Towards a real-world curriculum for computer studies higher grade in South Africa

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Abstract

The National Education Department of South Africa has mandated a policy of outcomes-based education for all learners and educators in this country. Two of the most important principles of outcomes-based education are collaborative work in groups and continuous assessment by the teacher and peers. In Computer Studies, taken on the higher grade, learners are expected to construct algorithms and programs by themselves. In the real world such algorithms and programs would be constructed by groups of people working together.

The researcher's purpose of conducting this study was to breach the gap that exists between what is done in accordance with the outcomes-based curriculum in schools – and what is expected in the real world where collaborative work is the norm. The researcher used Bloom's high-order thinking skills as his point of departure for this study and examined the implications of how they contribute to real-world situations in the school environment.

To evaluate the South African curriculum for Computer Studies on the higher grade, the researcher compared the South African curriculum was the curriculum used in Australia for learners of the same age group. The results led to an intervention in which South African learners were examined on high-order thinking skills and programming in the real world.

Keywords

Syllabus, curriculum, real-world, constructivism, collaborative learning, outcomes-based education, analysis, synthesis, evaluation, high-order thinking skills

CHAPTER 1

INTRODUCTION AND BACKGROUND

INTRODUCTION

Benjamin S. Bloom (1956) became widely known for the influence that his taxonomy had on learning models and curriculum studies. He based his taxonomy on the premise that cognitive operations can be understood on the following six levels (here set out from the lowest to the highest level):

- Knowledge
- Comprehension
- Application
- Analysis
- Synthesis
- Evaluation

Bloom regarded recall of information (knowledge) as the lowest level of cognition, and evaluation as the highest level. Bloom's assumption is that when one functions at the level of evaluation, one has already mastered all the other levels of his taxonomy. Thus, when learners are able to evaluate, they *possess* all the necessary information, they *understand* that information, they can *apply* such information to other information, they can *analyse* the information, they can *synthesize* the information, and, finally, they can *evaluate* the information.

RATIONALE

This research determines the different levels of skill that the South African curriculum requires in terms of Bloom's taxonomy (1956). Key words derived from Bloom's taxonomy are used to create the outcomes of a curriculum.

The researcher has focused in his research on the gap that exists between learners' output at school and their output in the real world because there is a noticeable difference between the outcomes that the learners have to present in order to leave school successfully after matriculation and the outcomes that they are expected to be able to produce in the real world.

The results of the research should be useful to all those who have to plan syllabuses in:

1. The Department of Education, South Africa
2. The Board of Education, Australia
3. Computer Studies teachers
4. Computer Studies learners
5. Researchers in this field

LITERATURE REVIEW

According to Chase (1989), two of the most important qualities of a good curriculum are that:

- the curriculum should be logically organized so that it demonstrates the scope and sequence of any topic
- the curriculum should be adaptable to a whole range of grade levels

The level at which a learner should perform should be implicit in the outcomes that are contained in a curriculum. One of Bloom’s major points is that a well-designed curriculum should allow a learner to master the lower levels first before he or she continues to the next level. Curriculum designers all over the world use Bloom’s taxonomy because its logical progression ensures that the desired educational outcomes are experienced in the correct sequence.

In this research, the researcher critically examines the curriculum for Computer Studies, Grade 10, in Gauteng, South Africa. The outcomes in this curriculum should all be derived from the higher levels of Bloom’s taxonomy. The researcher paid special attention to Bloom’s principle (1956) that states that the application of various thinking processes should have a decisive effect on desired educational goals.

Although Krathwohl and Anderson (2000) produced a refined model of Bloom’s taxonomy, the researcher decided to use Bloom’s 1956 model because it highlights the following four important principles:

- All learners are expected to master the curriculum on different levels.
- All learners are expected to master problem-solving and other "higher-order" thinking skills.
- All learners should be actively engaged in their own learning processes. Help from other learners and from the teacher should only facilitate their *own* efforts.
- If learners interact creatively with the curriculum, other learners and with the teacher, this will produce an improved self-concept in learners and will help to make them more productive individuals.

THEORETICAL UNDERPINNINGS

Table 1 contains a summary of the key words used in this mini-dissertation. An explanation of each key word is given in the right-hand column.

Table 1

Keywords	**Explanation**
Curriculum	A course of study offered in a school, college, etc. (Longman, p. 272)
Real world	A workplace where everything actually exists (Longman, p. 918)
Constructivism	A theory that states that new ideas are formed in the mind when a number of pieces of information are combined (Longman, p. 235)
Programming	An action taken to construct a plan of the operations that will be performed by an electric machine (Longman, p. 876)
Collaborative	Working together or with someone else towards the same goal (Longman, p. 206)

The researcher will later demonstrate how Gagné's events of instruction, Bloom's taxonomy, and construction as a learning theory are effectively combined.

What level of Bloom's taxonomy should be addressed in each event, and what sort of construction will take place during each phase? A model that answers these questions will be presented by the researcher.

RESEARCH DESIGN

The research was undertaken in two parts:

1) In the research reported in the first article, an analysis was made of the South African curriculum for Computer Studies HG (Higher Grade) for grade 10 and of the Australian curriculum for the same age group. The researcher focused on the keywords that he derived from Bloom's taxonomy (1956) and compared these to the keywords in both curricula. From the data the researcher drew certain conclusions.
2) In the research reported in the second article, the researcher questioned these conclusions. In his case study with South African learners, the researcher's aim was to produce the same or higher outcomes than the Australians produced for their learners. The results of the research should improve the South African curricula in such a way that it will benefit not only the South African learners, but also learners worldwide.

DATA COLLECTION TECHNIQUES

The researcher made an analysis of two curricula and followed this by a case study of learners' programming in the real world. The following techniques were used.

Document analysis

The researcher analysed and compared the South African and Australian curricula for Computer Studies. He counted and tabulated the keywords on the different levels of Bloom's taxonomy in an Excel spreadsheet. He ordered these key words according to

Bloom's taxonomy. He then counted the lower order skills as well as the higher order skills. He produced graphs to represent these results and documented a comparison of the findings.

Intervention

The researcher presented an assignment that details higher order thinking skills and the lesson programming in the real world. He required learners in the Grade 10 Computer Studies class to program a project for the school's annual fundraiser.

Observation

The researcher observed the whole intervention. His observations focused on:

- communication between the project leader, analysts and the programmers
- task performance
- collaboration in groups

The researcher then documented and analysed these observations.

Questionnaire

Each learner completed a questionnaire that provided information in response to the following questions:

- What did you enjoy about the whole project?
- What didn't you enjoy about the whole project?
- Did you learn anything new?
- What are your feelings about collaborative work?

Interview

The researcher then conducted interviews to obtain information in answer to the following questions:

- What is your contribution to the project?
- Is it easy to construct work?
- What methods do you think can be used to make construction easier in class?

Portfolio assessment

Each learner's work was assessed, analysed and recorded in his or her portfolio.

DATA VALIDITY

Two co-researchers validated the Excel table and results. Two colleagues observed and evaluated the results from the class intervention.

LIMITATIONS OF THE RESEARCH

Only the Australian curriculum for Computer Studies was compared to the South African curriculum for Computer Studies. The Australian curriculum for Computer Studies most closely resembles the work that is done in South Africa in the same subject. The curricula for Computer Studies in countries such as Canada and England could also be used for future research.

The researcher only used a small group (28 learners) for the intervention. Larger groups or more schools could be used in such an intervention. The researcher resorted to conducting the research in his own school because time constraints were problematic. The researcher selected the 28 learners from a group of 60 learners. Since the researcher's school only possesses 32 computers, he could only fit a group of such a size into the school timetable at one time. A more evenly distributed set of learners might have produced different results.

The problem that was under investigation only *simulated* the real world, and learners did not actually work under real-world conditions. Deadlines and limitations on finances also influenced this project.

THE STRUCTURE OF THE REPORT

In chapter 1, the researcher presents the rationale, literature review, theoretical underpinnings, research design, data collection techniques and the limitations of this research.

In chapter 2, the researcher presents an adaptation of his article entitled, "Towards a real-world curriculum for high school computer studies".

In chapter 3, the researcher presents an adaptation of his article entitled, "Programming in the real world".

In chapter 4, the researcher draws his final conclusions and presents a summary of his research.

The researcher includes a Bibliography of sources consulted at the end of this report.

CHAPTER 2

TOWARDS A REAL-WORLD CURRICULUM FOR HIGH SCHOOL COMPUTER STUDIES

(Adapted from an article written by Bartho Brittz, Head of Department: Hoërskool Garsfontein, Pretoria, South Africa)

Abstract

A comparison was carried out between the South African Computer Studies syllabus and the Australian Computer Studies syllabus for sixteen-year-old learners. The syllabuses were compared on the basis of the different key words that were used to write the outcomes that learners are required to master. These key words were compared in terms of Bloom's taxonomy and categorized according to his different levels. This was done in order to demonstrate that the South African syllabus lacks key words on the higher levels of thinking. The comparison proves that higher thinking skills are used more in the Australian syllabus than in the South African one. The researcher proposed a model for use in Computer Studies that will ensure that higher order thinking skills are addressed in lessons.

INTRODUCTION

This article reports on a comparative analysis of the curricula for Computer Studies of South Africa and Australia, in terms of the extent to which they address various levels on Bloom's (1956) taxonomy. The researcher argues that although the Australian syllabus addresses higher levels than its South African counterpart, *both* curricula are essentially mechanical and devoid of real-world relevance.

Background and context

Computer Studies, as a subject, was introduced into the South African curriculum in 1975. In the first years after its introduction, the subject could only be taken as a seventh (i.e. additional) subject. In the eighties it was introduced as a regular subject scheduled for teaching during school hours. The main emphasis of the curriculum was on theory. Although it is a practical subject, and most of the hours spent in class were spent on practical programming, the theory only counted for 60% of the final mark. Computer Studies was always presented as a higher-grade subject. Later it was introduced on the standard grade, where the emphasis was on end-user computing rather than on programming. Because the focus of this article is on teaching programming, it deals with Computer Studies on the Higher Grade in high schools in South Africa.

Programming is a higher-order cognitive process that requires abstract thinking. Each program that is developed requires human thinking skills that result in a new construction that has utilised resources, programming languages and programming tools. Typical learning tasks would be to produce simple programs for performing calculations to writing a small program for an imaginary company that processes the sales of the company and gives feedback. Over the years the curriculum in South Africa has not changed – except for the introduction of *Turbo-Pascal,* which replaced *Qbasic*. Learners have to learn the basics of programming and then do certain exercises that are required by the curriculum.

Once outcomes-based education had been incorporated in South African schools, it became apparent that the current curriculum statement for Computer Studies on the Higher Grade lacks essential real-world relevance.

THEORETICAL UNDERPINNINGS

This section will deal with aspects of curriculum design and evaluation as well as with the requirements of current South African educational policy. Some aspects of contemporary constructivist learning theory, relevant to the teaching of Computer Studies, will also be investigated.

The qualities of a good syllabus

In South Africa the items that have to be dealt with in the Computer Studies classroom is called a *curriculum*. In Australia the same document is called a *syllabus*. For the sake of simplicity, the researcher will regard the words *curriculum* and *syllabus* as equivalents, and will use them interchangeably. According to Chase (1989), a good syllabus/curriculum should fulfil the following requirements with regard to layout, content and outcomes.

Layout
Apart from professional typesetting, logical organisation and logical sequencing are important. The syllabus should be adaptable across grade levels. For instance, for younger learners' activities can be demonstrated, while older learners may carry them out as experiments. The curriculum should be user-friendly so that it is not necessary for the teacher to consult other sources in order to teach it. Finally it should be localised (have a regional identity) and contain stand-alone activities (Chase, 1989)

Content
Chase (1989) calls for a syllabus that is workable with available resources, and that addresses local conditions while also accommodating innovative teaching, co-operative learning and creative thinking skills. He further recommends the incorporation of local resources for fieldwork, and recommends that the syllabus be interdisciplinary in effect so that it could be equally relevant to mathematics, languages and arts.

Outcomes
Core and enrichment topics should be clearly separated, and the curriculum should provide a variety of resources, such as work sheets, readers, DVDs, etc.

Bloom's Taxonomy

Alessi and Trollip (2001:339) stress that any assessment of objectives (or outcomes) should be done against a set of criteria. A number of instruments or taxonomies exist for such evaluation, such as those of Anderson et al (1975), Bloom, Hastings and Madhaus (1971), Fink (1995), Flagg (1990) and Smith and Ragan (1999). For this research, the researcher decided to use Bloom's original (1956) *Taxonomy of Educational Objectives,* specifically because it is the most widely known taxonomy, it has been thoroughly researched, and many useful guidelines and tools for interpreting various levels of the taxonomy are widely available.

Although Krathwohl and Anderson (2000) created an adapted version of Bloom's taxonomy, the researcher used the original version in this analysis because numerous refinements have already been effected in terms of the verbs associated with each level of the taxonomy. Some of these verbs are listed in the table below. The left hand column contains the level indicators, ranging from the lowest, *knowledge*, to the highest, *evaluation*. The right hand column lists the associated verbs.

Table 2: Bloom's (1956) taxonomy of the cognitive domain and its associated verbs

Skill level	Levels	Key words
Lower order thinking skills	**Knowledge**: Recalls data	Defines, describes, identifies, knows, labels, lists, matches, names, outlines, recalls, recognizes, reproduces, selects, states
	Comprehension: Understands the meaning and interpretation of instructions and problems. States a problem in one's own words	Comprehends, converts, defends, distinguishes, estimates, explains, extends, generalizes, gives examples, infers, interprets, paraphrases, predicts, rewrites, summarizes, translates
	Application: Uses a concept in a new situation (this applies what was learned in the classroom in novel situations in the workplace)	Applies, changes, computes, constructs, demonstrates, discovers, manipulates, modifies, operates, predicts, prepares, produces, relates, shows, solves, uses
Higher order thinking skills	**Analysis**: Separates material into parts so that its organizational structure may be understood. Distinguishes between facts and inferences	Analyses, breaks down, compares, contrasts, diagrams, deconstructs, differentiates, discriminates, distinguishes, identifies, illustrates, infers, outlines, relates, selects, separates
	Synthesis: Builds a structure from diverse elements. Put parts together to form a whole, with emphasis on creating a new meaning or structure	Categorizes, combines, compiles, composes, creates, devises, designs, explains, generates, modifies, organizes, plans, rearranges, reconstructs, relates, reorganizes, revises, rewrites, summarizes, tells, writes
	Evaluation: Makes judgements about the value of ideas or materials	Appraises, compares, concludes, contrasts, criticizes, critiques, defends, describes, discriminates, evaluates, explains, interprets, justifies, relates, summarizes, supports

Maynard (2003) suggests questions that can be asked using the key words from Bloom's taxonomy. Table 2 shows the questions that can be asked, using the key words in Table 1.

Table 3: Questions applicable to levels of Bloom's taxonomy (Maynard, 2003)

Levels	**Questions**
Knowledge	Who is ...?; What is the ...?; When did ...?; How much ...?
Comprehension	State in your own words; Give an example of ...; Select the best option; Explain what is ...; Demonstrate ...
Application	Tell how ...; Predict the outcomes of ...; Identify the best ...
Analysis	Distinguish between ...; To what conclusions ...?; What is the function of ...?; Relate to ...; State the view of ...; Make assumptions ...
Synthesis	Create your own ...; Compose a ...; Formulate the ...; Solve the following ...; Design a ...; Plan a ...
Evaluation	Criticize the following ...; Defend ...; Compare the following ...; Judge the best ...

The researcher shows in the following sections that the *new* South African outcomes-based curriculum and contemporary learning theory express a clear bias away from the lower levels towards the higher levels of Bloom's taxonomy.

South African education policy

South African education policy has undergone major reconstructions since 1994. One of the main thrusts of change has been a shift to outcome-based education. Van der Horst and McDonald (1997) explain the new approach as follows:

> Outcome-based education can be described as an approach that requires teachers and learners to focus their attention on two things:
>
> - Firstly, the focus is on the desired end results of each learning process. These desired end results are called the outcomes and learners need to demonstrate that they have attained them. They will therefore continuously be assessed to ascertain whether they are making progress.
> - Secondly, the focus is on the instructive and learning process that will guide the learners to these end results. Teachers are required to use the learning outcomes as a focus when they make instructional decisions and plan their lessons (Van der Horst & McDonald, 1997:7).

In an outcome-based approach, the focus is on learner participation and achievement, while the role of the teacher shifts to that of researcher and facilitator. It becomes the responsibility of the teacher to *structure* learning events in such a way that learners can achieve outcomes that are appropriate to their situation and abilities. Assessment changes from an external one-time assessment at the end of the learning process, to a continuous process involving the educator as well as peer assessment. Outcomes are assessed as they are achieved, partially achieved or not yet achieved. (De Jager, 2003).

Three levels of outcomes are identified: generic critical cross-field outcomes, developmental outcomes, and specific outcomes. "Specific outcomes refer to the specific knowledge, attitudes and understanding which should be displayed by particular context. Specific outcomes function at the level of classroom instruction" (Van der Horst & McDonald, 1997:48).

The generic, critical cross-field outcomes for South African education, training and development as well as the developmental outcomes (SAQA, 1997; SAQA, 1998) are tabulated below.

Table 4: outcomes for South African education, training and development (SAQA 1997, 1998)

Critical cross-field outcomes	Developmental outcomes
• Identify and solve problems in which responses display responsible decisions using critical and creative thinking. • Work effectively with others as a member of a team, group, organization or community. • Organize and manage oneself and one's activities responsibly and effectively. • Collect, analyse and critically evaluate information. • Communicate effectively using visual, mathematical and/or language skills in the modes of oral and/or written persuasion. • Use science and technology effectively and critically, and show responsibility towards the environment and health of others. • Demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation.	• Reflecting on and exploring a variety of strategies to learn more effectively • Participation as responsible citizens in the life of local, national and global communities • Being culturally and aesthetically sensitive across a range of social contexts • Exploring education and career opportunities • Developing entrepreneurial opportunities

From the above table it can be seen that both the generic critical cross-field outcomes and the developmental outcomes focus on higher levels of Bloom's taxonomy, with key words such as *analyse, evaluate* and *use* playing a more dominant role than *know*.

The qualities of a good curriculum, as well as the requirements of the South African outcomes-based curriculum, as shown in the literature study thus far, have the following implications for a senior high school Computer Studies syllabus.

- The course should be vocationally oriented to prepare learners for the world of work.
- Not only people from the education sector, but also IT professionals from the real world should be included in drawing up the new curriculum.
- The application packages and programming languages used in school should be relevant to those used in business and industrial settings. Some exploring and experimenting to find how a new programming environment operates can be more valuable than rote learning of a new program.

- The focus of the curriculum should be to provide a non-specialist learner with an awareness of the capabilities, the potential and the limitations of Information Technology.

In a real-world environment, much of the planning and development is done in groups of practitioners working in teams. Collaboration and team management are highly valued attributes in the IT world. Pupils should use cooperative learning and collaboration to develop their projects. In addition to this, problem solving becomes an essential component of the syllabus. The following section deals with the theoretical aspects of constructivism and co-operative learning, as essential factors to consider in evaluating the current Computer Studies curriculum statement.

Contemporary learning theory for computers in education

Current South African educational policy, as discussed above, rests on the tenets of contemporary learning theory, much of which has been synthesized by De Villiers (2002) into six categories, called the *Hexa-C Metamodel* (De Villiers, 1999, 2000, 2002, 2003; de Villiers & Cronje, 2001). The categories are: cognitive learning theory, constructivism, components of instruction, collaborative learning, customisation, and creativity.

Cognitive learning theory
Cognitive learning theory focuses on the mental processes involved in learning. The psychology behind this theory views learning as a process that supports cognition, formation of internal knowledge structures, and retention. The implicit psychology used is based on an information-processing approach where information is stored initially in the short-term memory, and then is organized to be stored more permanently in the long-term memory. The instructional implications are that educators should direct learners' attention to key points, show them how material is organized, and make information more meaningful to learners. Moreover educators should recognize the limitations of learners' working memory and actively check understanding (Froyd & Cordes, 2001) .

Cognitive learning in the classroom involves the encoding of information and metacognition. Encoding of information refers to perception and attention, memory, comprehension, and motivation (Anderson, 1980;1981; Kozma, 1987). Metacognition refers to the transfer of learning, the accommodation of individual differences, the creation of mental models, and selecting an appropriate locus of control, either with the educator or learner, depending on the situation. Metacognition also calls for active learning (De Villiers, 2002).

Constructivism
Constructivist learning theory maintains that knowledge is not received from "outside", but rather that we as human beings construct knowledge in our heads. Learning is what we call that active process that we use when we construct knowledge in a new form from our previous encounters and from our pre-existing knowledge. Bruner suggests that instruction is not a matter of getting a learner to commit results to his or her memory. He says: "Rather, it is to teach him [or her] to participate in the process that makes possible the establishment of knowledge. ... Knowing is a process, not a product" (Bruner, 1967:72).

The following table provides of summary of principles that encourage constructivist learning. They are taken from Alessi and Trollip (2001):

Table 5: Actions that will encourage constructivist learning (Compiled from Alessi & Trollip (2001)

Emphasize	• learning rather than teaching • the actions and thinking of learners • active learning • learner choice and negotiation of goals • strategies and evaluation methods
Use	• discovery or guided discovery approaches • cooperative or collaborative learning activities • purposeful or authentic learning activities • authentic tasks and activities that are personally relevant to learners
Encourage	• learner construction of projects • learners to accept and reflect on the complexity of the real world
Support	• learner reflection • learner ownership of learning and activities

Components
"Components of learning and instruction relate to the basic knowledge, skills and methods of a domain – entailing unitary components and composite components, as well as de-contextualised skills " (De Villiers, 2002). An approach to components is Component Display Theory (CDT) (Merrill, 1983). The relationship between the content to be taught and the performance required are analysed in a two-dimensional table according to a set of components. The types of content are fact, concept, procedure and principle. The types of performances are embodied in the words *remember*, *use* and *find*.

Collaborative learning
According to Piaget (1951), children think and acquire knowledge, not only through their actions but also through interactions with other people. Piaget talks about peer groups in which learners of the same age and interests construct new ideas by using their common knowledge. Vygotsky (1978) talks about the interactions between adults and children, and about the learning that results from these interactions. Collaborative learning is learning that results from all these interactions. The sharing of responsibility in the group becomes the main focus. Collaborative learning usually goes hand-in-hand with constructivism.

Customization
"Customized learning aims for instruction that is learner-centric, adapting to individual learner's profiles, supporting personal processes and products, and allowing learners to take initiative with regard to (some or all of) the methods, time, place, and content of their learning " (De Villiers, 2002). User-control, personal goal-setting and exploration play key roles in this process. User-control, whereby learners navigate their own path, or control their instructional components by selecting their own content and/or instructional strategies, fosters individual learning.

Creativity
Creativity in instruction fosters intrinsic motivation that ensures the acquisition of knowledge and skills. Affective strategies will support the motivation and help the learning process. Wager (1998) argues that the complexity of the affective/cognitive connection can deliver better results if it is used correctly.

METHOD

The literature surveyed above indicates that both current South African educational policy and contemporary learning theory call for a constructivist, outcome-based approach to subject teaching. The appropriateness of such an approach is further supported by the fact that the real-world requirements for people working in the IT industry focus strongly on problem solving skills as well as the ability to work in groups. In spite of this, it is clear that the current curriculum statement for Computer Studies Higher Grade has not changed significantly over the past 25 years. Much of the focus int his document is still on theoretical knowledge, while the practical work concentrates on the development of small programs that do not require application in the real world.

The researcher therefore analysed the current curriculum statement to find those verbs that denote various levels in Bloom's taxonomy. By way of comparison, he did the same analysis on the current Australian syllabus. The two curricula were then categorized into four learning outcomes, and the exact statements of each outcome were extracted and compared. In order to achieve the benefits of triangulation, the comparison was done by three educators working independently. After the initial categorization, the curriculum statements were analysed by counting the occurrences of specific words determining various levels of the taxonomy. A tabulation and graphic representation of these results follow the category tables.

FINDINGS

The following section contains a number of tables that classify the outcomes as specified by the curriculum statements. The first set of tables analyses the South African curriculum statement. The second set of tables deals with the Australian curriculum for the corresponding school level. The two analyses are then followed by a summative table that compares the two curriculum documents by totalling the occurrences of verbs denoting various levels in Bloom's taxonomy.

The South African curriculum

The South African curriculum statement can be divided into the following four themes:

- hardware and system software
- communication
- social and ethical issues
- programming and software development

The following four tables present an analysis of the curriculum. In each table the left-hand column shows the outcomes. The second column shows the level in Bloom's taxonomy, while the third column depicts whether the outcome can be classified as a higher order thinking skill or a lower order thinking skill in the taxonomy.

When it comes to hardware and system software, the curriculum requires learners to identify various components, describe their functions and perform minor operations.

Table 6: Hardware and system software (SA Curriculum Statement, p. 14-16)

Outcomes	**Bloom's taxonomy**	**Thinking skill**
differentiates between the concepts of hardware and software	Comprehension	Low
identifies and distinguishes between computer types and associated software	Knowledge and comprehension	Low
identifies the main components of at least two types of computer	Knowledge	Low
distinguishes between system and application software	Comprehension	Low
identifies the functions of various types of operating system	Knowledge	Low
understands the concept of file organisation into multi-level directories	Comprehension	Low
distinguishes between different types of files by their extensions or applications types	Comprehension	Low
Effectively **uses** tools provided by the operating system and other utility packages to organise and manage the computer	Application	Low
demonstrates an ability to successfully install and uninstall new software programs	Application	Low
states and **discusses** the implications of the latest computer technologies	Comprehension	Low

From the above table it can be seen that the section on hardware and system software only addresses lower order thinking skills. Learners are required to name various parts and manipulate them according to a prescribed set of instructions. All of this can be done by means of rote learning, and no problem solving or integration of skills is required. Moreover, the curriculum does not allow in any way for the development of cooperative skills.

The following table deals with the section of the curriculum statement that covers computer-based communication. Learner activities involve working on the Internet.

Table 7: Communication (SA Curriculum Statement, p. 18)

Outcomes	Bloom's taxonomy	Thinking skill
describes the role of an Internet Service Provider (ISP) in facilitating communication	Knowledge	Low
makes efficient **use** of e-mail (including attachments, digital signatures, address books) as a means of communication	Application	Low
demonstrates responsible communication styles	Application	Low
navigates the Internet in order to retrieve information	Comprehension	Low
states and **discusses** how the latest technologies facilitate human interaction	Comprehension	Low

As is the case with hardware and software, the curriculum statement requires no higher order thinking skills. In this section, the omission of any form of *evaluation* of Internet-based resources is a serious weakness in the curriculum.

Social and ethical issues are analysed in the following table. This section is entirely theoretical and requires no practical work. Again, nothing more than rote learning is required, and the entire section of work can be covered without using a computer.

Table 8: Social and ethical issues (SA Curriculum Statement, p. 20)

Outcomes	Bloom's taxonomy	Thinking skill
lists the broad economic reasons for using computers	Knowledge	Low
discusses the effects of the use of computers across a range of application areas	Comprehension	Low
discusses the health and ergonomic issues related to frequent computer use	Comprehension	Low
discusses environmental issues relating to computer hardware and consumables	Comprehension	Low
comments on the use of computers in providing solutions to issues of national and international importance	Comprehension	Low
explains the responsible use, purpose and significance of any new computer developments	Application	Low

As in the previous two instances, the entire curriculum section requires lower order thinking skills only. The bulk of the work in this section is on the level of comprehension, which is the second level of the taxonomy.

The last section of the curriculum statement deals with the primarily practical aspect of programming and software development. It is to be expected that this section is more likely to contain at least some aspects that require higher order thinking skills.

Table 9: Programming and software development (SA Curriculum Statement, p. 22, 24)

Outcomes	Bloom's taxonomy	Thinking skill
produces an algorithm (incl. correct traces) of simple sequential statements involving variables, assignments and numeric expressions (incl. percentages)	Application	Low
produces useful tables by applying knowledge of arithmetic expressions in driving a software application	Application	Low
designs a simple user interface (output and basic input only) for a real activity of an informative nature	Synthesis	High
distinguishes between good and bad user interface design with respect to font size, layout and colour	Comprehension	Low
implements the user interface using an application package	Application	Low
identifies the basics of Boolean conditions and operators and applies this to simple Boolean expressions	Knowledge	Low
draws simple diagrams showing the decision making process involving simple selection and looping	Synthesis	High
calls the basic mathematical functions and **applies** them in formulae in application packages and programs	Application	Low
understands that simple data comes in different forms and that data typing is important	Comprehension	Low
implements selection and simple looping in a programming environment for a variety of simple algorithms	Application	Low
explains effects of rounding and truncation as seen through an application package	Application	Low
suggests ways in which well known software can be methodically tested for robustness	Application	Low
creates and queries a single table database	Synthesis	High
uses help files effectively for computer application packages	Application	Low
identifies where known help files fall short of the ideal and how they could be improved	Knowledge	Low

Eight of the fifteen outcomes listed above are at the level of application, which, though it involves some form of practical work, is still classified as a lower order thinking skill.

It is clear from the table that the South African curriculum statement uses more key words on the lower order thinking skills: knowledge, comprehension and application. Contrary to expectations, the section on programming and software development contains only three instances where higher order thinking skills are required.

It is disconcerting to note that, although the policy of outcome-based education calls for problem solving and other higher-order thinking skills, only three instances could be found in the curriculum where provision is made for the development of such skills.

By way of comparison, we will consider the Australian curriculum in the next section, and show the results of an analysis that used the same rubric that was used for the South African curriculum statement.

The Australian curriculum

The tables that follow analyses the Australian curriculum. Once again, the left-hand column shows the outcomes. The second column shows the level in Bloom's taxonomy (1956). The third column designates whether the outcome is a lower order or higher order outcome according to Bloom's taxonomy. The Australian curriculum can be divided into five sections, namely information systems, algorithms and programming, artificial intelligence, information systems, and computer systems.

The section on information systems involves retrieval of information, analysis of such information, and the production of similar information.

Table 10: Information Systems (Australian Curriculum, p. 15)

Outcomes	**Bloom's taxonomy**	**Thinking skill**
retrieve information from an existing database using queries and reports	Knowledge	Low
develop and publish a planning document	Application	Low
Perform a critical **analysis** of a functioning information system	Analysis	High
produce a specification document for an information system	Synthesis	Low
produce working information systems	Application	Low

From the above table it can be seen that the section on information systems addresses lower order thinking skills and higher order thinking skills. Learners are required to retrieve information and produce functional systems on various levels. A critical analysis forms the highest level of this section.

The following table covers the section of the Australian curriculum statement that deals with algorithms and programming. Learner activities involve working with, designing, implementing and evaluating programs.

Table 11: Algorithms and programming (Australian Curriculum, p. 21)

Outcomes	Bloom's taxonomy	Thinking skill
define a problem and specify a solution	Knowledge	Low
design a well-structured, modular algorithm	Synthesis	High
implement an algorithm in a programming language	Application	Low
document the process of software development	Application	Low
test and **evaluate** software	Evaluate	High
modification of completed solutions	Synthesis	High

The knowledge is assessed by lower order thinking skills, and programming and algorithms are assessed by higher order thinking skills. This is a good example of outcomes that cover the whole range of Bloom's taxonomy.

Artificial intelligence requires an in-depth analysis of the topic, and the learners must design, construct and evaluate their products from the knowledge they have obtained.

Table 12: Artificial intelligence (Australian Curriculum, p. 24)

Outcomes	Bloom's taxonomy	Thinking skill
use an expert system shell to interrogate and to build a knowledge base	Application	Low
investigate different programs and strategies for games	Analysis	High
construct and control robotic units	Synthesis	High
design and implement an expert system and a neural network	Synthesis	High
use and evaluate natural language query tools	Evaluate	High
discuss philosophical issues about artificial intelligence	Comprehension	Low

The above table shows that this section requires higher order thinking skills. Learners need to investigate different strategies, implement a strategy by means of constructing a unit, and evaluate the unit.

The following table deals with the section of the curriculum statement that deals with social and ethical issues. Learner activities involve analysing, criticizing, and evaluating issues on this section.

Table 13: Social and ethical issues (Australian Curriculum, p. 28, 29)

Outcomes	Bloom's taxonomy	Thinking skill
analyse the ideas and arguments of others	Analysis	High
evaluate the impact that the use of computers has had on our society	Evaluate	High
suggest methods to minimising problems that are caused by computers	Application	Low
distinguish facts from opinions	Comprehension	Low
make informed judgements about the effects of the use of computers in our society	Evaluate	High
analyse and criticize predictions made about the future uses of computers and their effects on society	Analysis	High

This section addresses lower and higher order thinking skills. Learners use lower order thinking skills to gather relevant information. Higher order thinking skills are then used to investigate and evaluate the topics.

The following table deals with the section of the curriculum statement that deals with computer systems. Learner activities involve searching for the best system, analysing the system, constructing a new authentic model, and applying this system in practice.

Table 14: Computer systems (Australian Curriculum, p. 33, 34)

Outcomes	**Bloom's taxonomy**	**Thinking skill**
undertake an introductory **analysis** of a computer system in a commercial, industrial or educational setting as a result of a series of field visits	Analysis	High
carry out a critical **appraisal** of different operating systems with respect to ease of use and functionality	Evaluate	High
experience many different types of input and output devices	Application	Low
investigate industry standards and applications	Analysis	High
use e-mail to support a group assignment	Application	Low
use the Internet to research an assignment topic	Application	Low
use an operating system effectively	Application	Low
interview a LAN administrator from within the school or local community about the administrator's responsibilities	Knowledge	Low
debate the advantages and disadvantages of distributed systems in a social context with specific reference to the Internet	Application	Low
specify and cost a computer system for their personal use	Application	Low
construct a web site	Synthesis	High

The table shows that the Australian curriculum is more practical and has a more even distribution between the lower and higher order thinking skills. The focus is on the application of systems built in the real world.

The table below shows the frequencies of the key words that describe the levels of Bloom's taxonomy in the two syllabuses. The number in each column represents how many times the word occurred in the syllabus of each country. At the bottom, a comparison of the number of key words on the lower order (levels 1-3) thinking and the higher order (levels 4-6) thinking are shown.

Table 15: Summative comparison of outcomes of the South African and Australian curricula

Knowledge	**South Africa**	**Australia**	**Analysis**	**South Africa**	**Australia**
identify	5	0	analyse	0	4
describe	1	1	investigate	0	2
list	1	0			
define	0	1			
retrieve	0	1			
interview	0	1			
Total:	**7**	**4**	**Total:**	**0**	**6**
Comprehension			**Synthesis**		
discuss	5	1	modify	0	1
understand	2	0	design	1	2
navigate	1	0	create	1	2
distinguish	5	1	construct	0	2
comment	1	0	draw	1	0
			produce	0	1
Total:	**14**	**2**	**Total:**	**3**	**8**
Application			**Evaluation**		
experience	0	1	evaluate	0	3
demonstrate	2	0	appraise	0	1
make use of	3	4	informed judgement	0	1
explain	2	3			
apply	1	0			
suggest	1	1			
produce	2	1			
implement	2	1			
develop	0	1			
debate	0	1			
document	0	1			
specify	0	1			
Total:	**13**	**15**	**Total:**	**0**	**5**
Knowledge, comprehension and application	34	21	**Analysis, synthesis and evaluation**	3	19

South Africa has more key words on **knowledge (7-4)**; South Africa has more key words on **comprehension (14-2)**; Australia has more key words on **application (15-13)**; Australia has more key words on **analysis (6-0)**; Australia has more key words on **synthesis (8-3)** and Australia has more key words on **evaluation (5-0).**

Figure 1 below shows how many times the key words are used on the different levels. The South African curriculum appears on the left, and the Australian on the right. It can been seen that the South African curriculum is biased towards lower-order thinking skills.

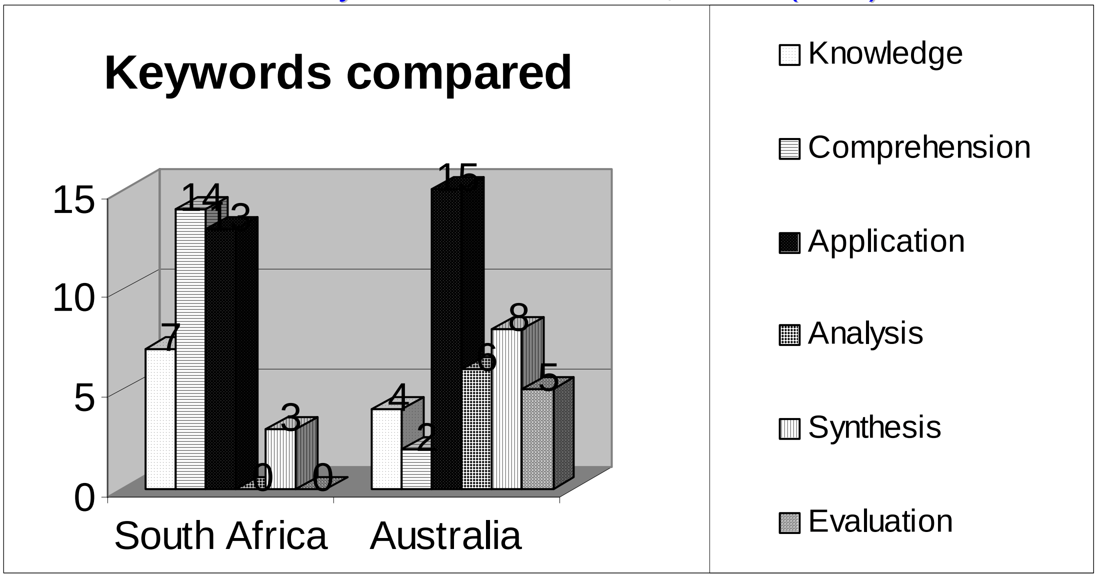

Figure 1: Levels of Bloom's taxonomy addressed by the South African and Australian curricula

The graph indicates that the South African curriculum is strongly focused on lower-order thinking skills, while the Australian graph has a more even distribution. South Africa has no outcomes on the level of analysis and evaluation.

Figure 2 below shows the difference between levels 1-3 and levels 4-6 in Bloom's taxonomy. The South African curriculum appears on the left, and the Australian on the right. The South African curriculum statement is very strongly biased towards lower order thinking skills (34-3), while the Australian curriculum shows an even balance between higer and lower order thinking skills. (21-19).

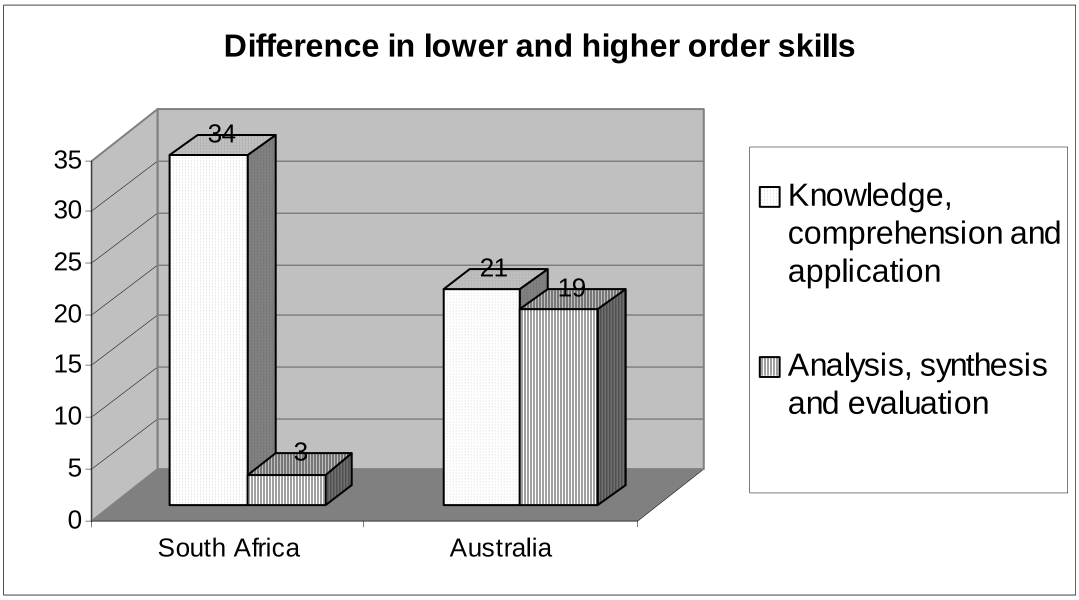

Figure 2: Lower and higher order thinking skills

Clearly South Africa's curriculum lacks key words on the higher-order thinking skill level.

DISCUSSION

In South Africa the curriculum focuses mostly on lower order thinking skills. Pupils must reproduce information in the form that they have learned it. While comprehension and application are emphasised in secondary schools in an attempt to move away from rote learning at the knowledge level, no attention is given to problem solving and evaluation. The syllabus also does not encourage teamwork. In Australia the pendulum is swinging towards high order thinking skills. The following section compares the two syllabuses at each level in Bloom's taxonomy.

Knowledge

The South African curriculum statement uses 3 different key words compared to the 4 in the Australian curriculum. The key words "identify" is used 5 out of the 7 times in the South African curriculum. The difference between South Africa and Australia is 7-4.

Comprehension

The South African curriculum uses 5 different key words compared to the 2 of the Australian curriculum. The South African curriculum favours the words "discuss" and "distinguish". This is the biggest difference between South Africa and Australia on this level (14-2).

Application

There are not many differences between the countries on this level. The South African curriculum uses 7 different key words compared to the 10 in the Australian curriculum. Both countries used the key word "make use of". Australia has two more key words at this level (15-13).

Analysis

The South African curriculum uses no key words compared to the 2 in the Australian curriculum. The key word "analyse" is used 4 times in the Australian curriculum. The difference between South Africa and Australia is 0-6.

Synthesis

The South African curriculum uses 3 different key words compared to the 5 of in the Australian curriculum. The difference between South Africa and Australia is 8-3.

Evaluation

Only the Australian curriculum used key words on this level (3 of them). The key word "evaluate" is used 3 out of the 5 times in the Australian curriculum. The difference between South Africa and Australian is 0-5. This is the big difference between South Africa and Australia on this level.

When one compares the lower order thinking skills to the higher order thinking skills, the difference can be seen in that the count for the lower order thinking skills is: South Africa 34; Australia 21. When one compares the higher order thinking skills, the count is: South Africa 3; Australia 19.
When one compares the six levels of each country, they both peak at the third level, application. In the case of the South African curriculum, the climb is very steep in the beginning with a collapse towards the end. In the case of the Australia curriculum, the graph has a normal distribution, except for the application level (15).

CONCLUSIONS AND RECOMMENDATIONS

The South African curriculum focuses more on lower order thinking skills than does the Australian curriculum. The difference is small if the two countries are compared, but if one compares the key words and graphs, one can definitely see the emphasis on the lower order thinking skills. Learners in South Africa have a much narrower view of the real world.

Australia also focuses on the lower order thinking skills, but has a 39% advance when it comes to the higher order thinking skills. While they provide their learners with a good foundation (lower order thinking skills), they also give them the tools to construct their own future with higher order thinking skills. If their learners were to walk into real-life situations, they would be better prepared than equivalent South Africans to handle problems. Australians (as evidenced here) have a much broader view of society and the real world. South Africa needs to adapt its syllabus to accommodate higher order thinking skills. A much greater emphasis on constructing and collaborative work needs to be incorporated into the syllabus.

The model shown in table 15 below proposes a process that can be used to incorporate real-world activities into the Computer Studies classroom – a model that addresses the higher levels on Bloom's taxonomy. The model is based on Bloom's taxonomy (Bloom, 1956) and the life cycle of a system in the real world. The first column shows the steps taken to solve any problem, from the problem to maintaining the model built. The second column focuses on the key words required to plan each step. The third column identifies the role of the student during each phase. Column four refers to Bloom's taxonomy. Column five shows how the teacher is implicated during each phase. The last column shows what assessment needs to be done in each phase.

Table 16: Model to be introduced in a constructivist learning event in the real world

Building steps	Key words	Role of student	Bloom's taxonomy	Role of educator	Assessment
Problem	Content	Study the relevant content.	Knowledge: defines, identifies, states, outlines, selects and reproduces	Give introduction and all the information available to assist students to understand the problem.	* Portfolio * Is the problem statement according to plan?
	What do I have to know?	Write the problem in your own words.			
	Why?	Write your own goal for this project.			
	Information	Gather all information relevant to understanding the problem better.			
	Define	State problem in your own words.			
Plan	Mind map	Draw a mind map of the whole project.	Compre-hension: estimates, explain, extend, give examples, interpret, rewrite, summarize	Observe and give guidance where necessary.	* Portfolio * Will model meet the goals set by the student? * Give a first mark for the product.
	Blueprint	Create a blueprint of steps to take to realise project			
	Model	Build model of final product			
Develop	Research	Gather all information to complete the project.	Application: apply, change, produce, use, modify, prepare, relate	Observe and assist with information	Portfolio
	Design	Write, draw all information into the model.			
	Little black book	Make notes of everything that happens in the whole process.			

Construct	Share	* Collaborate with other students. * Get another perspective.	Analysis: Compare, contrast, different-tiate, relate, break down	Observe and give alternative models to bring out the best in each student.	* Portfolio * Give a second mark for the product.
	Build	* Create the model. * Put it all together.			
Re-thinking	Testing ↓ Problem/ errors ↓ Reconstruct (→ back to Testing)	Test the final product for any problems.	Synthesis: Combine, compose, modify, reconstruct, reorganize, revise, rewrite	Actively participate and give input to get the best out of the students.	Portfolio
		Let other students test your product.			
		If problems occur, reconstruct and make adjustments.			
New ideas	New ideas ↓ Construct ↓ Add/Delete → (back to New ideas)	Do maintenance on your product and compare it to new products on the market.	Evaluation: Appraise, criticize, evaluate, compare, support	Give feedback and information about new products and new models.	* Portfolio * Give a final mark for the product.
		Construct new features for your product.			
		Add/delete new ideas to/from your product.			

The model can be adjusted to the needs of the teacher and according to the problems/model under construction.

The learning environment in which students have to perform their construction activities, have changed in the last twenty years. Technology has made it possible to look into the real world while sitting in a classroom or at home. The curricula, as presented in schools, the real world, and on the playing field every day, do not share the same goals. When students end their school career and they enter the real world, they realize that whatever they have learned until then can only help them up to a certain point. The differences between what happens in school and what happens in the real world are enormous. People from the real world should also be asked to give their input so that real world issues can enhance the curriculum.

Learners must become aware of the real world and what is happening every day in offices and practices around the world. If they want to construct new ideas, they should relate them to what is happening in the real world. If they put the above ideas and concepts into practice, they will be able to keep pace with what is happening in the real world. Students have to read computer magazines and surf the Internet because they are examined on these issues, which they should discuss in class. Projects during the year should also focus on issues and ideas that are relevant to the real world.

CHAPTER 3

PROGRAMMING IN THE REAL WORLD

(Adapted from an article by Bartho Brittz, Head of Department: Hoërskool Garsfontein, Pretoria, South Africa)

Abstract

This article reports on a constructivist-learning event that is designed to investigate how projects in the real world can help learners to construct their own programs in collaboration with other individuals and how learners can develop new ideas for future systems. The study was done because the South African curriculum for high school Computer Studies is weak on higher order thinking skills. An experimental lesson was presented to 28 high school learners who were then evaluated on their achievement of higher order thinking skills in Bloom's taxonomy. The outcomes of the research showed that the learners were able to perform at higher levels than the South African curriculum calls for. Using techniques developed for this lesson should help learners to do real world programming, and this would narrow the gap between school/university and the real world.

INTRODUCTION

Current South African educational policy calls for outcomes-based education that focuses on higher order thinking skills. However, the South African curriculum statement for higher grade Computer Studies in high schools does not reflect this. An analysis reported by Brittz (2003) shows that the Australian curriculum provides more outcomes on the higher levels than the South African one. To address the discrepancy between policy and practice, it is necessary to show that South African learners are able to function at higher levels of Bloom's (1956) taxonomy of the cognitive domain than is called for in the current curriculum statement. It is also necessary to develop teaching methods that would encourage learners to function at higher levels.

The researcher designed, presented and evaluated a constructivist learning event in an attempt to develop a classroom strategy for addressing higher order thinking skills and following current policy, while still working within the constraints of the current curriculum statement. The following six key questions guided the research:

- What learning principles should be applied to stimulate higher order thinking?
- Which learning models should be used to develop a workable learning experience?
- What instructional design principles can be followed?
- What type of assessment would be appropriate in this context?

- To what extent does the role of the teacher change?
- What new roles are required of the learners?

LITERATURE SURVEY

General learning theoretical principles

Gagné proposed the following nine events of instruction – strategies that designers can use in order to provide external conditions of learning (Gagné, Wager & Rojas, 1991):

- gaining attention
- informing learner of lesson objectives (Outcomes)
- stimulating recall of prior learning
- presenting stimuli with distinguishing features
- guiding learning
- eliciting performance
- providing informative feedback
- assessing performance
- enhancing retention and transfer

Bloom's (1956) *Taxonomy of Educational Objectives* identifies six major types of learning, ordered from lowest to highest:

- *knowledge:* remembering previously learned material – the lowest level of learning
- *comprehension:* grasping the meaning of material – the lowest level of understanding
- *application:* using learned material in concrete situations
- *analysis:* breaking down material into component parts to understand its structure
- *synthesis:* putting parts together to form new wholes, i.e. creative behaviours
- *evaluation:* judging the value of material for a given purpose. (This is the highest learning outcome in this cognitive hierarchy because it contains elements of all other categories plus value judgments based on defined criteria.)

Aspects of Constructivism

Two aspects of a constructivist learning experience form the basis of this research, the real world aspect and collaboration.

Hunt (2001) talks about *conjectural computing*. The purpose of conjectural computing is bringing real world conditions to the learner in the classroom. The old idea of coaching programs over and over again is something of the past. She asks: "How much can we expect to transfer to other knowledge domains? To what extent are the skills employed in programming domain-dependent? What do we mean by **doing** programming, when we compare what is done in the classroom with what skilled programmers do?" (Hunt 2001: online) The sooner learners start to program in the real world, the better their chance of being able to construct programs that will help society and a world in need of improved performance.

The second aspect is collaboration. De Villiers (2002) says that "Collaborative learning can be implemented in various ways, but [it] usually refers to groups of learners working jointly on a project, with the intention of producing a joint product" (De Villiers, 2002). For Savery and Duffy (1995), the value of individual understanding can be evaluated when learners share and debate perceptions and interpretations (Savery & Duffy, 1995).

Everybody has individual skills. Applying such skills in group-work will give each learner a broader perspective of the final product. Group work plays a major role in constructivism (Lebow, 1993). In South Africa, learners were used to do everything on their own; they never worked in groups. In the past couple of years, collaborative learning was introduced into the the South African outcomes-based education system. Collaborative learning has enriched many with new information. By using metacognition, this new information could be used in a better way than it was before.

General design issues

Bednar *et al* (1992) suggest the following three aspects that one should consider when one designs from a constructivist point of view:

(1) Content analysis. Background to the content should be researched. The outcomes should be aligned with assessment criteria. Content should be divided into the same areas/outcomes. Extra information should be provided for in the form of URLs or references to other books.
(2) Analysis of learners. The background of learners should be investigated. Strong and weak points of each learner should be observed. Individual and group work should be planned for different sessions.
(3) Objectives-specification. In a constructivist learning-event, the learners should set most of the objectives. Learners should be given the opportunity to think and construct under real life conditions. In real life, the user sets the objectives for the project.

According to Savery and Duffy (1995), design principles are important. All learning activities should be attached to a larger task or problem. Design an original task and support learners to take ownership of the overall task and the process of solving the problem. The design of the task and learning environment should reflect the complexity of the real world and should at the same time challenge the learner's thinking. Learners should be encouraged to test their ideas against alternative views. The opportunity to reflect on learned content and the learning process should be supported.

Assessment and evaluation issues

Willis and Wright (2000) suggest various alternative forms of constructivist assessment, such as projects, portfolios, activity logs, and the keeping of journals.

Jonassen (1991a; 1992) proposes criteria for constructivist evaluation. The tasks should be original and should cover multiple perspectives. The evaluation should be context-driven and goal-free evaluation methodologies should be used. Collaborative, negotiated construction should be of multi-modality.

What are higher-order thinking skills?

Higher-order thinking skills represent the upper three levels of Bloom's taxonomy (1956). These are analysis, synthesis and evaluation.

How do we teach to acquire higher order thinking skills?

We teach them by engaging in the following steps and methods:

(1) Problem-solving. The first step is to understand the problem and to disentangle what is and what isn't relevant to solving the problem. Language plays a major role in determining the problem. Words, construction of sentences and rephrasing of sentences can help the learner to understand the problem better. The teacher should make sure that the learner reads through the whole problem so as to get a global idea of the problem (Jonassen, 1991b). The learner should explain the problem to other learners and they should explain their problems to him. This will help to reflect back what is important and what isn't important to each learner. The learners should then study different aspects of the problem to see if they can rephrase the problem and put it in their own words. The last step for the learners is to see how many solutions they can arrive to by using all the resources available to them. These solutions will help them with the next step, and will prepare their minds to think in a new way. One should bear in mind that the learner is part of the solution.

(2) Planning. The learner should obtain a strategy or plan that will lead to the final solution. The teacher should first introduce a few strategies after which each learner should decide his or her own plan. The following strategies could be used in a lesson (de Bono, 2002). Break down the problem into smaller sections and then find a solution for each section. This is the easier strategy and it can be used by learners with learning disorders. The teacher can help with the different sections and how each learner reflects on it. The second strategy is that the learner should work backwards from the solution to the initial problem. The learner sees an image of the final solution and writes this down. He then breaks the solution up into all the sections needed to assemble the final product. Each section is then analysed until finally the problem is constructed. This will need cognitive analysis – and most learners will be able to do this. The last strategy uses analogical thinking in which strategies of similar problems are used to solve the current problem. This is a very high order thinking skill. The learners should choose the best algorithm for them and explain their plan to you, the teacher. This will help you and the learner to modify the plan to find the best possible solution.

(3) Implementing the plan. The plan is implemented stage-by-stage. The learner uses all available methods to execute the plan. The teacher monitors the whole process and encourages the learners to do their best. Learners should use other learners' knowledge and capabilities to help them to execute their plans. This will help the learner to see the plan from different perspectives. If their planning has been done correctly, implementation will go smoothly. On the other hand, if certain procedures are missing from the planning, the learner should go back to the original plan and adapt his or her plans accordingly (Pogrow, 2000). This will also help students to learn from their mistakes.

(4) Evaluating the solution. Ask the question: “Is this the best solution to the problem?” If not, start the process all over again and look at it from a totally new direction, or fix your mistakes and redesign the whole process to adapt to your errors. This is the highest level of thinking – evaluation (Bloom, 1956). Here the teacher and other learners play an important role. They can help each other to focus on words, strategies and problems which the learner has never seen before.

(5) Metacognition. One can, for example, take learners on an excursion and tell them to make notes of everything they see. When they are back in the class, write a problem about the excursion on the board. One could ask learners for possible answers and write them on the board. Stimulating the learners with key words will set their thoughts on a new tack (Hunt, 2001). Have a class discussion on possible strategies in solving the problem. In the end, the learner should choose one from each. The learner then constructs his or her own plan to solve the problem. All the results are put on the board and evaluated. The best solution wins a prize.

(6) Cooperative learning. Learners are divided into groups according to some strategy. A problem is presented to the groups. Learners should spend at least five minutes with each member in the group. During this time the learners should gather enough information from each other to solve the problem. The perspectives and views of others enrich each learner (Singhanayok and Hooper, 1998). A group discussion clarifies all the neglected issues. The best strategy is passed on to the rest of the class.

(7) Key words. The teacher should spend quality time preparing for a higher order-thinking lesson. A whole lot of planning and reading will be done by the time the learning event is presented.

Table 1 below shows the key words that will assist the teacher in planning the event (Bosch, 2001).

Table 1: Key words that will assist the teacher to plan the event

Key words	Definition
Substitutions	Generates new ideas by substituting words and ideas with better ones
Combinations	Combining words and ideas help to create new ones
Adapting	Adapting ideas to incorporate new ideas
Modify	Modifications must be made to plans so that new ideas can be viewed in action
Magnify	Generate magnifications of words and ideas
Minify	Generate "minifications" of words and ideas
Put to use	Put certain words to other uses
Eliminate	Eliminate unnecessary words
Reverse	Make reversals to key phrases
Rearrange	Rearrange the words and sentences into new meanings
Fluency	List as many ideas possible
Flexibility	Approach the problem in a number of different ways
Originality	Generate as many as possible clever, unique or unusual ideas
Elaboration	Expand and develop as many ideas as possible by adding details and making changes
Curiosity	Seek additional information and carry out independent study
Risk-taking	Be willing to change, to defend ideas, to experiment, to predict and to put plans into action
Complexity	Seek alternatives, deal with intricate problems and ideas, and develop plans into a logical order
Imagination	Visualize and imagine plans, thoughts, ideas, outcomes and consequences to a high degree

What teaching methods and tools are most likely to address Bloom's higher order thinking skills?

Students can construct their own ideas by **assimilating** ideas from their teachers. It is therefore important to use the correct teaching methods to lay the foundation for higher order thinking skills.

Play is a method in which students can create new games, graphics and ideas by playing along. Students enjoy play. They begin to create new and better ideas by analysing other games and evaluating the program segments. Play stimulates creativity on levels that are not easily accessible with normal teaching methods (Baum, 1990).

Exploration allows the students to examine, read, touch and try out every aspect of the model or content with which they are busy. You tutor your students in the new model by telling them the basics and by arousing in them as much curiosity possible. Students should be so fascinated by what you have said that they will explore whatever they can to as they compile and organize their model. By exploring new content, they are creating new meaning and structure in the content (Crump, Schlichter and Palk, 1998).

Experimentation and exploration are more or less the same as exploration, but experimenting is more specific. When new content is researched in the real world, experimenting is a method whereby ideas and new models can be tested to see how they perform in a real situation. A high order thinking skill is developed here. Reconstructing, rewriting, reorganizing and rearranging are the principles of experimentation (Hudgins and Edelman, 1986).

Conceptualisation is a method in which students put their ideas and thoughts into words and pictures. This creates high order thinking skills that force the student to give meaning to their ideas. Ideas start getting a new meaning when they are conceptualised (Sternberg and Bhana, 1986). Drawing a storyboard, picture, flowchart or a concept map focus the mind on another part of the brain. Processing the idea and picture stimulates the brain into new meanings and structures.

Collaborative or cooperative learning is a method in which students share their ideas with each other. This method allows students to see a model or content from another viewpoint. Creative thinking skills thrive on more input, other ideas and models. It is an impossible task for one individual to evaluate a model in all its aspects. Students will need the cooperation of their classmates to help them to obtain an optimum amount of information from the model or content.

Presentations by students help them and you to share the **responsibility** for the new content. The world we live in is very competitive. When students have to prepare new content and present it the class, they want to impress their teacher and their classmates. This should create a desire in a student to present a better model than the teacher and his or her classmates. They will compare, discriminate, criticize and generate as many new ideas possible. This process stimulates the student's minds into new creative and better structures and models (Mcrel, 1985).

Designing and producing their own models. When you put clay in front of a child and ask them to produce an apple you will see different styles of apples. If you ask them to draw their house you will also see different forms of houses. When students are asked to design and produce their own model they are forced to use more and higher thinking skills than before. While designing and producing new models, they analyse, synthesize and evaluate new ideas to form their own model (Robinson, 1987).

Problem solving helps students to construct new ideas. If students are asked to solve a problem in any situation, their thinking begins to work in a new way. Human beings like to solve a problem. To make it more challenging, place students in groups and ask them to solve a problem. Evidence that this works may be seen in television programs like "Survivor" and youth camps. One's mind is challenged to find the best solution for oneself and for one's group. In this situation, the teacher plays the role of a **facilitator** and is no longer the instructor. The teacher can play the role of a **user** in the real world. The teacher can also be the **project leader** who directs them in the right direction and – for the remainder of the journey – is regarded simply as another source of information.

Exercises to assist the learners to construct new ideas

(1) Mindtools. Jonassen (1996) compares the way in which students learn and construct a process to the a carpenter who uses tools to complete his work. Just as a carpenter uses tools to manufacture a chair or table, so a student uses intellectual tools to construct knowledge. These tools he calls Mindtools. Computers can be used as mindtools for critical thinking and to construct: "A Mindtool is a way of using a computer application program to engage learners in constructive, high-order, critical thinking about the subjects they are studying" (Jonassen, 1996, p. iv). On the website http://www.mindtools.com, new creative thinking skills are discussed.

(2) Matrix analysis. Features and attributes of a model are identified and used as column headings. These attributes can be dimensions, colours, weight, style, skills, etc. Underneath each heading all the variations of that attribute should be listed. By mixing the variations differently, new models can be created.

(3) Brainstorming. This thinking process creates new thinking patterns to help the student to see things in a different light. No evaluation of ideas will be made before the brainstorm exercise is over. Brainstorming can be done individually or in a group. Normally an idea or problem is put on the table. Students should generate as many ideas, features, characteristics and definitions of the model or content as possible. These are listed and then the best ones are picked to construct a new meaning for the model.

(4) The concept fan. The method makes use of a principle of taking one step back and seeing the problem from a broader perspective. The problem is written down. To the right of the problem the learners writes down as many solutions to the problem as they can find by using radiant lines. To the left, they write a broader definition for the problem. The problem can now be seen as one of the solutions to the broader definition. Other possible solutions to the broader definition can also be written down. If more ideas are needed, another step to the left can be taken to make it even broader. All the radiant lines form the fan from one concept.

PROJECT DESCRIPTION

In order to explore the possibility of adding a real-world context to a computer studies lesson, a problem was introduced to 28 Grade 10 Computer Studies learners (with an average age of 16) at a high school in a relatively well-to-do area of Pretoria, South Africa.

Every year the school raises funds by selling flower bulbs to the community. It takes many hours to administer the process. Learners were asked to computerize the whole process and create a system that could be used each year and that could be maintained for the next five years.

The teacher responsible for the fundraising-project (selling flower bulbs to the community) had approached the computer science department on several occasions to ask for a program that would be able to do what was required each year. This formed the basis of the constructivist learning event. The objectives of a real world context and collaborative work could be incorporated. Students could be put into project teams in which they could take the roles of project leaders and systems analysts. The learners therefore had to develop their own project in a real life context and in collaboration with other learners. The flower bulb teacher was the end-user.

The lesson

The lesson will be described according to Gagné's nine events of instruction.

Gaining attention

The learners were told about the flower bulb project. It was explained to them that someone had to write the project and they were asked whether they as a class would be interested in writing this project. Everyone agreed to do so.

Informing learner of lesson objectives (outcomes)

The project objectives

- Create the menu for the project. Declare all variables, the frame of the main program, and all the input to the project – this would be the task of group one.
- Generate a list of all pupils selling more than R200 of bulbs – this would be the task of group two.
- Generate daily totals with the pupil and grade selling the most – this would be the task of group three.
- Generate weekly totals for the pupil and grade selling the most – this would be the task of group four.
- Generate a final report on the top three pupils selling the most bulbs. Also generate a report on how the different grades have faired – this would be the task of group five.
- Be sure that input and output are user friendly – anybody should be able to use the program.

Learning outcomes

The project set out to achieve the following learning outcomes:

- To understand and implement the life cycle of a project
- To understand and implement communication with end-users
- To keep records of all documentation used and to sign off the stages in the life cycle of the project
- To understand and implement the maintenance of a project
- To understand and implement selection structures and loop structures
- To understand and implement debugging of a project using trace tables

Stimulating recall of prior learning

The learners were taken back to the three months prior when they had had to write a game. The process of writing the game was explained, and a recalling of the stages of writing the game was used to introduce the new project.

Presenting stimuli with distinguishing features
Because the teacher represented the user (company) for which the program was being written, he simulated real world conditions by meeting with the project leader and discussing everything that had to be done. He asked all the questions that he needed to and noted everything down in writing. A fixed date for implementing the program was agreed upon. The project leader had to provide the user with a budget. The project leader then had a meeting with his five analysers and each one's sub-project was given to them. Each analyser planned his project and divided it into sections and then had a meeting with their programmers (3-4). Each one had to construct their section. The analysers kept an eye on the work and help was given where necessary. The project leader kept an eye on each analyser and had meetings to discuss problems and the progress of the project.

Each group had to do the following:

- Interview the end-user about the conditions and features of the project
- Write about their part in the project in their own words
- Draw a mind map of their part of the project
- Present a blueprint with dates, deadlines, budgets and sign-offs to the end-user

They then had to report back on everything that was done.

Guiding learning
Learners were guided throughout the design and development phase of the project. Learners were encouraged to use their mind maps and to collaborate with team members to get the best plan on the table. The teacher, who had experience of real life programming, could foresee certain problems in some areas and asked the learner to re-design their work in those cases. Learners were also encouraged to use some of the key words that are explained in the literature survey. Key words like *substitute*, *modify*, *put to use*, *eliminate*, *rearrange*, *curiosity* and *imagination* were used.

Higher order thinking skills were fostered by the use of play, exploration, experimentation, conceptualisation and problem solving in the class. Learners were encouraged to use a search engine on the Internet to help them to solve some of their difficulties. Learners were also helped in areas where new programming was needed, and had never been done before.

Eliciting performance
Groups were informed of the time schedule and sign-off dates. Penalties in the form of marks were deducted when deadlines were not met. If, however, the group managed to finish and implement their work before the deadline, extra marks were allocated.

Extra marks were given for:

- creativity
- collaborative work
- well-designed projects
- error free projects
- new programming ideas

Providing informative feedback
The end-user made comments on the usability and friendliness of the program because she wasn't one hundred percent computer-literate. The design and programming feedback came from the teacher. The feedback always consists of comments that help learners to be more creative and to think other (novel) ways.

Assessing performance
In keeping with constructivist methods, the learners had the opportunity for self-assessment. They had to assess their own work as well as that of their group members. The system analysers gave each member a mark and the learners assessed the system analysers as well as the project leader. In cases where the project leader noticed that learners were not working, he made a note and it was reflected in their marks. The most important aspect of evaluation was their construction of ideas. Before the project started, pupils were reminded that extra marks would be given for creative ideas. In the end, each learner had two marks: one was for the learner's individual contribution and the other was given by the rest of the group and the system analyser.

Allocating these marks was not so easy. It depended on what and how the teacher assessed a learning outcome. Some of the pupils argued that what the user thought was not exactly creative to *him* was very creative to *them*. Both sides argued their views and, in the end, a mark was given that would (it was believed) reflect the product in the real world (Willis & Wright, 2000).

Each learner had his or her own portfolio. All the researched materials, images, flowcharts, pictures and the black book were kept in the portfolio. The black book operates like a notepad. When any idea or new thought comes up, it is noted down immediately. Just as in the real world, specifications are written in a contract for the project. Any changes from the user's side were noted in the black book and were signed off. All dates and appointments were recorded in the black book. The black book was also assessed, together with the portfolio, in the end.

When the project had been completed, the analysers implemented the program and together with the project leader assessed the whole project and submitted their results. The user (teacher) evaluated the project and gave his results as well as his recommendations for further projects in the future.

Enhancing retention and transfer
The project ran over a period of three months. During this time maintenance had to be done on the project. This means that some of the atheistic and programming had to change to make the project more streamlined and user-friendly for the end-user. The groups had to back track to do this. The learners were asked to note in writing that aspects of the project that could be improved.

Brittz (2003) introduced a model that can be used to implement higher order thinking skills. This model was used for the project. Table 1 presents the model.
The first column shows the steps taken to solve a problem, from the problem to maintaining the model built. The second column focuses on the key words that are used to plan each step. The third column identifies the role of the student during each phase. Column four refers to Bloom's taxonomy. Column five indicates the role of the

teacher during each phase. The last column shows the assessment that is required in each phase.

Table 2: Model used in learning event

Building steps	**Key words**	**Role of learner**	**Bloom's taxonomy**	**Role of educator**	**Assessment**
Problem	Content	Study the relevant content.	Knowledge: defines, identifies, states, outlines, selects and reproduces	Present an introduction and all the information available that will assist students to understand the problem.	* Portfolio * Is problem statement according to plan?
	What do I have to know?	Write problem in your own words.			
	Why?	Write your own goal for this project.			
	Information	Gather all the relevant information so that you can understand the problem better.			
	Define	State the problem in your own words.			
Plan	Mind map	Draw mind map of whole project.	Compre-hension: estimate, explain, extend, give examples, interpret, rewrite, summarize	Observe and give guidance where necessary.	* Portfolio * Will the model meet the goals that are set by the student? * Give a first mark for product.
	Blueprint	Create a blueprint of the steps that you will take to realise the project.			
	Model	Build model of final product.			
Design	Research	Gather all information that is needed to complete the project.	Application: apply, change, produce, use, modify, prepare, relate	Observe and assist with information.	Portfolio
	Design	Write and draw all information into a model.			

	Little black book	Make notes of everything that happens in the whole process.			
Construct	Share	* Collaborate with other students. * Get another perspective.	Analysis: Compare, contrast, differentiate, relate, break down	Observe and provide alternative models to bring out the best in each student.	* Portfolio * Give a second mark for product.
	Build	* Create the model * Put all together			
Re-thinking	Testing ↓ Problem/ errors ↓ Reconstruct (↑ back to Testing)	Test the final product for any problems.	Synthesis: Combine, compose, modify, reconstruct, reorganize, revise, rewrite	Actively participate and give input so that you get the best out of the student.	Portfolio
		Let other students test your product.			
		If problems occur, reconstruct and make adjustments.			
New ideas	New ideas ↓ Construct ↓ Add/delete (→ ↑ back to New ideas)	Do maintenance on your product and compare it to new products on the market.	Evaluation: Appraise, criticize, evaluate, compare, support	Give feedback and information about new products and new models.	* Portfolio * Give a final mark for product.
		Construct new features for your product.			
		Add/delete new ideas to/from your product.			

This model is used to explain the findings of the project in the next paragraph.

DISCUSSION

The model reflects the interaction of the project and reports the findings as they occurred. The headings used are from the left column of the model and the discussion is from the other columns.

The problem

If the learners don't understand the essence of the problem, they can't go nay further. Writing the problem in their own words helps them to start generating new ideas. Writing their own goals helps them to set the pace and standard for the project. The learners used the Internet to search for most of the information. They used Google as a search-engine, and key words like "flower bulb", "system cycle" and "ADDIE" were searched, as well as links to existing projects. When observing the learners, it was interesting to see that most of them went beyond the links that were given to them. With some guidance, the groups produced excellent problem statements.

The plan

Writing the blueprint of the project required research. Each member in the group had a responsibility, which varied from interviewing the end-user to drawing the mind map. The learners had the theory to do the interview but didn't ask the questions to get to the essence of the project. Some guidance was needed. The mind map was the real challenge.

Hidden creativity flowed from the learners as each member wrote his or her piece. The learners had to draw diagrams of what they indented to do. The flow of the project was presented in a big flowchart and this became the model that was used to build the project.

To generate the plan the learners had to transfer the information gathered by the interviews into a working plan. This fostered high order thinking skills in that the learners analysed and then synthesised as they built the model. Although learners presented good blueprints, the lack of real world tendencies was noted at this point. Some of the learners (18%) did not produce the correct program because they misinterpreted the instructions. One of the learners wrote: "Design means to code the problem in Pascal." He did not understand the concept of planning at all.

Design

Some of the learners had all the knowledge and skills to write programs, but found it difficult to apply this knowledge in a project in collaboration with other learners. One of the analysers (from group 4), who was one of the better programmers, had to divide the group's problem between three programmers. He had all the information but did not know how to apply the information in the correct sequence of events. After some explanation and help from the project leader, he could explain it to the other programmers in the group.

The learners quickly assessed their strengths and weaknesses and each applied their skills where they were most valuable. Group one assessed their problem and Pierro immediately said he liked designing the menus. Justin immediately claimed the variables as his strong point. Adri gathered all the input – it wasn't her strong point but it was better than doing the menus or variables – her weak point.

After two or three days, some of the learners changed from being analysers to programmers. Gerard (group 4) decided to step down as analyser (because that was not his strong point), and to focus on programming (his strong point).

Most of the learners enjoyed working with teachers as users. This made their efforts worthwhile. After they had had discussions with the teachers, they applied their knowledge so realistically that they were commended for their efforts.

None of the learners used the little black book to their advantage. If used correctly, it is a tool that manages all documentation and the extras that are added to the project. This tool is a must in the real world.

Matrix analysis and brainstorming were used to finalize the project. The matrix was used to generate better ideas and brainstorming was used for the flow of the project and the screens outlay. Collaborative work played an important role because the groups shared the same variables. One of the groups (four) had to wait for group two and three before finalizing their part (weekly totals).

Construction

Higher order thinking skills played an important part in this section. If the design is performed correctly, construction is easy. In some cases groups had to go back to the design and make changes. This had an effect on other groups and one group (two) had to wait two days before they could continue. Building a structure from diverse elements is a high order thinking skill. For most students this was the most difficult part. Learners should be trained to build structures from different elements. A video was shown to the learners of examples in real life of people building structures and creating from a variety of elements.

Collaborative work played the key role in this section. Getting different views of the structure helps the learner in to process the material in such a way that a holistic view guarantees a well-formulated solution. The report of group five was wholly dependent on the programming done by group three and four. Group five therefore had meetings with group three and four each day and discussed the variables used as well as the parameters.

Putting all the single programs together in one working system created some problems. Variables were not globally assigned. One analyser got the information wrong and used two different procedures. It took two days to solve that problem. Constructing can be fun too. Most of the learners said in the survey that they enjoyed that part. Lots of new creative ideas were implemented.

Constructing can be hard work. In one instance one of the learners had great difficulty in programming a sorting procedure. Another learner gave him a nice idea but it took him much longer to construct the idea than time allowed.

Re-thinking

The researcher's own experience has shown that testing a project for errors takes fifty percent of the total time allocated for the project. This was explained in the beginning but, in the real world, as the learners have discovered, it can take much longer if the testing is not coordinated and if team members don't communicate effectively.

Most of the groups lost marks here and said in the questionnaire that they learned the most from this part of the project. Learners used trace tables and the debugger from *Pascal* to test the program. Groups tested each other's work and learners exchanged ideas to make certain sections better. The only section that needed reconstruction and re-thinking was the weekly totals. Although some errors occurred, I was glad that we had this opportunity to reflect on a real life situation and higher order thinking skills. Everyone worked together and brainstormed the problem until the best solution was used. Re-thinking helps with transfer of knowledge – and this was indeed observed during this process. Finally the product was implemented and evaluated.

Learners didn't know how to evaluate. In evaluating other learners they gave each other high marks for work that had not been correctly done. Some didn't even assess work but gave a mark of 86%. When confronted, they had some explaining to do. The learners thought that the project was completed when it was implemented. After the evaluation process, they had to go back to their planning to make adjustments. This took much longer than anticipated.

Frequent evaluation gave the learners some peace of mind. If evaluation is done regularly, a student can rectify problems quickly and know that he or she is still on the right track. The portfolio brings the learner into contact with the real world. Everything should be kept in the form of a journal. Sign-off documents and changes are normally the big factors that distract the momentum of the project. Some changes to the project were made that were not documented. This caused a huge debate.

In the case of the researcher, the teacher played various roles in evaluating the process. The teacher assesses the educational process, the user's role, the role of the project leader, analysts and programmers, the role of the community, and the role of the real world. All sections should be included to ensure valid results.

The learner and his peers do fifty percent of the final assessment. The teacher and people from the real world do the other fifty percent.

New ideas

For their final mark, groups had to maintain the project for three months. During this period, adjustments were made to the project to render the project more functional and more user-friendly. The learners did not understand this phase. When users use a program in the real world the user always complains about small things that don't work so effectively in the normal daily routine. This provides an opportunity to reconstruct and come up with better ideas. If one uses high order thinking skills, one can produce better programs than other companies and this will give one's own company the edge that one seeks.

After some explanation, they understood this and made a few changes to the program. Feedback was provided during the project and after everything was assessed, it was discussed with the learners and they reflected on everything learned. The learners scored between 8-24% higher in the practical examination at the end of the year.

CONCLUSIONS

The questions asked in the beginning of the chapter will be answered in this section. The questions asked are used as headings.

What learning principles should be applied to stimulate higher order thinking?

Gagné's learning principles were used in combination with Bloom's taxonomy to present the lesson. Using this combination triggered the attention of the learners and helped the educator to set the objectives and assessment according to the curriculum.

Which learning models should be used to develop a workable learning experience?

"By exploring new content, they are creating new meaning and structure to the content" (Crump, Schlichter & Palk, 1998) and "Reconstructing, rewriting, reorganizing and rearranging are the principles of experimentation" (Hudgins & Edelman, 1986). These researchers focus on constructivism as an important learning model. "Ideas start getting a new meaning when they are conceptualised." Sternberg and Bhana (1986) show the importance of conceptualisation. "The value of individual understanding can be evaluated when learners share and debate perceptions and interpretations." Savery and Duffy (1995) express the essence of collaboration.

Constructing can be fun. Creativity was more than evident in the class. Ideas were shared, better planning was done, and contact was made with people in the real world, and all this was done in a good spirit.

Constructing can also be hard work. The project was scheduled for two weeks. In the end it lasted three weeks. To ensure the best solution in the market, one needs to cost hard work and long hours. Collaborative work in groups stimulates higher order thinking skills. Viewing different aspects of the problem helps the students to achieve better results in the end. In the real world, most of the work on a project is done in collaboration with other people. Training the mind to process different views and assumptions polishes the higher order thinking skills of learners. Constructivism, which include exploration and conceptualisation, and collaborative learning, constitute a workable learning experience.

What instructional design principles can be followed?

Bednar (2002) suggested analysis of the content, analysis of the learners, and object-specific goals. These principles, together with a mind map, flow chart, blueprint and the little black book help the learner to design the best possible model for a project.

The use of the model presented in the lesson focussed the learners' attention on all the small design issues that sometimes get neglected. Mind maps helped learners to develop each section as a stand-alone project. The flow chart helped learners to see the whole project at one glance. The blueprint helped them to administer the project, keep to dates and deadlines, and manage the financial side of the project. The little black book helped them to file all the changes to the project in one place.

What type of assessment would be appropriate in this context?

Willis and Wright (2000) suggest various alternative forms of constructivist assessment, such as projects, portfolios, activity logs, and the keeping of journals. Assessment is not onerous anymore. From the student's point of view, they had to perform to satisfy *one* person's beliefs and thoughts. From the point of view of the teacher, it was difficult to find a norm to assess. Now students evaluate and assess themselves. Individual skills as well as group work are assessed and together they work towards the ultimate goal – success. Constructing in the real world has changed the paradigm from getting good marks to constructing "for my own future". They don't work anymore for their parents or for marks, but for themselves. They start building their own portfolio when constructing new models and projects. These portfolios will speak for themselves when they apply for a job.

To what extent does the role of the teacher change?

Stimulating the learners with key words will set their thoughts on a new track (Hunt, 2001). The role of the teacher changes from presenter to facilitator. The teacher should aim to plan and prepare better than they ever did before. Some teachers have done it for years while others will need to do it if they want the best for their learners. It is the responsibility of the teacher to introduce the real world to their learners. By facilitating, the teacher will assess in a way that is different from the old way. Continuous assessment will reflect the learners process during the whole project.

What new roles are required of the learners?

The perspectives and views of others enrich each learner (Singhanayok & Hooper, 1998). The role of the learners has changed from that of passive listeners to that of active role players who construct and shape their own futures. Working together and collaborating with each other helps them to get closer to the real world tendency of group work in a project. They learn to subject their own beliefs and ideas to others by focussing on the task and not on themselves. They learn that two or three people construct better ideas than one. They learn to share their expertise and to speak in front of an audience (this improves their self-confidence). They learn what the real world is all about. They learn how to prepare a project, draw flowcharts, how to interview a user, what to look out for, how to use a little black book and make the user sign for any changes to the project.

The students enjoy what they do in the class. There is no more pleading for time to complete a project. Students work for *themselves* and take pride in their work. They also have the opportunity to assess themselves and other learners. This is a responsible role and learners need to be educated into this task.

RECOMMENDATIONS

Adjusting the curriculum. Key words and content should be adjusted according to higher thinking skills. Australia has taken the lead in providing a framework to work on by writing more creative outcomes for the future of Computer Studies. Content should be in line with the projects students work on and these should be relevant to the real world. Key words such as *construct*, *design*, *illustrate*, *evaluate* and *interpret* should set the scene for future curricula.

Getting role players from the real world involved in constructing the outcomes for the new curriculum. What students need are not CEOs or MDs, but the real workers who make the rules for constructing new models and ideas. These people can provide creative models and ways to attain the kind of outcomes that are needed in the real world.

Projects should be done in a real world context. Everything that has to be learned in the computer classroom should be as real as possible. Projects, assessments and content should conform to real world conditions. Students should go out and interview programmers, system analysers and users to get the experience of the real thing. Players in the real world can help to assess projects.

Assessment should be according to performance in the real world. What are the key features of a successful project? These are the outcomes that need to be assessed. No longer can only one person do assessment. Inputs from the group are needed for the new way to assess work that is done. While content can still be assessed individually, practical work should be done in collaboration with group members. Practical work should count at least 60-70% of the final assessment mark. Theory can count for the other 30%. At the moment the ratio is 50-60% for theory and 45% for practical work.

CHAPTER 4

CONCLUSIONS

This chapter gives a summary of this mini-dissertation and presents a discussion of what may be learned from this research and recommendations, both for further research, and for policy making and practice.

SUMMARY

Two research questions were asked. They were:

- To what extent, if any, do the South African curriculum on Computer Studies and the Australian curriculum for Computer Studies differ from each other in terms of key words from Bloom's taxonomy (1956)?
- Can South African learners produce the same or better results when higher order thinking skills are used in a lesson?

The first question was answered in chapter two, in the first article. This article discusses what a good curriculum should look like, and examines the South African and Australian curricula for Computer Studies for grade 10. The second question is answered in chapter three, in the second article. This article reports on a lesson that was introduced to South African learners in terms of the model proposed in chapter 2.

In chapter 2, the two curricula were compared and the counting of the key words produced the following results:

- South Africa has 92% lower order thinking skills and only 8% higher order thinking skills.
- Australia has 53% lower order thinking skills and 47% higher order thinking skills.

When learners do programming in Computer Studies, they construct a new model. The researcher developed a model to evaluate his learners on constructing, collaborative work and outcomes-based assessment.

Chapter 3 reports on a lesson that was presented to 28 learners, based on the model in chapter 2. The model used higher-order thinking skills and the higher levels of Bloom's taxonomy (1956), namely analysis, synthesis and evaluation. The class was divided into five groups, each with a system analyser and one project leader who instructed the analysers. The learners were observed and interviewed, and they completed a questionnaire.

The learners produced creative work and gained new knowledge from collaborating with other learners. Learners produced high quality work and experienced real world programming. Learners are stimulated by higher order thinking skills and are motivated to construct programs that can be used in the real world.

REFLECTION

To prove that South African learners in Computer Studies in grade 10 were deficient in higher order thinking skills and collaborative work under real world conditions, it was first necessary to prove that they were in fact deficient. In chapter 2, the South African curriculum was compared to the Australian curriculum because the work covered was most similar to the work required by the Australian curriculum.

The results were tabled in an Excel spreadsheet and were checked by two of the researcher's colleagues. The results showed that the South African curriculum has 39% fewer higher order thinking skills than the Australian curriculum. When one compares the lower order thinking skills to the higher order thinking skills, the difference can be seen in the figures for the lower order thinking skills, namely: South Africa 34; Australia 21. When one compares the higher order thinking skills, the figures are: South Africa 3; Australia 19.

Chapter 3 took the form of an article that reported on a learning event designed to investigate how this discrepancy can be overcome in a lesson where higher order thinking skills were presented under simulated real world conditions. Grade 10 learners worked on a real project for the school. Learners were observed, questioned and interviewed. The learners were assessed on their portfolios (as the literature suggests).

Conclusions were drawn from these results and were checked and discussed with two other colleagues of the researcher. The lesson was presented using Gagné's nine events of instruction. Higher order thinking skills were introduced and learners had to use these skills to solve the project. Six questions were asked and answered in the concluding section. These questions interrogated the learning models, design principles, assessment, and the role of teacher and learner when higher order thinking skills are used in a lesson.

The results of the observation, interviews and questionnaire show that South African learners construct programs that compare well to real world programs. By using the model in chapter 2, and the models and higher order thinking skills in chapter 3, teachers can motivate their learners to produce better programs for the real world. This could contribute beneficially to the economy of South Africa. It will also produce entrepreneurs who can build new companies and help to solve the unemployment issue in South Africa.

Anderson (1980; 1981), Kozma (1987) and Bruner (1967) explain the importance of active learning. They all agree that learners gain knowledge from actively constructing new ideas and projects. Piaget (1951) and Vygotsky (1978) say that learners who interact with each other in solving a problem, gain new ideas and views that enhance their knowledge and experience. Higher order thinking skills are based on an analysis of the problem in collaboration with other learners, on the construction of diverse elements, and on the evaluation of the whole process in collaboration with learners, teachers and people from the real world.

RECOMMENDATIONS

It is therefore apparent that the South African syllabus is deficient in that it needs:

- more higher order thinking skills included in the syllabus
- more emphasis on constructing and collaborative work

What should we do in response to this?

If we base our conclusions on those from chapter 3, we now know the following:

- Introducing higher order thinking skills in the South African syllabus is possible and should be done as soon as possible.
- The emphasis in assessment should be on the *practical* work and not so much on theory.
- Teachers should be trained in developing higher order thinking skills. This should be a continuing process and workshops should be regularly attended.
- Collaborative learning should be a focus in the higher grade.
- Programming in the real world, and constructing one's own projects, should be the basis for the new syllabus that will be introduced in 2006.
- More collaborative planning with players from the real world as well as with teachers in the profession should result in a syllabus that is better suited to the real world.
- Comparing the South African curriculum in other subjects on higher order thinking skills to the curricula of other countries should reflect how well South African learners are being prepared for the real world and for their futures.

SUGGESTIONS FOR FURTHER RESEARCH

South Africa requires more research to be carried out in Curriculum Studies, and the following suggestions for future research in this regard can be used for further studies:

- South African curricula in other subjects like Mathematics, Science, Biology need to be compared to the curricula of other countries.
- We need to introduce higher order thinking skills in other subjects to South African learners and assess such learners' responses and performance.
- We need to allow learners in other subjects do a project that relate to real world conditions by using learning models and keywords such as those that the researcher used in the second article.

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