

# The interdisciplinary nature of technology education: a means of promoting 'hands-on' and 'minds-on' activities

## Summary

Because the interdisciplinary nature of technology education facilitates its integration with other school subjects, the first aim of this study was to explore and illustrate the possible link between information technology (typewriting) and technology education. Secondly, the study attempted to determine learners' experiences in respect of the development of thinking skills by means of an interdisciplinary approach. This project was developed within a qualitative paradigm and with fourteen grade 10 pupils. It was evident that a link between the two abovementioned fields can be successfully established and that education can promote the type of meaningful learning which empowers learners to be independent, courageous and responsible in taking decisions. Purposeful learning opportunities must therefore be created in order to enable learners to participate in 'minds-on' activities.

## Die interdisciplinêre aard van tegnologie-onderwys: 'n metode om beide 'hands-on' en 'minds-on' aktiwiteite te bevorder

Vanweë die interdisciplinêre aard van tegnologie-onderwys wat die integrasie met ander skoolvakke moontlik maak, was die doel om eerstens die moontlike koppeling tussen inligtingstegnologie (tik) en tegnologie-onderwys te verken en te illustreer. Die tweede doel was om die persepsies van leerders ten aansien van die ontwikkeling van denkvaardighede in so 'n interdisciplinêre benadering te bepaal. Die projek is binne die kwalitatiewe paradigma, onder veertien graad 10 leerders gedoen. Dit kan afgelei word dat 'n koppeling tussen die twee velde suksesvol gedoen kan word en dat onderwys wat leerders bemagtig om onafhanklike, waagmoedige en verantwoordelike besluite te kan neem, bevorder behoort te word. Doelgerigte geleenthede vir leerervarings, waar leerders deel kan hê aan 'minds-on' aktiwiteite, moet bewerkstellig word.

*Dr A E de Swards & Prof P J Ankiewicz, Dept of Curriculum Studies, Rand Afrikaans University, P O Box 524, Auckland Park 2006; E-mail: aeds@edcur.rau.ac.za & pja@edcur.rau.ac.za*

During the introductory stages of typewriting and technology, instruction is focused on the teaching of keyboard and word processing skills. In these subjects certain schools follow a behaviourist instructional approach, emphasising the promotion of psychomotor skills or 'hands-on' activities (De Swardt 1991), thus neglecting 'minds-on' activities. It is a fact that repetitive learning and memorisation is common practice in South African schools (Mehl 1992: 1). From a survey, it was evident that 30% of learners in developing countries like South Africa, for example, devote their classroom time in physical science solely to the reproduction of knowledge and subject content (Weinstein 1991: 507). The examination process of current South African syllabi is also based mainly on the reproduction of knowledge rather than on promoting problem solving or creative and conceptual thought processes (NEPI 1992: 3). Drawbacks to the memorisation approach are, *inter alia*, that learners do not develop effective learning methods and that there is a discontinuity between the life world of the learners and their school world. This discontinuity results in an inability to meet the technological demands of everyday life where adaptability, coupled with initiative and creative thought, is regarded as vital in fully grasping and understanding complex situations (Custer 1995: 232). The individual is faced with the challenge of providing solutions to problems not based on past experience and knowledge (memory) alone, but involving a deeper technological and intellectual response. This requires technology education to "take advantage of technology as a powerful pedagogic domain for fostering lateral thinking and problem solving" (Waks 1996: 5). In a schedule of expected outcomes for technology education, higher order thinking skills feature prominently (*Technology 2005* 1996). Such outcomes will not be achieved unless creative, critical thinking is taught, fostered and encouraged as an integral part of technology education.

In a highly competitive world economy, critical, innovative thinking has become essential for survival, let alone the achievement of excellence (Willson 1993: 14). Hence the need for thinking skills to be taught at school level. The educational approach should promote 'minds-on' activities and ensure that the pupil learns by discovery and experience. Taking the essential features of technology

education into consideration, the constructivist instructional approach should ideally suit the subject:

... technology activity requires active use of a variety of thinking processes. Problem solving, decision making, planning, evaluating and reflecting are skills that can be reinforced in the technology education classroom (Johnson & Thomas 1992: 11).

In an instructional situation, the aim should be to develop cognitive, affective and psychomotor abilities. This does not take place in the teaching of typewriting, for example, which traditionally focuses on psychomotor skills ('hands-on' activities) with less emphasis on the development and stimulation of thinking skills ('minds-on' activities).

The historical development of technology education indicates its strong association with other school subjects (learning areas). Technology education encompasses such an extensive area and involves so much interdependence with the content of other subjects that an interdisciplinary approach is not unusual. The design process and its associated problem-solving activities are among the essential features of technology education<sup>1</sup> and, because typewriting learners sometimes have to execute a design process as well, the idea of following an interdisciplinary approach and integrating typewriting with aspects of the technological process (the core of technology education) evolved (De Swardt & Ankiewicz 1997: 7).

To illustrate the possible link between typewriting and technology education, one theme from the typewriting curriculum for Grade 10 was adapted to include the technological process. In making these adaptations, cognisance was taken of the essential features of technology education, creative thinking, the teaching of creative thinking, the constructivist approach and co-operative learning (De Swardt & Ankiewicz 1996). Learners were provided with a scenario to serve as a basis for the problem, as well as with certain objectives which could serve as guidelines for the completion of the project. Learners were expected to design a document (the

1 Cf DeLuca 1992: 26; Johnson & Thomas 1992: 7; McCormick *et al* 1994: 5; Custer 1995: 236.

product) for a special occasion. The product had to be small, attractive, colourful and easy to handle. Materials available in the classroom had to be used and the product had to be re-usable.

Because the integration of typewriting and technology education is a fairly novel idea, little or no research has been conducted to assess the experiences of learners exposed to an interdisciplinary approach. This study therefore posed the question: What are the learners' perceptions concerning their learning experiences with respect to thinking skills ('minds-on' activities) within an interdisciplinary approach involving typewriting and technology education?

A qualitative strategy (Krathwohl 1993: 29; Creswell 1994: 159) was the most acceptable and useful research strategy for this project, since the phenomenon examined concerned the learners' perceptions of their learning experiences.<sup>2</sup> The qualitative data collection methods were a spontaneous sketch (Giorgi 1985: 10) and a semi-structured focus group interview.<sup>3</sup>

To ensure the accuracy and credibility<sup>4</sup> of the project, various measures were introduced and applied: a case study was selected on the basis of the convenience principle (Patton 1990: 180; Hoepfl 1997: 51); independent, experienced researchers were involved as coders (Strauss & Corbin 1990: 61), and a thorough literature study was conducted to substantiate the findings derived from the data collected. The principles of triangulation were therefore applied (Cohen & Manion 1994: 233).

Fourteen Grade 10 pupils from a multi-cultural school in the feeder area of the Rand Afrikaans University (RAU) participated in this research project. After completion of the project, all respondents completed the spontaneous sketches under the teacher's supervision. The posed question was: "What were your experiences in relation to this project?" The respondents answered the question in writing.

2 Cf Anderson 1990: 163; Krathwohl 1993: 347; Husen & Postlethwaite 1994: 640; Yin 1994: 12.

3 Cohen & Manion 1994: 271; Creswell 1994: 159; Krueger 1994: 6.

4 Cf Lincoln & Guba 1985: 298; Mouton & Marais 1990: 15; Krefling 1991: 214; Yin 1994: 35.

After the responses had been analysed, meaningful categories (Kerlinger 1986: 481) were identified. In order to elicit more information, seven supplementary questions were formulated. Seven pupils were randomly selected to participate in the semi-structured focus group interview. This interview had to be conducted approximately four months after completion of the project due to the intervention of the end of the school year and the summer holidays. The interview was recorded on video and audiocassettes and a verbal transcription was also made.

## 1. Results

In an environment where learners are accustomed to direct instruction and the reproduction of knowledge, it was revealing to see from the data that they found the new experience different and informative. One should bear in mind that the learners were not fully competent in respect of life experiences and cognitive skills. That they felt they had learned, that they could be creative, that the learning experience made them feel competent, and that they had gained in self-confidence accentuated the importance of the interdisciplinary approach implemented in this project. The transfer of emphasis to a 'hands-on' and 'minds-on' approach is supported by the data.

From the spontaneous sketches and the semi-structured focus group interview, the perceptions of the respondents were divided into three main and thirteen sub-categories. The main categories of learning experience (with 7 sub-categories), co-operative learning environment (with 3 sub-categories) and empowerment (with 3 sub-categories) are presented in Table 1. For the purposes of this article, three sub-categories will be discussed under the main category learning experience, namely creativity, improvement in learning and new experience, thus illustrating the link between 'hands-on' and 'minds-on' activities.

Table 1: Categories of learner experience

Main categories	Learning experience	Co-operative learning environment	Empowerment
Sub-categories	Creativity	Group context	Self-confidence
	Improvement in learning	Sharing	Competence
	New experience	Facilitation	Decision-making
	Research		
	Stress		
	Enjoyment		
	Fun		

### 1.1 Main category: learning experience

One of the aims of effective teaching is to have learners achieve the maximum benefit. It is thus the duty of the teacher (or facilitator) to create a positive learning environment conducive to meaningful learning opportunities and experiences (Woolfolk 1995: 401-36). In this project, both the spontaneous sketch and the semi-structured focus group interview indicated that learning had indeed been enhanced.

The learning experiences were classified in terms of the following sub-categories: creativity, improvement in learning, and new experience (as well as research, stress, enjoyment and fun, which are not discussed in the present study). These sub-categories represent the learner's perceptions in respect of their learning experiences.

#### 1.1.1 Creativity

The new experience and different method of information gathering posed specific challenges to learners and called for initiative. From this point of view, specific stages of the thinking process were present and, due to the lack of background knowledge concerning the theme of the project, creativity had to be employed to acquire the necessary information. Woolfolk (1995: 304) defines creativity as "imaginative, original thinking or problem solving". Robert Sternberg (1996) emphasises that creativity also involves a tolerance of ambiguity, a

willingness to surmount obstacles and to grow, intrinsic motivation, moderate risk taking, a desire for recognition and a willingness to work for recognition. In this research project, learners were required to think innovatively and in a divergent fashion, which brought to the fore abilities of which they were not aware, correlating with the given descriptions of creativity. The respondents' comments excerpted below clearly show that they experienced an extraordinary sense of achievement.

"... had to make an attractive menu ..."

"... [it was] fun and creative ..."

"... it was creative ..."

"... it brought out creativity ..."

"... to use my mind and be creative ..."

"... we used our imaginations to make menus creative ..."

"... then we'd say no it's a bit different..."

"... we had to find a solution ... how to stabilise our menu ... it is very important to make sure we had a stand ... we just got a piece of wood ... and we cut it ... and it stood nicely ..."

"... we used a lot of our creativity ..."

"... to be creative in your own way ..."

"... gave us the chance to use our imagination because in other subjects we don't really have the chance to use our imagination ... never something like this ..."

"Yes more creative things ... much more interesting for the pupils ..."

"... made us very creative ... helped us all be better people ..."

"... it was very creative ... it made me see that I've got talent in drawing ..."

The respondents participating in the project indicated that they had opportunities to search for information, to exploit new ideas and to exchange views. It appears that respondents were exposed to a situation which encouraged creativity. This finding is supported by the literature. In such a learning environment the learner is indeed afforded the opportunity "to produce many unusual and unique ideas" (Young 1992: 49). Open-ended problems (assignments), where the learner is given freedom of choice in terms of gathering information and the generation of ideas, offer more opportunity for the development of critical and creative thinking skills (Wakefield 1996: 459). This correlates with Sternberg's view (1996: 82) that

there should be some scope for creativity in assignments and tests.<sup>5</sup> This approach is also in accordance with the conditions set by Couger (1995: 368) for the development of creativity, namely psychological safety and openness to experience. Evans (1991: 55) also supports the principle and estimates that a conducive climate is created for the development of creativity by:

providing freedom to do things differently, encouraging risk taking,  
[...] providing assistance in developing ideas, and providing time  
for individual efforts.

### 1.1.2 Improvement in learning

In the majority of cases, respondents believed themselves to have learnt more. The fact that new knowledge was acquired and that this was gained via new learning is an indication of the cognitive activities respondents required in order to construct new knowledge. This implies that specific thinking schemes were adjusted or new ones created to accommodate new knowledge in the learning process. The following quotations support this view:

"leer jou meer ... [teaches you more]"

"It taught me how a restaurant is run and how much trouble it goes through to run ..."

"It taught me different varieties of food and drinks ..."

"It improved my typing skills and helped me learn more about my typing machine ..."

"It taught me how important team work is ..."

"I learnt about a lot of different kinds of food and drinks ..."

"I think that I've learnt a lot from it ..."

"What I've learned in this project is that if you are a person there are things you can do ..."

"From that project I've learned that I can have my own restaurant ..."

"... this opportunity to use my mind ..."

"... and learn how to make a menu ..."

5 See Perkins in Brandt 1986: 17; Foster 1994: 34; Facione *et al* 1995: 21; Chubinski 1996: 23.



"I learn some other ways ..."

"... it made me think of many ideas ..."

"... and coming up with ideas of how our menu should work and be like ..."

"We wanted to learn more about different food ..."

"Dinge wat jy eers nie geweet het nie ... [things you did not know at first ...]"

"... meer van terminologie geleer ... [learned more terminology]"

"The more we thought and the more we worked together the more ideas we came up with ..."

"It was a good learning experience. You go out and you do things yourself ... you remember more about what you've done than just reading through it ... then you forget it ... but I'll remember this for the rest of my life."

"It was totally amazing for us when we had to learn many things ..."

"... we just copy what the teachers write ... we never really think what we're doing ... and this time really had to think ..."

The literature emphasises that learning occurs when experience causes a relatively permanent change in an individual's knowledge or behaviour (Biehler & Snowman 1993: G4; Woolfolk 1995: 196). The constructivist view holds that meaningful learning is the active creation of knowledge from personal experience (Biehler & Snowman 1993: 428). According to this view "meaning is 'constructed' by the learner via the interaction of 'new' information with 'old' information" (Marzano 1993: 156). According to Paul (1993: 23) knowledge is a distinctive construction by the learner, illustrated by the rational use of mental processes. Good thinking leads to understanding; thinking is thus the process that produces the outcome of understanding. Understanding implies the application (use) of thinking skills which are "relatively discrete cognitive operations that can be considered the building blocks of thinking" (Langrehr 1988: v; see also Lewis & Smith 1993: 133). When an individual is faced with a perplexing situation or a situation in which it is necessary to decide what to do (combining 'hands-on' and 'minds-on' activities), higher order thinking, requiring the interpretation, analysis or manipulation of information (Lewis & Smith 1993: 133,136). The respondents' perception was that the learning experience had been meaningful in the sense that they had had to

construct new knowledge by using their minds, thinking divergently, planning, developing and evaluating tasks related to their own lives.

### 1.1.3 New experience

The learning experience of the respondents in this project was radically different from anything to which they were accustomed – hence the perception that it was a new experience and that they had gained knowledge. The following responses support this statement:

“Dit was die eerste keer in my lewe ... [It was the first time in my life]”

“It was the first time that I've done a project like this ...”

“(the) idea ... because others like me it was a first time ...”

“... it was my first time to do that ...”

“It was my first time ...”

“I have never experience a TV-screen before ...”

“Firstly, it was a great experience for me ...”

“... it was a first time to do a menu ...”

“It was the first time in the typewriting class ...”

“The more we thought and the more we worked together the more ideas we came up with ...”

“... that's what made our progress even better because every day we came in with more ideas ...”

“Gave us the chance to use our imagination because in other subjects we don't really have that chance to use our imagination ... this was quite different ...”

“We had to decide which kind of restaurant it would be ... what kind of foods would be in that restaurant ...”

“... we had to decide what desserts to put in the menu ...”

“... we had to go to town... you have to go to a restaurant ... you have to save your money to go inside the restaurant and get the menu and eat and see how to choose ...”

“... we decided to save our money together in a group and went to this restaurant in town and sat at the table ...”

“... we had to think of the menu ... like ... it's not only food ... you know food and cool drinks ...”

“We have never thought of starters, the main course and then dessert ... to us it was like one thing ...”

"... we had to get the information ... and then we knew everything about menus ..."

"... your mind worked very much because now you got information ..."

"Normally in the classes we sit and do absolute ... well we just copy what the teachers write down ... we never really think about what we're doing ... and this time really had to think ..."

"... we had to (put) the ideas together and used a lot of our creativity ..."

"We can use this in our other classes ... mind maps ... that is also very creative instead of just writing down long pages we can put it in a mind map and use our imagination ..."

"... actually creates an environment where you learn and remember better ..."

The learners' experiences were categorised without favouring either radical constructivism (Von Glaserfeld 1989) or social constructivism (Cobb 1994; Driver *et al* 1994). Thus, with respect to the sub-category new experience, the comparison with the literature focuses on the essence of constructivism. From the literature it was established that the constructivist view of learning (Wheatly 1991: 12-3; Phillips *et al* 1994: 4; Wakefield 1996: 166) holds that meaningful learning is the active creation of knowledge structures from personal experience. Meaningful learning occurs when people create new ideas or knowledge from existing information (Orlich *et al* 1994: 35). Furthermore, most people agree that learning should to some extent involve problem-solving skills, creativity, basic intellectual skills and a knowledge of the subject matter and that learners should pursue their own problem-solving procedures as well as memorise a predetermined body of knowledge (Biehler & Snowman 1991: 425). Bruner maintains that when learners are given a substantial amount of practice in finding their own new solutions to problems, they not only develop problem-solving skills but also acquire confidence in their own learning abilities along with the ability to function as problem solvers later in life (Biehler & Snowman 1991: 427). This does not mean that learners have to discover every item of information (knowledge) on their own, but rather that they should be guided in discovering how new ideas relate to each other and to existing knowledge. The respondents realised that they were involved in a creative endeavour which required them to combine various ideas, to use their imaginations, and to make judgements and to adapt.

## 2. Conclusion and recommendations

Learners' perceptions in respect of the learning experiences and the associated minds-on activities involved in the project can be summarised as follows:

- More higher order thought development was elicited as a result of the open-ended assignment. Learners were not expected simply to reproduce knowledge.
- Learners' attitudes in respect of self-confidence, competence and ingenuity in thinking were enhanced. They exhibited boldness in investigating the unknown.
- Learners had the opportunity to exercise creativity.
- Learners experienced the methods developed along the lines of a technological process positively and were enthusiastic about this activity.
- Learners learnt more.
- Learners gained new experiences and new knowledge, attained personal goals and evinced better retention.
- A learning environment and learning opportunity that evoked enthusiasm ensured that learning would take place.
- Learners found this approach to learning enjoyable indicating that they would like to repeat it, and even, that it should be applied to other areas of learning.
- The use of co-operative learning enabled learners to benefit to a large degree, for example, in the promotion of social skills such as co-operation, communication and conflict resolution.

The results of the study indicate that:

- An interdisciplinary approach involving typewriting and technology education is possible.
- The accommodation of the technological design and the problem-solving processes in typewriting not only promoted 'hands-on' activities but also 'minds-on' activities among learners.
- The interdisciplinary nature of technology education should not be neglected as a result of the separate subject approach.
- The influence of technology education on other school subjects appears to hold specific advantages in respect of thinking development for learners.

In conclusion, learners should be encouraged to retain and develop the inquisitiveness, the curiosity and the thoughtful attitude which they have when they enter school. We expect them to develop independent thinking and to be innovative and creative. We therefore need to reinvigorate our teaching to include all the thinking skills. Learners need to be actively involved in constructing their own knowledge and the technology education platform provides an ideal opportunity for this in all learning areas and disciplines.

## Bibliography

### ANDERSON G

1990. *Fundamentals of educational research*. London: Falmer Press.

### BIEHLER R F & J SNOWMAN

1993. *Psychology applied to teaching*. Boston: Houghton Mifflin.

### BRANDT R S

1986. On creativity and thinking skills. *Educational Leadership* 43(8): 12-8.

### CHUBINSKI S C

1996. Creative critical-thinking strategies. *Nurse Educator* 21(6): 23-7.

### COBB P

1994. Where is the mind? Constructivist and socioculturalist perspectives on mathematical development. *Educational Researcher* 23(7): 13-20.

### COHEN L & L MANION

1994. *Research methods in education*. 3rd ed. London: MacMillan.

### COUGER J D

1995. *Creative problem solving and opportunity finding*. Danvers: Boyd and Fraser.

CRESWELL J N

1994. *Research design. Quality and quantitative approaches*. London: Sage.

CUSTER R L

1995. Examining the dimensions of technology. *International Journal of technology and Design Education* 5(3): 219-44.

DAVIS R, C N MAHER &

N NODDINGS (eds)

1989. *Constructivist views on teaching and learning mathematics*. Reston, VA: National Council of Teachers of Mathematics. Journal for Research in Mathematics Education monographs, 4.

DELUCA W

1992. Survey of technology education problem-solving activities. *The Technology Teacher* 51(5): 26-30.

DE SWARDT A E

1991. Produktiewe tikonderrig. Ongepubl D Ed-proefskrif. Johannesburg: Randse Afrikaanse Universiteit.

DE SWARDT A E & P J ANKIEWICZ

1996. The application of the technological process in other school subjects to develop technological awareness, literacy and capability among South African learners. Unpubl paper presented at the Pupils' Attitude Towards Technology (PATT-7) Conference in Cape Town, South Africa, 14-17 October 1996.

1997. The application of the technological process in other school subjects: an assessment of creative

thinking. Unpubl paper presented at the Pupils' Attitude Towards Technology (PATT-8) Conference in Scheveningen, The Hague, Netherlands, 17-22 April 1997.

DRIVER R *et al*

1994. Constructing scientific knowledge in the classroom. *Educational Researcher* 23(7): 5-12.

EVANS J R

1991. *Creative thinking in the decision and management sciences*. Cincinnati: South Western.

FACIONE P A *et al*

1995. The disposition towards critical thinking. *Journal of General Education* 44(1): 1-25.

FOSTER W T

1994. A discovery learning activity. *The Technology Teacher* 56: 34-5.

GIORGI A

1985. *Phenomenology and psychological research*. Pittsburgh: Duquesne University Press.

HOEPEL M C

1997. Choosing qualitative research: a primer for technology education. *Journal of Technology Education* 9(1): 47-63.

HUSEN T & T N POSTLETHWAITE

1994. *The International Encyclopaedia of Education*, 2. 2nd ed. Oxford: Elsevier Science.

- JOHNSON S D & R THOMAS  
1992. Technology education and the cognitive revolution. *The Technology Teacher* 51(4): 7-12.
- KERLINGER F N  
1986. *Foundations of behavioral research*. New York: Holt, Rinehart & Winston.
- KRUEGER R A  
1994. *Focus groups. A practical guide for applied research*. Thousand Oaks: Sage.
- KRATHWOHL D R  
1993. *Methods of educational and social science research: an integrated approach*. New York: Longman.
- KREFTING L  
1991. Rigor in qualitative research: the assessment of trustworthiness. *American Journal of Occupational Therapy* 45(3): 214-22.
- LANGREHR J  
1988. *Teaching students to think*. Bloomington: National Educational Service.
- LEWIS A & D SMITH  
1993. Defining higher order thinking. *Theory into Practice* 32(3): 131-7.
- LINCOLN Y S & E G GUBA  
1985. *Naturalistic inquiry*. Newbury Park: Sage.
- MARZANO R J  
1993. How classroom teachers approach the teaching of thinking. *Theory into Practice* 32(3): 154-60.
- MCCORMICK R, P MURPHY & S HENNESSY  
1994. Problem-solving processes in technology education: a pilot study. *International Journal of Technology and Design Education* 4: 5-34.
- MEHL M  
1992. The essence of quality education. Unpubl paper presented at the conference on "Quality education of (e)quality in South Africa". Pretoria: Vista University.
- MOUTON J & H C MARAIS  
1990. *Basic concepts in the methodology of the social sciences*. Pretoria: Human Sciences Research Council.
- NATIONAL EDUCATION POLICY INITIATIVE (NEPI)  
1992. *Report of the science curriculum group*. Houghton: Edunet.
- ORLICH D C *et al*  
1994. *Teaching strategies: a guide to better instruction*. 4th ed. Lexington, Mass: D C Heath.
- PATTON M Q  
1990. *Qualitative evaluation and research methods*. 2nd ed. Newbury Park: Sage.
- PAUL R W (ed) . . . . .  
1993. *Critical thinking*. Santa Rosa: Foundation for Critical Thinking.
- PHILLIPS D R *et al*  
1994. Beans, blocks and buttons: developing thinking. *Educational Leadership* 55(5): 50-3.

STERNBERG R J

1996. Investing in creativity: many happy returns. *Educational Leadership* 53(4): 80-5.

STRAUSS A & J CORBIN

1990. *Basics of qualitative research: grounded theory and procedures techniques*. Newbury Park: Sage.

TECHNOLOGY 2005 PROJECT

1996. Draft framework for developing a national curriculum in technology education. February 1996. Pretoria: Dept of Education.

VON GLASERFELD E

1989. An exposition of constructivism: why some prefer it radical. Davis *et al* (eds) 1989: 18.

WAKEFIELD J F

1996. *Educational psychology — learning to be a problem solver*. Boston: Houghton Mifflin.

WAKS S

1996. Generalist vs specialist teacher in technology education. *Technology For All* 3: 5

WEINSTEIN C S

1991. The classroom as a social context for learning. *Annual Review of Psychology* 27(10): 923-36.

WHEATLEY G H

1991. Constructivist perspectives on science and mathematics learning. *Science Education* 75(1): 9-21.

WILLEN J

1993. Accelerating change, the complexity of problems, and the quality of our thinking. Paul (ed) 1993: 1-16.

WOOLFOLK A E

1995. *Educational psychology*. 6th ed. Boston: Allyn & Bacon.

YIN K Y

1994. *Case study research, design and methods*. 2nd ed. London: Sage.

YOUNG L E

1992. Critical thinking skills: definitions, implications for implementation. *National Association of Secondary School Principals, Bulletin* 76(92): 47-54.