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Appendix 1

The 66 specific outcomes for the eight learning areas

L E A R N I N G A R E A S

Arts and Culture	Human and Social Sciences	Life Orientation	Economic and Management Sciences	SPECIFIC OUTCOMES
1. Apply knowledge, techniques and skills to create and be critically involved in arts and culture processes and products.	1. Demonstrate a critical understanding of how South African society has changed and developed.	1. Understand and accept themelves as unique and worthwhile human beings	1. Engage in entrepreneurial activities.	
2. Us the creative processes of art culture to develop and apply social and interactive skills.	2. Demonstrate a critical understanding of patterns of social development.	2. Use skills and display attitudes and values that improve relationships in family, group and community.	2. Demonstrate a personal role in the economic environment.	
3. Reflect on and engage critically with arts experience and works.	3. Participate actively in promoting a just, democratic and equitable society.	3. Respect the rights of people to hold personal beliefs and values.	3. Demonstrate the principles of supply and demand and the practices of production.	
4. Demonstrate an understanding of the origins, functions and dynamic nature of culture.	4. Make sound judgements about the development, utilisation and management of resources.	4. Demonstrate value and respect for human rights as reflected in *ubuntu* and other similar philosophies.	4. Demonstrate managerial expertise and administrative proficiency.	
5. Experience and analyse the role of the mass media in popular culture and its impact on multiple forms of communication and expression in the arts.	5. Critically understand the role of technology in social development.	5. Practise acquired decision making skills.	5. Critically analyse economic and financial data to make decisions.	
6. Use art skills and cultural expressions to make an economic contribution to self and society.	6. Demonstrate an understanding of inter-relationships between society and the natural environment.	6. Access career and other opportunities and set goals that will enable them to make the best use of their potential and talents.	6. Evaluate different economic systems from various perspectives.	
7. Demonstrate an ability to access creative art and cultural processes to develop self-esteem and promote healing.	7. Address social and environmental issues in order to promote development and social justice.	7. Demonstrate the values and attitudes necessary for a healthy and balanced lifestyle.	7. Demonstrate actions which advance sustained economic growth, reconstruction and development in South Africa.	
8. Acknowledge, understand and promote historically marginalised arts and cultural forms and practices.	8. Analyse forms and processes of organisations.	8. Evaluate and participate in activities that demonstrate effective human movement and development.	8. Evaluate the interrelationships between economic and other environments.	
	9. Use a range of skills and techniques in the human and social sciences context.			

SPECIFIC OUTCOMES	LEARNING AREAS			
	Language, Literacy and Communication	**Mathematical Literacy and Mathematics**	**Natural Sciences**	**Technology**
	1. Make and negotiate meaning and understanding.	1. Demonstrate an understanding about ways of working with numbers.	1. Use process skills to investigate phenomena related to the natural sciences.	1. Understand and apply the technological process to solve problems and satisfy needs and wants
	2. Show critical awareness of language use.	2. Manipulate number patterns in different ways.	2. Demonstrate the acquisition of knowledge and an understanding of concepts and principles in the natural sciences.	2. Apply a range of technological knowledge and skills ethnically and responsibly
	3. Respond to the aesthetic, affective, cultural and social values in texts.	3. Demonstrate an understanding of the historical development of mathematics in various social and cultural contexts.	3. Apply scientific knowledge and skills to problems in innovative ways.	3. Access, process and use data for technological purposes.
	4. Access, process and use information from a variety of sources and situations	4. Critically analyse how mathematical relationships are used in social, political and economic relations	4. Demonstrate an understanding of how scientific knowledge and skills contribute to the management, development and utilication of natural and other resources.	4. Select and evaluate products and systems
	5. Understand, know and apply language structures and conventions in context.	5. Measure with competence and confidence in a variety of contexts	5. Use scientific knowledge and skills to support responsible decision making	5. Demonstrate an understanding of how different societies create and adapt technological solutions to particular problems
	6. Use language for learning.	6. Use data from various contexts to make informed judgements.	6. Demonstrate knowledge and understanding of the relationship between science and culture.	6. Demonstrate an understanding of the impact of technology.
	7. Use appropriate communication strategies for specific purposes and situations.	7. Describe and represent experiences with shape, space, time and motion using all available senses.	7. Demonstrate an understanding of the changing and contested nature of the natural sciences.	7. Demonstrate an understanding of how technology might reflect different biases and create responsible and ethical strategies to address them.
		8. Analyse natural forms, cultural products and processes as representations of shape, space and time.	8. Demonstrate knowledge and understanding of ethical issues, bias and inequities related to the natural sciences.	
		9. Use mathematical language to communicate mathematical ideas, concepts, generalisations and thought processes.	9. Demonstrate an understanding of the interaction between the natural sciences, technology and socio-economic development.	
		10. Use various logical processes to formulate tests and justify conjectures.		

Appendix 2

The breakdown of competencies for each of the seven educator roles

ROLE: LEARNING MEDIATOR
Practical competencies:
Using key strategies such as higher level questioning, problem-based tasks and projects; and appropriate use of group work, whole class teaching and individual self-study.
Adjusting teaching strategies to: Match the developmental stages of learners, meet the knowledge requirements of the particular learning area; cater for cultural, gender, ethnic, language and other differences among learners.
Using media and everyday resources appropriately in teaching including judicious use of: common teaching resources such as text-books, chalkboards and charts; other useful media like over head projectors, computers, video, audio etcetera.; popular media and resources, like newspapers, magazines and other artefacts form everyday life.
Foundational competencies:
Understanding the pedagogic content knowledge – the concepts, methods and disciplinary rules- of the particular learning area being taught.
Understanding the learning assumptions that underpin key teaching strategies and that inform the of media to support teaching
Reflexive competencies:
Defending the choice of learning mediation action undertaken and arguing why other learning mediation possibilities were rejected.
Reflecting on how teaching in different contexts in South Africa effects teaching strategies and proposing adaptations.

ROLE: INTERPRETER AND DESIGNER OF LEARNING PROGRAMMES AND MATERIALS
Practical competencies:
Adapting and/or selecting learning resources that are appropriate for age, language competencies, culture and gender of learner groups.
Designing original learning resources including charts, models, worksheets and more sustained learning texts.
Foundational competencies:
Understanding the principles and practices of OBE, and the controversies surrounding it, including debates around competence and performance.
Understanding the learning area to be taught, including appropriate content knowledge, pedagogic content knowledge, and how to integrate this knowledge with other subjects.

ROLE: LEARNING AREA/SUBJECT/DISCIPLINE/PHASE SPECIALIST
Practical competence
Adapting general educational principles to the phase/subject/learning area.
Selecting, sequencing and pacing content in a manner appropriate to the phase/subject/learning area; the needs of the learners and the context.
Selecting methodologies appropriate to learners and contexts.
Integrating subjects into broader learning areas and learning areas into learning programmes.
Assessing in a manner appropriate to the phase/subject/learning area.
Teaching concepts in a manner which allows learners to transfer this knowledge and use it in different contexts.
Foundational competence:
Understanding the assumptions underlying the descriptions of competence in a particular discipline/-subject/learning area.
Understanding the ways of thinking and doing involved in a particular discipline/subject/learning area and how these may be taught.
Knowing and understanding the content knowledge of the discipline/subject/learning area.
Knowing of and understanding the content and skills prescribed by the national curriculum.
Understanding the difficulties and benefits of integrating this subject into a broader learning area.
Understanding a range of assessment approaches appropriate to the learning area/subject/discipline/phase/sub-field
Understanding the role that a particular discipline/subject/learning area plays in the work and life of citizens in South African society – particularly with regard to human rights and the environment.
Reflexive competence:
Reflecting on and assessing own practice.
Analysing lesson plans, learning programmes and assessment tasks and demonstrating an understanding of appropriate selection, sequencing and pacing of content.
Identifying and critically evaluating what counts as undisputed knowledge, necessary skills, important values.
Making educational judgements on educational issues arising from real practice or from authentic case study exercises.
Researching real educational problems and demonstrating an understanding of the implications of this research.
Reflecting on the relations between subjects/ disciplines and making judgements on the possibilities of integrating them.

Appendix 3

The specific outcomes, assessment criteria and range statements for technology education in Curriculum 2005 for the senior phase

SPECIFIC OUTCOME 1: UNDERSTAND AND APPLY THE TECHNOLOGICAL PROCESS TO SOLVE PROBLEMS AND TO SATISFY NEEDS AND WANTS

The technological process refers to the cycle of investigating problems, needs and wants and the designing, developing and evaluating of solutions in the form of products and systems. The technological process is the basis of all technological endeavours. An understanding of the process is fundamental to the acquisition of technological literacy. The technological process is an integrated and indivisible one and therefore assessment should apply to the whole process.

ASSESSMENT CRITERIA	RANGE STATEMENT
	At this level learners should show detailed, logical and articulate work indicating understanding of the integrated nature of the technological process. Learners should engage in processes of: • investigating (research) • planning and designing • developing (constructing, making, modelling) • evaluating (measuring, testing, deciding) Learners should apply the technological process in respect of the following South African and global themes: housing, textiles, communications, water, transport, food, energy, health, tourism, agriculture, manufacturing, media, sport and recreation; and in the following learning context: Perspective: local, national, international Modes: individual, pair and group work Presentation styles: oral, written, graphical, modelling, products, artefacts and simulation Resources: texts, interviews, observation, experimentation

SPECIFIC OUTCOME 2: APPLY A RANGE OF TECHNOLOGICAL KNOWLEDGE AND SKILLS ETHICALLY AND RESPONSIBLY

Technological knowledge and skills form the backbone of this learning area as it increases the learner's capability to engage confidently with the technological process and within a technological world. This outcome further seeks to develop the learner's ability to apply this acquired knowledge and skills in an ethical and responsible manner.
In this outcome evidence of achievement should show the acquisition of knowledge and skills in respect of the nature, functions and applications of:

- safety; information; materials; energy

in

- Systems and Control; Communication; Structures; Processing.

In practice learners will engage in the above in an integrated way.

ASSESSMENT CRITERIA	RANGE STATEMENT
Learners should present work in which: • knowledge and under-standing of: Systems and Control Communication Structures Processing is reflected • knowledge and understanding of: safety information materials energy as they manifest in Systems and Control • a range of hand and power tools and equipment are used • sensitivity to possible ethical issues and dilemmas is demonstrated • responsible behaviour is demonstrated	Systems and control, communication, structures and processing At this level learners will practice and develop: • investigation skills which include researching, recording, investigating, etc. • design skills which include planning, communicating, graphics, etc. • manipulation skills which include creating and modification according to specifications • evaluation skills including testing, drawing conclusions etc. • sensitivity to problems, dilemmas, issues and choices in society Systems and Control These skills will be applied within an understanding of: • input, process, output • open and closed systems • concepts of technological systems • components and devices • the way signals and information flows in and between systems • the multiple and complex nature of interconnections between and within as well as the control of: mechanical electrical and • hydraulics/pneumatics systems.
	Communication These skills will be applied within an understanding of: • the use of appropriate technical design and development skills, technical language and conventions for product development to meet given purposes and specifications (e.g. layout, printing, graphics and data presentation) Structures These skills will be applied within an understanding of: • Complex, made structures • Reinforcing within – complex made structures – composite materials • Internal and external forces • Simple calculations and formulae associated with volume, force, and other structural theory concepts Context: Shelter, transport, storage, containerisation etc. *Processing:* These skills will be applied within an understanding of: The activity of processing raw materials into refined materials and into products, with waste as a by-product. Processes: • conversion • preservation

	• reduction • combination Context: biotechnology, manufacturing, agriculture, mining ENERGY; MATERIALS; INFORMATION AND SAFETY Learners will develop sensitivity towards, an understanding of and appropriate application skills in the use of energy, materials, information and safety as common features of all technology. *Energy:* • Types and sources • Energy transformation • Energy storage and distribution • Energy as a resource – renewable, available and cost • Application
	Materials: Sources • Types – natural, synthetic and composite • Techniques – Processing (separating, combining, converting, joining, shaping and forming) – Storage – Preservation – Distribution • Properties (physical, chemical and aesthetic) • Selection (form, function, potential and suitability) • Cost Waste management of materials
	Information Safety • Housekeeping, organisation and management • Occupational safety • Appropriate behaviour, dress and procedures • Safe use of tools, equipment and materials • First aid Tools and equipment Understanding the operating principles of tools and equipment. Selection, use and maintenance of tools and equipment: • hand tools and power tools • simple and complex • electric, pneumatic, electronic, mechanical • applications (cutting, soldering, cooking, etc.) Learners should apply the Technological process in respect of the following South African and global themes: housing, textiles, communications, water, transport, food, energy, health, tourism, agriculture, manufacturing, media, sport and recreation.

SPECIFIC OUTCOME 3: ACCESS, PROCESS AND USE DATA FOR TECHNOLOGICAL PURPOSES

One of the features of a rapidly changing world is the accumulation of vast amounts of information and data which has an increasing impact on technology and all other aspects of modern life. In order for learners to engage effectively in the Technological Process, they need to be competent and confident in working with various forms of information and data.

ASSESSMENT CRITERIA	RANGE STATEMENT
Learners should produce work in which: • various types of data are accessed • various types of data are processed • various types of data are used	At this level learners should produce work that is articulate, logical and detailed. They should use combinations of data types in an integrated way to investigate, analyse and make decisions. Learners should understand: **Data storage and communication forms:** • verbal/non-verbal • audio • visual • electronic **Data types:** • numerical • text • graphics within the context of the following processes: • access (identify, observe, research, locate etc.) • process (collate, communicate, compare, evaluate etc.) • use (apply, make choices, accept, reject etc.) Learners should apply data for technological purposes in respect of the following South African and global themes: housing, textiles, communications, water, transport, food, energy, health, tourism, agriculture, manufacturing, media, sport and recreation. and in the following Learning Contexts: Perspective: local, national, international Mode: individuals, pairs, groups Presentation: oral, written, graphical, modelling and simulation Resources: texts, interviews, observation, experimentation

SPECIFIC OUTCOME 4: SELECT AND EVALUATE PRODUCTS AND SYSTEMS

All learners are exposed to a wide variety of products and systems. They need to acquire the critical skills necessary to operate as confidently as consumer and users of technology.

ASSESSMENT CRITERIA	RANGE STATEMENT
Learners should be able to present work in which: Products and systems are effectively selected	Learners at this level should produce ? logical and articulate indicating ? selection and evaluation of products and ? Selection and Evaluation

effectively selected Products and systems are effectively evaluated	• under the need • derive and prioritise the constraints ? influence the choice • compare the characteristics and ? range similar products in respect of constraints • test and evaluate products and systems **Products and Systems** • a range from simple to complex designs • a range from simple to complex application • mechanical, electrical and electronic • services (eg postal service) **Constraints and factors** In drawing comparisons learners should factors such as: • costs and value • aesthetics and ergonomics • social • environmental • materials • durability • life expectancy • fit to purpose • availability and maintenance

SPECIFIC OUTCOME 5: DEMONSTRATE AN UNDERSTANDING OF HOW DIFFERENT SOCIETIES CREATE AND ADAPT TECHNOLOGICAL SOLUTIONS TO PARTICULAR PROBLEMS

Technology is interwoven with the economic, social and cultural fabric of societies. These and other factors have influenced the way technology has evolved in different places and at different times. Learners need to understand the complex and diverse ways in which technology evolves.

ASSESSMENT CRITERIA	RANGE STATEMENT
Learners should be able to present work in which: • Various factors are considered • Different technological solutions are compared • New solutions are predicted? • Causal relationships between main factors influencing technological development are reflected upon • A variety of perspectives, modes, presentations and resources are used	Learners at this level should show detailed, logical and articulate work which reflects: ***Content*** • historical • geographical • cultural • economic ***Process*** • research • observation • analysis ***Context*** Perspective: local, national, international Mode: individuals, pairs, groups Presentation: oral, written, graphical, modelling and simulation Resources: texts, interviews, observation, experimentation

SPECIFIC OUTCOME 6: LEARNERS WILL DEMONSTRATE AN UNDERSTANDING OF THE IMPACT OF TECHNOLOGY

Human values and other factors influence technology. Technology in turn shapes and influences the nature and well being of society, the economy and the natural environment, in both intended and unintended ways. Learners need to appreciate the ways in which technology effects all aspects of life. Outcomes 6 and 7 should preferably be achieved by integrating them with tasks and activities designed to achieve outcomes 1 to 5.

ASSESSMENT CRITERIA	RANGE STATEMENT
Learners should be able to present work in which: • technological impact in a variety of contexts is reviewed	At this level learners should be able to research, analyse and draw conclusions and make predictions about the positive and/or negative impact of technology in the following: **Contexts** • society • the environment • the economy; **Perspectives** • local • national and • global **Time scales** • short • medium and • long term **Consequences** • intended and • unintended nature

SPECIFIC OUTCOME 7: LEARNERS WILL DEMONSTRATE AN UNDERSTANDING OF HOW TECHNOLOGY MIGHT REFLECT DIFFERENT BIASES AND CREATE RESPONSIBLE AND ETHICAL STATEGIES TO ADDRESS THEM

During the course of human history technology has been used to both promote and counter bias. Bias has also influenced the development and use of technology. Learners need to be aware of these relationships and aware of possible bias in their involvement in technological activities.
Outcomes 6 and 7 should preferably be achieved by integrating them with tasks and activities designed to achieve outcomes 1 to 5.

ASSESSMENT CRITERIA	RANGE STATEMENT
Learners should be able to present work in which: • The concept and types of biases are understood and identified. • Biases limiting access to and the application of technology are identified. • Strategies to address biases are developed.	*At this level learners should:* • understand the nature and causes of bias • be sensitive to and understand the complex ways in which bias affects important groups such as – gender – race – age – disability At this level learners should: • research and analyse how access to and benefits of technology have been denied to various groups. • understand the impact of this bias on such groups. • understand how the use and application of technology reflects, interests, priorities and biases in society At this level learners should identify existing and suggest possible strategies to counter biases and address their affects.

APPENDIX 4

Attitude questionnaire for the experimental group

ATTITUDE QUESTIONNAIRE FOR THE EXPERIMENTAL GROUP

Surname and Name: .... Respondent Number: ......

Encircle the number of your choice. Eg. 1 2 (3) 4 5

Numbers 1 to 5 have the following meaning:

1 = Not at all

2 = Not too much

3 = I don't know

4 = Quite a lot

5 = Very much

		Not at all	Not too much	I don't know	Quite a lot	Very much
1	Did you learn anything valuable from this particular task?	1	2	3	4	5
2	Was the research kit of any help to you?	1	2	3	4	5
3	Did you make use of the research checklist which was part of the kit?	1	2	3	4	5
4	Do you enjoy this new method in the teaching of a subject?	1	2	3	4	5
5	Do you think it is valuable to work in small groups with fellow learners?	1	2	3	4	5
6	Do you prefer to rather work on your own?	1	2	3	4	5
7	Did you have to work hard to execute this task?	1	2	3	4	5
8	This method has helped me to learn how to solve problems.	1	2	3	4	5

Appendix 5

Meta-learning checklist and format of the resource kit

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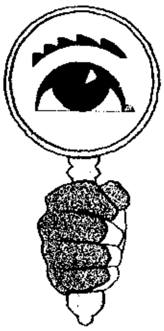
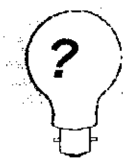
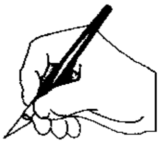
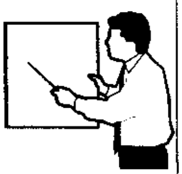
RESEARCH CHECK LIST

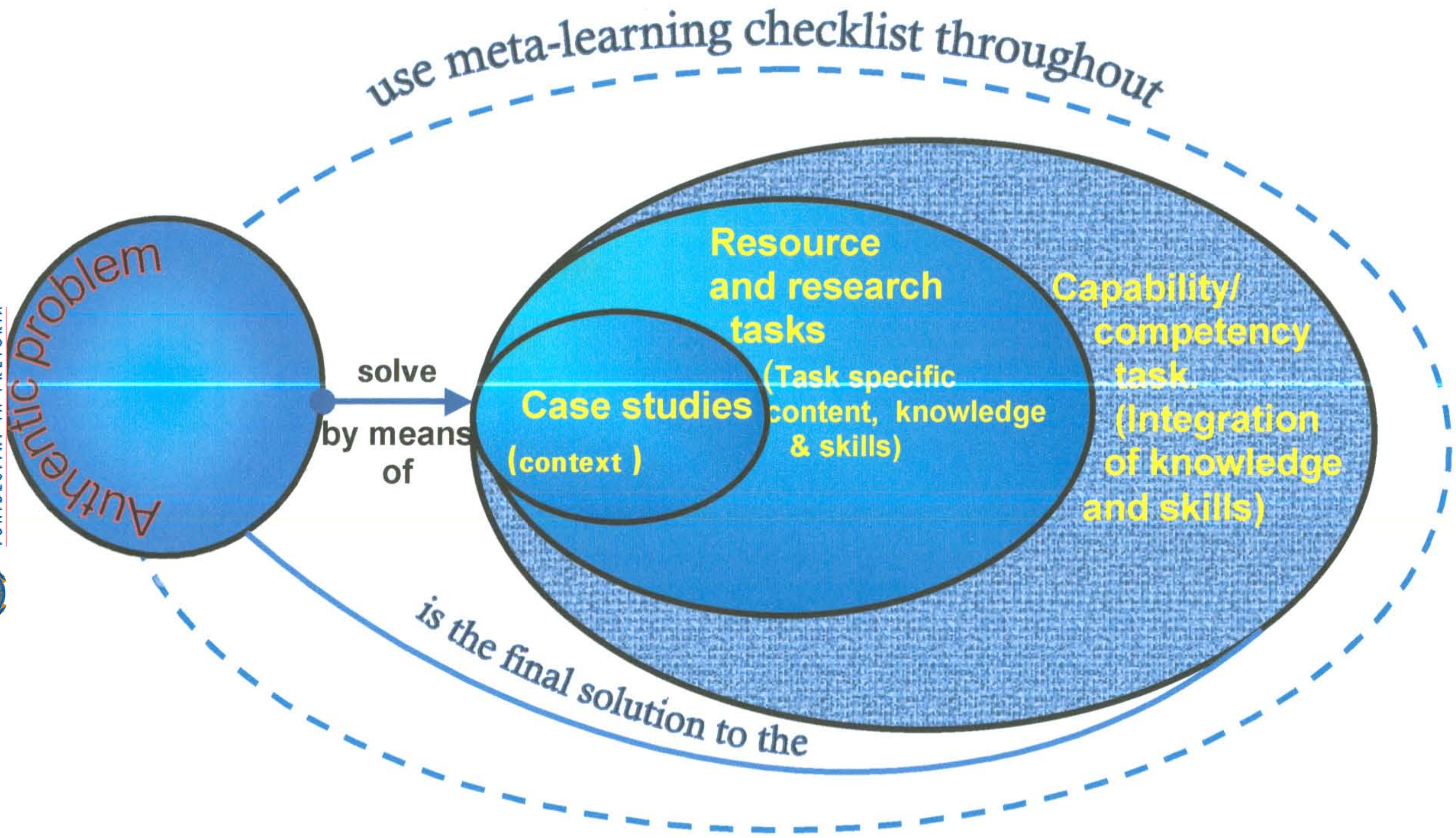
Animation	RESEARCH ACTIVITIES	❖ I have considered this issue ✓ ❖ Needs more consideration ❖ Comments
	Chapter 1: **Chapter 2: PHASE 1: THE PLANNING PHASE**	
	1. We have to solve a problem. Where should we start?	
	2. We first have to understand the problem! How? Should we read it again? Shall we first think about it individually? Shall we discuss it with one another? Do we need to do more reading?	
	3. We need to understand <u>all</u> the requirements and their implications before we can adhere to all of them.	
	4. We will need resources. Where shall we find and access our resources?	

 	5. Are the resources sufficient, relevant and reliable? Do we need to find more/other resources? Like what? ◆ Use the prior knowledge and experiences of each team member as a resource. Some of us might know quite a lot about energy, alternative resources and laws of energy conservation and transfer motion. ◆ Is the information in the information center in terms of books, articles, newspapers? ◆ Is the information in the information center in terms of the internet? ◆ Is the information in terms of video's and TV? ◆ Shall we phone environmentalists, enginees or anyone else who will be able to . ◆ Shall we phone environmentalists, engineers or anyone else who will be able to give advise? Shall we design and execute with prelimenary experiments to gather information.	
 	6. How are we going to organise and manage our team to get to the best solution?! ◆ Will each individual be working on his/her own? ◆ Will all the team members work simultaneously on all the aspects of this problem? ◆ Will each team member first work individually <u>before</u> we get together to brainstorm solutions and designs? ◆ Will each team member research and design their own prototypes and then select the best design and work on that as a team.	

	7. What other planning still needs to be put in place before we can start writing, designing and building our prototype ❖ How and who will manage the technical and language editing of our research and design portfolio? ❖ How and who will manage the presentation to the stakeholders?	
	8. Is each team member enthusiastic about the team's suggested solution?	
	9. Is the suggested solution/or design the <u>best</u> and competitive?	
	10. Are all team members satisfied that the suggested solution is the best one? If not, what else do we need to do?	
	PHASE 2: LET'S START WITH THE EXECUTION OF THE TASK AND SOLUTION OF THE PROBLEM	
	2.1 PHASE 3: MONITOR THE EXECUTION OF THE PLAN	
	While we are busy with the problem solution we need to consistently monitor our progress, quality of work time, and other available resources.	

	11. ◆ Are we still enjoying what we are doing? ◆ Are we still focusing or are we being side tracked?	
	12. ◆ Is our suggested solution and design still the best option? ◆ If not, what and how do we need to adjust it?	
	1. Are we keeping to our time schedule? ◆ If not, why are we behind schedule? ◆ What do we need to do to catch up?	
	14. What else needs to be monitored?	
	2.2 PHASE 4: WE NEED TO ASSESS AND EVALUATE OURSELVES, OUR INPUTS AND OUTPUTS	
	Finally, the last phase! As a team, we have gone through a **process** to get to our final solution, design and technological prototype. Before we can attempt to present or sell this to the world outside, we have to evaluate it **critically** and **objectively**.	
	15. Have we solved the problem?	

	16. Does our solution adhere to the initial requirements? If not, how should we address this fact?	
	17. Is our research and design portfolio complete? ◆ Is it technically and language edited? ◆ Does it display a professional quality?	
	18. Are we satisfied with the prototype? If I am an outside roleplayer, will I invest in this design and prototype for future development?	
	19. The presentation: ◆ How will we divide up for the presentation? ◆ How am I going to prepare for the section which I need to present? ◆ Am I going to make a slide show presentation? ◆ Am I going to make use of transparencies? ◆ Am I going to make use of video clips? ◆ Am I going to present my research data in table and/or diagram/form, format? ◆ Will I be able to answer the questions during the press conference?	
	20. Are we proud of our work?	
	21. Am I proud of myself?	
	22. I need to assess the project.	


use meta-learning checklist throughout
Authentic problem
solve
by means of
Case studies
(context)
Resource and research tasks
(Task specific content, knowledge & skills)
Capability/ competency task.
(Integration of knowledge and skills)
is the final solution to the

Appendix 6

Perceptions on technology, technology education and appropriate methodologies to facilitate learning in technology education of pre-service teachers prior to their PBL training

Vrae /Questions:

1. **Wat is tegnologie? Verduidelik./*What is technology? Explain.***
2. **Wat is tegnologie-onderwys? Verrduidelik./*What is technology education? Explain.***
3. **Is daar 'n verskil tussen tegnologie en Natuurwetenskap?/*Is there a difference between technology and natural physical science?***
4. **Wat is die verskil?/*What is the difference?***
5. **Wat is die effektiefste manier waarop tegnologie onderrig kan word?/*What is the most effective approach of methodology which may be used to teach technology?***
6. **Wat is die stappe van die tegnologiese proses?/*What are the phases in the technology process?***
7. **Dink jy Suid Afrikaanse onderwys is in die posisie om 'n vak tegnologie aan te bied?/*Do you think South African education is positioned to introduce technology as a new subject?***

PRE-SERVICE TEACHER A:

1. Technology is new developments on various terrains which can make life easier. Eg. a sewing machine which helps to safe time and enhance the quality of the final product. It differs from person to person. In Sa the new technologies are not the same as in the USA.
2. Technology education, according to me, is where learners are guided and exposed to developments which can make certain tasks easier and which may be used eg. computer software.
3. Yes, there is a difference.
4. They go hand in hand. Physical science facts/principles are fixed but technology may be developed by using the facts/principles.
5. Through practical application. It does not help to show learners a picture of a sewing machine. They must use it or else it is not technology for them. Learners must also be allowed to discover for themselves with the technology to their disposal.
6. Use equipment to make the best product in the shortest time.
7. Every school will be different and must decide for themselves what they want to offer in the community as technology.

PRE-SERVICE TEACHER B:

1. Technology involves new discoveries and apparatus which makes everyday life easier (comfortable). These apparatus does not necessarily have to be technical/electronical.
2. Where learners get the opportunity (with appropriate guidance) to discover new things and to resolve problems which they encounter and to make them easier. Furthermore, learners can develop the necessary technical skills (and discover knowledge).
3. Yes, somewhat.
4. The two are not exactly the same, but bot have aspects of each in them. Where the two are most similar, is that one has to be inquisitive in the you constantly look for problems and try to solve them. "Need to know" in part of both. It is this attitude which is of utmost importance in technology.
5. Technology cannot be taught – you cannot just use the old paradigm of transfer to learners. You as a teacher have to cultivate the attitude of being inquisitive and innovative and create a learning environment. You can also equip learners with the necessary knowledge (and practical skills) to solve problems effective and creative – through new technological discoveries.
6. No idea. Maybe something like
    - See problem/shortcoming (discover problem after an investigation);
    - Find solutions (few hypothesis);
    - Select the best option (test hypothesis – select the best);

- Evaluate and reflect;
- Back to first step.

7. Not 100% equipped at this moment; because teachers (facilitators are not well trained enough to implement it effectively. The shortage of facilities, media, etc is not (suppose) to be a limiting factor – the subject is about solving the problem!

PRE-SERVICE TEACHER C:

1. It is the progression and development of resources and aids for humans. Technologies used by man is improved constantly – strive for zero defect.
2. Teachers teach learners about the latest technologies. Learners learn about technology and try to make their own developments (improve on existing technology).
3. Yes.
4. As science is currently presented, it comprise the learning of basic scientific concepts (Biological, Physical, Chemical, Mathematical). Technology focuses on the use possibilities (and the production) of these basic concepts.
5. Practical investigations and experiments by learners, but especially research by the learners themselves about the latest technological developments. Teaching has to be done by someone who knows enough and who is interested in the subject, else it would only be another dead subject.
6. I don't really know. Maybe it is like the scientific process of hypothesising, experimenting (repeat and accurate). Verify or reject the hypothesis, formulate a theory and finally produce a final product.
7. SA has a lot of potential, but not the necessary funds to keep up with first world countries. If it's not about money, Yes.

PRE-SERVICE TEACHER D:

1. Personally I don't believe that there is one person who can give an exact definition of technology. For me the word has a very broad meaning. I tend to think about computers and all the modern electronic equipment. However, I know that technology is much more than that.

2. Technology education according to me is very practical and true to every day life. It is about teaching them the processes which should be used to discover equipment for themselves and to improve on it.

3. Yes.

4. Science do the research to develop basic knowledge which engineers then can use to design, develop, produce and improve ideas.

5. According to me the most effective method would be to use real life problems and to present it very practically.

6. No idea.

7. I do not think anyone knows in what position SA is in terms of anything. I do however feel that it should be made possible to present technology as a subject.

PRE-SERVICE TEACHER E:

1. It is the development of equipment, resources and techniques which have to fulfill certain functions in society. It also includes products which makes everyday life easier and quicker so that we can be more productive at a cheaper rate.
2. It is the facilitation of skills which learners have to learn to apply in technology, as well as developing a thinking process where learners have to think beyond the here, now and known.
3. There is a small difference between physical science, technology and engineering.
4. Physical science deals more with theoretical aspects, engineering deals with the practical aspects and technology is a combination of the two fields.
5. The most effective way is to give them practical exposure. The more learners are kept abreast of the latest technologies and the more they actually work with it, the more effective they can be in improvising and contributing.
6. I don't know, maybe it is: identify a problem, find a solution, test, evaluate and implement – it actually is the same steps which engineers use.
7. These days SA can also present technology. Earlier year not , because we were underdeveloped.

PRE-SERVICE TEACHER F:

1. It is the adding of value to ideas.
2. It can have a double meaning. On the one hand it is the teaching about new technology. On the other it is about teaching issues related to a specific area, such as food technology.
3. Yes and no.
4. Both strive for prosperity. In science some theories cannot be improved on such as Einstein's theory. Technology is much more modern than science.
5. Technology will be taught effectively if there are enough equipment (computers!) for each learner.
6. I do not know which process to follow.
7. No, there is not even enough money to buy textbooks. In private schools something like this will work because they have funds available.

Appendix 7

Semi-structured interviews with pre-service teachers after their PBL training and classroom interventions: Transcripts

RESPONDENT NUMBER: Pre-service-teacher 001

Name of School: A

10 September 1998

Question 1:
How did you experience the problem-based approach in your training?

Sjoe- it was really different to what we were used to – but subject didactics is supposed to be more practical than our formal lectures. And it was really practical orientated. In none of the other classes we really had an idea what this new type of teaching was, we were told about it but we never really understood what we had to do if we stand infront of a class. (Tell me more about the problem-based approach which was used to train you in the 6 months). At first we didn't know that you used this type of method called problem-based teaching – you only told us this name later. All I know is that we were given many problems, some shorter and some longer ones which finally helped us to understand tech education. It kept us very busy because we couldn't find all the answers of what we were suppose to do in textbooks – because you didn't; prescribe any.

Question 2:

2.1 How did the learners experience the problem-based approach? Think of your classroom experiences.

2.2 Tell me more about HOW you facilitated the PBL.

2.1 In the beginning they were very enthusiastic because it was something new and different. After 3 weeks the enthusiasm of some faded, because they realised it was not just a play-play task. The time came close to demonstrate their energy devices. They didn't' realise that it was such hard work to do their own research and to plan the whole thing on their own. I think if a facilitator doesn't know what he is doing it can become chaos in a class of 20 and bigger.

2.2 The learning opportunity design was already done and what to do when learners reach a certain stage was decided before the time by all the students. The control class was taught the way we discussed before the time. In the other class I moved in between the different group all the time. Actually all I did was to encourage and motivate them. Although they asked me questions when I reached a group, I didn't really give them any hints, because the idea is that they do the work, isn't it? Sometimes I got the idea that some individuals were very frustrated with this method.

How would you explain to a fellow student or parent what technology education is.

It is to use or apply science knowledge to solve problems which, when solved can make life easier on different levels.

Question 4:
Technology education was facilitated within an OBE framework. What expressions of OBE have you gained through this training and practice experience?

I don't think that you can teach technology in another way than this way. I will definitely use it to teach other subjects as well next year.

Interviewer: Explain more

Student: Finding solutions to problems, is something that cannot be given – the individual has to look for it by doing thorough research. Doing your own research under the guidance of a facilitator is OBE methodology, isn't it?

RESPONDENT NUMBER: Pre-service teacher 003

Name of School: B

9 September 1998

Question 1:
How did you experience the problem-based approach in your training?

Student: Mm – I think at first I found it a loose approach. I am one of those people who like structure.
Interviewer: Briefly explain what you mean by structure?
Student: I guess I like well organized presentations. I must say that I use the word presentation rather than lecture because it fits better into this new stuff. We also don't prepare "lesson" anymore but learning opportunities. I (Yes) tell met more about your training experience. I dind't know anything about technology – at least I understand technology better now and that technology is all about solving some needs of society and that is why you gave us all the .... I mean problems to solve. That is how it is going to be in a technology, or even a science classroom. I don't think that all subjects can be presented like this, but it will work in a subject didactics class.

Question 2:
2.1 How did the learners experience the problem-based approach? Think of your classroom experiences.
2.2 Tell me more about HOW you facilitated the PBL.

2.1 Some of them thought it was playtime because they didn't have formal lessons. For some of them the idea of doing the whole task as a group was the greatest attraction of the whole thing. Normally they work in groups when they do practical work, only – but then they don't' devide the work up so that each is responsible for something. To make sure that teach learner experienced the whole process, I reminded them frequently to use their checklists. They seemed to forget that.

2.2 It took a lot of my energy to work in this way. All the learners wanted your attention at the same time. "If a cooperative group show you their progress it was difficult for me to determine how much feedback to give them. My feedback was of the nature: "That's OK", It's great" "You need to rethink this", "You need to add something and so on"

Question 3:
How would you explain to a fellow student or parent what technology education is.

To teach children to identify problems, to look for solutions and to evaluate it. Technology is need-driven.

Question 4:
Technology education was facilitated within an OBE framework. What expressions of OBE have you gained through this training and practice experience?
Student: I think this training in technology education has given me a good idea of how to teach on a OBE way.
Interviewer: What ideas did you get?
Student:
- How to prepare and design problems.
- How to look for resources for a resource kit and how to plan cooperative groupwork.

Name of School: C

9 September 1998

Question 1:
How did you experience the problem-based approach in your training?

I feel that this training was very practically orientated and relevant and it is this fact which made the course successful. I have personally grown and I believe so have my fellow students. By means of cooperative learning we could access one another on a continuous basis, and we got valuable ideas and information from one another. At the beginning of the year I couldn't' think creatively at all because it was never necessary to be creative. Your approach has challenged me to develop my creative thinking to such an extend that I can think diverse about problems and solutions. For the problems which we had to do first before one went to the schools, I actually landed up in the Department of Biochemistry. I had some valuable discussions with lecturers there which broadened my horizon. Finally I think this approach will not only work for technology, but for many other subjects as well.

Question 2:
2.1 How did the learners experience the problem-based approach? Think of your classroom experiences.
2.2 Tell me more about HOW you facilitated the PBL.
Learners were exited about the whole project after they were presented with the problem. They have asked to work in groups themselves and the class was divided in 4 groups with 5-7 learners per group. Two of the groups have done good research. They have divided the research amongst themselves and each member had to report back to the group on their part of the research.
Interviewer: Did the themselves decide to divide the research work between one another?
Student: No – I told them (facilitated rather) to do that, because I wanted them to work cooperatively – there had to be positive independence. The other 2 groups didn't do much about their research and wanted to know from me certain answers. Some of the learners said that they have really learnt something and that it was fun. Some said it was a waste of time because they have fell behind with their regular work.

Question 3:
How would you explain to a fellow student or parent what technology education is.

When we were asked our perceptions of technology education earlier I said that it is the facilitation of skills which have to mastered to apply and use certain technology, and that it also develops a thinking process where learners have to think beyond the here and now and the familiar. With my new insights into technology education I don't think I was too far out. I still think it is not only about products, but about a thinking process.

Question 4:
Technology education was facilitated within an OBE framework. What expressions of OBE have you gained through this training and practice experience?

Well, in technology education, like in science education learners have to discover and explore on their own. In technology education they have to design and make their own ideas —they are not given a design to just copy and make. It seems to me that is what OBE is all about in practice. These learners had to analyse their own information from the kit and other books and the internet. The other class received notes and lessons within all the information. They were given the experiment and exactly how to do it. They actually only had to follow the prescribed instructions. That's the difference between OBE and the other method.

RESPONDENT NUMBER: Pre-service teachers 004 and 005

Name of School: D

10 September 1998

Question 1:
How did you experience the problem-based approach in your training?
A: There were so many new things that we actually had to learn. We did not really know what technology was. Everybody had their own ideas of this subject because it is so wide.
B: Sorry, I want to add that on top of a new subject, we had to do it in an OBE way.
Interviewer: Did the PBL approach help in any way?
B: Well yeas, technology and OBE is all about applying your knowledge and by giving us problems, we learn how to apply our own knowledge.
A: I don't think we know enough about technology education but at least we know something about the methodology of teaching it.
Interviewer: What is that methodology?
A: Well that learners must do their own research and set-up their own experiments if they want to investigate something.
B: Yes – but you can't really just leave them, some of them wont investigate anything. It will help you if you know the learners and then you put them in a group which will pull them along. It's the same with you R, if you weren't in my group you would do anything.
B, Ag sies man.
A: Joke.
B: Well I am glad that you divided us in groups to do the tasks.
Interviewer: Why?
B: It makes a big task like this much easier and we know all the benefits of groupwork.
What are they?
A: We brainstorm – the more ideas, the better we share the research work amongst us, and we learn how to work with fellow students. That's why R and I decided to do the project together at High School A.

Question 2:
2.1 How did the learners experience the problem-based approach? Think of your classroom experiences.
HOW you facilitated the PBL.

B: Some of the very clever learners felt that the project could have been done in 3 weeks. They forget however that the LEMOSS and other tests took time which was not teaching time. Some said that they also wanted the notes with the other class received, but P explained in nicely to them.
A: Yes, I told them that we didn't want to teach them facts only, but also the process of working through the facts to be able to do something useful with the facts. They understood this ideas quite well.I must say that I am glad that we were two.students.
Interviewer: Why?
I think if a facilitator doesn't know what he is doing it can be chaos in a big class.
Interviewer: Why?
A: There is a lot of noise and the more existed they become the louder they speak. They also move around a lot.
B: For the rest "Some of the groups were fine, but I was really worried about some of the group ....they loose interest if they really don't see their way out. Although we encourage them not to loose heart. I know that I am a facilitator who is not supposed to transfer, sometimes I felt like doing it.
A: I agree with B. I think we experience in working with cooperative groups. The easy way out will be just to tell them what they need so that they could carry on.

Question 3:
How would you explain to a fellow student or parent what technology education is.

A: It teaches a pupil to think problem-orientated. He must comprehend the problem, find a solution, design and make a product ad evaluate it. In the process numerous skills are being learnt through the "resource tasks" which help him to develop into a useful person.
Interviewer: Would you like to give an explanation B?
B: No, I can't improve on A's.

Question 4:
Technology education was facilitated within an OBE framework. What expressions of OBE have you gained through this training and practice experience?

B: I think that I understand now that outcomes are more than facts and textbook content. In technology one of the outcomes is the problem-solving process which learners need everyday in their lives. Outcomes can also be the skills which I has referred to in his explanation of technology.
A: And I think we showed the science teachers in this school a good example of OBE methods.
Interviewer: What are the OBE methods.
A: No lessons, where teachers transfer information but problems and cooperative work where learners look for their own info.

RESPONDENT NUMBER: Pre-service teacher 002

Name of School: E

9 September 1998

Question 1:
How did you experience the problem-based approach in your training?

I like new things. I liked it very much. Yes this was the one subject in which I have learnt the most in the whole year. Except for learning how to design lesson presentations, I also learnt a lot about the subject which I am to teach as well. All the extra effort I had to put in looking for relevant problem settings forced me to look beyond past textbooks. We had the opportunity to look and use everything in the subject didactics, but it also had relevance for our own classrooms next year. The evaluation process were excellent. I think the small theory tests were of utmost importance to refresh our knowledge. The exam evaluation was also very relevant. It tests that which we are supposed to demonstrate in practices

- design and setup ....
- skills
- evaluation skills
- how to apply outcomes-based methodologies

Question 2:
2.1 How did the learners experience the problem-based approach? Think of your classroom experiences.
2.2 Tell me more about HOW you facilitated the PBL.

2.1 Personally I think that the learners in this school have gained very much from this whole project. The problem forced them to use different resources, apart from the kit they received. I know that we had to do the same things in the different schools, but I decided to arrange a field-trip to a coal mine where they could see energy and technology in action. My husband is an engineer there so it was quite easy to organise it. I thought if other schools could use internet as an extra resource, I can use the coalmine experience as an extra resource. The principal liked the idea so much that he said that he would appreciate it if the whole grade 10 science group could go. I got so much support from the principal and the 2 science teachers. It think everybody enjoyed technology with its new approach. When the learners had to build their biogasmaker – I had to stop the parents from doing it. One farther wanted to build a real big thing for his daughters group.

2.2 I gave them a lot of motivation, and I believe if you show your enthusiasm they get it from you.

Question 3:
How would you explain to a fellow student or parent what technology education is.

Student: We all know the definition now, must I give the definition.
Interviewer: Explain to that enthusiastic father what technology education is.
Student: Ok. We use technology education to teach your child to (mmm….) think out different solutions and to select design and make the best solution. Technology is not only making things, but to do proper research before you start making it.

Question 4:
Technology education was facilitated within an OBE framework. What expressions of OBE have you gained through this training and practice experience?

I don't' think you can teach technology in another way, than this way. I will definitely use it to teach other subjects as well next year. If you give them problems and research to do, that is OBE. OBE is about taking them out of the classroom away from one textbook to the real life outside – like I did with the coalmine fieldtrip.

Appendix 8

The learning and motivation strategy questionnaire in science (LEMOSS)

LEMOSS

QUESTIONNAIRE FOR LEARNING

AND

MOTIVATION STRATEGIES

IN NATURAL SCIENCES

N J S BASSON, L F GEER, R GOOSEN

UNIVERSITY OF PRETORIA

INSTRUCTIONS

This is a questionnaire to help you to become a better learner in science. To be able to do this please answer all the questions **VERY HONESTLY**. On every question you must **CHOOSE ONE** of the following answers:

**N = NEVER
**S = SOMETIMES
**F = FREQUENT
**G = GENALLY
**A = ALWAYS

YOU MUST ANSWER ALL THE QUESTIONS

1. When trying to solve a problem in Science I usually do not know where to start and it seems that I can not use anything that I know.

2. While writing Science tests I realize I emphasized the wrong parts and did not realize that the work, that is asked about, was that important.

3. Although I know Science I always have difficulty with solving problems.

4. I do not always understand the essence of some questions in Science examination papers.

5. I always try to find connections between different concepts I study in Science.

6. I always try to investigate laws and definitions again in practice by doing experiments to obtain a clear understanding of the phenomenon.

7. When hearing or reading an explanation or conclusion in Science I look for alternatives with the same meaning.

8. When studying new concepts in Science I always try to relate them to concepts I already know.

9. I always try to find connections between new information that I come across in Science, and my existing knowledge.

10. I use simple diagrams and tables to summarise Science.

11. I use diagrams and tables in Science to organize the contents and form a complete image of the work.

12. I use the headings of chapters in my textbook to identify important aspects of the Science I am studying.

13. While studying Science I try to ascertain which concepts I do not understand.

14. When reading Science I try to follow the logical course of thought and facts by rereading parts of the contents.

15. When I do not understand what I study anymore I start again from the beginning in order to try to understand.

16. I think it is useful for me to study Science.

17. I think I would use the Science I studied in the classroom some day in my profession.

18. I know I can perform very well in Science if only I pay attention in class, do my homework frequently and have enough time to study.

19. If I try hard enough I will understand Science.

20. I would like to perform better in school than most of the other pupils if possible.

21. The greatest satisfaction I get from school work is to achieve good marks.

22. Almost after each test it is clear that I had to cram the information into my head and I only realize later how the information should have been applied.

23. It seems that if I overlook the main points while studying Science, but get entangled in the smaller detail.

24. While studying Science I am convinced that I understand it but when the teacher explains the memorandum, I discover that I did not understand it at all in the first place.

25. During tests and examinations in Science the teacher combines concepts in a single question, that I would never relate to one another.

26. When reading Science, I look for reasons why the work was done in the first place and how it can be applied in problem solving, because it gives me a clue of the logical course of the contents.

27. Before I study new laws, definitions or rules in Science, I try to ascertain which of the concepts they are compiled of, I already know.

28. I memorise new definitions and laws by imagining certain situations that contain the definitions and laws.

29. I try to relate new information in Science to my own experiences gained in the laboratory or in nature.

30. I find it important to know in which cases new information can be applied and when not.

31. I memorise key words to remember important concepts in Science.

32. I first scan through Science briefly in order to obtain the whole image of how it is structured, before I read it thoroughly.

33. While studying Science I think of possible questions that can be asked in the examination.

34. While working through Science I frequently stop to go through the reasoning in my mind.

Appendix 9

Specific outcomes, assessment criteria and range statements for selected outcomes in the natural science Learning Area

Specific Outcome 2	DEMONSTRATE AN UNDERSTANDING OF CONCEPTS AND PRINCIPLES, AND ACQUIRED KNOWLEDGE IN THE NATURAL SCIENCES

This specific outcome is central to the Learning Area of the Natural Sciences. Its concern is to make learners familiar with the developing array of knowledge, concepts and principles within the Natural Sciences. However, the demonstration of a learner's understanding of these concepts and principles should be seen as happening most meaningfully in those specific contexts which involve learners' activities. Theoretical knowledge is necessary but not sufficient. The ability to apply knowledge is essential. The range of learners' actions to attain this outcome is therefore related to the other specific outcomes. These other outcomes relate the Natural Sciences and its array of knowledge, concepts and principles to practical daily-life situations and issues. It is through the ability to use, extend and apply knowledge that a learner can be said to "understand" concepts and principles in the Natural Sciences.

SENIOR PHASE

Assessment Criteria	**Range Statement:**
Learners show work in which:	*In developing their work learners:*
❖ Acquired scientific knowledge, concepts and principles are used to inform actions.	Acquire and develop knowledge and an understanding of scientific concepts and principles – including laws and formulae – (See also S.O. 1, 3, 4, 5, 6 and 8 which concern activities such as investigating, problem solving and decision making in everyday contexts). Learners will develop their understanding of concepts and principles in each of the four Themes, separately or in combination: Key concepts and principles, laws and formulae within the four themes are understood applied in investigating, problem solving and decision making in contexts from either the learners' direct environment, or from environments not directly falling within the learners' day-to-day interests but which are of general importance to learners. Energy & Change: key concepts such as: force, heat, electricity, velocity, homeostasis… .

Specific Outcome 3	APPLY SCIENTIFIC KNOWLEDGE AND SKILLS TO PROBLEMS IN INNOVATIVE WAYS

This specific outcome concerns the development of the capacity of learners to work on problems using scientific knowledge and skills. The outcome is related to specific outcomes 1 and 5. The emphasis, however, in specific outcome 3 is the solving of problems. In the solving of problems, investigations have to be done and decisions also have to be made. It is therefore necessary to consider specific outcome 3 in connection with the assessment criteria and range statements of specific outcomes 1 and 5.

SENIOR PHASE

Assessment Criteria	**Range Statement:**
Learners show work in which: Problems are identified. Relevant information is gathered. Relevant scientific knowledge is selected. Relevant scientific skills are selected. The problem is re-evaluated. Innovative options are generated. Decisions are made. Possible plan of action is communicated.	*In developing their work learners:* Access a wide variety of sources to gather information on problems, scientific knowledge and skills through activities such as practical investigations, using various media and interview-techniques Use scientific skills for investigations (see also S.O. 1, Senior Phase). Use individual and group work strategies to make a detailed plan of action, outlining responsibilities, priorities and an ordered step-wise plan of work which could include experiments. Re-evaluate the problem through group or class presentations, discussions and debates, possibly developing a new perspective in view of all of the information gathered. Brainstorm to generate and debate innovative options and solutions to the problem. Decide on the best option, clearly justifying the choice on the basis of ordered and clearly presented scientific evidence. Communicate conclusions and recommendations in a variety of ways, each of which show logical build-up, coherency and consistency in methods and reasoning. Design and build – where appropriate – a usable device or technology that addresses the problem, or propose a plan of action. Learners will be involved in problem solving activities in each of the four Themes, separately or in combination:: The problems identified could be some general (e.g. provincial or national) importance, and its solution or way of addressing it could have an impact both within and outside the learners' direct environment.

Specific Outcome 5	**USE SCIENTIFIC KNOWLEDGE AND SKILLS TO SUPPORT RESPONSIBLE DECISION MAKING.**

This specific outcome concerns the development – in learners – of the capacity for making informed and responsible decisions, recognizing the use of scientific knowledge in the process of making decisions, and seeing that making decisions has consequences. The outcome is related to other specific outcomes, most notably numbers 1, 3 and 4. In these outcomes high-light aspects related to decision making – such as investigating and problem solving. Specific outcome 5 emphasizes decision making as an important part of using scientific knowledge and skills in everyday life. Important is that learners develop an understanding of how decisions are reached; how information gathering is important; and that scientific knowledge and skills must play a role throughout the process.

SENIOR PHASE

Assessment Criteria	**Range Statement:**
Learners show work in which: Issues are identified. Scientific information relevant to the issues is gathered. Information is prepared for the decision making process. Non-scientific issues are acknowledged. Alternatives are considered. Reasons for decisions are communicated.	*In developing their work learners:* Brainstorm, discuss and debate – using a wide variety of information sources – to identify issues. Access scientific information related to the issues from sources such as textbooks, libraries, television, interviews, pamphlets. Work individually or in a group to identify the critical and essential viewpoints, attitudes and values related to the issue. Reflect and argue how scientific input and other input generate action plans or alternatives. Communicate – in a variety of ways – decisions and possible consequences, relating viewpoints and scientific input in a consistent way. Learners will be involved in decision making in each of the four Themes, separately or in combination: Decision making will take place in a context that might relate to learners' direct experience or might relate to issues that also reflect a more general – but for the learners relevant – national or international concern.