "socio-scientific" topics taught in classes other than science. These are listed in Table 4.

Table 4 **Socio-scientific topics or issues taught in non-science classes**

Year level	Subject	Topic
Year 7/8	English	Cloning – a short story I use by Paul Jennings: *The Copy*
Year 12	English	Language of persuasion/language of rebellion
Year 13	English	Genetic and psychological engineering
Not specified	English	Evolution – as it comes up in stories or in newspaper articles
Year 9/10	Social studies	Food, GE – famine
Year 9	Not specified	Work is worship
Year 10	Not specified	Families in focus
Year 10	Not specified	Abuse of power
Year 12	Not specified	Division by race
Year 11	Not specified	Bigotry and ignorance in American history (great depression)

The survey data do not provide information about the pedagogical approaches teachers use for teaching socio-scientific issues in science classes, nor in these other subjects. However, it is interesting to note findings from UK research which sought to uncover how, and in which curriculum areas, controversies arising from bioscience were taught in UK schools and colleges (Levinson, R., & Turner, R., 2001). The UK study found that science teachers generally considered it their role to present the "facts" of their subject and not to deal with associated social or ethical issues, while humanities teachers appeared most confident when covering general ethical and social issues, and felt significantly less confident addressing socio-scientific issues. Similar research in New Zealand schools would be useful to provide a picture of different ways in which New Zealand students may encounter socio-scientific issues across the secondary school curriculum.

Familiarity with the resource

Prior to the workshop, most of the teachers surveyed either hadn't seen the *Time for critical thought* resource before, or had seen it but not looked through it in detail (*see* Table 5). However, three teachers (all science teachers) said they had already used it in their teaching.

Table 5 **Familiarity with the resource prior to the workshop**

Familiarity with the resource	Number of teachers
Never seen it before the workshop	25
Seen it but haven't looked at it in detail	20
Seen it and looked through it	10
I have used it in teaching	3
Total	58

Perceived relevance and use of the resource

Teachers were asked how relevant they thought the resource was for their teaching. Almost all teachers said it was either extremely relevant (45 percent) or possibly relevant (52 percent). Teachers were asked which class(es) they thought they would use the resource with (Table 6). Most science teachers indicated interest in using the resource with Year 9–11 students. A few said they would use it with Year 12 and 13 biology students.

Table 6 **Class levels that teachers would use the resource with**

	Number of responses (n=58)					
	Year 7/8	Year 9	Year 10	Year 11	Year 12	Year 13
Science (including biology)	2	4	12	10	7	4
Non-science		1	3	2		
Subject not specified				1	1	1

Non-science classes that were mentioned included Year 10 creative and critical thinking, Year 9–11 English, and Year 10–11 technology. Five teachers viewed the resource as most suitable for "high ability" or extension classes (or said the resource could not be used with "low ability" students).

Just under half the teachers (26 out of 58) named more than one year level with which they would use the resource. Some teachers suggested the resource would be used in different ways with different classes/year levels:

> Year 10 – the continuum model. Year 13 – Bloom's taxonomy.
>
> All classes to some extent. Year 11 and 12 classes more often.
>
> An able Year 10 class – genetics. Possibly Year 12 but fitting it in with the time available difficult.
>
> Yr 10 Science and Year 12 and 13 Bio – context of GM. [I would] use the processes in all levels/subjects.

One teacher said:

> I would use it with teachers who are interested in the idea that teaching is about 'thinking' not just learning facts.

Most useful aspects of the resource

Table 7 shows what teachers felt were the most positive or useful aspects of the resource. Many teachers commented on the "ready to go" activities, materials, and templates compiled in the resource, or made general comments about the usefulness of the resource in developing students' critical thinking skills. Teachers also mentioned particular parts of the resource—for example the "argument analysis" or "judging for bias" or "fact and opinion" activities. Some teachers said that the resource gave them ideas for strategies or approaches for teaching critical thinking.

Table 7 **Most positive or useful aspect of the resource**

Most positive or useful aspects of the resource	Number of responses[5] (n=58)
Materials and templates for use in the classroom	19
Can be used to develop students' critical thinking skills	14
The argument analysis process	10
Flowcharts and diagrams	8
Examples/ideas for teaching strategies	8
Detection of bias/distinguishing fact from opinion	7
Background information for teachers	5
Can be used to develop students' literacy/comprehension skills or ability to critically analyse text	5
Can be used across contexts/subjects	3
Other	18

Comments in the "other" category were varied. For example:

> It is a start and an opportunity to think about this approach to issues in science.
>
> Formalises what is done by many teachers, but also makes it accessible to those not familiar with the processes outlined.
>
> Useable for department and staff meetings.

Only one teacher made a negative comment, saying there were no useful aspects to the resource.

Shortcomings of the resource

The most commonly mentioned shortcoming of the resource was that the words, language, or jargon were too difficult (21 teachers), or that it was not suitable for all students' abilities or was "too advanced" for Year 9/10 (12 teachers). Eight teachers commented the resource would need to be modified or adapted to be used with their students. Seven teachers commented that the time required to become familiar with the resource in order to use it effectively was a problem.

Similarly, teachers said they might *not* be able to use the resource because of its language level, or because of time limitations, either to become familiar with the resource, or to fit it into the curriculum (Table 8). However, 18 teachers said there were no reasons they would not be able to use the resource.

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[5] Teachers' responses could be classified in more than one category, if they noted more than one positive aspect of the resource.

Table 8 **Reasons why teachers might not use the resource**

Reasons for not using the resource	Number of responses
No reason for not using	18
Reading level	14
Time	12
Students' abilities	9
Other	5

Discussion of the teacher survey findings

Most teachers who attended the *Time for critical thought* teacher workshops taught science. However, some teachers taught other subjects including English, social studies, or "critical thinking" classes. The workshops included some teachers with special interest in promoting "informed science debate" inside or outside the classroom, or some with responsibility for developing teaching schemes or providing in-house professional development for staff in their departments. A few teachers had a specific role in developing students' thinking skills or literacy development.

Most teachers named at least one "socio-scientific" topic or unit which was currently taught in their class(es). The most common topics were genetics/GM/GE and environmental issues, and these appeared across a range of year levels. Genetics/GM/GE were most often taught at Years 11 and 13, although some teachers included these topics with Year 9 or 10 students.

Although the survey indicated which topics teachers considered to be "socio-scientific", it did not solicit information about the pedagogical approaches teachers currently use for these topics. For example, do they involve the delivery of information by the teacher? Do they involve students researching and debating issues in the classroom? Is the focus mainly on teaching the science behind these issues, or does it include explorations into values and ethics as well? Also, while the survey indicates at which year levels each of these topics are taught, it does not explain why some topics are more commonly taught at some year levels, and rarely at other year levels. Teachers' decisions about what topics to teach at what year levels may be influenced by a whole range of factors, including decisions made at a departmental level (e.g. shared teaching schemes), or the nature of students' assessments (e.g. NCEA achievement standards), or teachers' perceptions of their students' abilities or maturity.

Teachers' views and ideas about teaching socio-scientific topics are likely to influence the way that they might use the *Time for critical thought resource* (if they use it at all). Given that the *Time for critical thought* resource was developed for Year 10 classes, it is interesting that a number of teachers felt they would not be able to use the resource with Year 9 or 10 students (or "low-ability" students), or felt the resource would first need to be modified so that the language was less demanding. The large number of comments about the literacy level of the *Time for critical thought* resource are interesting in view of the Ministry of Education's current priority on literacy development across the curriculum. A recent study on the impact of NCEA level 1 on the

teaching of science (Hipkins & Neill, forthcoming) found that school-wide professional development initiatives in this area do appear to be shifting classroom priorities, with many teachers perceiving that they spend more time on literacy skills than they did prior to the NCEA. Teachers have realised, with the more open-question styles of the externally assessed NCEA achievement standards, that adequate literacy skills are increasingly important for students' achievement in science (Hipkins & Neill, forthcoming).

The case study of the use of the *Time for critical thought* resource in one secondary school (Section 3) shows some interesting interactions between school literacy initiatives, and teachers' modification, adaptation, and use of the resource in their teaching.

3. A case study of the resource in use

Strategies for identifying schools using the resource

NZCER used several strategies to identify schools which were using the *Time for critical thought* resource for the case study component of the evaluation. Workshop facilitators in two of the regional workshops distributed letters to teachers, which explained the purpose of the NZCER research, and invited teachers to provide their contact details if their school might be appropriate for a case study (*see* Appendix 3). NZCER contacted workshop facilitators in two North Island regions to enquire whether they knew of schools that were using, or intended to use, the resource. We also made personal enquiries to science teachers and heads of department known to us through various professional science education networks.

Using this process, we identified one school in one region which was planning to use the resource with Year 10 classes in term 3, 2004.

This case study describes the use of the *Time for critical thought* resource by three science teachers and their Year 10 students at Rimu High school (a pseudonym). In August 2004, a researcher visited the school for 3 days to interview staff and students and observe the use of the resource in classrooms. The case study involved:

- an interview with the professional development workshop facilitator who introduced the resource to the school;
- an interview with the school's RTLB/literacy development teacher, who adapted the resource for use with the Year 10 classes;
- interviews with the three science teachers who used the resource with four Year 10 science classes;
- interviews with small groups of Year 10 students from the science classes; and
- observations of classrooms in which the resource was used in teaching.

Background: the introduction and adaptation of the resource

When the resource first arrived at Rimu High School, the science HOD used parts of it with Year 12 biology students but had not identified the resource as something for Year 10 students. A confluence of factors stimulated the HOD to consider using the resource with Year 10 students. First, she attended a *Time for critical thought* teacher workshop run by School Support Services. Not long after, School Support Services also ran a workshop at the school about "effective

teaching", in which GM was used as a context for thinking about this kind of teaching. When the HOD went to SCICON[6] she learned that a teacher who worked with primary school students had developed the resource. The HOD decided she wanted to find a way to use the resource with Year 10 students. However, she felt that she needed guidance and support to adapt it so that it would be suitable for these students.

The HOD sought the assistance of the school's resource teacher for learning and behaviour (RTLB) who was an expert in literacy and language development teaching strategies. In the previous few weeks the RTLB had provided some in-house professional development about literacy strategies specifically for maths, science, or technology teachers and the HOD had used some of these strategies with her Year 10 science class.

The RTLB was attracted by the resource's emphasis on critical thinking, and thought that it would be valuable to adapt the resource so that Year 10 science classes could use it for this purpose. She spent several hours reading the resource and decided that she could develop a unit of lessons based around the resource. Her focus was on providing materials and activities that would scaffold students' entry into the topic of GM, and into the critical thinking activities. For example, she felt there was a significant amount of new vocabulary that the students would need if they were to start to make sense of the materials and activities. The RTLB collected additional resources and materials relating to the topic of GM and developed a 5-lesson unit plan, in consultation with the HOD.

About a week prior to the teaching, the RTLB ran a lunchtime session to introduce the unit plan to two other Year 10 science teachers, neither of whom had attended the *Time for critical thought* workshops. The HOD and the two other science teachers subsequently used the unit with the four classes they taught (the HOD and one teacher each taught one Year 10 class, and the other teacher taught two Year 10 classes).

The classes

The way the resource was adapted and used at Rimu High School was heavily influenced by staff perceptions of the learning needs, interests, and abilities of the Year 10 students they taught, and of the general characteristics and dynamics of these Year 10 classes.

At Rimu High School, junior classes are not totally streamed, but three of the nine Year 10 classes are called "streamed" classes for the "top" students. All other students are in what are termed "mixed ability" classes. Two of the Year 10 science classes observed in this research were streamed (Classes B and C) and two were mixed ability classes (Classes A and D).

One group of between four and six students from each of Classes A, B, and C was interviewed on the third day of the case study visit, after the researcher had seen some lessons in their class.

[6] A national conference for New Zealand science teachers.

Students from Class D did not arrive at the interview room at the scheduled time and were not able to be interviewed.

To see whether teachers' and students' views about the interests and abilities of students in the class were similar or different, the teachers and the student groups were asked to describe their class, in terms of abilities, interests, and general characteristics of the students. The teachers' and students' descriptions of the classes are summarised below.

Class A—mixed ability

The teacher described this class as a "true mixed ability class". Some students found writing difficult. As far as the *Time for critical thought* resource was concerned, the teacher felt students' vocabulary would be relatively limited and some of the GM/GE articles would include words or whole sentences that would not be understood by some of the students. Some students showed more interest than others in their science class, and were "prepared to give things a go". Overall, the teacher was not sure if many of the students in this class would read the paper or listen to the news, or were aware of, or interested in, social issues like GM/GE at this stage in their lives.

The Class A focus group said the students in their class liked to do "hands-on" things that were "interactive". For example, instead of just sitting and writing all the time, they preferred doing things together as a class. One of the students in a Class A focus group interview said:

> Most [students in the class] will sit and listen to the information, but the rest of them go 'Oh we don't need to know that.' But then when it comes to a question, they ask everyone else.

Class B—streamed

The same teacher taught Class A and Class B. The teacher's perception was that students in this class seemed to know something about the topic of GM/GE, and had been able to contribute some basic ideas to the discussions thus far. Compared to Class A, the teacher thought students in Class B seemed better at communicating their ideas and could analyse what they were reading more quickly and competently. However, he was not sure that their interest level in GM/GE was any greater than that of other Year 10 students.

Focus group students in Class B described their class as "pretty laid back" but able to work well when they focused. Students said some students in their class didn't really like school. As a class, they liked learning conditions where "we can take it in our own way, at our own pace".

Class C—streamed

The teacher who taught Class C felt that most students in the class were "above average". She felt they were used to having to think, and did not seem to have trouble reading or multi-tasking. Her impression was that the students didn't know that much about GM before the unit. Class C focus group students described their class as "segregated" into certain groups—for example, the "goody-goods", the "try-hards", the "immature boys". As a class, they thought they worked better

with music playing. The students agreed that they were good multi-taskers because they could talk and work at the same time. In science, they enjoyed doing practical work, because it was more fun and involved less writing.

Class D—mixed ability

The teacher who taught Class D felt the students in this class were "a mixed group, very volatile". Some had very low levels of literacy. The physical and emotional maturity levels of students in the class covered quite a broad range. The teacher found she had to be prepared to change her lesson plans during classes, depending on how things were going. Unfortunately, students in this class could not be interviewed for the case study.

Summary

Teachers and students both thought the four classes included students with a mixture of different interests, and attitudes towards their schoolwork. Teachers thought that GM was not something most students had much awareness of or knowledge about before the unit began. These characteristics of the Year 10 classes were in teachers' minds as they worked through the lessons and activities prepared by the RTLB.

Whatever their perceived "ability" level, most students said they liked to learn at their own pace, and liked activities where they worked together with their friends.

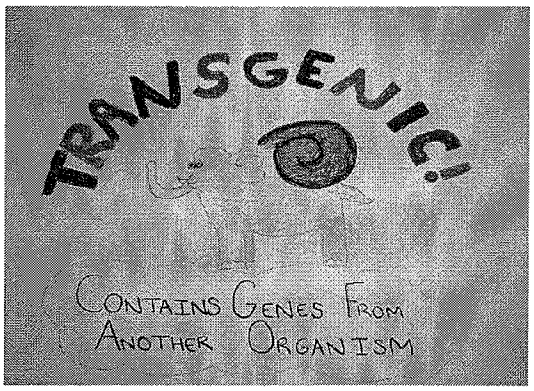
The teaching unit

The teaching unit developed by the RTLB comprised about five lessons, designed to lead into the resource if the teachers wanted to continue with the topic and take it further. Teachers did not have to follow the lesson plan and sequence rigidly and there was some variation in the order and mix of activities observed in different classes. The four Year 10 classes were observed for one or two lessons. Each class was somewhere between lessons two and five during the case study research visit. The following outline of the 5-lesson unit plan combines information from the RTLB's written plan, and observations of the lessons as they occurred in the four classes.

Lesson one

In the first lesson students are introduced to the theme of GM. The teacher aims to discover how much the students already know about the topic, and introduces the students to some of the "essential" vocabulary. This is done through a mix-and-match activity. Students have to match up 10 cards with GM words or phrases to their correct definitions. The terms are *genetic engineering*, *genetically modified*, *organic farming*, *DNA*, *moratorium, chromosomes, pollination, mutation, recombinant DNA*, and *transgenic*. Working in pairs, students then take one word or phrase and its definition and turn this into a poster to put on the classroom wall as a glossary (Figure 1).

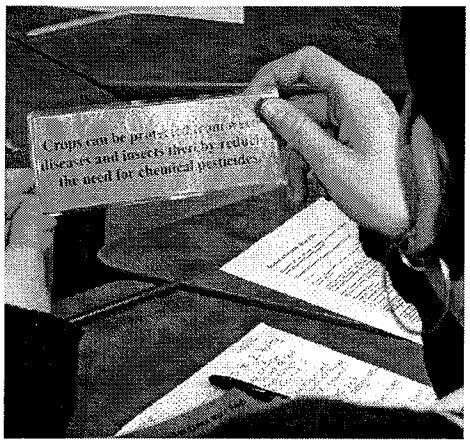
Figure 1 **Student posters for wall glossary (lesson one)**



Lessons two and three

After recapping the vocabulary they learned in the previous lesson, students are given a set of cards with statements about GM. They have to discuss and sort these statements into two piles: "advantages" of GM (for example, "Crops can be protected from weeds, diseases and insects thereby reducing the need for chemical pesticides" and "disadvantages" (for example, "Genes could escape from crops into related wild species. This could create indestructible weeds." Once the students have done this, each student selects a few of the advantages or disadvantages and goes to a computer lab to make these into a 5-slide PowerPoint presentation (Figure 2).

Figure 2 **Deciding on advantages and disadvantages of GM (lessons two and three)**



Lesson four

This lesson uses an adapted version of the "Distinguishing fact from opinion" activity on pages 18–19 of the *Time for critical thought* resource. Page 18 of the resource shows a continuum between fact and opinion, and lists seven statements organised sequentially along the continuum. For example, at the "Fact" end of the continuum is the statement "involves numbers or measurements", while at the "Opinion" end is the statement "is based on someone's beliefs or feelings". Statements in between include "is based on the experience of many people" and "will possibly happen in the future". In the modified version of this activity, the students are given a

sheet with the seven statements out of order, and have to discuss in their groups how to arrange them on the fact-opinion continuum. Next, students then do Fact and Opinion task 1 from page 19 of the resource. The teacher introduces the idea of "verification" as a way of identifying whether something is a fact.

Lesson five

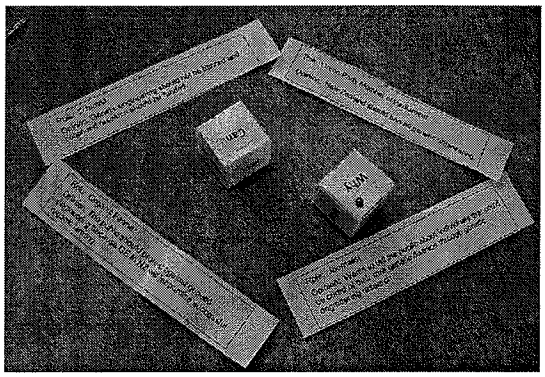
In this lesson students work through the "Fact and Opinion" activities on pages 22 and 23 of the resource. These activities present a passage of text from newspaper articles about GM. Working in pairs or groups, students have to go through the text sentence by sentence and decide whether each statement is a fact, an opinion, or neutral/unsure. The teacher then discusses with students the meaning of the term "bias". Students work through the "Judging for bias" activities on page 28 of the resource.

There are some additional activities available for teachers to use during the unit. These include a GM word-find activity, and a role-play activity in which students are given cards with "roles", for example:

- Role: Journalist. Opinion: Wants to tell the public about individuals who could be cured of their rare genetic disease through genetic engineering research.
- Role: Organic farmer. Opinion: The public should protest against genetic engineering because GM in New Zealand will jeopardise successful organic farming.
- Role: Scientist. Opinion: Genetic engineering should not be banned and continued research should be funded.

The role cards come with a set of dice with question-starter words like "where", "why", "what", "can", "will" on them. Students are supposed to roll the dice and ask each other questions about GE, each playing the role of the person described on their card (Figure 3).

Figure 3 **Role play dice and cards**



Comments on the observed lessons

The purpose of the classroom observations was to see how the teachers used the materials and lesson structures developed by the RTLB, and to get a sense of students' level of engagement and interest in the activities. Field notes were taken, but a structured observation schedule was not used.

Two classes (A and B) were taught in a traditional school science laboratory, with rows of fixed benches and high stools. Classes C and D were taught in two newer classrooms, in which tables and chairs could be arranged in any formation. In both classrooms, tables and chairs were set up so that students sat in clusters of about 4–6. Class D had the radio playing during class. The teacher switched this off from time to time when she wanted to speak to the whole class.

There were similarities and differences in the structure of each lesson, and the teachers' and students' roles in each of the classes. In each class, the period began with the teacher briefly recapping what students had done in the previous lesson(s) and introducing new ideas or activities for the current lesson. The teachers generally started by asking students to explain or write on the board the definitions of the GM/GE words they had learned and for which they had drawn wall-posters.

Class C was observed for only one lesson. Students in this class largely worked independently, with the teacher moving around the room to talk to students individually or in groups from time to time. As students in this class completed the activity to sort out the advantages and disadvantages of GM, they were allowed to go off individually to use computers scattered among different classrooms in the science block to make up their PowerPoint presentation. In the next period the class worked in a computer lab to complete their PowerPoint presentations. In Classes A, B, and D, the teachers alternated between addressing the whole class to ask questions or explain tasks, and moving around the class while students worked through each activity for 5–10 minutes at a time. Classes A and B both went to a computer lab for a period or two to make up their PowerPoint presentations.

In all four classes, students' interest and engagement in the activities appeared to vary. The classrooms were all characterised by high levels of conversation and discussion among students, although most often this was unrelated to the teaching activities. Some activities fostered more conversation among students than others. Some students spent a considerable amount of time drawing their GM word-and-definition poster for the classroom wall glossary. Most students quickly completed the activity which required them to sort the cards with advantages and disadvantages of GM, and there were no observed instances of students arguing or discussing the classification that another student in their pair/group had made. Students said they found this task "quite easy". The "Fact and Opinion" activity that Classes A and B were observed doing required them to discuss and decide their answers in pairs and fours, before the teacher asked the whole class to explain their answers. Some individuals were observed debating within their groups whether particular sentences in the text they were analysing were fact, opinion, or neutral statements.

In the second of the two lessons observed for Class D, in the second half of the lesson, the teacher introduced the role-play dice activity (*see* Figure 3). She explained that the idea of this activity was for students to start to give *reasons* for particular points of view that people might have about GM. She drew students' attention to the concept of bias, asking "What is it [bias]? Does it affect what people say? Some people may leave out information to persuade you to their way of thinking."

Students were given a set of dice and role-play cards for each table. However, after a few minutes, students appeared to be struggling with the activity. The teacher decided to change the task, telling the students to "forget about the role-play—now we are going to decide where *we* stand on GE". The teacher drew a continuum of 1 to 10 on the whiteboard, labelling 1 as "strongly disagree" and 10 as "strongly agree". Students were asked to indicate where on the scale how they felt about GM and to place a tick on the continuum. A few minutes later, moments before the end of the period, the teacher translated the ticks into a histogram on the whiteboard, to show how the class felt about GE. One student was overheard saying "But I don't even know what it [GE] is—what is it?"

Summary of the lessons observed

From the classroom observations it was difficult to assess how "engaged" students were with the activities they were doing. Some students seemed to be interested in what they were doing, while other students seemed less interested. (However, see students' own opinions about the lessons later in this section.)

Teachers used the lesson materials flexibly, and had to be prepared to vary activities or introduce new ones depending on how the students seemed to be getting on. In all four classes, the teachers spent more time moving around the student groups as students worked through the activities, than standing at the front of the classroom addressing the whole class. In Class D, the teacher found that students were not yet ready for the role-play task, and made an on-the-spot decision to

simplify the activity to ask students to give their own opinions on GE. However, this activity showed that some students felt they didn't yet know enough to offer their opinion.

Teachers' views about critical thinking and GM

The relevance of teaching genetic modification at Year 10

The three science teachers and the RTLB all felt GM/GE was a relevant topic for Year 10 students. However, they recognised that many of these students were not all that aware of GM/GE and might not necessarily perceive that it was relevant to their lives or interest. One teacher thought that for many of the students, GM/GE was:

> ...just another topic that we are saying 'you are going to study'. Having said that, once you do start, I think some of them do recognise words, phrases, issues that have been in the news. (Teacher)

All the teachers commented that most students seemed to know little about it when students were asked to brainstorm what they already knew about the topic in the first lesson:

> They started asking 'What *is* GM? What *is* genetic engineering?' (Teacher)

Two of the three teachers had previously taught issues related to GM/GE in their Year 12 and 13 biology teaching, but neither had taught this topic at Year 10. One teacher commented that compared to the way she had taught GM in Year 12 and 13 biology, the Year 10 *Time for critical thought* unit:

> ...[places] a great deal more emphasis on looking at people's opinions, and how they make decisions, compared with 'How do you make a transgenic organism?' So looking more at social issues and consequences, rather than just the technical side of the biology.

Even though the students' awareness or interest in GM/GE seemed to be relatively low, the teachers thought students would probably think this unit was the most relevant of all the science units they had done.

The value of teaching "critical thinking skills"

All the teachers felt that it was important for students to develop critical thinking skills as part of their science learning. The RTLB felt a critical thinking skills approach was "very much the type of thinking you would associate with 'arts' subjects, social science, or humanities". She defined critical thinking skills as the ability to look at a text or an image, deconstruct it, and look at what other "hidden" messages might be in there. For example: Who is the author? Does it promote racist or sexist views? What sort of language is it using? She felt it was important for students to learn these skills, in science, and in all other aspects of their learning:

> It's important that kids learn these aren't just things you do in social studies, that they're actually life skills. (RTLB)

She was not certain that critical thinking skills were usually touched upon much in school science. This was what appealed to her about the *Time for critical thought* resource, and why she was prepared to spend the time adapting and modifying the resource so that it could be used with the Year 10 students.

The three science teachers also considered that learning to think critically should be part of students' science learning. Their definitions of "critical thinking skills" included:

- being able to make judgements about what you read, and decide whether it is relevant or biased;
- recognising that information you read or are told comes from a certain viewpoint;
- being able to evaluate, analyse, and interpret information;
- looking at how we think and being able to analyse the way we think; and
- being aware of how we learn and what works best for us as individuals.

The critical thinking skills approach was felt to align with a general emphasis in the school "to look at how to learn", and looking at new kinds of pedagogy, particularly at the junior level. One teacher commented that students also needed good literacy skills to be able to interpret and draw meaning from information. She suggested that the *Time for critical thought* unit:

> ...takes what we are trying to do in our normal practice a step further. We have a focus on not just literacy but high-level thinking. We're trying really hard to get away from 'recipe science'... not just to collect the data, but to analyse it, and to evaluate what we've been doing. (Science teacher)

Another said students needed to learn how to "think for themselves":

> There are too many followers. And if you tell them 'This is the way that you do it' they don't think, they just do. (Science teacher)

What does a "critical thinking" classroom look like?

The teachers were asked to describe how an observer would know, if they went into a classroom, that it was a classroom where students were developing critical thinking skills:

> Students questioning. Teachers may have some strategies for getting students to analyse particular parts of the lesson, or parts of texts. There may be prompts on the wall, with certain statements about processes you can go through to arrive at conclusions. Teachers may have activities to elicit the students' thinking on a particular topic, e.g. the validity of sources. (Science teacher 1)

> Possibly by looking at what's on the walls, but mainly by talking to students. [What kind of questions might you ask the students?] Asking them 'why' questions or 'explain'. It's hard to say because I don't do a lot of thinking about that type of stuff, I just *do* it. (Science teacher 2)

> Perhaps from the students' questions, to each other, or to those observing. Perhaps their willingness to engage. And maybe the quality of the questions they are asking. In this Year 10 class, the students don't have a great deal of trust in each other. It makes teaching

> difficult because they are scared of being wrong, they don't want to 'risk' giving an answer. (Science teacher 3)

The challenges of teaching critical thinking

One teacher suggested that traditionally, critical thinking skills have not been explicitly taught in science, and that most teachers needed support to be able to do this well. Thus far, she was finding that it took a lot of time and preparation to teach in this way and she "couldn't do it for five lessons a day". Another teacher agreed and made similar comments:

> We [science teachers] teach more the 'hard factual' side of science, rather than the social biology or the social issues that have traditionally I guess been left for social studies... Already I find that I'm not able to perhaps get the lesson going as I would like because I lack some of those [teaching] skills and experiences. (Science teacher)

He suggested that social studies teachers could be a helpful source of pedagogical skills and knowledge:

> I'm quite keen to develop skills in looking at the social issues of science, and make science less of a rather cut-and-dried subject... I would think that many of the other [science] teachers would not mind science being taken out of the basket that it's been in.

Another teacher said the *Time for critical thought* unit was working well with her class so far. She felt the students were learning:

> *[R: how do you know they are learning?]* The way they use the words...the way they were asking questions about what it means, that type of thing. To go from not knowing what the topic meant, to being able to illustrate a specific word, was quite a big step.

Summary of teachers' views about teaching critical thinking and GM

Teachers in the case study school expressed a willingness and interest to teaching critical thinking in science. They described an ideal "critical thinking skills" classroom as one in which students would be working in groups, analysing and questioning information, and discussing and debating ideas with their peers and their teacher.

The perceived ability levels, learning needs, personalities, and classroom dynamics of the Year 10 classes were a major factor in shaping both the RTLB's lesson plans for the GM unit, and the science teachers' approaches to teaching these students. A key focus was the use of literacy strategies to get students familiar with the language and ideas associated with the GM debate, and to provide opportunities for discussion about these in the classroom. This was seen as an entry point into the more complex ideas and activities presented in the resource.

Teachers felt that the debate about GM was a relevant and important area for students to address in their science learning. However, teachers commented that Year 10 students might not be particularly aware of the GM debate, or see at first how it was relevant to their lives. Although they were only a few lessons into the unit at the time of the case study, teachers in the case study school were pleased with the way the activities were working in their classroom.

Students' views

Students from each of the four classes were told about the purpose of the research visit, and were given a letter inviting them to be part of a group interview. The researcher randomly selected four to six students from among those who volunteered to be interviewed, trying to get a mixture of male and female students. It should be noted that the views and opinions of the students who volunteered to be part of the group interview may not represent the views and opinions of all students in the classes.

The student focus group interviews explored five main areas (*see* Appendix 4):

- students' perceptions of the unit and the lessons they had had so far;
- what students thought their teachers intended them to learn from the unit, and students' own perceptions about what they had learned so far;
- students' views about teaching and learning in their science classes, and ways that they liked to learn;
- students' ideas about "critical thinking skills"—what they thought these were, and whether school helped them to develop these kinds of skills; and
- students' ideas and thoughts about GM/GE now, compared with before they started the unit.

Perceptions of the GM/GE unit

Students in all three of the focus groups had positive things to say about the GM/GE unit, and the activities they had done so far:

> We have to learn some vocabulary before we start the topic fully. Most of these are to help us understand the topic a lot better. We've only had two lessons so far but they've been really good. (Student)

Several students talked about the GM unit as part of a unit on "genetics", as this unit followed directly after a sequence of lessons about genetics and genetic disease. In comparison with other topics they had studied in science, students from each of the groups suggested they were enjoying the GM/GE (or genetics) unit more, or that it "made more sense":

> Some of the other projects we do [in science], we don't know what we are doing. (Student)

Topics they had found less interesting or more difficult included electronics, DNA structures and how they replicate, the periodic table, and acids and bases:

> The genes project was a lot better to understand than the acids one, I didn't like that one. (Student)

Students' comments suggested two main reasons why students thought the GM/GE topic was more interesting or made more sense than other things they had done in science. First, some students considered that the GM/GE topic was "more relevant", or that they had some existing knowledge or awareness about it:

> It's all over the news, and you read about it, maybe kind of get an idea. (Student)

> We started off with a little bit of an understanding when we came to the classroom...some of the things we do in science I have no idea about and I wish I did...genetics was a lot easier for me to understand. (Student)
>
> [The GM unit is] more interesting, it's actually to do with our society and what's happening at the moment. (Student)

However, most students considered themselves to have known very little about the topic before they started. The students were asked what they would have said about GM/GE had they been asked 6 weeks ago, before they had done anything about genetics in their science classes. The quotes below are drawn from students in each of the three focus groups, and seem to confirm the teachers' views that GM was not part of most students' consciousness:

> I would have just thought of tomatoes, sheep with pig's head. Weird stuff. (Student)
>
> I probably would have said repeat the question. I would know nothing, nada. (Student)
>
> We knew what was in the news and stuff, but other than that, we would have been totally blank. They aren't that specific in the news either. (Student)
>
> [Just] what we'd heard on news. That it's bad for you, that they took genes from animals and put them into different foods. That products with GE ingredients have to be labelled. (Student)
>
> I wouldn't have known anything, I don't really watch the news. (Student)
>
> I knew there was a song about GE by Anika Moa. (Student)

The second reason students felt the GM unit was more interesting than other topics in science related to the way that the unit was being taught, and the kind of activities they were doing:

> There's no right or wrong answers, the teacher said none of the stuff she is going to make us agree or disagree with what she says, whether it's good or bad. It's what we think. (Student)
>
> [The unit is] pretty good – not just copying [information into our books]. We are actually taking it in. (Student)
>
> [This unit] has made us develop our own opinion. It has made us very argumentative too. (Student)

Some students commented that the mix-and-match activities had been useful for learning the meanings of the GM-related words:

> When you look at the words you don't know what it means, but when you read the meanings you figure out what it actually means – 'like transgenic, I didn't know what that was.' *[R: Had you seen the words before?]* We probably saw them in books, but we didn't exactly get them, or take any notice. Just sort of read past them, 'I don't know what that means.'

Summary of students' views about the GM unit

Focus group students from the case study classes preferred the genetics and GM unit to other things they had done in science, because it was more relevant and interesting, even though they

didn't know much about it to begin with. Students also liked the unit because it involved different kinds of activities and the opportunity to discuss ideas, not just copy down information.

How the students like to be taught

The focus group students had clear opinions about how they were taught in their secondary subject classes, and what kinds of teaching they liked and did not like. For example, in many subjects students said they spent a lot of time listening, and copying down information, which they found boring:

> [In the GM unit] we have more things to do, rather than the teacher talking to us and we have to listen.
>
> Basically all subjects are the same: teacher talks, we listen. Teacher writes, we put it down. We don't get much say in most subjects I would think...it's pretty cool that [in the GM unit] we get to discuss it in a group as well, and kind of relay information off each other.

In most subjects, students said their ideas and opinions were rarely brought into their classroom learning:

> Hardly ever. The only time I think that ever applied to a subject was social studies, where we get to choose our own topics.
>
> In science, we get to discuss our ideas/opinions – but [the teacher] gives us a timeframe, he says 'You have a certain amount of time to do it' [e.g. 5 minutes]. When we're just getting into it, that amount runs out.

A few students commented that they often got to include their own ideas and opinions into their learning in dance/drama classes. They commented that there seemed to be more flexibility in this subject for units to be developed from their views and interest than in their other subjects like maths, science, or English:

> The [dance/drama] teacher is versatile. [The teacher] listens to our ideas, and puts them across. [Whereas] in other subjects they set up units for us to do across the term.

One group of students was asked how their secondary school teaching compared to the way they were taught at intermediate school. The students said they had not done much science at intermediate, but noted some key differences in teaching style between the two school settings:

> At our intermediate, our teacher used to always talk to us, like have a full-on conversation. Not just say 'do this' and that.
>
> Yeah, like get our opinions, and then work off that.
>
> They'd make sure that we understood it before we started working on it fully.
>
> Basically they didn't act like teachers, they acted liked friends and they were teaching something. I think that's a better way of teaching. (Group of students)

Summary of students' views about how they like to be taught

Students said in most classes they didn't have many opportunities to bring their own ideas and opinions into their classroom learning. Some classes/teachers were noted to be "more flexible" to allow this to occur. Students noted that in some subjects (including maths and science) the sequence of topics they covered was already set up in advance, and this meant less flexibility to bring their own interests or ideas into the learning activities. This was different to students' experiences of learning at intermediate school.

What students think their teacher wants them to learn from the unit

Students were asked what they thought their teacher wanted them to learn from the unit. Most students thought the point was to get a general awareness and understanding of the topic, so that they would recognise words and ideas when they came across them outside school, and in preparation for further science learning as they moved up through high school:

> To know what GM and GE means, what it is all about, how it affects people and the land, businesses and stuff.

> To know all the sophisticated little niggly bits about it – like big words.

Several students saw the GM/GE unit as part of the previous topic they had done, which was about genetics, and genetic diseases:

> They actually do a lot more testing than you think...like with the DNA, they go through millions of processes to get down to the tiny little [samples of DNA].

> To get a basic understanding of genes and genetics, why some fish are black and some fish are red. Dominant and recessive genes. So that it won't be like a foreign language when we move onto 5th and 6th form.

One student, referring to the "Fact and Opinion" activity they had done the previous day, talked about learning how to look beyond information that is presented, and to question whether it is true or not:

> Trying to say that people have different opinions and before we make a decision we have to figure out if it is true, or whether it's just what someone says. We found this activity challenging – sometimes we came across 'factual opinions'. We didn't really know if it was an opinion or a fact. Maybe it's just the way the reporter said it.

The students did not mention the idea of "critical thinking skills", and when they were asked about this idea, said their teachers had not actually mentioned this term. However, students in at least one class thought that the idea of "making our own minds up" was clearly part of the GM unit:

> [The idea of making up your own mind], that's just what we are doing now. I always question the teacher 'Why will this help us?' A lot of it just seems pointless. (Student)

We asked the students whether they thought learning to think critically was important, second, whether school helped them to be able to "think critically" or make up their own minds, and third,

what teachers could do to help them develop these skills. Most students felt that learning to think for themselves *was* important:

> ...because when we go out and get a job, we're not going to have anyone there to tell us what to do.
>
> Yeah like our teachers aren't going to follow us around to help us!

Students commented that secondary school didn't seem to emphasise this idea particularly strongly, or help students to make their own choices:

> [Teachers] are kind of getting more into it now. Before, we were just writing down stuff. Now we are actually getting to write our opinions.

Some students felt that they had few opportunities to express their opinions in school, and that sometimes teachers didn't like this:

> My mum's brought me up to speak my view, put my point across. It doesn't really work at school, you can't speak your mind to most teachers.

The students suggested ways that teachers could do more to help them to develop their own views, and to learn how to make their own choices and decisions:

> Most of our teachers should just listen to us more. We go off-task, we get bored writing. We'd like more of what's happening today, rather than what happened years ago. We want to know what's going on around us, it's more relevant. We can understand it.
>
> They could maybe ask what our opinions are of the subjects they are talking about. Maybe take it a bit slower, so we can process it, think about it, and think about what we actually think about it.

One student said "it would be great" if all their subject teachers would teach in this way.

Summary of students' views

The idea of "critical thinking" was not explicitly discussed with the students during the GM unit, although teachers did talk about students thinking for themselves or making up their own minds. Students thought it was important to learn how to do this, but that it didn't happen that often in secondary school classes. Students suggested teachers could help by listening more to students, teaching about things that were relevant to students, and giving them more time to process their ideas.

What is important to learn at school

Students were asked what they thought it was important to learn at school. Students in one group said it was important to learn how to survive in the "real world":

> *[R: What do you need to know to survive in the real world?]* We don't know! We're not there yet! *[Can you think of some kinds of things it might be useful or important for you to learn?]* People skills, money skills. How to do bills.

One student talked about how his mum always stressed to him the importance of learning how to be independent:

> Ever since I was little she's taught me how to run a house, and do all the things adults do, so that when it comes time when I have to leave, it won't be that hard on me. That's why I started applying for jobs, doing things that adults do, but not like fully. She'll teach me really good things about banking, and housekeeping, and jobs, how to stick to one, how to get better at it. *[R: Do you think your teachers know about the kinds of experiences you are getting outside of school?]* Nah. They don't have a clue.

Some other students said that they felt they were given lots of homework, and that it was often difficult to fit this in amongst the other things going on in their lives:

> But we have heaps of other things to do, like sports, friends, work, family. We might have problems, and they say 'Where's your homework?' and you try to explain and they go 'Well I've heard that excuse before.' But it's not an excuse, it's the truth.

Summary

Students thought it was important to learn "real world" skills at school. Some students thought they learned these things outside school. They felt like teachers didn't know enough about the experiences students were getting outside school.

Students' opinions on GM

By the last day of the case study visit, students from two classes (B and C) had finished designing their PowerPoint presentation of advantages and disadvantages of GM. The last slide in this presentation was supposed to present students' own opinion on the issue. In the interviews, students explained what opinion or conclusion they had put on their presentation (*see* Table 9).

Table 9 **Students' views on GM, given on the last slide of their PowerPoint presentation**

Students from Class B	Students from Class C
Student 1: I think it would be good to have GM, but only for certain uses. Like only for people overseas in third world countries who are stuffed up and can't afford it. Otherwise, if some countries got GM products and someone didn't, then they'd beat them in competition and selling, because they'd be able to produce way more. If anyone else tried to use it they'd be able to control our food supply. Student 2: I didn't think it was necessary for us to be doing GE. I was against it, because I didn't think it's right... there are already too many unforeseen risks. Like we already tried it once with corn, and the butterflies are suffering from the BT toxin. There's some other examples, like there is a species of eagles that have got DDT contamination from genetic modification, it has really screwed up their habitat. I'm thinking if it continues we might destroy more than we build. Student 3: I think it's good, because it could save millions of people that are starving overseas. Like even if they got it wrong they could keep on doing it till they got it right, and then start giving it to other people. Student 4: I think it's too risky. Because all the disadvantages are too great to gamble with. It could be good but we're not 100 percent sure so I reckon just stay away from it.	Student 5: I don't really like GM. It should just be all natural. If God intended, he would have made it that way from the beginning. Student 6: Basically I agree with [student 5], but my opinion might change depending on how it goes over the years. It might improve. Student 7: I disagree. It could be better in other countries—like produce more food to feed hungry people. I disagree with the manipulation of genes to produce something, I think it should be natural. Student 8: I think it's necessary, it will boost the economy. It won't be harmful if scientists know what they are doing. On the other hand New Zealand is quite a natural country, there's a lot to lose. Student 9: I think it's a good idea in some cases. It might change weeds or something, they might be hard to get rid of.

Unfortunately, the case study visit ended before the lessons in which students presented their PowerPoint slide shows to the class. In the light of some students' comments above, it would have been interesting to see what sort of responses and discussions occurred in the classrooms during or after these presentations.

Teachers' evaluations of the resource and the GM unit

The resource itself, and modifications to the resource

The RTLB felt that the *Time for critical thought* resource contained some very useful templates, but felt there was too much repetition in the activities. In particular, she felt there were too many activities based around analysing of pieces of text:

> But there are all sorts of activities you can do with text. [For example] reciprocal reading, sequencing activities. [For instance] I might get students to look at the text as it stands, and

> then a completely modified one so you can match up which sentence means which. [It's a way of] scaffolding them before getting onto the 'fact or opinion' [activity]. (RTLB)

The RTLB felt there were assumptions about the level of reading age in the resource, and that it needed more "user-friendly" information and activities, along the lines of what she had developed. It seemed unlikely to her that the resource had been trialled with secondary students before being sent out to all schools:

> I think it's much more accessible now that we've modified and changed it...I think we're providing something that is tangible [for other science teachers] to back up teaching in a different way...you have to give some support to teachers who are under a huge amount of pressure. I'd like to think I could give them something solid and say 'Here you are, here's four lessons that you can pretty much run with. And if you want to take it further, here's the resource, and continue from this.' (RTLB)

The three science teachers all felt it was valuable to have had the RTLB spend time modifying the resource and preparing the lesson plans:

> When a resource comes into the school it is good to have someone within the school to 'unpack' it, someone who has the time and the ability to do so. The resource can be unpacked in a way that is familiar to them and that we have the resources for – and that's going to be different for every school. (Science teacher)

> I told [the RTLB] what the problems and needs of the class were. Literacy is such a huge issue with this topic, I didn't feel confident without the support of someone with far more skills in literacy teaching. So I was delighted with the result...it has been really positive. (Science teacher)

One teacher commented that it was very important to have resources that the students would find "approachable", and equally, having a range of resources was important for teachers so that they could pick and choose which activities or resources to use with their own students:

> The easier [the resources] are to use, and the greater the variety of approaches, the more useful they will be. Teachers can select and build up their own unit—I don't think all teachers like to use the same sorts of approaches. (Science teacher)

> It's been very encouraging, although I wasn't happy with the resource to begin with, it has certainly pushed and supported me to be able to feel confident that I'm doing what I set out to do – that I am focusing on analysing and critical thinking. (Science teacher)

Summary

Both the RTLB and the science teachers thought the resource required "unpacking" and modification to make it usable for the Year 10 classes. The RTLB adapted some of the materials and activities presented in the resource using literacy strategies that were familiar to her. Teachers and the RTLB felt the support and expertise of the RTLB were valuable in enabling them to use the resource in their teaching. At least one teacher thought it was important to have a range of activities and materials on hand, for individual teachers to select from to suit their own teaching approaches or the needs of their students.

School-level constraints

Some of the challenges the teachers identified for teaching critical thinking in Year 10 science related to school-level constraints, such as curriculum and timetable structures. As one teacher said, "Critical thinking takes time."

> It's really difficult with the way that secondary teachers work, because you have an hour, and the most interesting and most difficult part of the lesson is right at the end. So it is definitely an issue. (Science teacher)

In the past the school had attempted to do block timetabling. However, changes to timetable structures have an impact across the school, and the teacher suggested that tinkering around the edges with the school timetable was not enough:

> The whole structure has to change. You can't do it piecemeal. It all goes, and you have to re-think it.

Another teacher commented that there were a lot of topics to "get through" during the year in the current school science curriculum. The teacher felt the science department could make topics more relevant for students by having many fewer achievement objectives within each topic:

> That will give us room within the timeframe of the topic to go off on tangents, or for students to do more group-work on particular side issues. [At the moment] I just feel the course is so full that we don't really have time for that luxury.

Summary of findings from the case study

How the resource came to be used in the case study school

- The way the resource was adapted and used in the case study school was heavily influenced by staff perceptions of the learning needs, interests, and abilities of the Year 10 students they taught, as well as the general characteristics and dynamics of these classes.
- The school's RTLB was a critical factor in explaining why the resource was used with Year 10 students. The RTLB spent time adapting and modifying the resource into a series of lessons and activities for Year 10 students.

Teaching GM using a critical thinking skills approach

- The RTLB and the science teachers all supported the idea of a critical thinking skills approach, and thought the context of GM was relevant and appropriate for Year 10 students.
- However, staff also felt Year 10 students may not necessarily see how GM was relevant to them, nor have much existing knowledge or awareness of this area.
- The lessons developed in the case study school were intended to scaffold students' entry into the topic of GM, and the kinds of activities included in the resource. This included the use of literacy strategies to help students become familiar with some of the language and vocabulary

associated with GM, and some of the important ideas and issues usually associated with the debate about GM.

- Teachers appreciated the role of the RTLB in "unpacking", adapting, and modifying the resources and providing them with a set of activities and a sequence that they could use with students. Teachers noted that it took a lot of time to prepare to teach using these kinds of approaches, and also expressed a desire for more support and ideas about how to be effective in this style of teaching.

Students' perceptions of the unit

- It was difficult to gauge, through classroom observation, how interested and engaged students were in the activities in the observed classes. Some students appeared visibly interested in the activities they were doing, while others seemed to be focused on social discussion or the completion of tasks such as colouring in their wall poster. However, focus group students said they were enjoying the activities, and preferred this unit to other science units they had done.
- Students preferred the GM unit because it was "more relevant" or "more interesting", and because there was the opportunity to include their own ideas and opinions, and they were doing different kinds of activities. Some students said that in science and other classes, their learning often involved the teacher telling or writing information for them to copy down.
- "Critical thinking skills" were not specifically mentioned in the science classes. However, students felt it had been made clear that the GM unit was designed to assist them to make up their own minds about GM. Students thought it was important to learn how to make choices and decisions for themselves, but felt that school was not always helpful in supporting them to do this.

Teachers' perceptions of the resource, and the support and constraints on its use

- The RTLB felt that the *Time for critical thought* resource contained some very useful templates, but felt there were too many activities based around analysing of pieces of text. She suggested a range of other kinds of literacy-based activities that could be useful for a unit such as this. Teachers felt that it would be helpful to build up a range of possible lessons and activities and a suggested sequence for these, so that each teacher could pick and choose how to structure the teaching to match the needs of their particular classes.
- Teachers in the case study school identified existing practices and structures of secondary science teaching as constraints for bringing "critical thinking skills" teaching approaches into their practice. These included the structure of the school timetable, the amount of content in the existing departmental teaching schemes, and the lack of opportunities for teachers in different discipline areas to work together or learn about different teaching approaches from each other.

4. Interviews about non-use of the resource in schools

When Rimu High School was identified as a case study school, we contacted the *Time for critical thought* workshop facilitator for that region to enquire whether there were other nearby schools which might also be using the resource. The workshop facilitator contacted several teachers and HODs who had attended *Time for critical thought* workshops in the region, but could not find other schools using the resource. However, she suggested interviewing two science teachers (science HOD 1 and science HOD 2) from two different schools. Both HODs had expressed interest in the resource, but were not using it with their Year 10 classes. Information from these interviews is presented in this section of this report. The workshop facilitator and these teachers were interviewed for the research. The purpose of interviewing the workshop facilitator and teachers who were *not* using the resource was to:

- investigate their perceptions of the resource and the workshops;
- identify their views of the relevance or appropriateness of the "critical thinking" teaching approach and the context of GM for Year 10 students; and
- discuss reasons why teachers were not using the resource.

The workshop facilitator

The workshop facilitator was asked to describe the structure and content of the workshop session, and her impressions of how teachers responded to the resource. The facilitator was a useful informant for the research, as she had regular communication with many of the science HODs in her region through her role as a science adviser. She thus had insights into the general features of science teaching practice in many of the schools in which the resource could have (but was not) being used with Year 10 students.

Description of the workshop

The workshop facilitator ran four 1.5 hour *Time for critical thought* workshops at schools in her region. Between four and nine teachers from the host school and other local schools attended each workshop. Most of these were science teachers, although there were at least one or two teachers of other subjects. The facilitator began the workshop by introducing the resource and explaining its structure. She focused most of the session on the argumentation section of the resource. She felt this was the most user-friendly part of the resource, and had the most potential to be used in

science classes. Most of the session was spent discussing with teachers how, and when, various activities in the resource might be used with students.

The workshop facilitator felt the workshops went well. Teachers generally liked the idea of teaching GM through a critical thinking skills approach. However, teachers voiced concerns in two areas. The first concern related to the learning needs of the Year 10 students, and the amount of modification teachers felt the resource needed to make it usable with their students. Many teachers felt the resource was too complex for Year 10 students, and could perhaps be more useful for senior biology students. The second concern related to the possible place of the unit in the school's science curriculum/teaching scheme. Although teachers saw a need to teach the skills of critical thinking in science, they wondered aloud about "where to put it" in their Year 10 schemes. The workshop facilitator's impression was that teachers would like to use the resource, but could not see how they could do this.

The science HODs

Two science HODs who attended *Time for critical thought* workshops but were not using the resource at Year 10 were also interviewed (*see* the interview schedule in Appendix 5). At the time of the interviews (Terms 3 and 4), the resource had not been used with Year 10 students at either school, although parts of it had been used with Year 13 biology students. Both HODs expressed support for a critical thinking skills approach to science teaching at Year 10, but felt that the resource was currently pitched at too high a level for their Year 10 students.

Science HOD 1

Introduction to the resource

Science HOD 1 received two copies of the *Time for critical thought* resource in the mail. He kept one copy in the science department and passed the other copy to the English department. He and several other science staff also attended a *Time for critical thought* workshop run by the workshop facilitator at their school.

Previous teaching of genetics or GM

Science HOD 1 had taught genetics and GM before, but generally this had taken a "classic biological" approach, with a primary emphasis on fact, rather than interpretation. At Year 10 this comprised an introduction to the topic, with a focus on human and plant reproduction. Year 11 science teaching extended to look at genetic traits, selective breeding, inheritance, and genetic disease.

Teaching critical thinking

HOD 1 suggested the *Time for critical thought resource* and the associated workshops opened up a new way of thinking about teaching in this area. In particular, he had started to think about the kind of questions that he might normally have introduced near the *end* of the topic, and bringing these up to the *beginning* of the topic:

> [For example], what would you do if you discovered the gene for cystic fibrosis, or Parkinson's disease, and you could actually remove it [through genetic modification]? (HOD 1)

HOD 1 felt that most students were not aware enough of the media to be familiar with the GM debate, and did not yet know what kinds of questions they needed to be asking about this area. He felt that putting a "personal angle" on such topics (for example, thinking about how they or people in their families might be affected by genetic diseases) would stimulate students' interest more than a facts-based, bottom-up teaching approach, and would lead students into "common-sense, rational discussion and debate":

> As soon as you get into cloning, or manipulation, their brains start going off into Playstation 2....weird and fanciful. And rather than focus on what you want to do in the discussion, they are conceptualising alien figures. (HOD 1)

Positive aspects of the Time for critical thought *resource*

Several aspects of the resource appealed to the HOD. He liked the activities which prompted students to distinguish between "fact" and "opinion", and in theory, would like to introduce the resource into Year 10 teaching:

> Somewhere along the line they've [students] got to be taught how to think. And literally how to sort out fact from opinion. That to me is the key to what this whole thing [the debate about GM] is all about. Because there is a lot of stuff going around that is based on opinion, not fact.

Science HOD 1 described critical thinking skills as "the ability to sort out fact from fiction, to decide what is opinion, and to be able to interpret and justify". In a classroom where there was an emphasis on developing these skills:

> [students] wouldn't be sitting in rows. You'd be attempting to develop group work and strategies with sharing of information. You'd be attempting to develop analysis, reason, and logic....Textbooks could be used, but not in a traditional sense. Hopefully you would see kids being asked to pull a topic [text] apart – what are the key points – rather than answering the questions at the end of the piece of text.

HOD 1 felt that although he and other staff were working their way towards this kind of teaching, for the most part they still had a very traditional science teaching style. He felt that students themselves had certain expectations about teaching and learning in science classes, and getting them to recognise that a critical thinking skills approach *was* part of science learning could be a challenge:

> When they walk into a science lab, they think test tubes, Bunsen burners, what can we play with and blow up next? (HOD 1)

He felt it was important for students to come out of school knowing how to think for themselves and make decisions. However, he suggested there may be a contradiction between this intention, and how students have traditionally been taught:

> We are too committed, traditionally, to regurgitation of information...we push too much content down them. (HOD 1)

He felt science teaching needed to include more time teaching students how to seek out and analyse information, and make good judgements about the information they had:

> [We need] a lot less content and far greater emphasis on 'Where do I find things out?' and 'How do I really know this is giving me my answer?' To do the comparison, the contrasting, and the analysis. (HOD 1)

Science HOD 2

Introduction to the resource

Science HOD 2 and one or two other science staff also attended a workshop at their own school.

Previous teaching of genetics or GM

Science HOD 2 had taught issues around GM at senior level (Year 13 biology). This included using activities that she described as similar to those presented in the *Time for critical thought* resource. For example, selecting articles about GM from a range of sources, and having students look at what kinds of bias these articles contained. The Year 10 teaching programme included a unit on "elementary genetics", in which students were introduced to simple Mendelian genetics. One reason she did not see the *Time for critical thought* as appropriate or usable in the Year 10 programme related to the timing of this unit in the year:

> [The Year 10 elementary genetics unit] fits into our yearly program right at the end, so it tends to get a bit swallowed up with other things that happen at that time of the year. So there's not that opportunity for more in-depth coverage that this resource would demand. (HOD 2)

Teaching critical thinking

HOD 2 described "critical thinking skills" as the ability to look at something and decide what sort of position the writer is coming from, and to be able to consider and critique a variety of positions on an issue. In a "critical thinking skills" classroom, an observer might see students who were "questioning the material and the ideas" presented to them. Although she thought critical thinking skills should be part of students' secondary science learning, she felt this kind of approach was only suited to particular kinds of science topics:

> Perhaps environmental topics, genetic modification, would be the main areas I would see that sort of thing happening in. (HOD 2)

Positive aspects of the Time for critical thought *resource*

Science HOD 2 thought the resource contained a lot of good material. She thought that the debate about GM was "absolutely" relevant for students' secondary science learning, from the point of view of students as future consumers:

> The whole issue of genetically modified food is an important issue, and I think consumer demand, or lack of it will have an important influence on whether GM foods become accepted or not. (HOD 2)

HOD 2 thought the *topic* of GM was relevant for Year 10, "but the form of the resource perhaps is not appropriate for Year 10". Specific problems with the resource in her view included the reading level of the resource, the amount of text on pages, and the small size of the text:

> The impression is a lot of text on one page, with not much break-up, and I think that's off-putting for students at Year 10. (HOD 2)

The two HODs' views about how the resource could be more usable

Each HOD identified barriers to the use of the resource in teaching and suggested several ways that the resource could be more usable for teachers. HOD 2 mainly commented on the content and format of the resource itself, while HOD 1's suggestions included modifications to the resource, as well as changes to the structures and practices of science teaching and the school curriculum and timetable.

Suggested modifications to the resource

Science HOD 1 felt Year 10 students would have difficulty understanding some of the language used in the resource. He suggested that it would be useful to modify the resource to include more pictures, cartoons, articles re-written with big print, and using contexts that would appeal to Year 10 students "and the world they perceive themselves to live in". This might include using science fiction, or cartoon imagery that students would recognise and connect to other interests such as movies and video games. He felt these sorts of modifications would mean that students' energies would not be expended on struggling to read and comprehend the text, making it easier for students and teachers to focus on the "critical thinking" aspect of the topic.

HOD 2 thought that if the target audience for the resource was changed to senior level, more teachers might use it. If the resource was to be used at Year 10, she suggested that it could include articles that might interest Year 10 students, and present these in an "attractive way". From a teacher's perspective:

> I don't feel that [the resource] is presented in a way that makes an easy progression through it for the teacher...in a way that would make [the teacher's] selection of activities easy. It doesn't make me want to use it. (HOD 2)

HOD 1 suggested that the resource could include a sample unit scheme or lesson sequence for teachers:

> Then it becomes an active teaching document...that you're actually going to pick up and use. (HOD 1)

Support for a critical thinking skills teaching approach

Science HOD 1 thought the workshop approach was useful for familiarising teachers with the resource. He stressed the importance of teachers having someone work through the resource's activities and teaching strategies with them. He felt teachers needed a lot of time to develop the kind of re-modelled teaching strategies that a critical thinking skills approach required.

The obstacles of existing school structures

Like teachers at Rimu High School (*see* Section 3), science HOD 1 noted some structural barriers to the use of a critical thinking skills approach in Year 10 science teaching. For example, having a timetable with 1-hour periods made it hard to get students thinking critically, when they had to start and stop and pick up again where they left off the next day. There were also few opportunities for teachers to work and plan together, particularly across different curriculum areas. This was just beginning to change, as the school's science and technology departments had recently joined together into a single faculty, and were working towards a more common approach to teaching and learning.

Summary of findings about the non-use of the resource

- The interviews discussed in this section suggest that teachers who attended the workshops liked the idea of the critical thinking skills approach, and thought GM was a relevant topic for Year 10 science teaching.
- However, teachers identified two obstacles to the use of the resource in their teaching. First, they felt the resource in its current form was not appropriate to the learning needs of their students and would need to be adapted or modified. Second, they were uncertain about how the topic/unit would be fitted into their existing Year 10 departmental teaching schemes.
- Interview participants felt that the workshop approach was a useful way of introducing and familiarising teachers with the resource. However, the workshop facilitator and at least one teacher felt that more sustained support was needed to help teachers to become familiar and confident with the kinds of science teaching approaches that the resource could stimulate.
- Participants felt that more guidance for teachers about how to select activities and ideas from the resource, and put these together into a unit plan, would make the resource easier to use.
- Participants felt the "look" of the activities in the resource was not appealing enough for Year 10 students and suggested a reduction and simplification of text on each pages, and the addition of pictures, cartoons, or articles that would appeal to the interests of Year 10 students.

- At least one teacher was beginning to think about different ways to approach genetics teaching, in order to stimulate stronger connections for students with the topic. However, some existing practices and structures of secondary science teaching were identified as constraints on teachers' abilities to bring such teaching approaches into their practice. These included the nature and structure of the yearly departmental teaching schemes, the structure of the school timetable, and teachers' and students' existing expectations about what secondary science teaching and learning should be like.

5. Discussion

This purposes of this evaluation were to gather information about teachers' perceptions of the *Time for critical thought* resource, look at how the resource was used in classrooms, investigate the impacts for students' learning, and identify barriers to the effective use of the resource and suggestions for further development of this type of resource. This section summarises key themes to emerge from this evaluation. In this section we draw together our findings from the surveys, interviews, and the case study, and frame them within the current science education literature. Implications of this research for further development or support for the *Time for critical thought* resource or other similar resources or initiatives are discussed.

Summary of themes from the research

- Many teachers interviewed in this study expressed a willingness and interest to teaching critical thinking in science. Teachers described an ideal "critical thinking skills" classroom as one in which students would be working in groups, analysing and questioning information, and discussing and debating ideas with their peers and their teacher. However, teachers did not necessarily see this approach as appropriate or achievable for all topics, or at all year levels.
- In its current form, many teachers did not think the resource was immediately usable, particularly for Year 10 students, although some of the activities were immediately useful for senior level biology students.
- Some teachers commented that the resource was "too advanced" for Year 10 students. In the surveys, it was not always clear whether this referred to the language level of the resource, or to the kinds of skills or knowledge it might require of students, or to some other aspect of the resource that they thought did not fit the needs, abilities, or interests of Year 10 students.
- Teachers felt that the debate about GM was a relevant and important area for students to address in their science learning. However, some teachers commented that Year 10 students were not particularly aware of the GM debate, or may not see how it was relevant to their lives.
- In the case study schools, the perceived ability levels, learning needs, personalities, and classroom dynamics of the Year 10 classes were a major factor in shaping both the RTLB's lesson plans for the GM unit, and the science teachers' approaches to teaching these students. A key focus in the case study school was the use of literacy strategies to get students familiar with the language and ideas associated with the GM debate, and to provide opportunities for discussion about these in the classroom. This was seen as an entry point into the more complex ideas and activities presented in the resource.

- Although they were only a few lessons into the unit at the time of the case study, teachers in the case study school were pleased with the way the activities were working in their classroom. These teachers commented on the time and level of support they felt they needed to become proficient in this way of teaching.
- Focus group students from the case study classes preferred the genetics and GM unit to other things they had done in science, because it was more relevant and interesting, and because it involved different kinds of activities and the opportunity to discuss ideas, not just copy down information.
- Frequently suggested modifications and adaptations to the resource included:
  - a reduction of the level of reading difficulty of the resource;
  - simplification of the activity pages, with a reduction in the amount of text on each page;
  - making the pages more attractive to Year 10 students by including cartoons, images, and stories and articles likely to interest Year 10 readers; and
  - providing more guidance for teachers about how to put activities from the resource together into a teaching unit (for example, by providing a suggested unit plan).
- In addition to modifications to the resource, teachers identified school-level challenges for bringing a critical thinking approach to teaching science. These included:
  - the amount of time needed for teachers to "unpack" the resource, and modify or adapt it into a series of lessons for their own classroom;
  - teachers' lack of experience or confidence teaching in this way, particularly with students of this age;
  - the structure of the school timetable (in particular, the 1-hour blocks for each subject which constrained the depth of discussion that could go on); and
  - the number of topics, or amount of content to cover, in the school's Year 10 teaching schemes.

Discussion of the research findings

This section frames the research findings within wider educational issues for secondary science teaching and learning. We explore possibilities for further work on the resource itself, or with science teachers via ongoing professional development and support, so that they might more readily accept this or similar resources in the future.

Four key areas are discussed:

1. the issue of content coverage;
2. views about what is appropriate learning for Year 10 students;
3. science learning and literacy demands; and
4. critical literacy and critical thinking.

Issues of "content coverage"

As we have seen, one reason teachers gave for not using the resource was that they would not have time to use it within their existing teaching programmes, where they saw a need to "cover" many existing curriculum topics. While teachers in the case study school made time to include aspects of the resource in their programme, they too could only afford to spend a short block of teaching time on this unit.

Internationally, teachers' adherence to the coverage of large amounts of "content" as the key focus of their science programmes is widely seen as an impediment to reforms of science education. This issue has been commented on by research panels investigating curriculum and teaching reforms in the United Kingdom (Millar & Osborne, 1998) and in Australia (Goodrum, Hackling, & Rennie, 2000), to name just two examples. The emphasis on large amounts of content, too quickly covered, has been identified as a major impediment to student enjoyment of, and continuation with, school science (Osborne & Collins, 2000). In the Third International Mathematics and Science Survey (TIMSS) New Zealand was one of only three nations that reported intending to teach all 79 identified "content standards" at Year 8 (Cogan, Wang, & Schmidt, 2001). A recent survey of 744 New Zealand secondary school teachers found that just 13 percent wanted to see overall content reduction in the curriculum[7] they taught (Hipkins & Hodgen, 2004).

It seems that many New Zealand teachers, like teachers elsewhere, interpret curriculum documents primarily as a list of content to be covered. Yet it is possible to take an entirely different reading of *Science in the New Zealand Curriculum (SNZC)*. In an analysis of the range of outcomes that could be read from *SNZC*, Hipkins and Barker (2002) pointed out that achievement objectives are written in a relatively non-specific manner and were never intended to constitute a definitive list of "facts to be learnt". In principle, *SNZC* is designed to have the flexibility to allow teachers all over New Zealand to meet the particular needs of their mix of students and is very forthright about this, with its explicit emphasis (p. 11) on "Science for All". Furthermore, the structure of the curriculum signals that opportunities for learning about "the nature of science and its relationship to technology" and for "developing scientific skills and attitudes" should be integrated with content from one or more of the contextual strands (Ministry of Education, 1993b). These three features—the themes of the integrating strands, the focus on science for all, the generality of the actual achievement objectives—point to the appropriateness of providing learning experiences for students such as those intended in the *Time for critical thought* resource. However, the persistence of "curriculum coverage" as a driving force in secondary science teaching schemes seems to impede the realisation of these more forward-looking interpretations of curriculum and of purposes for learning science.

At the time of completing this evaluation, leaders of the Ministry of Education's New Zealand Curriculum/Marautanga Project were consulting teachers on matters related to curriculum

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[7] These were teachers of many curriculum areas, not just science.

interpretation and implementation. Groups convened by the Ministry of Education to advise the Curriculum Project on science education were discussing such matters as:

- the purposes for learning science;
- possibilities for reducing or refocusing curriculum coverage;
- development of "key competencies"; and
- the inclusion of values in the curriculum.

As part of the Curriculum Project, the Ministry of Education has also begun to explore the notion of school-based curriculum development (Bolstad, 2004). It may be that these developments, with the intended revision of the New Zealand Curriculum, will build an impetus that finally helps break the "content coverage" stranglehold, allowing more curriculum space for resources such as *Time for critical thought*. However there are other seemingly equally intractable barriers to discuss and we turn now to issues of developmental assumptions.

"Appropriate" learning for Year 10 students

Some teachers surveyed or interviewed in this research expressed concerns about the appropriateness of the resource for Year 10 students. There were two levels of concern: the first was about the appropriateness of the *language level* of the resource, and the second was about the appropriateness of the content or teaching approach modelled by the resource. Concerns about literacy demands are discussed in the following section. Here we focus on the perception that Year 10 students are "not ready" to explore issues such as GM in the manner laid out by *Time for critical thought,* and that the resource would have been better targeted at students in the senior secondary school.

Literature suggests three powerful influences on teachers' views of what is appropriate for students to learn at different ages and stages of schooling. These are: 1) developmental theories, 2) views about the logical order in which curriculum content should be organised to support progression of students' science learning, and 3) the idea that students need to know "the basic facts" of a topic, before they can enter into debate about controversial or uncertain aspects of the topic.

Many teachers hold tacit theories of learning that have behaviourist and developmental roots. Their views about appropriate ways for students to progress through their years of science learning typically derive from the "internal logic of the academic disciplines of science, as they have developed, particularly conceptually since the mid 20th century" (Fensham, 1994, p. 79). Therefore, teaching schemes (e.g. for the term, for the year, and as students progress through their years of school) are structured according to what is seen as the logical order of development of subtopics. Curriculum organisation is based on criteria such as a move from simple relationships to complex patterns, or from concrete experiences to ideas that involve abstract logical thinking. Progression can also be theorised as having a biological basis. In this view children are not ready for particular sorts of learning until they have reached some physical and/or psychological maturation stage. This has recently been described as a "folk theory", albeit one that is still widely

held amongst the teaching profession (Watson, 1996). Thirdly, views of progression are subtly influenced by ideas about knowledge that we have inherited from the Greek scholars of antiquity. In their society, youth were required to serve a sort of "knowledge apprenticeship" before they would be allowed to engage with the substantive issues of the day (Gilbert, forthcoming). In modern education practice, this has translated to the view that it is necessary to learn the key theories of any science field before being allowed to engage with areas of new research and/or related socio-scientific issues.

Together these three very commonly held theories—biological views of maturation, the logical development of a theory field, and the need to serve a knowledge apprenticeship before engaging with any uncertain aspects of knowledge—constitute a powerful impediment to the use of socio-scientific issues as contexts for engaging younger students in school science learning. This study suggests these views have been one influence on the non-use of the *Time for critical thought* resource with Year 10 students. However, as in the case of content coverage, there are grounds for cautious optimism that, with access to appropriate professional development and time for reflection, teachers could begin to change their views about how to engage younger students in socio-scientific issues.

Science learning and literacy demands

Time for critical thought drew extensively on media articles about genetic engineering. Some teachers who responded to the survey thought the reading demands were too high for their Year 10 students. The teachers in the case study school relied on an RTLB to use her knowledge of literacy strategies to modify the materials, because they too considered the reading demands to be one barrier to use of the resource in its original form.

Recent research carried out in Australia has described the impotence many secondary school science teachers feel when they recognise students' reading problems. They are typically at a loss to know what they can do:

> I bite my tongue to stop myself from saying 'What do you want me to do about it? I'm a secondary teacher, I'm not supposed to teach them to read.'....the most frustrating thing of all is that many of us do not have a clue where to begin with literacy problems...everything we are teaching them is like building on sand (Sandy Roberts, cited in Dennett & Milburn, 1999, p. 10).

In a comprehensive survey of literacy issues, Wellington and Osborne (2001) described a range of strategies designed to help secondary science teachers become explicit teachers of basic literacy skills. International research about the difficulties that science language poses for learners suggests there are two main types of challenge: vocabulary and grammatical challenges.

While they support the appropriate teaching of vocabulary, Wellington and Osborne suggest there is a danger that technical terms, given too soon, may encourage students to use these words in superficial ways that conceal misunderstandings. They recommend the explicit use of models and analogies as effective pedagogical strategies for building the shared meanings of science technical

vocabulary. There is an interesting dilemma here for this evaluation. The teachers at Rimu High School recognised that the technical vocabulary of GM could create a barrier to their students' reading of media texts, and they spent the first of their five or so periods on building term recognition and meanings. But did students really gain an understanding of the processes that lay behind the terms they were learning to use, sufficient to bring critical thinking to bear on the overall issues of GE? The student comments in Table 9 (*see* Section 3) suggest that students had not yet had time to develop deep understandings of some of the terms they were using. However, the strategies proposed by Wellington and Osborne would require more time than was available for the GM unit at Rimu High School. There are clearly connections here with the issue of curriculum coverage, discussed above.

Wellington and Osborne also identify other features of written science text that pose specific types of learning challenges for students. For example, the use of "logical connective" words such as "frequently", "simultaneously", "consequently", "thus", and "conversely". These are vital components of the language of hypothesising, comparing, sequencing, attributing causes, and other key aspects of scientific reasoning. However, Wellington and Osborne caution against responding to students' difficulties with these words by simplifying the language structures used. They argue that if students never have the chance to read and learn about logical connectives, they are less likely to learn notions of sequencing and causality, nor will they recognise these features in other texts they read. Other features of science writing that need to be explicitly taught include the use of the passive voice, the use of qualifiers (e.g. "in the majority of cases"), and the process of nominalisation where nouns are substituted for verbs, or for a whole action sequence, (crystalisation, evaporation, acceleration), or are used as adjectives (glass crack growth rate). Again, Wellington and Osborne suggest, students need deliberate and considered exposure to these features, if they are to learn to read science texts.

Critical literacy and critical thinking

In addition to educating those students who will become scientists, a widely described purpose for science education is for the development of "scientific literacy" (Laugksch, 2000). From this perspective, a "science literate" citizen would be able to meaningfully engage with science in their life beyond school, when and if they felt the need to do so. Clearly this aim aligns well with the intention to develop students' abilities to think critically about issues to do with GE.

Teaching strategies which explicitly seek to develop "science literacy" would ideally help students to develop understandings *about* science (that is, the nature of science as a discipline or a knowledge-building enterprise), as well as developing students' science content knowledge and skills. While there is heated debate amongst science philosophers about the nature(s) of science, a degree of consensus about what this phrase could mean within science education has recently emerged in the international literature (Hipkins, Barker, & Bolstad, in press). Much of this literature documents teachers' own lack of understanding of the nature of science, and an associated lack of teaching for the explicit purpose of developing science literacy. The small

amount of local research available suggests that in this respect, New Zealand science teachers are in the same boat as their international peers (Hipkins et al., in press).

Some researchers are beginning to develop strategies to help teachers develop aspects of the nature of science (NOS) in their science lessons. For example, Ryder (2001a, 2001b) suggests the use of secondary data derived from authentic science research (for example, data on the safety of cell phone use for human health) in carefully structured tasks. However, an attempt to put this idea into practice in senior physics classes met with mixed results (Hind, Leach, & Ryder, 2001). Naïve NOS views hindered students' (and in some cases teachers') engagement with the prepared materials and in this study some teachers gave misleading messages about science when they attempted to handle students' ideas sensitively.

Research into strategies for developing NOS pedagogies provides useful insights for the *Time for critical thought* evaluation. There is a clear tension here between challenging students to build critical thinking skills in authentic contexts and moving them (or the teacher) too far from their familiar comfort zones and roles. In the introduction we noted literature about teachers' discomfort with the idea of discussing values associated with socio-scientific issues in their science classes (Dawson, Lock, Brickhouse, & Crosthwaite, 2002a; Levinson, R. & Turner, S., 2001a). It seems likely that lack of familiarity with NOS strategies could compound this discomfort and increase the odds that teachers will balk at teaching that demands so many personal risks. In this context it is also worth noting that the NZCER 2003 National Survey of Secondary Schools (Hipkins & Hodgen, 2004) found that just 24 percent of the 744 teachers surveyed felt there was good or very good support at their school for taking risks with their teaching.

Currently, the Ministry of Education is sponsoring the development of a website—*Science IS*—that will provide pedagogical guidance for making NOS interpretations of the integrating strands (IS) of *SNZC*. When it is available, it could provide a useful support to the further development of *Time for critical thought*. It may be that a way can be found to more closely align the two resources, so that professional support for the one becomes support for the other.

Looking ahead

This evaluation has demonstrated the considerable challenges that face developers of innovative resources like *Time for critical thought* which aim to support change in science teaching practice. The evaluation suggests that the *Time for critical thought* resource will not achieve its intended purposes without further professional support for secondary teachers as they learn to use it.

The perceived barriers to be created by the widespread lack of basic literacy skills are a serious obstacle to the development of any sense of "science for all". How might today's students, as tomorrow's adults, engage with socio-scientific issues in a thoughtful manner if they cannot read newspaper reports at the very least? This issue brings into question a fundamental reason for

including science in the curriculum at all. Indeed some have suggested a danger that there will be no place for science in the general curriculum of the future if these issues, along with the knowledge issues outlined above, are not addressed (Gilbert, 2001).

With the current Ministry of Education policy emphasis on developing literacy skills, this aspect seems a promising place to begin to address the tangle of teacher knowledge challenges we have described above. Further development of literacy support materials, if envisaged, should bring students to the challenge of reading science texts, rather than avoiding these. Strategies that can do this are described in the science education literature, and have been in circulation since at least the early 1990s. What richer context to develop them further than GE? However it is also apparent that much more professional development will be needed if teachers are to make the many changes necessary to accommodate a forward-looking resource such as *Time for critical thought* in their teaching programmes.

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Appendix 1: Teacher survey

NEW ZEALAND COUNCIL FOR EDUCATIONAL RESEARCH

TE RUNANGA O AOTEAROA MO TE RANGAHAU I TE MATAURANGA

Teacher Evaluation Form

The New Zealand Council for Educational Research is evaluating the resource and workshops for *Entering the debate on Genetic Modification, by developing a critical thinking response.* Please help us by filling in this short evaluation form.

Instructions for filling in forms
These forms will be scanned. To help the scanner to read your answers correctly please fill in the bubbles (O) by shading them in. Please do not use ticks or crosses as they can confuse the scanner! If you use a soft pencil, you can erase the mark if you want to change your answer

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Form number: _____

Section A: Background Information.

Please fill this section in BEFORE the workshop begins

1. Are You:

O Female O Male

2. Please indicate your age.

O 20-29 years O 30-39 years O 40-49 years O 50+ years

3. For how many years have you been teaching?

O 0 to <2 O 2 to <8 O 8 to < 15 O 15+ years

4. For how many years have you been teaching at your current school? _____

5. What is your position/level of responsibility in your school?

O **1st or 2nd year teacher**, e.g. Provisionally Registered 0 to <2
O **Teacher**
O **Middle Management**, e.g. Management/PR Units, Head of Department, Curriculum or Syndicate Leader, Senior Teacher, Dean 8 to <15
O **Senior Management**, e.g., Principal, Deputy Principal

6. What subjects do you teach, and at which Year Level(s)?

O Year 9 Science
O Year 10 Science
O Year 11 Science
O Year 12 Science
O Year 13 Science
O Year 11 Biology
O Year 12 Biology
O Year 13 Biology
O Year 12 Chemistry
O Year 13 Chemistry
O Year 12 Physics
O Year 13 Physics
O Year 9 Maths
O Year 10 Maths
O Year 10 Horticulture
O Year 11 Horticulture
O Year 12 Horticulture
O Year 9 Health
O Year 10 Health
O Year 9 English
O Year 10 English
O Year 11 English
O Year 12 English
O Year 13 English
O Year 9 Social Studies
O Year 10 Social Studies

7. Do you currently cover any socio-scientific topics or issues in any of the classes you teach?

0 Yes ***(Go to Question 8)***

0 No ***(You have finished Section A. Please complete Section B AT THE END of the workshop.)***

8. If yes, please describe which classes, and which topics.

	Socio-scientific topics or issues covered in this class
Subject and Year Level(s)	
1.	
2.	
3.	
4.	
5.	

Section B: Your views about the resource and the workshop

Please fill this section AT THE END of the workshop

9. Before today's workshop, how familiar were you with the resource. ***Entering the debate on Genetic Modification, by developing a critical thinking response?***

- ○ I have not seen it before
- ○ I have seen it but haven't looked at it in detail
- ○ I have seen it and looked through it
- ○ I have used it in teaching

10. How relevant do you think the resource might be for your teaching?

- ○ Extremely relevant
- ○ Possibly relevant
- ○ Probably not relevant
- ○ Not at all relevant

11. Which, if any, class(es) do you think you might use this resource with?

12. In your opinion, what are the most positive or useful aspects of the resource?

Appendix 2: Achievement and unit standards that might be linked to the teaching of "socio-scientific" issues

(US= unit standard, AS=achievement standard)

Science Level 1

US 6349	Investigate how knowledge of science and related technology is used by people
US 18988	Interpret information from a range of sources
AS 90187	Research, with direction, how science and technology are related
90188	Describe aspects of biology

Biology level 1

US 6299	Describe how people apply biological principles to plant or animal management
US 18978	Demonstrate knowledge of biotechnology
AS 90162	Research, with direction, how biology and technology are related

Biology level 2

US 6310	Investigate an example of applied biology
AS 90483	Describe the impact of human activities on an ecosystem

Biology level 3

US 6319	Make an informed judgement on a contemporary biological issue
US 6320	Describe a biological technique used in contemporary molecular biology or biotechnology
AS 90714	Research a contemporary biological issue
AS 90718	Describe applications of biotechnological techniques

Appendix 3: Letter to teachers

Dear Teacher,

The New Zealand Council for Educational Research is doing research to evaluate the *Entering the debate on Genetic Modification, by developing a critical thinking response* resource and workshops

The research will involve:

1. surveying teachers who attend Professional Development workshops for the resource, and
2. "case studies" of the resource-in-use in about 3 high schools.

We are currently seeking out potential case study schools. We are hoping to do these case studies in term 1 or 2 this year. The case studies would involve an NZCER researcher visiting the school for a few days, talking to teachers and students using the resource, and looking at how it is used in the classroom.

If you think your school could be a suitable case study for using the resource, please note down your contact details below and hand them back to the Workshop Facilitator.

Thanks very much,

Rachel Bolstad (Researcher), New Zealand Council for Educational Research

Yes, I think my school/class/department might be suitable for a case study of the use of *Entering the debate on Genetic Modification, by developing a critical thinking response.*

My name:_____

My schools name:_____

Phone number: _____

Email: _____

Best time of day/week to contact me: _____

If possible, please indicate:

- how many classes and what year levels would use the resource? _____

- what week(s) would this be happening? _____

Appendix 4: Case study interview schedules

RTLB interview schedule

1. Can you briefly describe your role/teaching background, and how you were introduced to the resource?
2. Can you please describe the unit you have developed, e.g. in terms of
   - the number of lessons it involves?
   - how it fits into the Year 10 science scheme for this term/this year?
   - the aims/objectives/goals of this unit?
3. To you, what are "critical thinking skills", and why should they be featured in students' science learning?
4. How would an observer know, if they went into a classroom, that it was a classroom where students were developing critical thinking skills? (i.e. what would they see happening in the classroom?)
5. How do you think the approach that this unit takes compares to normal teaching practice in Year 10 science at this school?
   - How is it similar/different?
   - If it is different, what is different?
6. How would you describe the four Year 10 classes that are using this resource:
   - in terms of the mix of students in these classes?
   - in terms of any learning issues/challenges for students in these classes?
7. How would you describe the three teachers that are using this resource with these classes? E.g.
   - their approaches to teaching?
   - their perceptions of the learning needs/challenges of their Year 10 students, and how to address these in their teaching?
   - their experience/confidence to teach socio-scientific issues using a "critical thinking skills" approach?
8. Tell me about the process of preparing for the current unit of work. For example:

A. Preparing the lessons and materials: Can you explain what you did, and how you made decisions about:

- Selecting elements/aspects of the resource
- Modifying/adapting material or developing new activities/material
- Gathering other resources

B. Working with the science teachers:

- What did you do to help the teachers get ready for this unit?
- What have been the teachers' responses/reactions to the unit you have prepared?
- How confident do you think the teachers feel about teaching this unit of work?

9. What outcomes would you hope that the "GM by developing critical thinking skills" unit will achieve:

   - For this group of students?
   - For this group of teachers?
   - For other students or teachers at this school? (now or in the future)
   - For future use of the resource, at this school?

10. How do you think things are going so far with this unit?

    - For students?
    - For teachers?

11. Are the lessons working the way that you hoped that they would?

    - What is going well?
    - What (if anything) is not going so well?

12. If you could give advice to the resource developers about how to make this resource work well in schools, what would be your advice? e.g.

    - Would you recommend changes or modifications for the resource itself?
    - Would you recommend additional materials or resources that would help?
    - Would you recommend further support or professional development for teachers? If so, what kind of support/professional development?

13. Is there anything else you would like to say about anything we have discussed?

14. Do you have any questions?

Science teacher interview schedule

1. Can you briefly describe your role/teaching background? E.g.

   - How many years you have been teaching?
   - How many years at this school?
   - Which subjects you teach?

2. How were you introduced to the resource "entering the debate on GM by developing a critical thinking response" , and how did it come to be included in your current Year 10 teaching?

3. To you, what are "critical thinking skills"?

4. Should critical thinking skills be featured in students' science learning? Why/why not?

5. How would an observer know, if they went into a classroom, that it was a classroom where students were developing critical thinking skills? (i.e. what would they see happening in the classroom?)

6. Have you ever taught this topic/area (Genetic modification) before? If so, at what Year levels?

7. How would you compare the current unit to previous units you have taught about GM/GE?

   - How is it similar/different?
   - If it is different, what is different?

8. How do you feel about the activities and teaching approach that the RTLB has developed for this unit?

   - Do you feel confident to teach in this way?
   - Do you think it is a good way to teach this topic?
   - Do you think it is a good way to work with this group of students?

9. How does this unit compare, in terms of teaching approaches or learning activities, to normal practice in your Year 10 science class(es)?

   - How is it similar/different?
   - If it is different, what is different?

10. How would you describe the Year 10 class(es) that you are using this resource with?

    - in terms of the mix of students in the class(es)?
    - in terms of any learning issues/challenges for students in the class(es)?

11. What outcomes would you hope that the "GM by developing critical thinking skills" unit will achieve:

    - For this group of students?
    - For you and the other science teachers?
    - For other students or teachers at this school? (now or in the future)
    - For future use of the resource, at this school?

12. How do you think things are going so far with this unit?

    - For students?
    - For you?

13. What is going well? Is there anything that is not going so well?

14. How are you evaluating how things are going in this unit?

15. Is there anything else you would like to say about anything we have discussed?

16. Do you have any questions?

Student focus group interview guide

1. THE UNIT

- The unit you're doing at the moment—can you describe what it's about? And what you have done?
- Does this unit interest you? (why/why not)
- Have you enjoyed the activities you've done so far? (what have you enjoyed and why?)
- Is there anything you haven't enjoyed, or found difficult?

2a. THE LEARNING

- What do you think your teacher wants you to learn from the things you have been doing in this unit?
- Do you feel like you've learned/or are learning from this unit?

2b. GM/GE

- Is this something new to you? Had you heard much about it before?
- What did you know/think?

3. YOUR CLASS

- Tell me about yourselves and the other students in your class. How would you describe your class as a group of people?
- What things interest you and the other students in your class?

4a. CRITICAL THINKING SKILLS

- Have you talked (or has your teacher talked) about "critical thinking" during this unit? (probe: thinking for yourself, making your own mind up about issues)
- What do you think about this? Is it important?
- Does school help you to think about things this way?
- Are there ways your teachers could help you to work out what you think about issues that interest you?

4b. YOUR IDEAS/OPINONS/INTERSTS

- Do you get the chance to talk about your ideas and interests when you are learning in class? (In science? In other subjects?)

5. GM

Today I've asked for your thoughts and views about the issue of GM/GE. Imagine if I'd come and asked you about GM/GE last term, what do you think you would have said? (probe: same/different?)

Appendix 5: Interview schedule for workshop facilitator

Views about the "teaching GM by developing critical thinking skills" approach

1. What do you think about the *topic/issue* that this resource deals with (i.e. the debate about Genetic Modification). Is this an important/relevant topic for secondary science teaching and learning?
2. What do you think about the teaching *approach* that this resource promotes—that is, aiming to "develop students" critical thinking skills?". Is this important/relevant approach for secondary science teaching and learning?
3. Who do you see as the target group(s) for this resource? Do you have any comments about the target group(s) for this resource?

Views about the resource and the workshops

4. What do you think about the resource itself? E.g.

    - What do you think is *good* about the resource?
    - Do you think the resource has any problems or drawbacks?
    - Do you think it is useful for teachers (and students)?

5. Can you tell me about the workshops you facilitated in support of this resource

    - How were these organised?
    - Who came?
    - What was the content/process for the workshops?
    - How do you feel the workshops went?
    - What were teachers' responses/comments/reactions to the resource/workshops?

Ongoing contact and discussion with teachers

6. Can you tell me about your ongoing contact/conversations with teachers about the resource, and your understandings about why it is or isn't being used?

7. In your opinion, what could help the resource to be used in schools? (or used by more schools/teachers) e.g.

    - Modifications to the resource itself?
    - Strategies for promoting/familiarising teachers with the resource?
    - Strategies for working with teachers to use the resource in their school?
    - Other ideas?

8. Is there anything else you would like to say?

Appendix 6: Interview schedule for science HODs not using the resource with Year 10 students

1. Can you briefly describe your role/teaching background? E.g.
   - How many years you have been teaching?
   - How many years at this school?
   - Which subjects you teach?
2. How were you introduced to the resource "entering the debate on GM by developing a critical thinking response"?
3. Are you currently, or do you plan, to use this resource at your school now or in the future? *(if yes- please describe. If no, can you explain why?)*
4. What do you think about the *topic/issue* that this resource deals with (i.e. the debate about Genetic Modification).
   - Is this an important/relevant topic for secondary teaching and learning? (at Year 10?)
5. Have you ever taught this topic/area (Genetic modification) before? If so, at what Year levels? (and can you describe what/how you taught this?)
6. What do you think about the teaching *approach* that this resource promotes—that is, aiming to "develop students' critical thinking skills?".
   - Is this important/relevant approach for secondary teaching and learning? (at Year 10?)
   - Have you ever taught using this sort of approach?
7. To you, what are "critical thinking skills"?
8. Should critical thinking skills be featured in secondary students' learning? Why/why not?
9. How would an observer know, if they went into a classroom, that it was a classroom where students were developing critical thinking skills? (i.e. what would they see happening in the classroom?)
10. Who do you see as the target group(s) for this resource (in terms of subject, or Year level)?

- Do you have any comments about the target group(s) for this resource?

11. What do you think about the resource itself? E.g.

    - What do you think is good about the resource?
    - Do you think the resource has any problems or drawbacks?
    - Do you think it is useful for teachers (and students)?

12. In your opinion, what could help the resource to be used in schools? (or used by more schools/teachers) e.g.

    - Modifications to the resource itself?
    - Strategies for promoting/familiarising teachers with the resource?
    - Strategies for working with teachers to use the resource in their school?
    - Other ideas?

13. Is there anything else you would like to say, or any questions you would like to ask?