An Approach to Modeling ICT Educational Policies in African Countries

I. Ya. Zlotnikova

Makerer University, Kampala, Uganda
e-mail: izlotnikova@kist.ac.rw, i_zlot@yahoo.com

Th. P. van der Weide

Radboud University, Nijmegen, the Netherlands
e-mail: tvdw@cs.ru.nl

Abstract—Based on the research of sub-Saharan African countries, this paper proposes a model for ICT educational policies. In this model, the authors identify parameters (political, socioeconomic, demographic, geographic, cultural etc.) that contribute to the success or failure of ICT educational policies, making a distinction between components and parameters. Then Formal Concept Analysis is applied to identify an effective managerial framework for this model. to effectively handle this special stable combinations of components and parameters. These stable combinations are proposed as a managerial framework to apply the proposed model in practice. Currently the model has a qualitative, descriptive character. An initial rough setting of the quantitative parameters is taken to get an impression of the potential of the proposed model.

Index Terms— Modeling, Information Technology, Education, Developing Countries

1 Introduction

In sub-Saharan Africa, most countries of which are among the world poorest both in the sense in ICT (especially Internet deployment) and Gross Domestic Product per capita (GDP PPP), there are significant attempts to implement ICT educational policies. Almost all African countries currently have either ICT policies and/or ICT educational policies. The only exceptions are Equatorial Guinea, Guinea-Bissau, Sao Tome and Principe, Somalia and Togo. There are also numerous ICT educational projects initiated by both governmental and non-governmental organizations (NGO).

African ICT educational policies and practices have to be summarized yet. The main question to be answered is what components ICT educational policies should consist of and what external parameters make these policies succeed or fail. Knowing these components and parameters, how they relate and how they form meaningful clusters would help ICT educational policymakers and practitioners in African countries to be more effective and to avoid steps that would lead to waste of time and money.

1 Current address: BP 3900, Avenue del’ Armee, Kigali Institute of Science and Technology, Kigali, Rwanda
The general objective of this study is to create a qualitative model for ICT educational policy success. In order to achieve this objective, the area of research is decomposed into the following specific objectives:

1) Identify the components of a successful ICT educational policy and links between them.

2) Identify country-related parameters potentially influencing ICT educational policies and links between those parameters and components of ICT educational policies.

3) Construct a model relating these components to these parameters.

4) Find useful component-parameter combinations and construct an effective managerial framework.

5) Provide a proof of concept.

2 Literature Review

In this section we overview literature on models related to ICT educational policy and their practice in African countries.

1. 2.1 Review of Existing Models of ICT in Education

The study of the present-day literature has led to the identification of a number of models of ICT in Education. A summary of eight most relevant models is presented in compact format in Table 1. These models have been created from the particular point of view depending on their purpose. All of them can be used for evaluating either ICT educational policies or ICT educational projects. However, external parameters that influence these components are not explicitly mentioned.

This part of the literature review allows for the identification of the components for a model of ICT educational policies in the context of African countries, as well as the gaps in existing models of ICT in education.

<table>
<thead>
<tr>
<th>№</th>
<th>Name</th>
<th>Purpose</th>
<th>Main Components</th>
<th>Cite</th>
</tr>
</thead>
</table>
| 1 | InfoDev Conceptual    | Monitoring and evaluation of ICT in education projects                  | 1. Development Context  
1.1 National Economic and Social Development  
1.2 Education Context  
2. Target ICT Intervention  
2.1 Intervention Design  
2.2 Infrastructure  
2.3 Teacher Training  
3. ICT USE in Home and Community  
4. Local Support  
5. Implementation  
6. Digital Education Content  
7. Student Impact  
| 2 | InfoDev Knowledge Maps| Representing current knowledge about the effective use of ICT in developing countries | 1. Impact  
1.1 Impact on Learning and Achievement  
1.2 Monitoring and Evaluation Issues  
1.3 Equity Issues: Gender, Special Needs and Marginalized Groups  
2. Costs  
3. Current Implementations of ICT in Education  
3.1 Current Projects and Practices  
3.2 Specific ICT Tools used in Education  
3.3 Teachers, Teaching and ICT  
3.4 Content and Curricula Issues  
4. Planning  
4.1 School Level Issues  
4.2 ICT in Education  
3. Four in Balance
Achieving a balance of four core components while integrating ICT into education
1. ICT Infrastructure
2. Expertise, knowledge and skills
3. Vision and Policy
4. Educational software and content

4. UNESCO ICT Competency Standards for Teachers
Establishing international ICT Competency Standards for teachers
1. Policy and Vision
2. Curriculum and Assessment
3. Pedagogy
4. ICT
5. Organization and Administration
6. Teacher Professional Development

5. UNESCO Indicators for ICT in Education
For measuring a progress in integrating ICT into education and the locality
1. Basic Core
2. Extended core
1.1 % of schools with electricity
1.2 % of schools with radio sets
1.3 % of schools with TV sets
1.4 Student to computer ratio
1.5 % of schools with the basic telecommunication infrastructure or telephone access
1.6 % of schools with an Internet connection
1.7 % of students using the Internet from school
2.1 % of students enrolled by gender at the tertiary level in an ICT-related field
2.2 % of ICT-qualified teachers in primary and secondary schools

6. ICT in the School System
Representation of access and use of technologies in the school system
1. Access to ICT
- old
- new
2. School Policy
3. ICT Training of Teachers
4. Teachers Usage of ICT in Curriculum
5. Students Usage of ICT
6. Enhancing the Quality of Education and Student outcomes

7. InfoDev/ UNESCO ICT in Education Toolkit
ICT in Education policy making
1. Mapping of present situation
1.1 National Vision, Goals and Plans
1.2 Educational Context
1.3 ICT in Education
2. Development of an ICT-enhanced Policy Programme
2.1 Identification of Educational Areas for ICT Intervention
2.2 Formulation of ICT Policy Interventions
3. Planning for Implementation
3.1 Physical and Human Requirements
3.2 Contentware
3.3 Summation (Cost and Finance)
4. Assessment and Subsequent Actions
4.1 Evaluation of ICT Intervention
4.2 Adjustment and/or Scaling Up

8. ICT in Youth & Community Development
Depicting a role of ICT in Youth & Community Development
1. Access
2. Efficiency
3. Learning
4. Teaching
5. Skill Formation
6. Lifelong Learning
7. Planning and Management
8. Community Linkages

II. 2.2 Review of ICT Educational Policies and Practices in African Countries

The review of ICT educational policies and practices in general has been based on the reports on ICT in education provided by InfoDev (Farrell & Shafika 2007). InfoDev is a reputable programme sponsored by the World Bank and many other international development agencies. These reports under the general name “Survey of ICT and Education in Africa: 53 Country Reports” picture the situation in all African countries. The fact that those reports are dated back to 2007 does not undermine their importance since these reports still present the most complete information about ICT educational policies and practices in African countries.

Some gaps in these reports have been filled using other available sources on African countries - Botswana (Batane 2004; Patterson 2007; Government of Botswana 1994), Cameroon (Ministry of Post and Communications of...

The study of the existing literature on ICT educational policies and practices in African countries has been the basis for the model proposed in this paper to describe successful ICT policy and influencing parameters (economic, political, demographic, technological and cultural).

3 Methodology

III. 3.1 Overall Review of the Employed Methodologies

To achieve the objectives stated above the following methodologies have been employed.

First, a critical analysis of existing models of ICT in Education has been done in order to identify both the components of these models and their existing gaps. Simultaneously, the available literature on ICT educational policies and practices in African countries as specified in Section 2 of this paper has been reviewed. As a result a list of components contributing to the success of an ICT educational policy has been compiled.

Second, to identify the external parameters influencing the success of an ICT educational policy the authors have critically analyzed open sources of the statistical information about African countries such as the IndexMundi website (www.indexmundi.com). This website provides most complete country profiles. The data are based on reputable sources such as CIA World Factbook, International Monetary Fund, United Nations Statistics Division etc. The existing gaps have been filled with alternative data sources, or by personal experience of the authors. As a result the list of identified parameters (political, socio-economic, demographic, geographic, cultural etc.) that contribute to the success or failure of ICT educational policies has been obtained.

Third, based on the literature review and personal experience in the area of ICT in Education, the model of the successful ICT educational policy in African countries comprising both its components and external influencing parameters has been compiled. The components have been divided into four clusters, according to the widely accepted in the Netherlands “Four in Balance” framework (Engelen, Ludeking & Myk 2006). The four core components of the framework are: 1) Vision and Leadership; 2) Knowledge, Attitude and Skills (professional development); 3) Educational Software and Content; 4) ICT Infrastructure. This framework has been chosen because it is known in the Netherlands as giving good practical results that contribute to its validation. Since it does not contain components specific to the Netherlands or developed countries in general, thus universal, it can be easily applied to developing countries.

Then, taking into consideration components of the proposed model, the set of metrics or Balanced Scorecard for evaluating ICT educational policies in Africa has been created. The Balanced Scorecard concept refers to the theory of metrics linked by the specific rules, where the total value is calculated using specific formulas (Kaplan & Norton 1996, Balanced Scorecard Institute 2010). Metrics are considered as a means of accessing performance in institutions, businesses, programs or resources.
The proposed metrics also have been divided into four clusters, according to the “Four in Balance” framework (Engelen, Ludeking & Myk 2006). All metrics have been normalized to the interval [0, 1], where 0 is the worst score, and 1 is the best. Sometimes also the metric is shown as a percentage. Weights have been assigned according to the importance of the parameter and then adjusted to give maximum total performance of 1. The total performance is calculated using the simple formula:

\[ P_{\text{total}} = \sum_{i=1}^{n} x_i \cdot w_i, \]  

(1)

where

- \( P_{\text{total}} \) is total performance in ICT in Education, achieved within the country,
- \( x_i \) – the score assigned to the \( i^{th} \) parameter of the ICT educational policy,
- \( w_i \) – the weight of the \( i^{th} \) parameter,
- \( n \) – number of parameters.

Since the weights add up to 1, the value \( P_{\text{total}} \) will range between 0 and 1. The value \( P_{\text{total}} \) allows evaluating the ICT educational policy. The closer is the value to 1 (or 100 when seen as a percentage), the more successful is a policy (Fig. 1).

![Fig. 1. A simple scale indicating the degree of success of an ICT Educational Policy depending on the total performance value \( P_{\text{total}} \).](image)

Finally, the model has been elaborated on using a data mining technique called Formal Concept Analysis (FCA), introduced in (Wille 1992). This technique will be described in details in the next subsections.

### IV. 3.2 Formal Concept Analysis

In Formal Concept Analysis we assume a binary relation between a set of so-called formal objects and a set of so-called formal attributes. In our case this binary relation is between components of the model of the ICT Educational Policy and the influencing parameters. This relation will be given in the table form in Section 4 “Results”. In the remainder of this section we will introduce Formal Concept Analysis. As a running example we will use the following situation. We consider a school management trying to improve the quality of the school. The school has identified the following goals: study speed, depth of understanding, broadness of knowledge, valorization and societal aspects. For this purpose the following success factors goals have been recognized: material, teachers, practicum, supervision and organization. In terms of formal lattice theory, we interpret success factors as objects and goals as attributes:

<table>
<thead>
<tr>
<th>Formal Objects:</th>
<th>Formal Attributes:</th>
</tr>
</thead>
</table>

...
The following table shows the influence relation between goals and factors that has been established by this school for their specific situation:

<table>
<thead>
<tr>
<th></th>
<th>P₀ – learning speed</th>
<th>P₁ - depth</th>
<th>P₂ - broad</th>
<th>P₃ - valorization</th>
<th>P₄ – society</th>
</tr>
</thead>
<tbody>
<tr>
<td>C₀</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C₁</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C₂</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C₃</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C₄</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C₅</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The school is interested to set up an effective managerial structure consisting of managerial units and their communication structure. Managerial units should precisely contain all relevant stakeholders and their responsibility should be precisely unique for that combination of stakeholders. In the next section we will see how the formal concept lattice will help to define such a structure.

V. 3.2.1 Formal Concepts

In general, let C be a set of objects and P be a set of parameters. The considered relation between C and P is referred to as ~. When object \( c \in C \) is related to attribute \( p \in P \), then this is denoted as \( c \sim p \). We introduce the operators as follows.

- Let \( C \subseteq C \) be a set of objects, then their common attributes are:

\[
\text{ComAttr}(C) = \{ p \in P \forall c \in C \sim p \}.
\]  \hspace{1cm} (2)

We may say that \( \text{ComAttr}(C) \) is the interpretation of the meaning of the set of objects \( C \) in terms of the attributes from \( P \). Some examples in the context of our running example are:

1. \( \text{ComAttr}(C₁, C₃) = \{ P₄ \} \)

2. \( \text{ComAttr}(C₅) = \{ P₁ \} \)
3. \( \text{ComAttr}() = \{P0, P1, P2, P3, P4\} \)

4. 
   - Let \( P \subseteq P \) be a set of attributes, then the objects having these attributes in common are:

5. \( \text{ComObj}_P = \{c \in C \mid \forall p \in P, c \sim p\}. \) \hspace{1cm} (4)

6. We may say that \( \text{ComObj}(C) \) is the interpretation of the meaning of the set of attributes \( P \) in terms of the objects from \( C \). Some examples in the context of our running example are:

   1. \( \text{ComObj}(P0, P2) = \{C1\} \)

   2. \( \text{ComObj}(P1) = C0, C2 \)

   3. \( \text{ComObj}(\{\}) = C0, C1, C2, C3, C4, C5 \)

   4. \( \text{ComObj}(P0, P1, P2, P3, P4) = \{\} \)

5. 

6. These operators can thus be interpreted as meaning translators between the visions as expressed in terms of \( C \) and \( P \). Describing a notion in terms of objects is called an extensional view, while the description in terms of attributes is called an intensional view. Then a formal concept is defined as a pair \((C, P)\) where the intensional and extensional view are equivalent in terms of the mutual meaning translations transformations.
8. \( \text{ComAttrC} = \{P\} \)  \hspace{1cm} (6) \\

9. \( \text{ComObjP} = \{C\} \)  \hspace{1cm} (7) \\

10. \\

11. For example, the pair \( \{C0,C2\}, \{P1\} \) is a formal concept since

1. \( \text{ComAttr}(C0,C2) = \{P1\} \) and

2. \( \text{ComObj}(P1) = \{C0,C2\} \)
In general we can find formal concepts given a set of objects, a set of attributes and a binary relation between them. It will be informative to order these concepts according to their strength. Let \((C,P)\) and \((D,Q)\) be formal concepts. Then we call \((C,P)\) a generalization of \((D,Q)\) if it has a larger extension, or \(C \supseteq D\). This can also be expressed as \((C,P)\) having a smaller (i.e. less restrictive) intension than \((D,Q)\), or \(P \subseteq Q\). Using generalization, the concepts can be displayed as a so-called lattice. The term ‘lattice’ is a technical term for a structure that shows all the concepts as points that are connected by lines that represent the generalization structure.

5. Fig. 2. The school lattice

6. Suppose we want to make a committee responsible for learning speed and depth of the program, then we see from the influence table 3 that we need a committee with members from the material group since only members from this group oversee both learning speed and program depth. Would we focus on depth alone, then stakeholders from the practicum group are also relevant. So here we see two decision units, one deciding on depth in general and the other on depth in combination to learning speed. Both are present as formal concepts in the concept lattice. The line connecting them shows that these decision units depend on each other, the line represents a communication structure. In practice these decision units will be joined into committees, for example in such a way that internal communication is optimized. We will not discuss this grouping problem in the context of this paper.

7. 4 Results

8. The results of our investigations have led to the proposal of a new model of the ICT educational policy that extends the reviewed models. In our model, we distinguish between components and parameters.

9. Components of the ICT educational policy are influenced by numerous parameters (economic, political, demographic, technological and cultural). Models reviewed in Section 2 do not take into consideration those parameters. Our model of the ICT educational policy includes influencing parameters.
13. Then in the next subsection we focus on the relation between the components and the parameters, expressing what parameters are required for what components. We use this relation to find stable requirement patterns as formal concepts. We see these patterns and their generalization relation as a managerial framework to support ICT educational policies in practice.

VI. 4.1 Proposed Model of the ICT Educational Policy

14. Both components of the model of the successful ICT educational policy and the influencing parameters are presented in Table 4 and in Fig. 3.

15. Table 4. Parameters and components of the model of the successful ICT educational policy

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic Parameters</td>
<td>Vision</td>
</tr>
<tr>
<td>Pₐ – GDP (PPP) per capita</td>
<td>C₀ – Implemented and Adopted ICT Educational Policy</td>
</tr>
<tr>
<td>Political Parameters</td>
<td>C₁ – Provisions for Equal Opportunities in ICT Access</td>
</tr>
<tr>
<td>P₁ – Political Stability</td>
<td>C₂ – Provisions for Free and Open Source Software (FOSS)</td>
</tr>
<tr>
<td>P₂ – Democracy, Lack of</td>
<td>Knowledge and Skills</td>
</tr>
<tr>
<td>Censorship</td>
<td>C₃ – Knowledge and Skills gained as a result of studying the</td>
</tr>
<tr>
<td></td>
<td>Subject of Computer Science/ICT</td>
</tr>
<tr>
<td>Implemented and Adopted</td>
<td>C₄ – Knowledge and Skills gained as a result of Using ICT in</td>
</tr>
<tr>
<td>ICT Policy</td>
<td>Teaching and Learning</td>
</tr>
<tr>
<td>P₃ – Education Legal Framework</td>
<td>C₅ – Knowledge and Skills of Teachers (Pre- and In-service</td>
</tr>
<tr>
<td></td>
<td>Teacher Training) in Computer Science Education</td>
</tr>
<tr>
<td>Demographic Parameters</td>
<td>C₆ – Knowledge and Skills gained in Non-formal Education and</td>
</tr>
<tr>
<td>P₄ – Education Expenditures</td>
<td>Community Outreach Projects (COP)</td>
</tr>
<tr>
<td>P₅ – Literacy Rate</td>
<td>C₇ – Knowledge and Skills Gained in Gender-related Projects</td>
</tr>
<tr>
<td>P₆ – Gender Parity</td>
<td>Educational Content/Software</td>
</tr>
<tr>
<td>Technological Parameters</td>
<td>C₈ – Usage and Development of the Digital Content</td>
</tr>
<tr>
<td>P₇ – Developed ICT</td>
<td>C₉ – Usage and Development Educational Software</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>C₁₀ – Usage and Development of Software for Administering</td>
</tr>
<tr>
<td></td>
<td>Educational Institutions</td>
</tr>
<tr>
<td>P₈ – Mobile Phones per 100</td>
<td>C₁¹ – Availability of Free and Open Source Software</td>
</tr>
<tr>
<td>population</td>
<td>ICT Infrastructure</td>
</tr>
<tr>
<td>Cultural Parameters</td>
<td>C₁₂ – Multimodality of Open, Distance and e-Learning</td>
</tr>
<tr>
<td>P₉ – Value of Education in</td>
<td></td>
</tr>
<tr>
<td>the Society</td>
<td></td>
</tr>
<tr>
<td>P₁₀ – Parental Attitude</td>
<td></td>
</tr>
<tr>
<td>35.</td>
<td></td>
</tr>
<tr>
<td>58.</td>
<td></td>
</tr>
</tbody>
</table>
We have grouped the parameters in coherent groups. The components that are distinguished in our proposed model have been organized in four coherent groups according to the Dutch model “Four in Balance”.

The identified links between these components and parameters are presented in Table 5. Each identified direct link is denoted by “1” in this table. Indirect links when one parameter influences another parameter are not considered, they will be described in the extended version of this paper.

Table 5. Relation scheme between components and influencing parameters
<table>
<thead>
<tr>
<th></th>
<th>18.18</th>
<th>18.18</th>
<th>19</th>
<th>19.06</th>
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<tr>
<td>2</td>
<td>19.20</td>
<td>20.10</td>
<td>20</td>
<td>20.19</td>
</tr>
<tr>
<td>3</td>
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<td>21.32</td>
<td>21</td>
<td>21.32</td>
</tr>
<tr>
<td>4</td>
<td>22.22</td>
<td>22.22</td>
<td>22</td>
<td>22.22</td>
</tr>
<tr>
<td>5</td>
<td>23.34</td>
<td>24.24</td>
<td>24</td>
<td>24.24</td>
</tr>
<tr>
<td>6</td>
<td>25.36</td>
<td>25.36</td>
<td>25</td>
<td>25.36</td>
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<td>7</td>
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<td>26.38</td>
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<td>27.40</td>
<td>27.40</td>
<td>27</td>
<td>27.40</td>
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<td>9</td>
<td>28.42</td>
<td>28.42</td>
<td>28</td>
<td>28.42</td>
</tr>
<tr>
<td>10</td>
<td>29.44</td>
<td>29.44</td>
<td>29</td>
<td>29.44</td>
</tr>
<tr>
<td>11</td>
<td>30.46</td>
<td>30.46</td>
<td>30</td>
<td>30.46</td>
</tr>
</tbody>
</table>
4.2 Balanced Scorecard for Evaluating ICT Educational Policies

Using the methodology described in Section 3, the authors proposed a Balanced Scorecard for evaluating ICT educational policies. It has to be noted that metrics comprising the Balanced Scorecard do not necessarily repeat components of the ICT Educational Policy model. For example, the metric Implemented and Adopted ICT Policy is an influencing parameter presented at the left part of Fig. 3. Components related to Knowledge and Skills cannot be measured without direct communication with teachers and students (through questionnaires, tests, practical assignments, discussions, observations etc.). Thus those components have been replaced by simpler metrics. For example, the metric School Subject of Computer Science/ ICT reflects the fact of having the compulsory subject of Computer Science/ ICT at school, but not the level of knowledge and skills acquired by students while learning.

In general, while selecting metrics the authors took into consideration the following criteria:

1. importance of the component/parameter expressed numerically as Weight
2. its measurability from outside.

Table 6 presents the identified metrics together with their scores and weights.

<table>
<thead>
<tr>
<th>Name of the metric</th>
<th>Score</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vision</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Implemented and Adopted ICT Policy</td>
<td>0 – No</td>
<td>6.42</td>
</tr>
<tr>
<td></td>
<td>0.5 – Implemented, but not adopted</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 – Yes</td>
<td></td>
</tr>
<tr>
<td>Implemented and Adopted ICT Educational Policy</td>
<td>0 - No</td>
<td>9.17</td>
</tr>
<tr>
<td></td>
<td>0.3 – Some provisions in ICT or educational policy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.5 – Implemented, but not adopted</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 - Yes</td>
<td></td>
</tr>
<tr>
<td>Provisions for Equal Opportunities in ICT Access</td>
<td>0 – No</td>
<td>2.75</td>
</tr>
<tr>
<td></td>
<td>1 – Provisions for Equal Opportunities in ICT Access in ICT/ ICT educational/ gender policies</td>
<td></td>
</tr>
<tr>
<td>Provisions for Free and Open Source</td>
<td>0 – No</td>
<td>1.83 – if</td>
</tr>
</tbody>
</table>
346. 1 – Provisions for FOSS in ICT / ICT educational policies

there is no skilled and comparatively cheap labor in the country; thus the goal of using FOSS is not feasible.

348. 6.42 – if there are skilled and comparatively cheap labor in the country.

349.  

**Knowledge and Skills**

<table>
<thead>
<tr>
<th></th>
<th>351. School Subject of Computer Science/ICT</th>
<th>352. 0 – No</th>
<th>355. 2.75</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>353. 0.5 – Elective</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>354. 1 – Compulsory</td>
<td></td>
</tr>
</tbody>
</table>

357. Using ICT in Teaching and Learning Subjects

<table>
<thead>
<tr>
<th></th>
<th>358. If the precise percentage of schools using ICT in teaching and learning subjects is known then the score varies from 0 to 1 depending on the percentage.</th>
<th>366. 6.42</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>359.</td>
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<tr>
<td></td>
<td>360. If the precise number is not known:</td>
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<tr>
<td></td>
<td>361. 0 – No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>362. 0.1 - Meager</td>
<td></td>
</tr>
<tr>
<td></td>
<td>363. 0.33 – Some private or pilot schools</td>
<td></td>
</tr>
<tr>
<td></td>
<td>364. 0.67 – Most schools</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>365.</strong></td>
<td>1 – All schools on the regular base</td>
</tr>
<tr>
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</tr>
<tr>
<td>3</td>
<td><strong>368.</strong> Pre- and In-service Teacher Training in Computer Science Education</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td><strong>369.</strong> 0 – No</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td><strong>370.</strong> 0.33 – Only by NGO</td>
<td></td>
</tr>
<tr>
<td>.</td>
<td><strong>371.</strong> 0.67 – Either pre-service or in-service</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td><strong>372.</strong> 1 – Yes, both</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><strong>375.</strong> Pre- and in-service Teacher Training on Using ICT in Education</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td><strong>376.</strong> 0 – No</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td><strong>377.</strong> 0.1 - Meager</td>
<td></td>
</tr>
<tr>
<td>.</td>
<td><strong>378.</strong> 0.33 – Only by NGO</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td><strong>379.</strong> 0.67 – Either pre-service or in-service training</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><strong>380.</strong> 1 – Yes, both</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><strong>383.</strong> Open, Distance and e-Learning (ODeL) Projects</td>
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</tr>
<tr>
<td>8</td>
<td><strong>384.</strong> 0 – No</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td><strong>385.</strong> 0.1 - Meager</td>
<td></td>
</tr>
<tr>
<td>.</td>
<td><strong>386.</strong> 0.5 – by NGO only</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td><strong>387.</strong> 1 – Most projects are run by the government or under the governmental control</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><strong>390.</strong> Non-formal Education and Community Outreach Projects</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td><strong>391.</strong> 0 – No</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td><strong>392.</strong> 0.1 - Meager</td>
<td></td>
</tr>
<tr>
<td>.</td>
<td><strong>393.</strong> 0.5 – by NGO only</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td><strong>394.</strong> 1 – Most projects are run by the government or under the governmental control</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><strong>397.</strong> Gender-related Projects</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td><strong>398.</strong> 0 – No</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td><strong>399.</strong> 0.1 - Meager</td>
<td></td>
</tr>
<tr>
<td>.</td>
<td><strong>400.</strong> 0.5 – by NGO only</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td><strong>401.</strong> 1 – Most projects are run by the government or under the governmental control</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>403.</strong> <em>Educational Content/ Software</em></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td><strong>405.</strong> Usage and Development of the Digital Content</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td><strong>406.</strong> If the precise percentage of schools/ institutions using Digital Content is known then the score varies from 0 to 1 depending on the percentage.</td>
<td></td>
</tr>
</tbody>
</table>
| 4 | **414.** 6.42 – develop ment of
If the precise number is not known:

0 – No

0.1 - Meager

0.33 – Some private or pilot schools/ institutions

0.67 – Most schools/ institutions

1 – All schools/ institutions on the regular base

If the precise percentage is known then the score varies from 0 to 1 depending on the percentage.

Usage and Development of Educational Software

If the precise percentage is not known:

0 – No

0.1 - Meager

0.33 – Some private or pilot schools/ institutions

0.67 – Most schools/ institutions

1 – All schools/ institutions on the regular base

If the precise percentage is known then the score varies from 0 to 1 depending on the percentage.

Usage and Development of Software for Administering Educational Institutions

If the precise percentage is not known:

0 – Administrative software is not available

0.1 - Usage is meager.

0.33 – Administrative software is used for fulfilling separate tasks and is used in some educational institutions or

the content within the country

3.21 – using the content developed outside the country

6.42 – development of software within the country

3.21 – using software developed outside the country

4.59 - development of software within the country

2.3 – using software developed outside the country
436. 0.67 – Administrative software integrates most tasks in one environment and is used in most educational institutions, but not developed for local conditions.

437. 1 – Administrative software integrates most tasks, is used in most educational institutions and developed specially for local conditions (inside the country)

441. Availability of Free and Open Source Software

442. 0 – Not available

443. 0.1 – FOSS is available, but its usage is meager

444. 0.5 – FOSS is used in teaching some subjects or fulfilling some administrative functions

445. 1 - FOSS is used in teaching most subjects and fulfilling most administrative functions

449. ICT Infrastructure

451. ICT Access in Primary Schools

452. If the precise percentage of primary schools with ICT Access is known then the score varies from 0 to 1 depending on the percentage.

453.

454. If the precise number is not known:

455. 0 – No

456. 0.1 - Meager

457. 0.33 – Some private or pilot schools

458. 0.67 – Most schools

459. 1 – All schools on the regular base

462. ICT Access in
Secondary Schools

If the precise number is not known:

- 0 – No
- 0.1 - Meager
- 0.33 – Some private or pilot schools
- 0.67 – Most schools
- 1 – All schools on the regular base

ICT Access in Post-Secondary Institutions

If the precise percentage of institutions with ICT Access is known then the score varies from 0 to 1 depending on the percentage.

- 0 – No
- 0.1 - Meager
- 0.33 – Some private or pilot institutions
- 0.67 – Most institutions
- 1 – All schools on the regular base

Multimodality of Open, Distance and e-Learning

- 0 – No distance and e-learning at all
- 0.33 – Only “old” ICT
- 0.67 – Only “new” ICT
- 1 – Both

Maximum Total Performance

- 0 – No
- 100
Justification of the choice and importance of each of metrics in the Balanced Scorecard for evaluating ICT educational policies is as follows.

1. ** Implemented and Adopted ICT Policy** creates a legal framework for ICT in Education if there is no separate ICT educational policy. It demonstrates a general commitment of the government to develop ICT projects in the country though not necessary ICT educational projects. This metric is considered as very important.

2. **Implemented and Adopted ICT Educational Policy** creates a legal framework for ICT in Education in the country. It demonstrates a commitment of the government to develop ICT Educational projects, thus is considered as extremely important.

3. **Provisions for Equal Opportunities in ICT Access** - in the ICT educational policy or ICT policy - demonstrate the commitment of the government to provide equal opportunities in ICT access and develop ICT educational projects involving minorities and underprivileged groups. Nevertheless, provisions in policies do not necessarily mean that minorities would have this access in practice. Being just one component of the overall ICT educational policy, **Provisions for Equal Opportunities in ICT Access** are considered as less important.

4. **Provisions for Free and Open Source Software (FOSS)** - in the ICT educational policy or ICT policy - show the understanding of the role of FOSS, especially in the developing country, but do not necessarily mean that it would be actually integrated into the educational process. It is just one of the components of the policy. The following arguments also should be taken into consideration: handling problems related to using FOSS requires more qualified staff, than as to commercial software. Thus though software itself can be acquired free of charge, the cost of maintenance of FOSS sometimes could be even higher than the cost of commercial software. It is a question of having high-qualified (and underpaid – comparatively to developed countries) local IT professionals. Thus this metric is less important.

5. **Discussing the importance of the School Subject of Computer Science/ ICT**, the following should be noted. In some developed countries (such as, for example, the Netherlands and the US), the subject of Computer Science/ ICT is not included into the school curricula as compulsory. Some secondary schools have it as an elective, while others do not have it at all. The common vision is that it is more important for students to have skills of applying ICT to real-life tasks (such as studying other subjects – math, language, biology etc.) than to have knowledge of programming and theoretical concepts of Computer Science. In the developing country, having just one computer lab (in the best case) it is easier to organize teaching just one computer-related subject than to integrate ICT in every subject. This metric is less important.

6. **Using ICT in Teaching and Learning Subjects** in some developed countries is considered as more important than having a compulsory subject of Computer Science/ ICT. Thus this metric is very important.

7. **Pre- and In-service Teacher Training in Computer Science Education** is considered as less important than **Teacher Training on Using ICT in Teaching Subjects** for similar reasons, but still it is an important metric.

8. **Pre- and in-service Teacher Training on Using ICT in Education** is considered as more important than Pre-and In-service Computer Science Education for reasons given above. This metric is very important.

9. **ODeL Projects** make a significant contribution to developing ICT knowledge and skills among students, teachers and members of the community. But the success (or otherwise – failure) of the ODeL project is determined by too many factors which are subject of further consideration. This metric is very important.
10. *Non-formal Education and Community Outreach Projects* make a significant contribution to developing ICT knowledge and skills among members of the community (women, farmers, children, especially underprivileged). This metric is considered as important.

11. *Gender-related Projects* can fall under either formal or non-formal education/community outreach projects. The *Non-formal Education and Community Outreach Projects* are discussed above. The *Gender-related Projects* are included as a separate component to emphasize their importance. Nevertheless, the weight of the metric is reduced, and it is considered as less important.

497. Before discussing the next two metrics, it is necessary to explain the difference between digital content and educational software. *Digital Content* is an educational content presented in the digital form (including the text, images, video). The interaction between the learner and the learning material is either non-existent or meager. Nowadays the digital content normally is presented at the website or with the web interface, but also can appear in the form of documents, presentation slides or any other multimedia file format. *Educational Software* allows interaction with students, including passing tests, doing assignments and even conducting computer experiments. In the e-learning system it is easy to distinguish between educational software and digital content. Files uploaded by teachers comprise the digital content. The e-learning platform itself is educational software.

12. Since Using ICT in Teaching and Learning Subjects is very important, then the Usage and Development of the Digital Content is also very important. The digital content, once created, can be replicated at low cost or no cost at all. It can be used as a replacement of traditional textbooks with all advantages provided by multimedia. This metric is very important.

13. Usage and Development of Educational Software is very important due to same reasons as the digital content, thus this metric is very important.

14. Administrative software greatly improves the work of the administrative staff of educational institutions. But in relation to the process of teaching and learning, software for administering educational institutions fulfills supplementary functions. *Usage and Development of Software for Administering Educational Institutions* is important.

15. *Availability of Free and Open Source Software* is a complicated parameter. Last few years FOSS is widely advocated in developing countries since it can be legally used without fees paid for software itself. Nevertheless, as it was mentioned above, FOSS requires significant investments into its support and maintenance. The interface of FOSS usually is not user-friendly like in commercial software, thus advanced expert knowledge and skills are necessary. This knowledge might not be available within the developing country at the affordable price. All these reasons make Availability of FOSS less important.

16. *ICT Access in Primary Schools* is important, since it allows forming ICT skills in the early age. The percentage of pupils enrolled into the secondary education in most African countries is meager. For example, in Guinea Bissau only 6% and in Burkina Faso 8% of the number of children in the eligible age group are enrolled into the second education. The only positive exclusions are Botswana with the enrollment ratio of 69.6%, Mauritius (64.2%) and South Africa (57.2%). Still, it is too low comparatively to developed countries. Since the majority of children in African countries attend only the primary school (if any), gaining ICT skills in the primary school would be their only chance. But at the current stage, providing computers to primary schools hardly can be a priority for most African governments. To provide ICT access in each primary school is hardly feasible, especially in developing countries. The alternative approach widely adopted in South Africa presumes that mobile phones in many cases can be considered as
replacement of ICT or even as a separate kind of ICT. Being not feasible, this metric is considered as less important.

17. **ICT Access in Secondary Schools** is very important since as it was discussed above, establishing computer facilities in primary schools is hardly feasible. All ICT educational policies adopted in African countries contain provisions for ICT access in secondary schools, but the real situation is more complicated. As a rule, an ICT access in private schools (where modern computer labs are often sponsored by parents) is better than in public schools. The metric is very important.

18. **ICT Access in Post-Secondary Institutions**, including institutions of higher learning is very important since almost any professional activity today involves using ICT. It should be mentioned that the ICT situation in institutions of higher learning, in general, is much better than in secondary and especially primary education. Even if universities have no financial support from their governments, they always can get it from international organizations and/ or through grants. The metric is very important.

19. **Multimodality of Open, Distance and e-Learning** means that it can be delivered in different modes - by means of a variety of both “new” and “old” ICT. Countries with the poor ICT infrastructure still would be able to organize ODeL on the base of TV and radio, as well as printed materials, books, audio- and videocassettes sent by the regular mail. Botswana, Cape Verde, Ghana, Guinea, Kenya, Namibia, Senegal and South Africa demonstrate the good level of multimodality in ODeL. South Africa is also known for its active development and usage of mobile services. The metric is very important.

498. The Balanced Scorecard is used to establish the general taxonomy of countries of sub-Saharan Africa regarding to the success (or otherwise – a failure) of the ICT Educational Policy in the country. It is also can be considered as a simple validation of the proposed model and the Balanced Scorecard.

**IX. 4.3 A Derived Managerial Framework**

499. In the case of Table 5, the application of the Formal Concept Analysis leads to the conceptual lattice structure displayed in Fig. 4. For the computation of this conceptual lattice we used the Lattice Miner Platform (release 1.4) from Laboratoire LARIM (2009). We call this resulting lattice the managerial framework for our model.
The most general concept is the concept on top of the lattice. This concept has no restriction at all in terms of required parameters. In Figure 4 we see that there are several base concepts at the first level, directly related to the top concept and are successively obtained by adding the following parameters as a restriction:

1. \( P_6 \) - Parameter Literacy Rate
2. \( P_2 \) - Parameter Democracy, Lack of Censorship
3. \( P_{10} \) - Parameter Value of Education in the Society
4. \( P_3 \) - Parameter Implemented and Adopted ICT Policy

We focus further on the first concept, determined by parameter \( P_2 \) - Parameter Democracy, Lack of Censorship. This parameter forms a formal concept with the components \( C_0, C_1, C_2, C_3, C_4, C_5 \), since all these components are influenced by parameter \( P_2 \), while these components have as common influencing parameter.

These components are:

1. The complete Vision group:
   a. \( C_0 \) – Implemented and Adopted ICT Educational Policy
   b. \( C_1 \) – Provisions for Equal Opportunities in ICT Access
   c. \( C_2 \) - Provisions for Free and Open Source Software (FOSS)

2. The ‘gained’-part of the Knowledge and Skills group:
   a. \( C_3 \) - Knowledge and Skills Gained in Open, Distance and e-Learning Projects
   b. \( C_4 \) – Knowledge and Skills Gained in Non-formal Education and Community Outreach Projects (COP)
   c. \( C_5 \) – Knowledge and Skills Gained in Gender-related Projects

3. The ‘availability’-part of the Educational Content/Software group
a. \textit{C_{13}} - Availability of Free and Open Source Software

To measure the quality of the concepts, we have assumed that we are interested in components, and measure the quality of a concept as the fraction of components covered. We have added the quality scores in Figure 4. We may conclude that the parameter $P_3$, \textit{Implemented and Adopted ICT Policy} leads to the best coverage of 72.2 (using the 100 point scale). The coverage of a formal concept is the fraction of components in that concept.

508. \textbf{5 Example of Using a Balanced Scorecard – Taxonomy of African Countries}

In Section 4.2 we presented a Balanced Scorecard for Evaluating ICT Educational Policies. This section demonstrates an attempt to apply it to the situation in countries of sub-Saharan Africa. The result although is somewhat disputable since it cannot be compared with other similar taxonomies due to their non-existence. Currently the resulting taxonomy can be considered rather as a theoretical exercise than exact ranking of African countries.

\textbf{X. 5.1 General Approach to Countries Ranking}

Our approach is as follows. From several points of view, we set up a classification, and assign a score to each class. The resulting score vector is used as the ICT Educational Policy characterization for that country. The country characterizations (Balanced Scorecard) are displayed in Table 6, Section 4.2. In this paper we take a straightforward and simple approach, and use the \textit{Total Performance in ICT in Education} (represented by the formula (1)) as an overall measure to compare countries. This total score gives an overall impression of ICT policies, which is sufficient for the purposes of this paper.

\textbf{XI. 5.2 Taxonomy of Countries}

The authors have calculated \textit{Total Performance in ICT in Education} for each country of sub-Saharan Africa using the formula (1) given in Section 3.1 and a Balanced Scorecard for Evaluating ICT Educational Policies given in Section 4.2. After that, countries have been ranked in descending order according to their total performance. The resulting taxonomy is given in Table 7.

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|}
\hline
\textbf{Country} & \textbf{Total Performance} & \\
\hline
\textbf{Group 1} & & \\
\hline
\textbf{Group 2} & & \\
\hline
\textbf{Group 3} & & \\
\hline
\textbf{Group 4} & & \\
\hline
\end{tabular}
\end{table}

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|}
\hline
\textbf{Country} & \textbf{Total Performance} & \\
\hline
\textbf{Namibia} & 94.5 & \\
\hline
\textbf{Nigeria} & 39.7 & \\
\hline
\end{tabular}
\end{table}
<p>| | | | | |</p>
<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>South Africa</td>
<td>94.2</td>
<td>53.5</td>
<td>38.4</td>
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<tr>
<td>3</td>
<td>Botswana</td>
<td>83.3</td>
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<td>Rwanda</td>
<td>81.5</td>
<td>54.9</td>
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<tr>
<td>5</td>
<td>Mauritius</td>
<td>81.2</td>
<td>55.8</td>
<td>34.3</td>
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<tr>
<td>6</td>
<td>Tanzania</td>
<td>81.0</td>
<td>56.3</td>
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<td>7</td>
<td>Uganda</td>
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<td>Senegal</td>
<td>70.8</td>
<td>58.9</td>
<td>28.7</td>
</tr>
<tr>
<td>10</td>
<td>Ghana</td>
<td>69.5</td>
<td>59.3</td>
<td>28.5</td>
</tr>
<tr>
<td>11</td>
<td>Sudan</td>
<td>64.3</td>
<td>60.3</td>
<td>28.0</td>
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<tr>
<td>12</td>
<td>Cameroon</td>
<td>54.2</td>
<td>61.8</td>
<td>24.4</td>
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<tr>
<td>13</td>
<td>Comoros</td>
<td>54.8</td>
<td>61.5</td>
<td>25.3</td>
</tr>
<tr>
<td>14</td>
<td>Eritrea</td>
<td>54.7</td>
<td>61.6</td>
<td>25.2</td>
</tr>
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</table>
### Table of ICT Educational Policy Scores

<table>
<thead>
<tr>
<th>Country</th>
<th>Score 1</th>
<th>Score 2</th>
<th>Score 3</th>
<th>Score 4</th>
<th>Score 5</th>
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</thead>
<tbody>
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<td>Zambia</td>
<td>52.6</td>
<td>9</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Malawi</td>
<td>51.2</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cote D’Ivoire</td>
<td>50.9</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guinea</td>
<td>48.7</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gabon</td>
<td>47.2</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cape Verde</td>
<td>45.9</td>
<td>1</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Mozambique</td>
<td>45.8</td>
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<td></td>
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</tr>
<tr>
<td>Zimbabwe</td>
<td>45.1</td>
<td>1</td>
<td></td>
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</tr>
<tr>
<td>Gambia</td>
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<td>7</td>
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</tr>
<tr>
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<td>42.1</td>
<td>0</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Benin</td>
<td>40.8</td>
<td>0</td>
<td></td>
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</tbody>
</table>
if they will be successful (the total score is 40-59). Group 4 presents countries where ICT educational policy is currently unsuccessful, but might be corrected (a total score is 20-39). Countries from Group 5 have no ICT Educational Policy at all (a total score is 0-19).

698. Since we only can rely on our rough estimates of parameter values, the result cannot be considered as exact ranking of countries of sub-Saharan Africa. But, as can be expected, we see that countries like Namibia and South Africa are ranked in Group 1, while in Group 5 we find countries as Guinea-Bissau, Chad and Sao Tome which are known as not having ICT Educational Policy at all.

699.  

6 Discussion

700. The main result of the study is a validated model of the ICT educational policy. The model can be recommended to the policy makers and other stakeholders at the initial stage of the ICT educational policy development (since not all African countries, such as Uganda, have ICT educational policies at place). It presents components of the ICT educational policy necessary for its success. Using it, organizations involved into the process of developing an ICT educational policy can be sure that none of components contributing to its success are missed.

702. Limitations of the study were caused by limitations of accessibility of resources. Some of resources are not available for researchers from outside.

703. Further research will include further adjustment of a Balanced Scorecard for evaluating ICT educational policies, as well as case studies in institutions of higher learning in Uganda, Rwanda, Mozambique and other countries of sub-Saharan Africa.

704.  

7 Conclusions

706. The research provides results which contribute to the deeper understanding of ICT educational policies in countries of sub-Saharan Africa, especially of components of those policies leading to their success (or otherwise – to the failure).

707. First, the components of a successful ICT educational policy and links between them have been identified. Second, country-related parameters have been identified based upon available sources of the statistical information. Third, links between components of the ICT educational policy and the country-related parameters influencing the ICT educational policy have been established. Components of the ICT educational policy, country-related parameters and links between them make the model of the successful ICT educational policy. Finally, the proposed model has been elaborated using a data-mining technique called Formal Concept Analysis.

708. The research thus provides a framework for developing and improving ICT educational policies in countries of sub-Saharan Africa, as well as a tool for evaluation of ongoing ICT educational projects and forecasting of future projects. Potential users of research results include policymakers, and practitioners involved into ICT educational projects.

709.  

710. References


742.