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A Cognitive Model to Design a Real World Curriculum in Computer Science

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Abstract

A comparison was carried out between the Eritrean computer studies curriculum and the Australian computer studies curriculum for sixteen-year old learners. The curriculums were compared on the basis of the different keywords that were used to design the outcomes that learners are required to master. These keywords were compared in terms of Bloom's taxonomy and categorized according to the different levels. This was done in order to demonstrate that the Eritrean curriculum lacks keywords on the higher levels of thinking. The comparison proves that the higher thinking skills are used more in the Australian curriculum than in the Eritrean one. The researcher proposed a model for use in Computer Studies that will ensure the implication of higher order thinking skills.

Keywords: Knowledge, Comprehension, Application, Analysis, Synthesis, Evaluation, Lower order thinking skills, Higher order thinking skills.

1.Introduction

This research paper is a comparative analysis of the curriculum for Computer studies in Eritrea and Australia, in terms of the extent to which they address various levels on Bloom's Taxonomy (1956). The two regions are chosen at contrast to each other, as Eritrea (North-East Africa) is a new nation, which is under development, and the Australia which is a developed part of the world. The researcher argues that although the Australian curriculum addresses higher levels than its Eritrean counterpart, both curriculum are essentially mechanical and devoid of real-world relevance.

1.1 Background and context

Computer studies as a course is newly introduced in Eritrean curriculum. The main emphasis of the curriculum is still on theory. 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. Typically a learning task is to produce some simple programs like performing calculations, writing programs for small imaginary company etc. Over the years the curriculum at Ministry of Education in Eritrea has not been updated. Learners have to learn the basics of programming and then do certain exercises that are required by the curriculum.

2.Theoretical underpinnings

This section will deal with aspects of curriculum design and evaluation as well as with the requirements of the current educational policies.

2.1 The qualities of a good syllabus

According to Chase (1989), a good syllabus/curriculum should fulfill the following requirements with regard to layout, content and outcomes.

Layout
Although professional typesetting, logical organization 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 instructor to consult other resources in order to teach.

Content
Chase calls for a syllabus that is workable with available resources, and that addresses local conditions while also accommodating innovative teaching, cooperative learning, and creative thinking skills. He further recommends the incorporation of local resources for fieldwork, and recommends that the curriculum 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 worksheets, readers, DVDs etc.

2.2 Bloom's Taxonomy
For this research, the researcher has used Bloom's original Taxonomy of Education Objectives (1956), specifically because it is the most widely known and accepted taxonomy in education.

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:

i. Knowledge
ii. Comprehension
iii. Application
iv. Analysis
v. Synthesis
vi. 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.

Bloom's Taxonomy

Skill level	Levels	Keywords
Lower order thinking skills	**Knowledge:** Recall data	Defines, describes, identifies, knows, labels, lists, matches, names, outlines, recalls, recognizes, reproduces, selects and states.
	Comprehension: Understands the meaning and interpretation of instructions and problems. States a problem in own words	Comprehends, converts, defends, distinguishes, estimates, explains, extends, generalizes, give examples, infers, interprets, paraphrases, predicts, rewrites, summarizes, translates.
	Application: Uses a concept in a new situation	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 judgments about the value of ideas or materials.	Appraises, compares, concludes, contrasts, criticizes, defends, describes, discriminates, evaluates, explains, interprets, justifies, relates, summarizes, supports.

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…

3. The Eritrean Curriculum

The Eritrean 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 first 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 higher order thinking or a lower order thinking skill in the taxonomy.

3.1 Hardware and System software (Eritrean Curriculum)

Outcomes	Level in Bloom's taxonomy	Thinking skills
Differentiates between the concepts of hardware and software	Comprehension	Low
Identifies and distinguishes between computer types and associated software	Knowledge & Comprehension	Low
Distinguishes between system and application software	Comprehension	Low
Identifies the functions of various types of operating systems	Knowledge	Low
Understands the concept of file organization into multi-level directories	Comprehension	Low
Distinguishes between different file types by their extensions or application types	Comprehension	Low
Effectively uses tools provided by the operating system and other utility packages to organize 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 address 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.

3.2 Communication (Eritrean Curriculum)

Outcomes	Level in Bloom's taxonomy	Thinking skills
Describes the role of an Internet Service Provider (ISP) in facilitating communication	Knowledge	Low
Makes efficient use of emails (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

This table deals with the section of the curriculum statement that covers computer based communication. Learner's activities involve working on the internet, and similar to the previous table this also addresses the lower order thinking skills only.

3.3 Social and Ethical issues (Eritrean Curriculum)

Outcomes	Level in Bloom's taxonomy	Thinking skills
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 major work here is on the level of comprehension, which is the second level of taxonomy.

3.4 Programming and Software development (Eritrean Curriculum)

Outcomes	Level in Bloom's taxonomy	Thinking skills
Produce an algorithm of simple sequential statements involving variables, assignments and numeric expressions	Synthesis	High
Produce useful tables by applying knowledge or arithmetic expressions in driving a software application	Synthesis	High
Design a simple user interface for a real life example	Synthesis	High
Distinguishes between good and bad user interface design with respect to font size, layout and color	Comprehension	Low
Implements the user interface using an application package	Application	Low
Identifies the basic of Boolean conditions and operators and applying this to simple Boolean expressions	Knowledge	Low
Draw simple representations showing the simple selection and looping	Synthesis	High
Calls the basic mathematical functions and applies it to application packages and programs	Application	Low
Understands the simple data that comes in different forms and types	Comprehension	Low
Implements selection and simple looping structures in programs	Application	Low
Explains effects of rounding and truncation	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 the limitations of help files and how they could be improved	Knowledge	Low

Six 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 lower order thinking skills.

It is clear from the above tables that the Eritrean curriculum statement uses more keywords on the lower order thinking skills i.e. Knowledge, Comprehension and Application. Contrary to expectations, the section on programming and software development contains only five 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 five 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 Eritrean curriculum statement.

4.The Australian Curriculum

The tables that follow analyses the Australian curriculum, once again, the first column shows the outcomes, the second column shows the level in Bloom's taxonomy, and the third column designates whether the outcome is a lower order or higher order. The Australian curriculum can be divided into following five sections:

- Information System
- Algorithms and Programming
- Artificial Intelligence
- Social and Ethical issues
- Computer Systems

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

4.1 Information System (Australian Curriculum)

Outcomes	**Level in Bloom's taxonomy**	**Thinking skills**
Retrieve information from an existing database using queries and reports	Knowledge	Low
Develop a critical analysis of a functioning information system	Application	Low
Perform a critical analysis of a functioning information system	Analysis	High
Produce a specification document for an information system	Synthesis	High
Produce working information systems	Synthesis	High

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

4.2 Algorithms and Programming (Australian Curriculum)

Outcomes	Level in Bloom's taxonomy	Thinking skills
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.

4.3 Artificial Intelligence (Australian Curriculum)

Outcomes	Level in Bloom's taxonomy	Thinking skills
Use an expert-system-shell to interrogate and to build a knowledge	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.

4.4 Social and Ethical issues (Australian Curriculum)

Outcomes	Level in Bloom's taxonomy	Thinking skills
Analyze the ideas and arguments of others	Analysis	High
Evaluate the impact of using computers on society	Evaluate	High
Suggest methods for minimizing the problems that are caused by using computers	Application	Low
Distinguish facts from opinions	Comprehension	Low
Make informed judgments about the effects of using computers on society	Evaluate	High
Analyze and criticize predictions made about the future use 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, and then use higher order thinking skills to investigate and evaluate the topics.

4.5 Computer Systems (Australian Curriculum)

Outcomes	Level in Bloom's taxonomy	Thinking skills
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 email 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 an organization about his responsibilities	Knowledge	Low
Debate the advantages and disadvantages of distributed system 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 website	Synthesis	High

The above table deals with the section on the curriculum statement that deals with computer systems. Learner's activities involve searching for the best system, analyzing the system, constructing a new authentic model, and applying this system in practice.

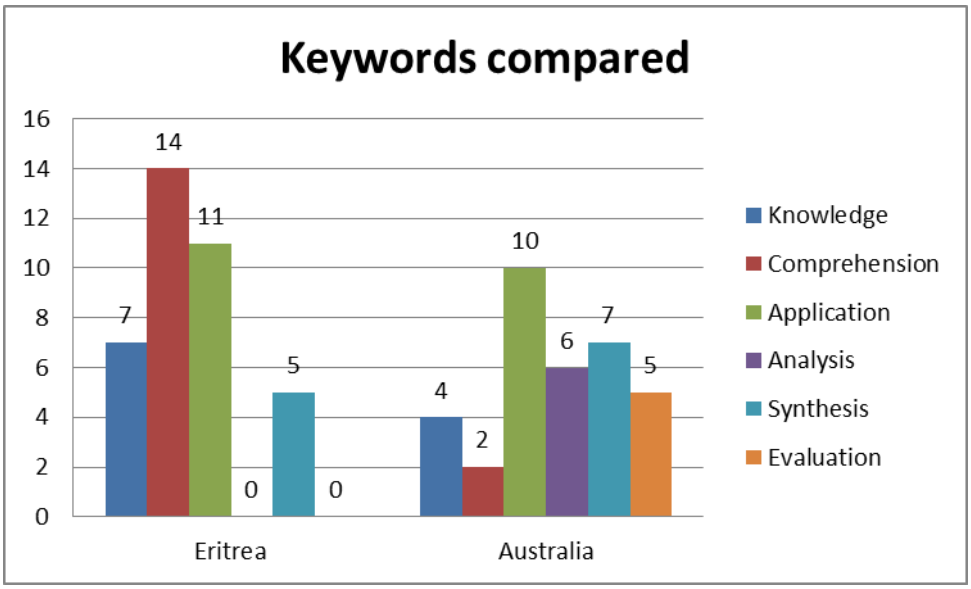
All the tables above shows that the Australian curriculum is more practical and has more even distribution between the lower order thinking skills and the higher order thinking skills. The focus is on the application of systems built in the real world.

5. Summative comparison of outcomes of Eritrean and Australian curricula

Thinking skills	Eritrea	Australia
Knowledge, Comprehension and Application	32	16
Analysis, Synthesis and Evaluation	5	18

Eritrea has more keywords on knowledge (7-4); Eritrea has more keywords on comprehension (14-2); Eritrea has more keywords on application (11-10); Australia has more keywords on analysis (6-0); Australia has more keywords on synthesis (7-5); and Australia has more keywords on evaluation (5-0).

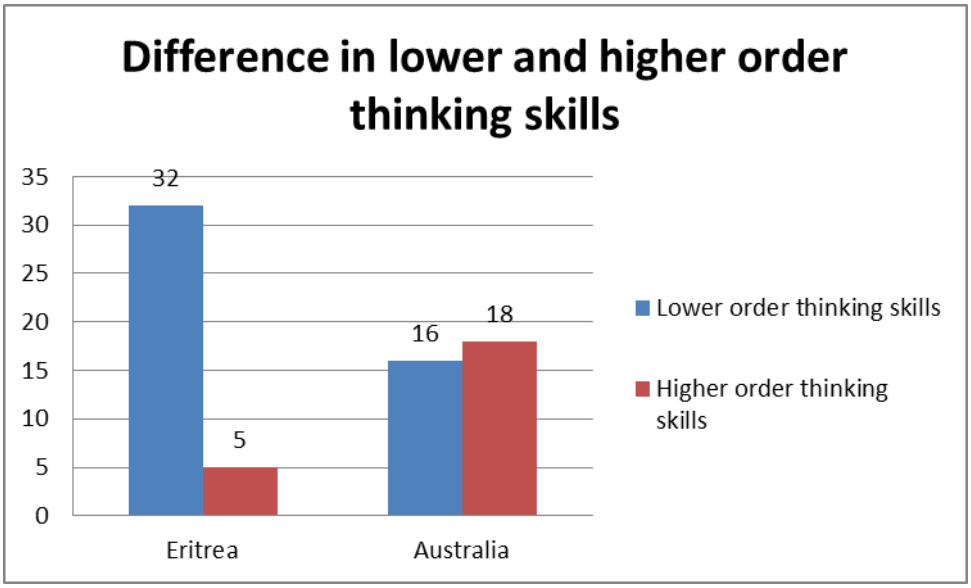
Figure below shows how many times the keywords are used on the different levels. The Eritrean curriculum appears on the left, and the Australian on the right.it can be seen that the Eritrean curriculum is biased towards lower order thinking skills.



Levels of Bloom's taxonomy addressed by the Eritrean and Australian curriculum

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

Figure below shows the difference between lower order and higher order thinking skills in Bloom's taxonomy. The Eritrean curriculum appears on the left, and the Australian curriculum on the right. The Eritrean curriculum statement is very strongly biased towards lower order thinking skills (32-5), while the Australian curriculum shows an even balance between higher and lower order thinking skills (16-18).



Lower and higher order thinking skills

6. Model to be introduced in a constructivist learning event in the real world

Building steps	Keywords	Role of student	Bloom's taxonomy keywords	Role of educator
Problem	Content	Study the relevant contents.	Knowledge: defines, identifies, states, outlines, selects and reproduces	Give introduction and all the information available to assist students to understand the problem
	What do I have to know?	Write the problem in your own words.		
	Define	State your own goals for the project.		
	Information	Gather all information relevant to understanding the problem better.		
Plan	Mind map	Draw a mind map of the whole project.	Comprehension: estimates, explain, extend, give examples, interpret, rewrite, summarize	Observe and give guidance where necessary
	Blue print	Create a blueprint of steps to take to realize 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
	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, differentiate, relate, break down	Observe and give alternative models to bring out the best in each student
	Build	Create the model. Put it all together.		
Re-thinking	Testing	Test the final product for any problems.	Synthesis: combine, compose, modify, reconstruct, reorganize, revise, rewrite	Actively participate and give inputs to get the best out of the students
	Problem/ errors	Let other students test your product.		
	Reconstruct	If problem occurs, reconstruct and make amendments.		
New ideas	New ideas	Do maintenance on your product and compare it to new products in the market.	Evaluation: appraise, criticize, evaluate, compare, support	Give feedback and information about new products and new models
	Construct	Construct new features for your product.		
	Add/ Delete	Add/ Delete new ideas to/ from your product.		

7. Conclusion and recommendations

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

Australia also focuses on the lower order thinking skills, but is much advanced when it comes to higher order thinking skills. While they provide their learners with a good foundation, 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 the equivalent Eritreans to handle problems. Australians (as evidenced here) have a much broader view of society and the real world. Clearly Eritrea's curriculum lacks keywords on the higher order thinking skills. Eritrea needs to adapt its syllabus to accommodate higher order thinking skills.

The model shown, proposes a process that can be used to incorporate real world activities into the computer studies classroom – model that addresses the higher levels on Bloom's taxonomy. The model is based on Bloom's taxonomy (1956), and the life cycle of a system in real world.

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.

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. Student projects should also focus on issues and ideas that are relevant to the real world.

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