

An approach to modeling ICT educational policies in African countries

I. Y. Zlotnikova
Kigali Institute of Science and Technology, Rwanda

Th. P. van der Weide
Radboud University Nijmegen, the Netherlands

ABSTRACT

This paper aims at creating a model of an ICT educational policy. The geographic scope of the study includes countries of sub-Saharan Africa. First, the components of an ICT educational policy have been identified. Second, country-related parameters have been identified based on available sources of the statistical information. Third, the links between the components of ICT educational policy and the country-related influential parameters have been established. These components, the influential parameters and the links established make the model of an ICT educational policy. Then the proposed model has been elaborated using the data-mining technique called Formal Concept Analysis. We propose two applications that are benefiting from the resulting concept lattice. Finally, a simple validation of the proposed model has been done by establishing taxonomy of sub-Saharan African countries. This research provides a framework for developing and improving ICT educational policies in these countries, as well as a tool for evaluation of ongoing ICT educational projects and success forecasting of future projects. Potential users of the results of this research include policymakers and practitioners involved in ICT educational projects.

Keywords: *Modeling; Information Technology; Education; Policies; Developing Countries.*

INTRODUCTION

Most countries of sub-Saharan Africa are among the world poorest both in the sense of Information and Communications Technologies (ICT), especially Internet deployment, and Gross Domestic Product at Purchasing Power Parity (GDP (PPP)) per capita. However, there are significant attempts to implement ICT educational policies. Almost all African countries currently have either ICT policies or ICT educational policies or both. 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 an ICT educational policy should consist of and what influential parameters make this policy succeed or fail. Knowing these components and parameters, how they relate to each other 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.

According to Wild (2011)

...national ICT policy exploits information and communication technologies to further national economic and social goals. It matches the economic and social environment in which it is to be implemented.

Bassi (2011) emphasizes the importance of an ICT educational policy.

To enhance the reach and quality of teaching and learning through the effective use of ICTs, policy makers need to be aware of how to best utilize ICTs to create value-add for their country's education system. A supportive policy environment and framework, developed at the national level is a key to the successful integration of ICTs into any education system" (Bassi, 2011).

Swarts (2006) argues importance of ICT in Education policies:

The provision of technology alone will not optimally harness the potential of ICTs to improve access, student achievement and the transformation of teaching and learning. To take full advantage of the different technologies and to direct their maximum use for the benefit of all students, there needs to be a clear framework which sets the scene and provides the enabling environment for technologies to be integrated, deployed and used to their fullest potential. The ICT in Education Policy can provide such a framework.

The general objective of this study is to create a model of an ICT educational policy. In order to achieve this objective, the area of research is decomposed into the following specific objectives:

1. Identify strengths and weaknesses of existing models;
2. Identify the components of an ICT educational policy, country-related influential parameters and links between those components and parameters;
3. Find useful component-parameter combinations;
4. Develop a Balanced Scorecard for evaluation of ICT educational policies and provide a simple validation of the proposed model through establishing taxonomy of countries of sub-Saharan Africa.

Limitations of the study were caused by limitations of accessibility of resources. The authors have used open sources of the data. Some of the data are not available for researchers from outside. Due to gaps in available data about ICT in education in countries of sub-Saharan Africa, the authors were only able to provide a simple validation of the proposed model in the form of taxonomy of countries. The goal was to make to provide an overall tool for evaluating ICT educational policies and not to go into details pertaining to its components. For example, an application of the proposed model to Open, Distance and e-Learning projects has been considered in (Zlotnikova & Weide, 2011).

The geographic scope of the study includes 48 countries of sub-Saharan Africa, with the focus on those countries where the authors worked or carried out ICT educational projects (Uganda, Rwanda, Mozambique, Ghana, Ethiopia and South Africa).

LITERATURE REVIEW

In this section, the authors give an overview of the literature on models related to ICT educational policies and practices in African countries.

Review of Existing Models of ICT in Education

The study of present-day literature has led to the identification of a number of models of ICT in Education. A summary of the eight most relevant models is presented in a 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 in any of them.

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

Table 1. Summary of models of ICT in Education

No	Name	Purpose	Main Components	Cited in
1.	InfoDev Conceptual Framework	Monitoring and evaluation of ICT in education projects	<ol style="list-style-type: none"> 1. Development Context <ol style="list-style-type: none"> 1.1 National Economic and Social Development 1.2 Education Context 2. Target ICT Intervention <ol style="list-style-type: none"> 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 8. ICT Outcomes 	Wagner, 2005
2.	InfoDev Knowledge Maps	Representing current knowledge about the effective use of ICT in education in developing countries	<ol style="list-style-type: none"> 1. Impact <ol style="list-style-type: none"> 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 <ol style="list-style-type: none"> 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 <ol style="list-style-type: none"> 4.1 School Level Issues 4.2 ICT in Education Policy Issues 	Trucano, 2005
3.	Four in Balance	Achieving a balance of four core components while integrating ICT into education	<ol style="list-style-type: none"> 1. ICT Infrastructure 2. Expertise, knowledge and skills 3. Vision and Policy 4. Educational software and Content 	Engelen, Ludeking & Myk, 2006
4.	UNESCO ICT Competency Standards for Teachers	Establishing international ICT Competency Standards for teachers	<ol style="list-style-type: none"> 1. Policy and Vision 2. Curriculum and Assessment 3. Pedagogy 4. ICT 5. Organization and Administration 6. Teacher Professional Development 	UNESCO, 2008
5.	UNESCO Indicators for ICT in Education	For measuring a progress in integrating ICT into education and the locality	<ol style="list-style-type: none"> 1. Basic Core <ol style="list-style-type: none"> 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 	UNESCO, 2006

			<ul style="list-style-type: none"> 1.7 % of students using the Internet from school 2. Extended core 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	<ul style="list-style-type: none"> 1. Access to ICT <ul style="list-style-type: none"> - 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 	UNESCO, 2006
7.	InfoDev/ Unesco ICT in Education Toolkit	ICT in Education policy making	<ul style="list-style-type: none"> 1. Mapping of present situation <ul style="list-style-type: none"> 1.1 National Vision, Goals and Plans 1.2 Educational Context 1.3 ICT in Education 2. Development of an ICT-enhanced Policy Programme <ul style="list-style-type: none"> 2.1 Identification of Educational Areas for ICT Intervention 2.2 Formulation of ICT Policy Interventions 3. Planning for Implementation <ul style="list-style-type: none"> 3.1 Physical and Human Requirements 3.2 Contentware 3.3 Summation (Cost and Finance) 4. Assessment and Subsequent Actions <ul style="list-style-type: none"> 4.1 Evaluation of ICT Intervention 4.2 Adjustment and/or Scaling Up 	InfoDev, 2007
8.	ICT in Youth & Community Development	Depicting a role of ICT in Youth & Community Development	<ul style="list-style-type: none"> 1. Access 2. Efficiency 3. Learning 4. Teaching 5. Skill Formation 6. Lifelong Learning 7. Planning and Management 8. Community Linkages 	Evoh, 2009

Review of ICT Educational Policies and Practices in Countries of African Countries

The review of ICT educational policies and practices in general is 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. However, InfoDev reports have their limitations and gaps. As stated by the authors (Farrell & Shafika, 2007), “the data presented in the individual Country Reports should be regarded as illustrative rather than exhaustive. This survey was not an exercise in primary data collection”.

Gaps in these reports have been filled using other available data sources on African countries - Botswana (Government of Botswana, 1994; Batane, 2004; Patterson, 2007), Cameroon (Ministry of Post and Communications of Cameroon, 2004; Nana & Ogechi, 2008; Palamakumbura, 2008), Kenya (Ministry of Information and Communications of Kenya, 2006; Kariuki, 2009; Kinuthia,

2009), Namibia (Government of Namibia, 2005; Patterson, 2007), Rwanda (Government of Rwanda, 2000; Government of Rwanda, 2005; Ministry of Finance and Economic Planning of Rwanda, 2002; Zlotnikova, 2008), South Africa (Jaffer, Ng'ambi & Czerniewicz, 2007; Mostert & Quinn, 2009), Seychelles (Patterson, 2007), Tanzania (Miller Essellar, & Associates, 2001; Tilya, 2007; Moens, Broerse & Bunders, 2008), Uganda (Ministry of Information and Communications Technology of Uganda, 2001; van Reijswoud & Mulo, 2006), Zimbabwe (Government of Zimbabwe, 2005). Bassi (2011) provides the most complete list of ICT in Education policies and plans worldwide, including African countries, also used in this study.

The analysis of the available data has shown that Digital Divide exists not only between developed and developing countries, but also between different countries of sub-Saharan Africa and different locations/communities within a country. Barnard and Vonk (2003, cited in Ng'ambi, 2006) noted a greater presence of advancement in terms of the use of ICTs of the Southern African countries followed by the Eastern and West African States. Most of the Central African states have been lagging behind.

In sub-Saharan Africa there exist severe disparities between different locations within a country. While urban areas demonstrate rather high level of ICT development (especially country capitals with numerous Internet cafes), in remote rural areas there are hardly any ICT access. For example, in Uganda there are ICT disparities between Central Uganda (especially downtown Kampala) and Northern Uganda. Mozambique demonstrates uneven deployment of ICT in Maputo and provinces. There are also disparities between different types of educational institutions. Private schools normally have better computer facilities than public ones.

Gender disparities in access to ICT can be explained by traditional values still dominating in African societies. That is why special legal provisions for gender equity in ICT access and ICT educational projects targeting underprivileged minorities (including women) are so necessary.

There are significant efforts to overcome these disparities. In Kenya the ICT sector is currently more active in urban areas, resulting in wide regional disparities in the distribution of ICT facilities (Kenya ICT Board, 2011). In order to address this disparity, the Kenya ICT Board (KICTB) supports the roll out of new "electronic centers" (commonly known as community telecenters). These are hubs that provide a host of services to the public via computers connected to the internet, or by using and marketing other ICT-enabled applications. This work shall be done under the Kenya ICT Program (KICTP) initiative, which has an aim to provide internet access and e-services at the grassroots level via multi-stakeholder partnerships.

Other ICT educational initiatives also widely deploy multi-purpose community telecenters as a solution to overcome digital divide between urban and rural areas (Jensen & Esterhuysen, 2001; Mayanja, 2007).

The proposed model of an ICT Educational Policy has been developed on the base of analysis of

1. existing ICT educational policies in African countries
2. existing ICT in Education models
3. statistical data
4. personal experience of the authors.

METHODOLOGY

To achieve the objectives stated in Introduction the following methodology has 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 Literature Review 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 IndexMundi website (www.indexmundi.com). This website provides most complete country profiles. The data are taken from 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 personal experience of the authors. One of the authors has worked for more than two years in Rwanda and for two years in Uganda. She also participated in NUFFIC project on e-Learning in Mozambique. The other author has participated in NUFFIC projects in Uganda, Ghana and Ethiopia and coordinated ICT-based Community Outreach Projects in many African countries. They took every opportunity to know more about ICT educational policies and practices through both studying available documents and interviewing (mostly informally) people in charge for ICT in education.

Second, as a result of the analysis of the said data sources, the list of identified parameters (political, socio-economic, demographic, geographic, cultural etc.) that contribute to the success or, otherwise, failure of an ICT educational policy has been obtained.

Third, based on the literature review and personal experience of working in the area of ICT in Education in African countries, the model of an ICT educational policy comprising both its components and external influential parameters has been proposed..

Fourth, the proposed model has been elaborated using a data mining technique called Formal Concept Analysis (FCA) introduced in (Wille, 1992). This technique allows to find formal concepts and their relation of being more or less generic/specific. It has been employed in many areas, for example, Social Sciences, Biology and Medicine. A modern application is found is (Ren et al., 2011) where FCA is used to find topics of news stories on the Internet.

So far, to the best of the authors' knowledge, FCA has not been systematically used in Political Sciences, except for (Kohler 1989) in which the project analyzing international regimes and their relationships using FCA is presented. The similar project is also described in Eklund and Wille (2007). It is the evaluation of international regimes in terms of 24 attributes like power structure, institutional environment, field of distribution (security, welfare and power). Specific questions are answered by defining suitable sub-contexts. Eklund and Wille (2007) discuss some examples of such questions, for example, they want to prove the following hypothesis on a suitable subset of the data obtained: *"Intense regimes are found mostly under hegemonial structures"*. Conceptual structures generated from Formal Concept Analysis on relevant data are easily recognized by experts as a good reflection of the structure in practice. Eklund and Wille (2007) tell about the Hessian Science Minister who immediately recognized such a generated conceptual diagram and also could use this in his managerial process.

Fifth, the proposed model has been used as a base for developing the Balanced Scorecard for evaluating ICT educational policies. 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.

All metrics have been normalized to the interval $[0,1]$ where 0 is the worst score and 1 is the best. Weights have been assigned according to the importance of the metric and then adjusted to give maximum total performance of 100. Let x_i be the score assigned to the i^{th} parameter of an ICT educational policy, and w_i the weight of this parameter, then the total performance P_{total} is calculated as the weighted average:

$$P_{total} = \sum_{i=1}^n x_i \cdot w_i. \quad (1)$$

Since the weights add up to 100, the value P_{total} will range between 0 and 100. The value P_{total} allows evaluating an ICT educational policy. The closer is the value to 100, the more successful an ICT educational policy is (see Figure 1).

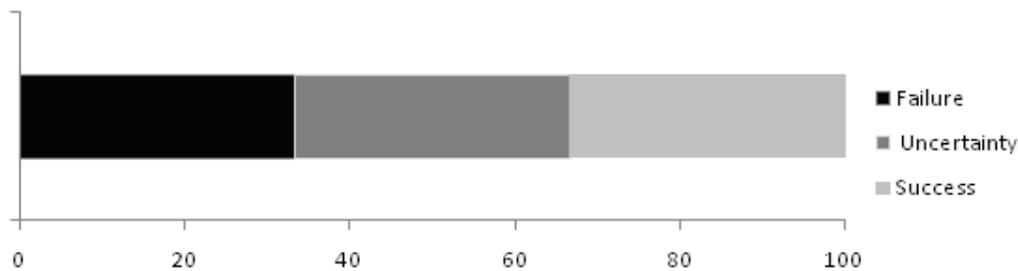


Figure 1: A simple scale indicating the degree of success of an ICT Educational Policy depending on the total performance value P_{total} .

Finally, a simple validation of the proposed model is provided by establishing taxonomy of selected countries of sub-Saharan Africa.

Formal Concept Analysis

In Formal Concept Analysis a binary relation between a set of *objects* and a set of *attributes* is considered as a basis for further analysis.

As a running example to present the Formal Concept Analysis theory, the authors consider a school management trying to improve quality of teaching and learning in their school. The school has identified the following *parameters* as being important: *learning speed*, *depth of understanding*, *broadness of knowledge*, *valorization* (transformation of knowledge into economic and social value) and *societal aspects*. These parameters are linked with functional characteristics, also referred to as *components*. The example school has recognized the following components: *teachers*, *material*, *practicum*, *outreach*, *supervision* and *organization*. The parameters are the *formal objects*, the components are the *formal attributes*. Table 2 shows identified objects and attributes.

Table 2: Objects and Attributes – an example

<p><i>Formal Objects:</i> C₀ – teachers C₁ – material C₂ – practicum C₃ – outreach C₄ – supervision C₅ – organization</p>	<p><i>Formal Attributes:</i> P₀ – learning speed P₁ – depth of understanding P₂ – broadness of knowledge P₃ – valorization P₄ – societal aspects</p>
---	--

Table 3 shows the influence relation between objects and attributes (parameters and components) that has been established by this school for their specific situation.

Table 3: The influence table: A formal context of the example school

	P ₀	P ₁	P ₂	P ₃	P ₄
C ₀	1	1			
C ₁	1		1		1
C ₂		1		1	
C ₃					1
C ₄	1			1	1
C ₅	1				

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. The next subsection shows how the formal concept lattice helps to define such a structure.

Formal Concepts and Concept Lattices

If there is a binary relation between objects and attributes, a *formal concept* can be defined as the combination of two sets: *C* of some components and *P* of some parameters such as that the components *C* share precisely all parameters from *P*, and the parameters from *P* are common precisely to all components in *C*. For example, the pair $(\{C_0, C_2\}, \{P_1\})$ is a formal concept since

- $\{C_0, C_2\}$ have in common $\{P_1\}$
- $\{P_1\}$ have in common $\{C_0, C_2\}$.

It is informative to order these concepts according to their strength. Let (C, P) and (D, Q) be formal concepts. Then (C, P) is a generalization of (D, Q) if it has a larger extension, or $C \subseteq D$. 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.

For the school management example (see the previous subsection “Formal Concept Analysis”) the resulting concept lattice is shown in Figure 2. Each concept is labeled with its associated set of components and parameters. The top concept (*material, teachers, practicum, outreach, supervision, organization*) is the most specific concept, the bottom concept (*speed, depth, broad, valorization, society*) the most general.

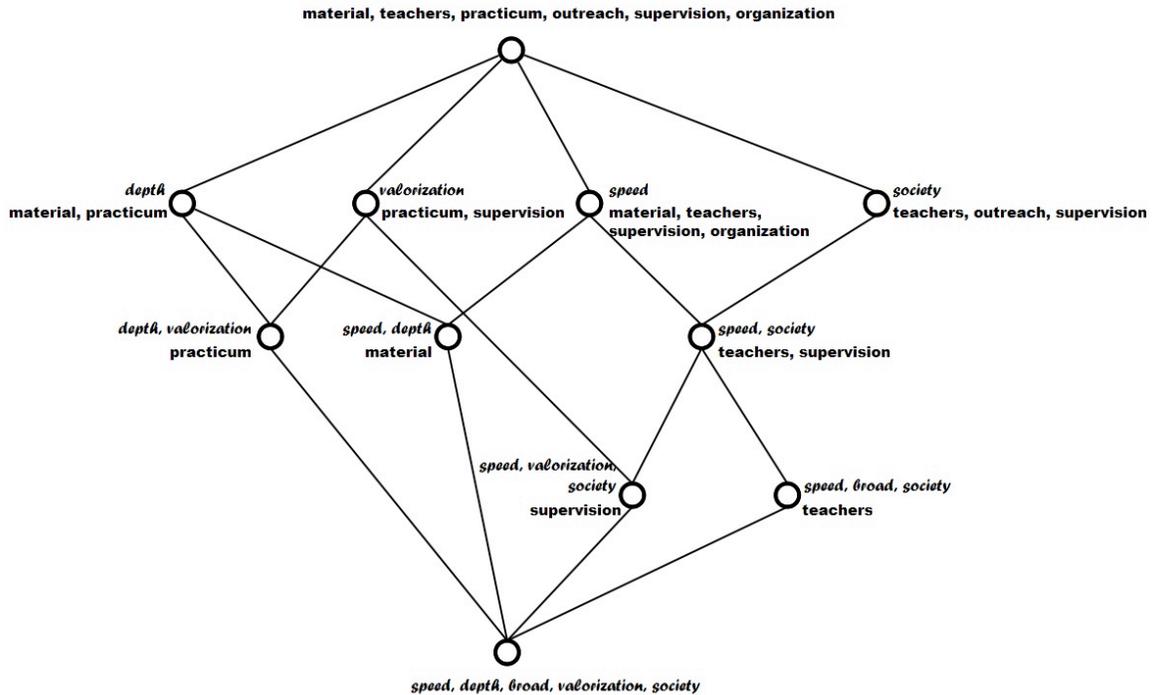


Figure 2: The school concept lattice

Formal concepts are closed circles in terms of mutual influence between components and parameters. The concept lattice organizes the concepts in terms of being more generic (covering more components) or, in other words, being for specific (covering less parameters).

The concept lattice can be used in various ways. Here a managerial interpretation is discussed. Suppose that there is a need in the school to make a committee responsible for *learning speed* and *depth of knowledge*. Then Figure 2 shows (see the concept marked with attributes *speed* and *depth*, and with object *material*) that a committee with members from the material group is needed since only members from this group oversee both *learning speed* and *depth of knowledge*. Would it be necessary to focus on *depth* alone, then stakeholders from the practicum group are also relevant. So then there are two decision units, one deciding on *depth of knowledge* in general and the other on *depth of knowledge* in combination with *learning speed*. Both are present as formal concepts in the concept lattice. The line connecting these formal concepts shows that these decision units depend on each other, the line represents a communication structure. In practice these decision units may be joined into a single committee to optimize internal communication. But this grouping problem is left outside the context of this paper.

The application considered in the subsection “Balanced Scorecard and Managerial Framework” uses the lattice as a scoring device.

RESULTS

The investigations have led to the proposal of a new model of an ICT educational policy that extends the reviewed models. In this model, authors distinguish between components and parameters.

Components of an ICT educational policy are influenced by numerous parameters (economic, political, demographic, technological and cultural). Models reviewed in the section “Literature Review” do not take into consideration those parameters. The proposed model of an ICT educational policy includes influential parameters.

The next subsection “Proposed Model of an ICT Educational Policy” focuses on the relation between the components and the influential parameters of the proposed model, expressing which parameters influence which components. The authors use this relation to find stable requirement patterns as formal concepts. These patterns and their generalization relation are considered as a managerial framework to support ICT educational policies in practice.

The proposed model is used as a base for developing the Balanced Scorecard for evaluating ICT educational policies. A simple validation of the proposed model is provided by establishing taxonomy of selected countries of sub-Saharan Africa.

Proposed Model of an ICT Educational Policy

The components of the model and influential parameters have been identified on the base of analysis of

1. existing ICT educational policies in African countries
2. existing ICT in Education models
3. statistical data
4. personal experience of the authors.

Both components of the proposed model of an ICT educational policy and the influential parameters are presented in Figure 3.

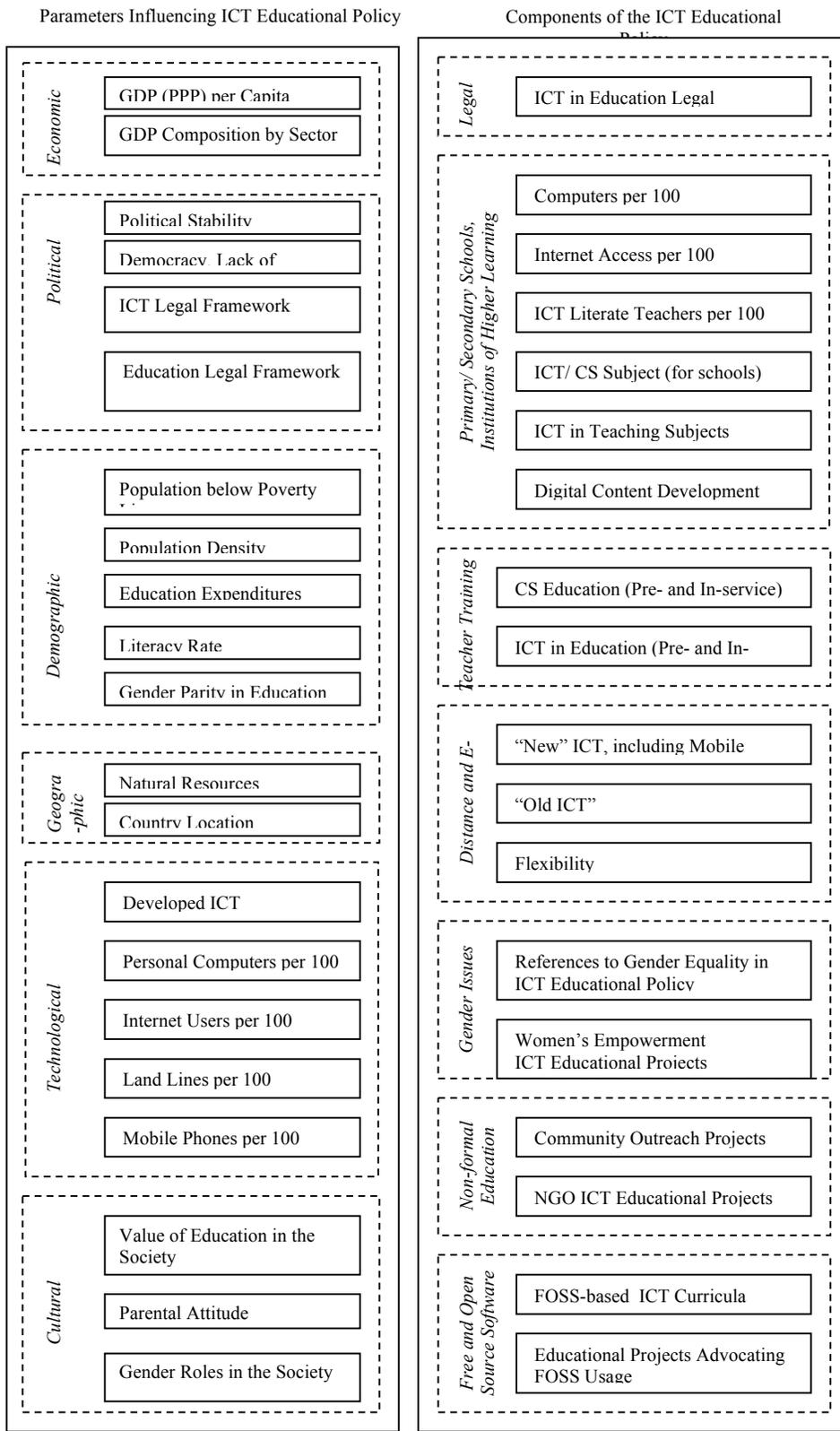


Figure 3: Proposed model of an ICT educational policy: components and influential parameters

The following parameters have been identified as having a main influence on an ICT educational policy. They are presented in groups of coherent parameters:

Economic Parameters

P₀ - GDP (PPP) per capita

Political Parameters

P₁ – Political Stability

P₂ – Democracy, Lack of Censorship

P₃ – ICT Legal Framework

P₄ – Education Legal Framework

Demographic Parameters

P₅ – Education Expenditures

P₆ – Literacy Rate

P₇ – Gender Parity

Technological Parameters

P₈ – Developed ICT Infrastructure

P₉ – Computers per 100 population

P₁₀ – Internet Users per 100 population

P₁₁ – Land Lines per 100 population

P₁₂ - Mobile Phones per 100 population

Cultural Parameters

P₁₃ – Value of Education in the Society

P₁₄ – Parental Attitude

The following components are distinguished in the proposed model. These components are organized in coherent groups:

Legal

C₀ – ICT in Education Legal Framework

Primary/ secondary schools, institutions of higher learning

C₁ – Computers per 100 student population

C₂ – Internet Access per 100 students population

C₃ – ICT Literate Teachers per 100 teacher population

C₄ – Compulsory ICT/ Computer Studies Subject in Schools

C₅ – Using ICT in Teaching Subjects

C₆ – Digital Content Development

Teacher Training

C₇ – Teacher Training in Computer Science Education (pre- and in-service)

C₈ – Teacher Training on Using ICT in Teaching Subjects (pre- and in-service)

Open, Distance and e-Learning

C₉ – “New” ICT including Mobile Services

C₁₀ – “Old” ICT (printed materials, TV, radio, landline phones etc.)

C₁₁ – Flexibility (using both “new” and “old” ICT)

Gender Issues

C₁₂ – References to Gender Equality in ICT Educational Policy

C₁₃ – Women’s Empowerment ICT Educational Projects

Non-formal Education

C₁₄ – Community Outreach Projects

C₁₅ – ICT Educational Projects Run by NGO

Free and Open Source Software (FOSS)

C₁₆ – FOSS-based ICT Curricula

C₁₇ – Educational Projects Advocating FOSS Usage

The identified links between these components and parameters are presented in Table 4. 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 forthcoming extended version of this paper.

Table 4: Components and influential parameters relation scheme

	P ₀	P ₁	P ₂	P ₃	P ₄	P ₅	P ₆	P ₇	P ₈	P ₉	P ₁₀	P ₁₁	P ₁₂	P ₁₃	P ₁₄
C ₀		1		1	1										
C ₁	1					1			1	1					1
C ₂	1					1			1	1	1	1	1		1
C ₃	1					1				1					1
C ₄	1					1									1
C ₅	1					1									1
C ₆	1					1									1
C ₇	1					1								1	
C ₈	1					1								1	
C ₉	1					1	1		1	1	1	1	1		
C ₁₀							1		1			1			
C ₁₁							1		1			1	1		
C ₁₂				1				1							
C ₁₃								1							
C ₁₄		1	1				1		1						
C ₁₅		1	1				1		1						
C ₁₆			1												
C ₁₇			1												

Derived Managerial Framework

In the case of Table 4, the application of the Formal Concept Analysis leads to the concept lattice structure displayed in Figure 3. For the computation of this concept lattice the PCbo tool has been used (Krajca, Outrata & Vychodil, 2008). In this figure the authors have used reduced labeling, only mentioning the parameters associated with each concept, and the component(s) that are introduced in the lattice by this concept.

This resulting concept lattice is called the managerial framework for the proposed model. The managerial framework can be seen as an important supporting framework for policy makers since it provides stable groupings of combinations of parameters and components. So when some parameters are present at a sufficient level, the associated components are a well-chosen target. Furthermore, the framework shows what parameters are most promising to make a next step.

In the subsection “Balanced Scorecard for Evaluating ICT Educational Policies” the authors introduce a balanced scorecard that provides an overall success score for an ICT educational policy. This scorecard is also related to the managerial framework.

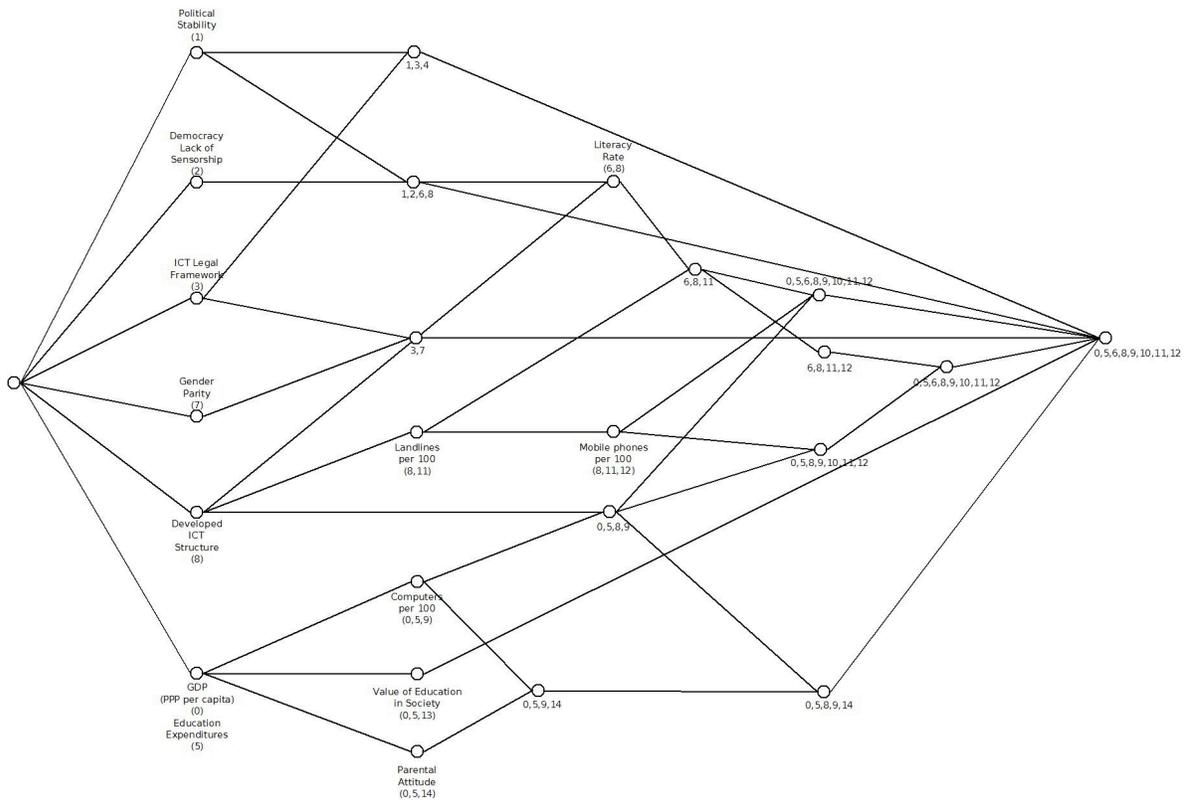


Figure 4: The concept lattice structure

Conceptual Scaling

Conceptual scaling is a method to make a restriction to a particular sub-area of interest. In Figure 3 (subsection “Proposed Model of an ICT Educational Policy”) parameters and components are grouped in meaningful clusters. In this application the authors use these clusters as a higher level of abstraction, and only consider these groups and their relations. This leads to the sub-context as shown in Table 5.

Table 5: The influence table between groups of parameters and components: a formal sub-context

	Eco	Pol	Demo	Tech	Cult
Legal		1			
Edu	1		1	1	1
Teacher	1		1		1
ODeL	1		1	1	
Gender		1	1		
Non-formal		1	1	1	
FOSS		1			

The denotations used for groups of components are:

- Primary/ Secondary Schools, Institutions of Higher Learning - Edu
- Teacher Training - Teacher
- Open, Distance and e-Learning - ODeL
- Gender Issues - Gender
- Non-formal Education – Non-formal
- Free and Open Source Software – FOSS

The denotations used for groups of parameters are:

- Economic Parameters - Eco
- Political Parameters - Pol
- Demographic Parameters - Demo
- Technological Parameters - Tech
- Cultural Parameters - Cult

In the context of Table 5, a value of 1 means that there is some influence relation between particular groups of components and parameters. Note that the strength of such a relation in this example is left out of consideration. This leads to the conceptual lattice as shown in Figure 5.

In Figure 5 the reduced labeling of both components and parameters has been used. A component is only mentioned at the highest concept where it is introduced in the lattice. Parameters are only mentioned at the lowest concept where they are introduced.

Suppose that the government wants to focus on the component groups *Primary/ Secondary Schools, Institutions of Higher Learning and Teacher Training*. Then the most relevant concept (marked with * in Figure 5) is $(\{Edu, Teacher\}, \{Cult, Eco, Demo\})$. So, according to the concept lattice, the parameters *Eco*, *Demo* and *Cult* are the most relevant parameters for this particular policy. After this the government will focus on the individual parameters of this group. However, *Teacher* is not a concept by its own, that it can only go together with *Edu*.

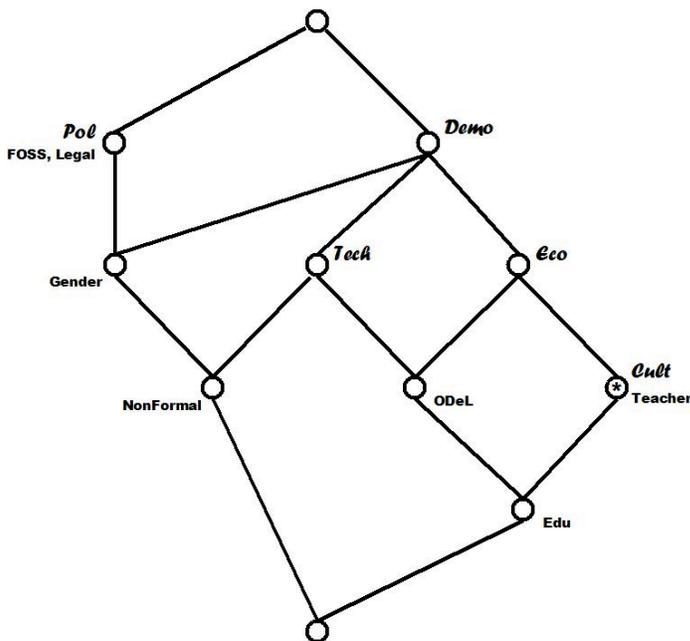


Figure 5: The conceptual lattice

SIMPLE VALIDATION

Balanced Scorecard for Evaluating ICT Educational policies

Using the proposed model of an ICT educational policy the authors developed 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 model of an ICT educational policy. For example, components C_1 and C_2 are combined into one integral metric named ICT Access. In the model the authors for the sake of compactness did not distinguish between various levels of education. In the Balanced Scorecard there are separate metrics for primary and secondary schools and institutions of higher learning. The metric Implemented and Adopted ICT policy is not a component of the proposed model, but an influential parameter.

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

1. Importance of the component/ parameter expressed numerically as weights
2. Its measurability from outside.

The choice and importance of each of metrics in this Balanced Scorecard has been justified, but justification has been omitted in this paper due to its length.

Table 6 presents the identified metrics together with their scores and weights. The weights are assigned according to relative importance of metrics. For example, having ICT Educational Policy is considered as more important than having ICT Policy because the model as its name suggests is specifically about ICT educational policies. ICT access in primary schools is less important (and less feasible) than in secondary schools and institutions of higher learning. Flexibility of Open, Distance and e-Learning (ODEL) is less important than the existence of ODeL projects itself. Non-formal education and community outreach projects are considered as less important than the formal education due to lack of continuity and sustainability. Normally these projects are short-term and stop when the financing stops.

Table 6: *Balanced Scorecard for evaluating ICT educational policies*

	Name of the metric	Score	Weight
1.	Implemented and Adopted ICT Policy	0 – No 0.5 – Implemented, but not adopted 1 –Yes	3.57
2.	Implemented and Adopted ICT Educational Policy	0 – No 0.5 – Implemented, but not adopted 1 –Yes	5.36
3.	ICT Access in Primary Schools	0 – No access 0.33 – Unsatisfactory 0.67 – Satisfactory 1- Good	3.57
4.	ICT Access in Secondary Schools	0 – No access 0.33 – Unsatisfactory 0.67 – Satisfactory 1- Good	5.36
5.	ICT Access in Institutions of Higher Learning	0 – No access 0.33 – Unsatisfactory 0.67 – Satisfactory 1- Good	7.14
6.	School Subject of Computer	0 – No	5.36

	Name of the metric	Score	Weight
	Science/ ICT (Secondary Schools)	0.5 – Elective or in some schools 1 - Compulsory	
7.	Using ICT in Teaching and Learning Subjects (Primary Schools)	0 – No 0.33 – Meager 0.67 – Some Schools (private/ pilot) 1 – Majority of Schools	3.57
8.	Using ICT in Teaching and Learning Subjects (Secondary Schools)	0 – No 0.33 – Meager 0.67 – Some Schools (private/ pilot) 1 – Majority of Schools	5.36
	Using ICT in Teaching and Learning Subjects (Institutions of Higher Learning)	0 – No 0.33 – Meager 0.67 – Some Schools (private/ pilot) 1 – Majority of Schools	7.14
9.	Development of Digital Content for Primary Schools	0 – No 0.5 – Some subjects 1 – Most subjects covered	3.57
10.	Development of Digital Content for Secondary Schools	0 – No 0.5 – Some subjects 1 – Most subjects covered	5.36
11.	Development of Digital Content for Institutions of Higher Learning	0 – No 0.5 – Some subjects 1 – Most subjects covered	7.14
12.	ICT Pre- and In-service Teacher Training	0 – No 0.5 – Either pre- or in-service teacher training 1 – Both	7.14
13.	Teacher Training in Computer Science Education in Institutions of Higher Learning	0 – No 1 – Yes	7.14
14.	Open, Distance and e-Learning (ODeL) Projects	0 – No 0.5 – Mostly carried out by non-governmental organizations (NGO) 1 – Mostly carried out by governmental organizations	5.36
15.	Flexibility of ODeL	0 – No ODeL 0.5 – Only “old” or “new” ICT employed 1 – Both “old” and “new” ICT employed	3.57
16.	Advocacy of Free and Open Source Software (FOSS)	0 – No 0.5 – By NGO and individuals 1 – Provisions for FOSS	3.57
17.	Gender Equity in ICT Access	0 – No 0.5 – NGO ICT projects promoting Gender Equity 1 – Legal provisions for Gender Equity in ICT Access/ governmental projects promoting Gender Equity in ICT Access	5.36
18.	Non-formal Education and Community Outreach Projects (COP)	0 – No 0.5 – NGO projects 1 – Legal provisions for Non-formal education and COP/ governmental projects	5.36
	Maximum Total Performance		100

This leads to a total performance P_{total} calculated using Formula (1). In the next subsection, “Taxonomy of Selected Countries of sub-Saharan Africa”, this total performance is used to establish taxonomy of selected countries of sub-Saharan Africa.

Taxonomy of Selected Countries of sub-Saharan Africa

To validate the proposed model of an ICT educational policy, authors have taken the Balanced Scorecard developed on the base of the model and applied it to the data obtained in four countries of sub-Saharan Africa - Ethiopia, Mozambique, Rwanda and Uganda (Table 7). The authors are familiar with these countries since they either worked or participated in long-term projects there.

Table 7: Taxonomy of selected countries of sub-Saharan Africa regarding to their ICT educational policies

S/N	Country	Total Performance (out of 100)
1.	Ethiopia	40,2
2.	Mozambique	69,6
3.	Rwanda	74,1
4.	Uganda	76,8

Taxonomy correlates with a general characterization of the said countries as observed by the authors and found in the literature. Rwanda and Uganda demonstrate rather high level of ICT in education development. Rwanda has a complete set of ICT/ ICT educational policies and most ICT educational initiatives are controlled by the Ministry of Education. Any ICT educational project initiated by an NGO/ international organization has no chances to thrive if having no governmental support. As it is claimed in (Government of Rwanda, 2000; Government of Rwanda, 2005), by 2020 Rwanda will become an information-technology hub for the resource-rich nations of Eastern and Central Africa, but the country still has a very long way to go. In Uganda which is not so regulated by the government, there are numerous ICT educational projects run by NGO/ international organizations, but no coordination under them. Some ICT educational projects duplicate each other and are not sustainable. Once funding stops, the project stops as well.

In Mozambique the development of ICT in education is uneven and depends on the location of the school/ institution and the source of its financing (Zlotnikova, Muyinda & Lubega, 2010). University of Eduardo Mondlane (public) and Instituto Superior de Transportes e Comunicações (private) located in Maputo, the capital of Mozambique, demonstrate a high level of an ICT access and digital content development. Catholic University of Mozambique (with many up country branches) has vast experience of running distance education programmes. Programme coordinators take into consideration the fact that in most places in Mozambique an ICT infrastructure is undeveloped, so they employ both “new” and “old” ICT (including printed materials and audio and video records). The Ministry of Education and Culture of Mozambique takes significant efforts to coordinate ICT educational initiatives. But, in general, the situation in Mozambique needs improvement.

ICT in education developments in Ethiopia are still in their infant stage compared to developed countries (Tegegne & Weide, 2011). But the government strives to improve connectivity between schools by launching a network for high schools. ICT as means of facilitating a solution to social problems, including those arising in the education sector, have not yet been fully considered neither by government nor by society.

The general conclusion is that the proposed model can show and explain essential elements of an ICT educational policy.

Balanced Scorecard and Managerial Framework

The Balanced Scorecard leads to a single score, the total performance P_{total} , indicating the degree of success of an ICT Educational Policy (section “Methodology”). The derived managerial framework (using formal concept analysis) allows adding more interpretation to the Balanced Scorecard. The essence of the relations between parameters and components (as displayed in Table 4) is represented in the concept lattice (Figure 4). The scoring of the parameters (as done in the Balanced Scorecard, Table 6) also can be used to provide a score for each formal concept. The political choices made in a country (in this paper limited to ICT educational policies) will lead to taxonomy of these concepts. The concept scores will help policymakers to define their best next steps.

Let us assume that the policymakers describe their global policies as a combination Q_c of highly desirable components. Q_c is considered as the description of some overall goal. Suppose in some country, government wants to focus on the components *Teacher Training* (i.e. C_7 and C_8) and *Open Distance and e/Learning* (i.e. C_9 , C_{10} and C_{11}). Then

$$Q_c = \{C_7, C_8, C_9, C_{10}, C_{11}\}. \quad (2)$$

The quality of the formal concept (C, P) is introduced as how well the components C of this concept match the goal Q_c . The similarity between the sets C and Q_c of components may be measured using the Jaccard similarity coefficient (Jaccard, 1901) which is defined as the ratio between the commonality and the generality of its arguments:

$$Sim(C, Q_c) = \frac{|C \cap Q_c|}{|C \cup Q_c|}. \quad (3)$$

The quality of concepts is used for taxonomy of concepts. From the Balanced Scorecard a score $score(p)$ for each parameter p in the proposed model is obtained. Then the score for concept (C, P) is defined as the product of the external score $Sim(C, Q_c)$ of the concept and the internal score over all parameters:

$$Score(C, P) = Sim(C, Q_c) \cdot \sum_{p \in P} score(p). \quad (4)$$

Policymakers will look for the highest scoring concept in the managerial framework. As the next step, they may select the neighboring concept that best improves the concept quality. Improving the score for the individual parameters of this concept is the best step to improve the overall quality of the status of ICT education, measured in terms of goal Q_c .

DISCUSSION

The main result of the study is a model of an ICT educational policy. The proposed model can be recommended to the policy makers and other stakeholders at the initial stage of an ICT educational policy development. It presents components of an ICT educational policy necessary to ensure 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. It also provides a managerial framework that can help policy makers in various ways to evaluate the effects of their policy, to define next steps and to set up efficient managerial structure and effective communication lines.

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

Further research will include a full validation of the proposed model and the Balanced Scorecard for evaluating an ICT educational policy, as well as case studies in institutions of higher learning in countries of sub-Saharan Africa.

CONCLUSIONS

The results of this study contribute to a deeper understanding of ICT educational policies in countries of sub-Saharan Africa, especially of those components of policies leading to their success (or otherwise – to their failure).

First, the components of an ICT educational policy and links between them have been identified. Second, country-related parameters have been identified based upon available sources of the available statistical information. Third, links between components of an ICT educational policy and the influencing country-related parameters have been established. Components of an ICT educational policy, country-related parameters and links between them make the proposed model of an ICT educational policy. The model has been elaborated using a data-mining technique called Formal Concept Analysis. This resulting concept lattice can be used to set up an effective managerial framework for an ICT educational policy. Fourth, a Balanced Scorecard for evaluating ICT educational policies has been developed on the base of the proposed model. The authors also have described how the concept lattice can help to make more effective use of the balanced scorecard. Finally, a simple validation of the proposed model has been done through a establishing taxonomy of selected countries of sub-Saharan Africa. The country score has been calculated using the Balanced Scorecard.

Research 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 success forecasting of future projects. Potential users of research results include policymakers and practitioners involved into ICT educational projects.

REFERENCES

- Balanced Scorecard Institute. (2010). "What is the Balanced Scorecard". [online] Available at <<http://www.balancedscorecard.org/BSCResources/AbouttheBalancedScorecard/tabid/55/Default.aspx>> [Assessed December 12, 2011]
- Bassi, R., 2011. "ICTs in Education (ICT4E) Policies and Plans worldwide". [online] Available at: <<http://www.gesci.org/assets/files/Knowledge%20Centre/country-policies.pdf>> [Assessed December 4, 2011]
- Batane, T., 2004. "Inservice teacher training and technology: A case of Botswana". *Journal of Technology and Teacher Education*, vol. 12 (3), pp. 387-410.
- Eklund, P., and Wille, R., 2007. "Semantology as Basis for Conceptual Knowledge Processing". In: S.O. Kuznetsov and S. Schmidt (eds.), *ICFCA 2007, LNAI 4390*, pp. 18–38.
- Engelen, M., Ludeking B., and Myk, A., 2006. "Dutch ICT-tools for a Balanced Use of ICT in the Netherlands". The Hague: Ict op School.
- Evoh, C.J., 2009. "The role of Social Entrepreneurs in Deploying ICTs for Youth and Community Development in South Africa". *The Journal of Community Informatics*. [online] Available at <<http://ci-journal.net/index.php/ciej/article/view/459/438>> [Assessed December 4, 2011]
- Farrell G., and Shafika I., 2007. "Survey of ICT and Education in Africa: A Summary Report, Based on 53 Country Surveys". [online] Available at: <<http://www.infodev.org/en/Publication.353.html>> [Assessed December 4, 2011]
- Government of Botswana, 1994. "Revised National Policy on Education", Gaborone, Botswana.
- Government of Namibia, 2005. "ICT Policy for Education and Training Sector", Windhoek, Namibia.
- Government of Rwanda, 2000. "The 1st NICI Plan (2001 to 2005)", Kigali, Rwanda.
- Government of Rwanda, 2005. "The 2nd NICI Plan (2006 to 2010)", Kigali, Rwanda.
- Government of Zimbabwe, 2005. "Zimbabwe National Information and Communication Technology Policy Framework", Harare, Zimbabwe.
- InfoDev, 2007. "ICT in Education Toolkit: for Decision Makers, Planners and Practitioners: Concept and Blueprint". [online] Available at: <<http://www.ictinedtoolkit.org/icttool/usere/conceptblueprint.php>> [Assessed December 4, 2011]
- Jaccard, P., 1901. "Distribution de la flore alpine dans le basin des dranses et dans quelques régions voisines", *Bulletin de la Société Vaudoise des Sciences Naturelles*, 37:241–272.
- Jaffer, S., Ng'ambi, D. and Czerniewicz L., 2007. "The role of ICTs in higher education in South Africa: One strategy for addressing teaching and learning challenges". *International Journal of Education and Development using Information and Communication Technology*, Vol. 3, Issue 4, pp. 131-142.

- Jensen, M., and Esterhuysen, A., 2001. "The Community telecenter cookbook for Africa". [online] Available at <<http://unesdoc.unesco.org/images/0012/001230/123004e.pdf>> [Accessed on July 6, 2006]
- Kaplan, R.S., and Norton D.P., 1996. "The Balanced Scorecard: Translating Strategy into Action". Harvard Business Press, Cambridge, MA.
- Kariuki, G., 2009. "Growth and improvement of information and communication technology in Kenya". *International Journal of Education and Development using Information and Communication Technology*, Vol. 5, Issue 2, pp. 146-160.
- Kenya ICT Board, 2011. "Kenya ICT Board together with the Ministry of Information and Communication Hands Over a cheque of USD 1.3 Million to Family Bank". [online] Available at < <http://www.ict.go.ke/index.php/digitalinclusion/pasha/pasha-updates/344-kenya-ict-board-together-with-the-ministry-of-information-and-communication-hands-over-a-cheque-of-kshs-108490000-to-family-bank?tmpl=component&print=1&page=>> [Accessed December 15, 2011]
- Kohler-Koch, B., 1989. "Zur Empirie und Theorie internationaler Regime". In: *B. Kohler-Koch (ed.), Regime in den internationalen Beziehungen*. Nomos, Baden-Baden, 15-85.
- Kinuthia, W., 2009. "Educational development in Kenya and the role of information and communication technology". *International Journal of Education and Development using Information and Communication Technology*, Vol. 5, Issue 2, pp. 6-20.
- Krajca P., Outrata J., and Vychodil V., 2008. "Parallel Recursive Algorithm for FCA". In: *Proc. CLA 2008, CEUR WS*, 433(2008), 71-82.
- Mayanja, M., 2006. "The African Community Telecenters: in Search of Sustainability". [online] Available at <<http://portal.unesco.org>> [Accessed December 15, 2011]
- Miller Essellar, & Associates, 2001. "A Country ICT Survey for Tanzania". [online]. Available at: <<http://www.iste.org/AM/Template.cfm?Section=NETS>> [Accessed December 4, 2011]
- Ministry of Finance and Economic Planning of Rwanda, 2002. "Vision 2020 Plan", Kigali, Rwanda.
- Ministry of Information and Communications of Kenya, 2006. "National ICT Policy", Nairobi, Kenya.
- Ministry of Information and Communications Technology of Uganda, 2001. "Vision Statement". [online] Available at: <http://www.ict.go.ug/index.php?option=com_content&view=article&id=58> [Assessed December 4, 2011]
- Ministry of Post and Communications of Cameroon, 2004. "Cameroon National Information and Communication Infrastructure (NICI) Policy Plan", Yaounde, Cameroon.
- Moens, N.P., Broerse J.E.W., and Bunders, J.F.G., 2008. "Evaluating a participatory approach to information and communication technology development: The case of education in Tanzania". *International Journal of Education and Development using Information and Communication Technology*, Vol. 4, Issue 4, pp. 88-110.

- Mostert, M., and Quinn, L., 2009. "Using ICTs in teaching and learning: Reflections on professional development of academic staff". *International Journal of Education and Development using Information and Communication Technology*, Vol. 5, Issue 5, pp.72-84.
- Nana, W.W., and Ogechi O., 2008. "Cameroon: Computer Science Teachers Improve Knowledge on ICT". [online] Available at: <<http://allafrica.com/stories/200808041740.html>> [Assessed December 4, 2011]
- Ng'ambi, D., 2006. "ICT and Economic Development in Africa: The Role of Higher Education Institutions". [online] Available at < <http://www.foundation-partnership.org/pubs/leaders/assets/papers/ICTandEconDev-RoleofHEIafinal.pdf> >. Accessed on December 15, 2011].
- Palamakumbura, T., 2008. "The computer revolution: Struggling for survival in rural Cameroon", *Journal of Education and Development using Information and Communication Technology*, Vol. 4, Issue 3, pp. 166-168.
- Paterson, A., 2007. "Costs of information and communication technology in developing country school systems: the experience of Botswana, Namibia and Seychelles". *International Journal of Education and Development using ICT*, vol.3, No. 4.
- Reijswoud, van V. and Mulo, E., 2006. "Applying Open Source Software in a Development Context: expectations and experiences. A Case Study of a University in Uganda". *E-Learning*, 3(3), pp. 361-372. [online] Available at: <http://www.worldwords.co.uk/pdf/validate.asp?j=elea&vol=3&issue=3&year=2006&article=9_Reijswoud_ELEA_3_3_web> [Assessed December 4, 2011]
- Swarts, P., 2006. "ICT & the Third Revolution in Education Policy". [online] Available at <<http://digitalllearning.eletsonline.com/2006/09/ict-the-third-revolution-in-education-policy-2/>> [Accessed December 14, 2011]
- Tegegne, T. and Weide, van der T., 2011. "eHealth Service Discovery Framework: A Case Study in Ethiopia". In: *A. Holzinger & K.-M. Simonc (eds.), USAB 2011 – Information Quality in eHealth*. Graz, Austria, November 24-25, 2011. Springer
- Trucano, M., 2005. "Knowledge Maps: ICT in Education". [online] Available at: <<http://www.infodev.org/en/Publication.8.html>> [Assessed December 4, 2011]
- Tilya F., 2007. "ICT in Education in Tanzania: Lessons and Experiences from IICD-supported projects". [online] Available at: <http://www.iicd.org/files/Tanzania_ICT%20in%20education.pdf> [Assessed December 4, 2011]
- UNESCO, 2006. "ICTs and Education Indicators". [online] Available at: <http://www.itu.int/ITU-D/ict/partnership/material/ICT_Education_Paper_Nov_2006.pdf> [Assessed December 4, 2011]
- UNESCO, 2008. "ICT Competency Standards for Teachers: Implementation Guideline". [online] Available at: <<http://unesdoc.unesco.org/images/0015/001562/156209E.pdf>> [Assessed December 4, 2011]

- Wagner, D., 2005. "Monitoring and Evaluation of ICT in Education Projects: A Handbook for Developing Countries". [online] Available at: <<http://www.infodev.org/en/Document.9.pdf>> [Assessed December 4, 2011].
- Wild, K., 2011. "What is ICT Policy" [online]. Available at: <http://old.apc.org/english/capacity/policy/mmtk_ictpol_intro_handout.doc> [Assessed December 9, 2011]
- Wille, R., 1992. "Concept Lattices and Conceptual Knowledge Systems". *Computers & Mathematics with Applications*, 23, 493-515.
- Zlotnikova, I., 2008. "Comparison of Rwandan and Russian ICT Educational Policies". In: *Special Topics in Computing and ICT Research: Strengthening the Role of ICT in Development*. Kampala, Uganda: Fountain Publishers, pp. 332-340.
- Zlotnikova, I., and Weide, van der T.P. (in press). "An Approach to Modeling Open, Distance and E-Learning Projects in African Countries", *Distant Education Journal*. Australia. (Submitted for publication on February 13, 2011).
- Zlotnikova, I., Muyinda, P.B., and Lubega J., 2010. "Training Needs Assessment Done in Six Public and Private Universities of Mozambique" [report], July 2010. Kampala: Makerere University.

Copyright for articles published in this journal is retained by the authors, with first publication rights granted to the journal. By virtue of their appearance in this open access journal, articles are free to use, with proper attribution, in educational and other non-commercial settings.

Original article at: <http://ijedict.dec.uwi.edu/viewarticle.php?id=1334>