The Science of Yeast: More than the Silent Partner in Technology Education

The New Zealand Primary Curriculum

The 1990s have been a time of on-going curriculum reform within New Zealand. In 1991 a new national curriculum was introduced and the publication of *The New Zealand Curriculum Framework* (Ministry of Education, 1993) gave expression to this educational philosophy by providing a framework for the education of all students from years 1–13 (ages five to seventeen).

In this document the principles, essential learning areas, essential skills, attitudes and values are described. The principles are based on the premise that 'all young people in New Zealand have the right to gain, through the state schooling system, a broad, balanced education' (Ministry of Education, 1993, p. 5). The seven essential learning areas are: Health and Physical Education, The Arts, Social Sciences, Technology, Science, Mathematics and Language and Languages. These learning areas are inter-related and the essential skills of communication, numeracy, information, problem-solving, self-management and competitive skills, social and co-operative skills, physical skills, and work and study skills are developed across all curriculum areas. Attitudes and values along with knowledge and skills are considered to be an integral part of the New Zealand curriculum.

National curriculum statements continue to be developed for each learning area. These describe the expectations for development of knowledge, understanding, skills and attitudes through achievement objectives which are expressed at eight progressive levels and provide a tool for measuring students' progress. Assessment for national monitoring focuses on the national system rather than the individual school and involves a light sample of students at ages eight (year 4) and twelve (year 8).

Primary education in New Zealand covers years 1–8 (ages five to twelve) with a tradition of years 7 and 8 being taught in Intermediate Schools.

Primary schools may achieve a balanced curriculum by allocating specific time blocks to each learning area by using an integrated approach or by using a topic or thematic approach. The non-prescriptive nature of each curriculum document allows schools to design programmes to reflect the unique learning needs of their students with the principles of equity, individuality and the unique position of Maori in New Zealand society being recognised and valued.

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Abstract

Biotechnology education as practised in the New Zealand technology education curriculum provides an opportunity for students to use their scientific understanding during the exploration of technological solutions. This paper describes and analyses a science-focused teaching programme taught to year 2 and 3 (6 and 7 year olds) children that develops an understanding of yeast physiology and scientific methodology. These science understandings are utilised in a subsequent biotechnology-focused programme where children developed a niche market bun product. The science and biotechnology-focused programmes are described and analysed to illustrate how science can be utilised in technology education so that the technology focus is maintained without losing the integrity of the science contribution.

The programme was analysed to illustrate the transformation of science knowledge and technical skills into technological knowledge that drove the realisation of this biotechnological learning experience.

Introduction

Bread making is a popular context for language development in New Zealand primary classrooms. When language development is the focus, children follow a recipe and the experiential situation provides the context for speaking, reading and writing (Smith and Elley,1997). This approach tends to ignore the role of yeast and its properties.

There are, however, other learning areas that are available for New Zealand teachers. *The New Zealand Curriculum Framework* (Ministry of Education, 1993) requires that all children from year 1 (new entrants) to year 13 (16–17 year olds) undertake studies in seven essential learning areas (Health and Physical Education, The Arts, Social Sciences, Technology, Science, Mathematics and Language and Languages) as well as developing the 'essential skills, attitudes and values' that require attention across all curriculum when carrying out these studies (Ministry of Education, 1993, p. 5).

When yeast is identified as a living component of the bread making process there is an opportunity to provide a learning experience with another focus. This focus can be science or technology education. This paper will describe and discuss a teaching programme where a science unit contributed to a technology education programme when biotechnology was selected as the technological area for particular attention. This programme developed by Megan Chambers is described in *Towards Teaching Technology, Knowhow 2, Book 2* (Ministry of Education, 1997) and the following analysis will demonstrate how science education can contribute to a technology education programme without the integrity of each discipline being compromised.

Science knowledge and technical skills contributed to the technological knowledge that these children developed. These contributions will be identified to illustrate how the science of yeast made an essential contribution to the technological process that was worked through by these children who were in years 2 and 3 (6 and 7 year olds).

The following account will:

- discuss the role of science in biotechnology education
- describe a primary classroom programme where the science of yeast was taught to enhance a biotechnology focused programme
- analyse the science knowledge and technical skills that contributed to technological knowledge development for this biotechnological problem solving situation.

The role of science in biotechnology education

The stated aim of the New Zealand technology curriculum document *Technology in the New Zealand Curriculum* (Ministry of Education, 1995, p. 8) is to develop technological literacy for the learner across a broad range of technological areas. These areas are listed as biotechnology, electronics and control technology, food technology, information and communication technology, materials technology, production and process technology and structures and mechanisms. In contrast to the England and Wales curriculum document (Department for Education and Employment, 1995), design is acknowledged as an essential component of the technological process rather than the prime focus.

Technological literacy is a concept that encompasses an understanding of the technological knowledge and skills, technological capability as well as an understanding and an awareness of the societal influences on any technological outcome (Ministry of Education, 1995, p. 8). Students are expected to be provided with learning experiences that enable their exploration of these facets of technological literacy (Jones, 1997) in the range of technological areas listed above.

Biotechnology is one of the seven technological areas in the New Zealand technology curriculum and its definition acknowledges the central role of living organisms in the biotechnological process. It states that:

> '...biotechnology involves the use of living systems, organisms or parts of organisms to manipulate natural process in order to

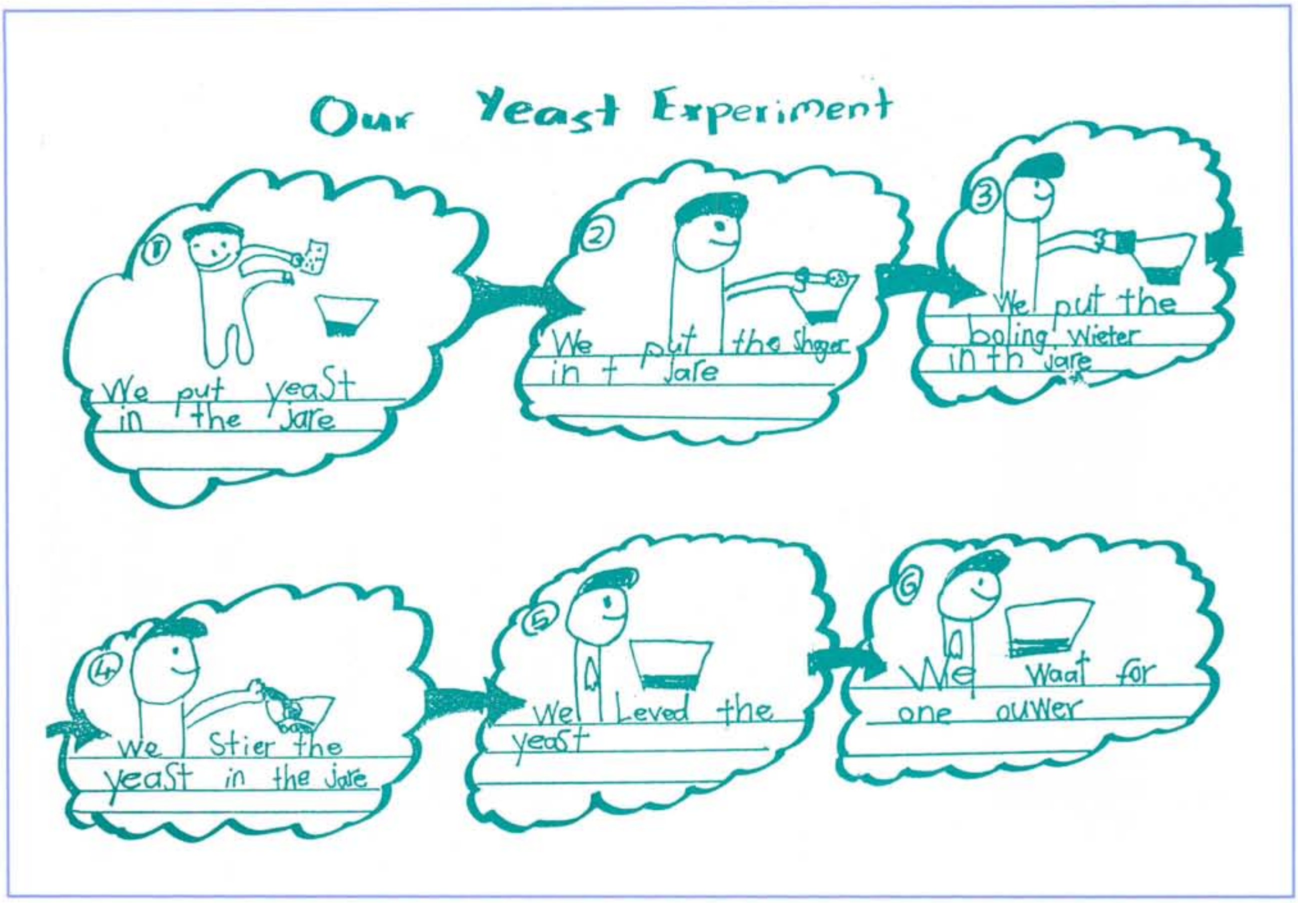

Figure 1: Our yeast experiment. Annotated sequence of drawings that describe the activation process when boiling water was substituted for warm water.

develop products systems, or environments to benefit people.' (Ministry of Education, 1995, p. 12).

In order to use living organisms or their parts in biotechnological processes effectively it is important to understand their science. The close links between science and biotechnology can be translated into an applied science approach to technology and when this view is in operation there is the assumption of a causal relationship between the development of scientific understanding and technological applications (Gardner, 1995). This provides a limited view of the biotechnological process (France, 1997) and in accordance with Jones and Carr's (1993) research that demonstrates that teachers' views of technology strongly influenced their teaching approach, it is important that an applied science view of biotechnology is not adopted.

Although there are close links between science and technology there are differences in the purpose and the way their end points are achieved. Layton (1971) summarises the goals of the science and technology communities as 'knowing' for science and 'doing' for technology, where 'knowing' in science results in the generation of scientific explanations that can be used to explain a variety of examples. In contrast the practice of technology is focused on a particular outcome that is specific for that situation (Farmer, 1994 and Gilbert, 1993).

When biotechnology education is the focus, the difference between the scientific study of living organisms and their use in biotechnological processes needs to be made plain if an applied science focus is to be avoided.

The following teaching programme demonstrates how Megan's class was able to use their science understanding to enhance a biotechnological problem solving situation. Megan taught the programme 'What is Yeast?' with a science focus, followed by 'We Can Make Bread' with a biotechnology focus to a class of 32 year 2 and 3 (six and seven year olds) children in an unspecialised primary classroom.

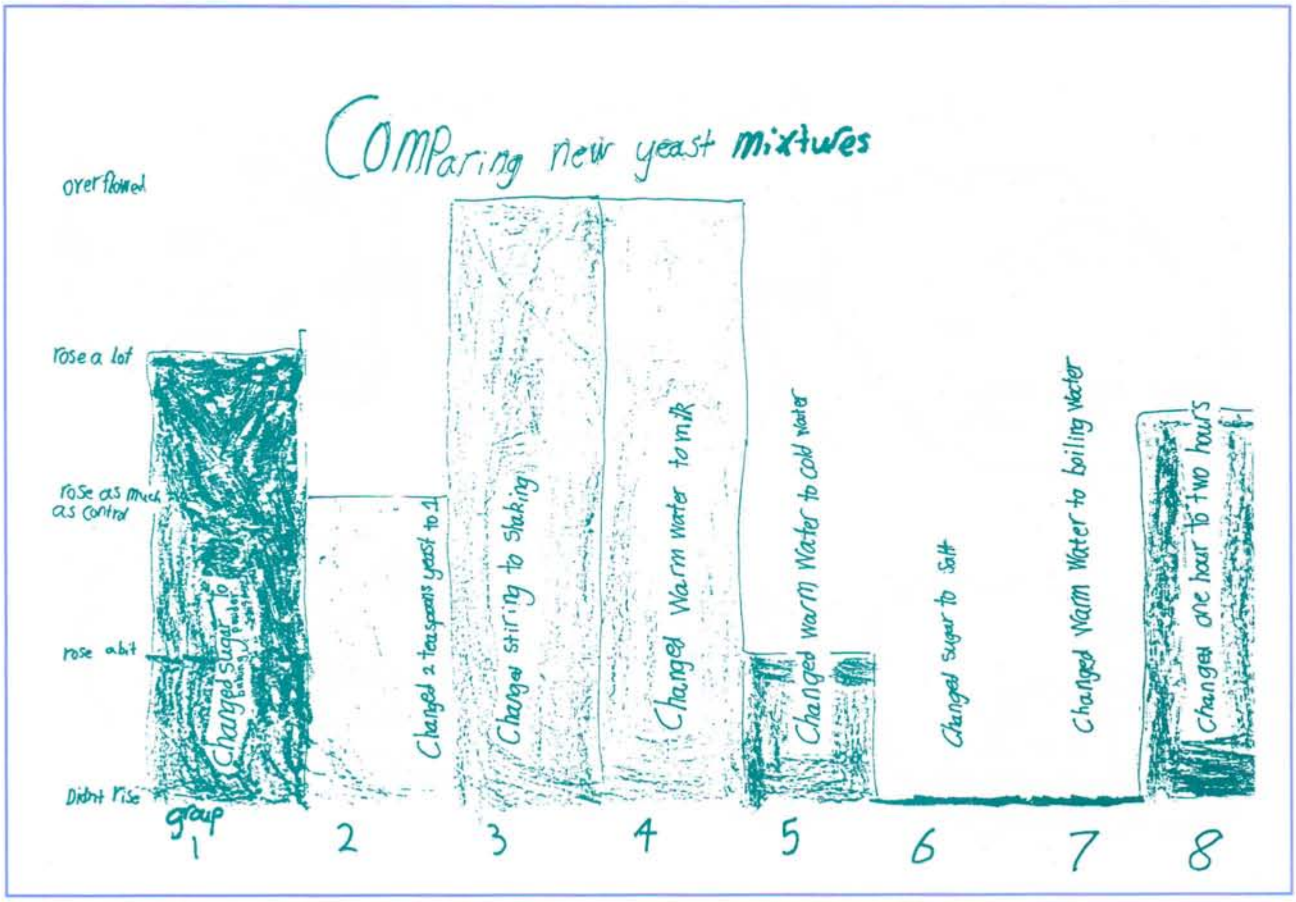

Figure 2: Comparing new yeast mixtures. The description of each mixture was decided by the class and each group contributed to the histogram that was recorded in a shared record book.

Description of the primary programme that focused on science and biotechnology.

Science programme: 'What is Yeast?'

During this science programme Megan explored yeast physiology by explaining and modelling the scientific method when setting up experiments. She demonstrated the procedure for activating dried yeast and the class practised this technique. This experimental situation showed children that warm water and sugar were necessary for yeast to produce gas bubbles and gave them the opportunity to observe that gas bubbles were given off over a period of time. An understanding of the scientific method was developed when children were required to identify the components of the yeast activation mixture and select one aspect to change.

In this exercise children substituted baking powder for sugar, milk for water, salt for sugar, cold water for warm water, boiling water for warm water and two teaspoons for one teaspoon of yeast.

Each child was expected to develop a sequence of annotated drawings that recorded their experiment where they altered one component of the activation process so that they could compare this reaction with the standard process. An example of one of these sequences has been drawn by Alison (a pseudonym).

The salt substitution group predicted that the solution would rise but their observations noted the reverse situation '*with salt instead of sugar it won't rise*'. The warm milk substitution group thought the solution '*would go a bit fat*' and their comments demonstrated that they had some understanding of the comparative nature of a control with the prediction that they thought '*it would go bigger than the control if we use milk*'.

The group that substituted baking powder for sugar found out that there were more bubbles produced initially, but the bubble production did not continue.

'The mixture rose before my own eyes. It smells nice then it went down quickly.

When yeast granules, baking powder and warm water mix they make it go up and down quickly.'

All of these different activation yeast mixtures were compared in a combined group histogram. Megan initiated a 'qualitative' measure of comparison when these children described the amount of bubbles produced as didn't rise, rose a bit, rose as much as the control, rose a lot and overflowed.

The class summarised their understanding in a collaboratively developed shared book.

'Now we know what a control is. It's one experiment that is normal so that we can compare results. We have also learned that yeast is made up of tiny living bugs but what makes them rise or not rise is in the yeast mixture.'

The following account of the biotechnology focused teaching programme 'We Can Make Bread' demonstrates that these children were able to use their scientific understanding of yeast physiology and scientific method to manipulate variables when working through the biotechnological process.

Biotechnology programme: 'We Can Make Bread'

Megan taught her class how to make and bake buns. During this period of technical skill development the children identified and selected equipment, measured ingredients, activated the yeast, mixed and proved the dough, kneaded the dough and formed it into buns and baked them in small bench top ovens that were part of the school's technology equipment.

Once children were equipped with this bread making skill they were asked to identify a niche market for their own speciality bun. The class identified the following markets: adults, grandparents, children, babies, teenagers, pregnant women and sick people.

The idea of changing a variable in a scientific experiment was translated into this technological situation when children were required to change their basic bread recipe so they could fulfil the requirements that they had identified from the questionnaire they had administered to their target group. The substitution of ingredients reflected the procedure they had carried out in the science unit when they investigated the optimum conditions for yeast activation. The range of additives selected reflected the range of target groups. For example some children decided to incorporate chocolate and hundreds and thousands into buns baked for children. It was amusing to note the questionnaire developed for the grandparents target group probed their need for mushy bread. Surprisingly these grandparents didn't take to this idea, false teeth or not, and instead indicated they preferred a wholemeal flour substitution for standard flour (see Figure 3).

The buns were made and a taste-test evaluation was conducted with the target group. From this analysis the children were able to specify any alterations that were required in the next baking. All of these experiences contributed to the children developing a bun that fulfilled the requirements of their identified niche market.

Analysis of technological knowledge development

Megan was able to direct her class's attention to what they had found out about yeast physiology and use this knowledge in the bread making process. Her careful

Baking in progress.

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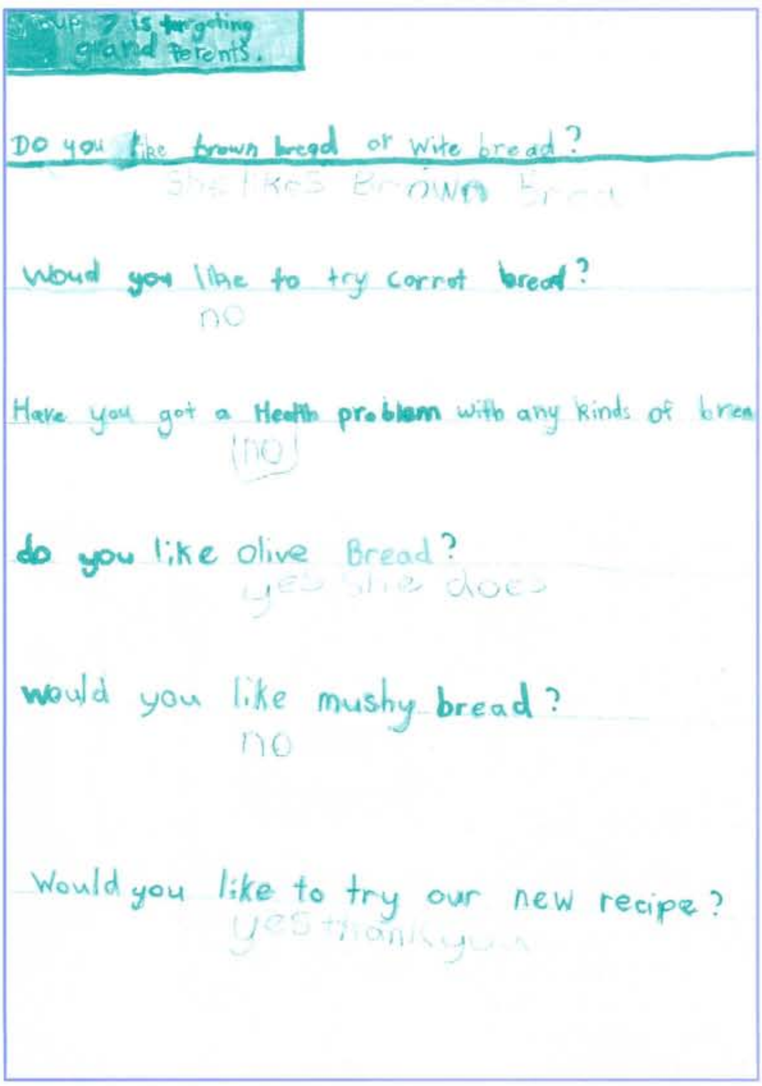
The finished product



Group 7 is targeting grand parents.

Do you like brown bread or wite bread?
She likes Brown bread

Would you like to try carrot bread?
no

Have you got a Health problem with any kinds of brea
no

do you like olive Bread?
yes she does

would you like mushy bread?
no

Would you like to try our new recipe?
yes thankyou

Figure 3: Questionnaire developed for grandparents

classroom analysis and modelling of scientific methodology enabled her class to use these techniques when there was a biotechnological focus.

Figure 4 identifies the science understanding that has contributed to the biotechnological process.

An understanding of scientific methodology enabled these children to identify and isolate variables when altering the bun recipe. They understood the concept of fair testing when they compared differing methods of yeast activation and used these processes in their analysis of their buns. They used quantitative measuring skills when variables were altered in the yeast activation experiment and these techniques were employed when ingredients were substituted in the bun recipe. Quality control procedures were developed from their understanding of fair testing and the children's understanding of a control was used when they compared the range of buns produced with the standard buns.

In addition the understanding that yeast was a living organism and knowledge of its basic physiology helped these children monitor and provide optimum conditions for yeast activation and dough formation.

Technological knowledge is specific for each context (France, 1997 and Staudenmaier, 1989) and in this situation the biotechnological knowledge for bread making had been developed during the programme.

The following quotes from the collaboratively developed book that recorded the process and an analysis of the lesson sequence provide the data for the following table (Table 1), identifying the scientific knowledge and technical skills that these children developed during this biotechnological learning experience.

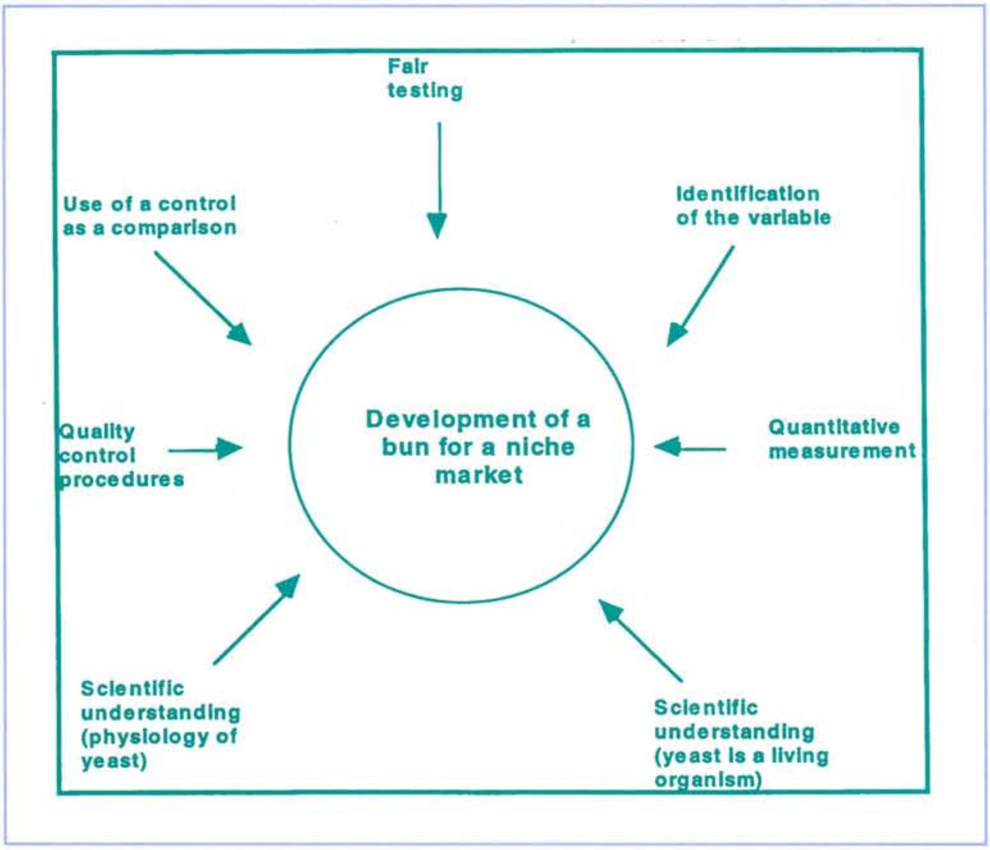


Figure 4: Science understandings that have contributed to the biotechnology unit 'We Can Make Bread'.

Data from the recording book:
We found out that:

Yeast helps bread rise
Boiling water kills yeast organisms
Yeast rises because it is alive
Warm milk makes yeast overflow
Yeast doesn't keep on rising forever
Sometimes yeast does not rise
Baking powder makes the rising and falling quicker
Cold water does not activate yeast
Leaving yeast over half an hour it rises more
Yeast needs warmth to rise

Discussion

Staudenmaier's (1989) view that technological knowledge is restuctured by the demands of the situation, set within a context, informs the process and arises out of practice is illustrated in this analysis of the bread making process that was carried out by year 2 and 3 children. Carrying out the technological process involved children developing scientific attitudes and mastering technical skills which contributed to their developing technological capability. Of course there were many other disciplines and technological areas that contributed to this teaching programme such as social studies where the class explored the role of yeast and bread in differing historical concepts as well as the role of bread in different cultures and religions. These aspects of bread making enhanced their appreciation of societal influences on technological solutions.

During this programme Megan was also able to integrate language, mathematics and the development of the 'essential skills' (Ministry of Education, 1993) into this biotechnology-focused teaching programme. Even though the integration of these curriculum areas is not part of this account it is important to mention the diversity of the knowledge areas drawn on in order to demonstrate that science was not the only contributing discipline.

This teaching programme demonstrates that science education does not need to be the major focus when biotechnology is used as a context. Instead, science education can be employed to enhance the development of a biotechnological solution. The science and technology programmes contributed to the

Science knowledge	Technical skills	Technological knowledge
Yeast is a living organism	Observation How to activate yeast	Identification of the optimum conditions for dough proving
Yeast requires sugar and warm water to activate and takes time	Measurement of ingredients Sequencing Following a recipe	Adaptation of a recipe for a niche market Allowing appropriate time for proving
Bubbles of gas are produced when yeast works	Observation Measurement and comparison	The proving period is limited Identification of ingredients and optimum conditions for proving
Yeast activity changes when you alter the substances	Identification of components Measurement	Varying the recipe according to specifications Quality control of the bread making process
Yeast works better with warm water than boiling or cold water	Temperature measurement Comparison of bubble production	Identification of the optimum temperature to activate the yeast
Scientific method only allows one variable to be changed at a time	Selection of the variable Keeping all other variables constant	Realistic predictions about what might happen when additives are introduced and conditions changed
A control is used as a comparison	Measurement of bubble height Description and conversion into a visual image (histogram)	Quality control Comparison of product against standard recipe

Identification of science knowledge and technical skills that contributed to the developing technological knowledge that was needed to solve this biotechnology-focused problem.

children's appreciation and understanding of technological literacy (Ministry of Education, 1995, p. 8) where technological knowledge, capability and an understanding of societal influences could be explored during the development of a solution to a biotechnology-focused problem.

The science of yeast contributed to the biotechnological problem of making buns for a specialised market niche. In this situation the science of yeast was transformed from a silent partner to the living and active component of the biotechnological process.

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