

## **Multidimensional analysis model of using information technologies and information systems in higher education**

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### **ABSTRACT**

In the context of global changes the role of higher education is becoming increasingly important. Higher education is more and more reliant on information and communication technology and information systems (ICT& IS). In this sense, the purpose of this paper is to set up a multi-dimensional model for measuring the quality of ICT& IS use in the context of higher education in the tourism and hospitality industry. Also the paper will present the model of measurement and presentation of results in a multidimensional space. The introduction will present the specifics of the educational process in higher education. Challenges and specific issues of measurement the quality of ICT use & IS in the context of higher education will be explained. Furthermore, with the purpose of setting up of an analytical model the segmentation of specific points and aspects of the use of ICT and parts of IS will be performed. After that, the modules of multidimensional model for measuring the quality of IS & ICT use in higher education will be elaborated. Based on the defined modules a multi-dimensional analytical model will be presented. Based on the proposed model the process of making an application interface for multidimensional measurement of quality IS & ICT use in higher education will be described. Originality of this research and this paper reflects in the part of which a model for a multidimensional measurement of the quality and presentation of the results (the planes and directions of multidimensional space) using ICT & IS in the context of higher education will be presented. Also, the application interface for entering data for multidimensional analysis will be suggested and described. In this way, the measurement and raising the quality of IS & ICT use in higher education will increase the contribution in both the scientific and practical level.

Keywords: Higher Education, ICT, information systems, multidimensional analysis, quality

## INTRODUCTION

Higher education is one of the most important factors responsible for the development of society. The knowledge society as the basis of development and progress of the community is based precisely on Higher Education (UNESCO 2013). Use of Information and Communication Technology (ICT) and Information Systems (IS) in various processes is more and more present and necessary at the higher education institutions (Weske, 2012). In higher education, using various information systems and ICT support is obligatory. The main reason for using ISs and ICTs in higher education is the quality and speed of execution of process (administrative processes, instructional processes, scientific research processes). Globalization processes are determined to a great extent by the general development of ICT. Very often, IS and ICT in the field of higher education are not integrated properly. But the question is, how to measure the quality of IS and ICT support used by institutions in higher education - colleges?

For a last several years authors are engaged in the research and development of integrated modular information system for higher education. An important part of the research represents a segment of measuring the quality of IS and ICT. Assumptions in the design and development of a best quality universal modular IS as a support of all kinds of "business processes" (Valcke, 2004) in the context of higher education, in the wider sense are:

- Defining common group activities (scope of work) within the institutions of higher education - processes
- Defining subgroups of activities groups - Sub processes
- Define "space of action" of all processes and sub processes, as elements of analysis
- Defining analytical modules - parts of IS and ICT support
- Defining and labeling analytical modules parameters for making the analysis application data input interface
- Defining the visual structure of visual reporting module for displaying the results of multidimensional analysis

The next part of this paper presents the approach to the production of multidimensional model for measuring the quality of ICT and IS in higher education.

## SHARE OF BUSINESS PROCESS IN HIGHER EDUCATION

In the system of higher education processes necessary for the functioning of higher education institutions can be divided into three main groups (Figure 1).

Each of the featured group of the process consists of a large number of interconnected sub processes. For effective functioning of the institutions of higher education ICT and IS should provide integrated processing and monitoring of the showed groups of processes and their sub-processes process in real time.

However, this is often not the case. Colleges as business systems of higher education for the operation and monitoring of the process each group use different IS or Software solution while ICT is used to support in a variety of ways (Hong and Songang, 2011). In this context, the purpose of this section is to present existing problems and requirements of IS and ICT and the way to resolve them through the division within the business processes and elements of analysis.

## THE ROLE OF ICT AND ISA PROCESS IN HIGHER EDUCATION

Figure 1 of this paper shows the main operational processes and sub-processes of the faculty as a business system in higher education where elements of analysis which determines the space of multi-dimensional analysis with a model to measure the quality of use of ICT and IS to support and monitor the course of the "business" of the process at the Faculty are also pointed out. This are simplicity (S), modularity (M), integration (I) and the functionality (F).

To set up and create models for quantitative multidimensional analysis it is necessary to understand the concept of an information system and to know of which components it consists of.

Information system is a regulated set of elements or components that in interaction perform the functions of collecting, processing, storing, and sharing information.

Today the most renowned authors of technology of business information technology system is a system that consists of the components shown in the figure 2.

## MODULES OF MULTIDIMENSIONAL MODEL FOR MEASURING QUALITY USING ICTS AND ISA IN HIGHER EDUCATION

Modules of multidimensional model for measuring quality using IS and ICT as a support for development of all administrative, teaching and scientific research processes at the Faculty are the components of an information system on the one hand and the corresponding elements of the multi-dimensional analysis on the other hand. Through an analysis of information system components, their parameters and their tasks quality of a certain part of the information system is measured while the defining of element analysis indicates the quality characteristic space of ICT or IS. Defining the structure of all the parameters of recorded process and sub processes is performed by assigning affiliation and dependence of components of IS or per support of ICT infrastructure (Wong, 2008). Clearly defining the model structure parameters is a prerequisite for multi-dimensional qualitative-quantitative analysis.

In this sense, it is necessary to make the structure of parameters of the processes, sub processes, belonging to the area of analysis and type of support from the IS & ICT (Table 1). In this article, the parameter is static display of specific data-information, functions, devices, measurement, as the state of the system used to support the business processes in a certain moment. The parameter value can be defined in two ways:

1. to reduce all static parameter values of the components of ISA to the level of dual values YES-NO
2. for part of the parameters (functionality, modularity, ...) parameter values can be presented by the dual principle (YES-NO) and for the second part of the parameter value can be presented by the principle of n-values ( $n > 2$ )

Following tabulation presents a conceptual model of the development of parameters per affiliation to IS components or ICT support. Also, if necessary, developing of parameters can be initially worked out according to the "business processes and sub processes. "But since the topic of this paper is "Multidimensional analysis model of using Information Technologies and Information Systems in Higher Education" (UNESCO, 2009), the primary development of the structural analysis starts about the component of ISA and ICT Support. Also in the table it is listed the label of space affiliation (F - functionality, M - modularity, S - simplicity of use, I - Integration) within the multi-dimensional analysis of using Information Technologies and information systems in higher education. By defining the label of space

affiliation analysis provides an accurate insight into the quality of the individual components of an ISA or ICT Support.

### **Functionality (F)**

IS and ICT support must provide a functional and a good quality business functioning of faculty as a higher education institution, while at the same time it is ensuring adequate supervision and control by the management team, the university and the ministry (of higher instances).

### **Simplicity(S)**

IS and ICT support system should be designed and integrated according to real needs of users. Great attention should be devoted to ergonomics of software which provides the simplicity and intuitiveness when working.

### **Modularity (M)**

IS or ICT support used must be designed and constructed in a way that allows the implementation and use in all schools regardless of their individual characteristics and differences. The possibility of expanding and upgrading the current or future needs of the different wants of users should be predicted.

### **Integration (I)**

#### **Horizontal integration (HI)**

ISA should provide simple, uniform and comprehensive management, monitoring and analysis of all groups and sub-groups of business processes of faculty as a highly educational institution.

#### **Vertical integration (VI)**

VI should provide the relevant institutions (line ministries, respective universities or other higher authorities) continuous and easy multi-dimensional monitoring and insight into the current state on individual colleges and universities through numerous individual and group analysis, surveys and reports in real time (see Table 1.).

Based on the elaborated structure of process parameters within the H, S, L, D, O, N - components (Table 1) IS and ICT support in "business-operational processes" of higher education in a multidimensional space, we can define the characteristic points  $\alpha xyz$ , which can be described to the smallest detail, analyze and define the characteristics of quality of using a particular IS and ICT support in the Faculty as a business system.

Most important is the fact that on the basis of precisely defined data structure of the process in such a shown system it is very easy and quickly after a simple data entry passing through the plane and directions of multidimensional systems simply define the quality characteristics of the individual segments IS and ICT support, by which a particular business system is described. But what is to be elaborated in detail is:

- Detailed recording of all process groups and sub-processes;

- The bigger and better abstraction of the data points from the real world (business system);
- The creation of a functional object model that would ensure a smooth adaptation and integration of ICT and IS to the faculty as a business system in the higher education;
- Further development of the algorithm for the best possible analysis.

Within the presented model (Figure 3.) the following organized sets can be observed that can be used in a variety of quantitative and qualitative analyzes of IS & ICT. A set of features for all the observed processes and static conditions (data-information, devices, functions,), their sub-processes and values defined point's  $\alpha_{xyz}$ , XYZ-prisms and expression:

$$S = \{ \alpha_{xyz} \} \quad \begin{array}{l} x=1,2,3,\dots,m \\ y=1,2,3,\dots,n \\ z=1,2,3,\dots,r \end{array}$$

This approach allows the description and analysis of all the existing features of the Faculty as a business system in higher education and creates conditions for quality analysis of supporting the business processes through the IS and ICT.

**CONCEPT OF SOFTWARE'S INPUT DATA GRAPHICAL USER INTERFACE - SOLUTION FOR MULTIDIMENSIONAL ANALYSIS OF USING IS&ICT IN HIGHER EDUCATION**

In the Figure 4. The paper presents a conceptual suggestion of data input interface.

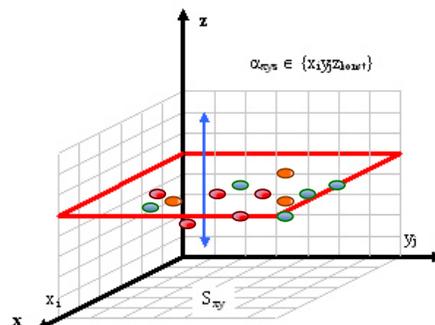
After entering the data for the analysis data analysis is performed. The result of processing the tabular and graphical displays of the results from which one can easily read off the quality of IS and ICT support to each group or subgroup of "business processes" within the Faculty as a part of the institution of higher education.

Dot density  $\bullet$  shows at what level of quality support to the IS and ICT in a particular segment of the business processes is by observing particular component of information systems.

The following shows the results derived from the proposed model, the programming interface.

**S<sub>xy</sub>- XY PLANE**

$$S_{xy} = \{ \alpha_{xyz} \} \quad \begin{array}{l} x=1,2,3,\dots,m \\ y=1,2,3,\dots,n \\ z=const. \end{array}$$

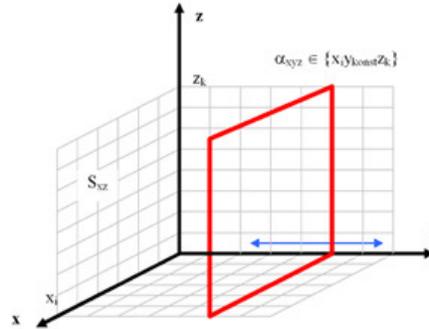


This set presents the set of all points in

the xy - plane, and it is in fact a review of all existing sub-processes of the group of the process monitored, which is obtained by observing the specific parameter of the IS or ICT Support.

$S_{xz}$  - XZ PLANE

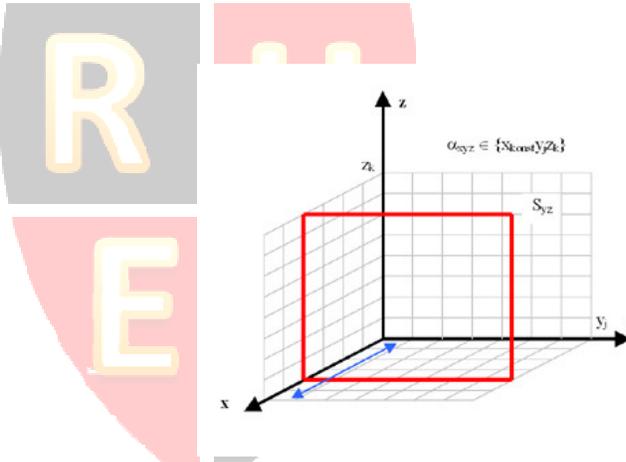
$$S_{xz} = \{ \alpha_{xyz} \} \quad \begin{array}{l} x=1,2,3,\dots,m \\ y=const. \\ z=1,2,3,\dots,r \end{array}$$



This set is the set of all points of xz-plane, so, the set all the parameters of support IS or ICT by main groups of processes.

$S_{yz}$  - YZ PLANE

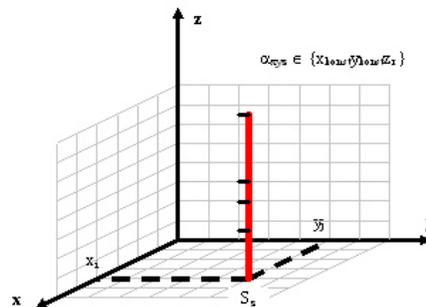
$$S_{yz} = \{ \alpha_{xyz} \} \quad \begin{array}{l} x=const. \\ y=1,2,3,\dots,n \\ z=1,2,3,\dots,r \end{array}$$



This set is the set of all points in yz-plane, which is a set of parameters or parameter values of IS and ICT support sub processes viewed through a specifically defined group of processes.

$S_z$  - Column Z

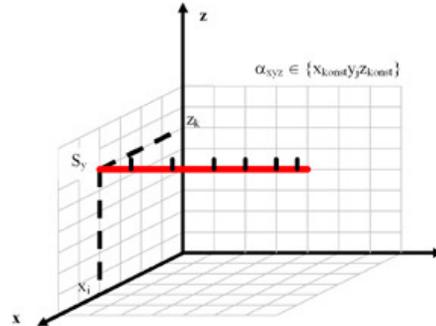
$$S_z = \{ \alpha_{xyz} \} \quad \begin{array}{l} x=const. \\ y=const. \\ z=1,2,3,\dots,r \end{array}$$



This set of points, column-z is a set of all parameters or parameter values for a particular sub-process in a specific group processes.

$S_y$  – Column Y

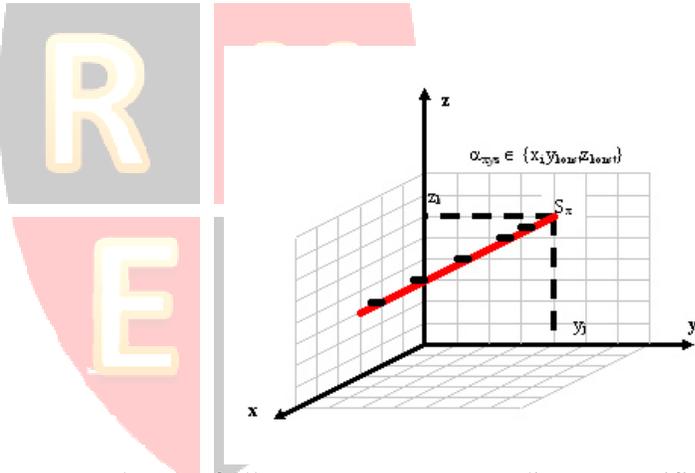
$$S_y = \{ \alpha_{xyz} \} \quad \begin{array}{l} x = \text{const.} \\ y = 1, 2, 3, \dots, n \\ z = \text{const.} \end{array}$$



This set of points, column-y represents the set of all sub-processes viewed through a specific process group and exact parameter support of ISA or ICTs.

$S_x$  – Column X

$$S_x = \{ \alpha_{xyz} \} \quad \begin{array}{l} x = 1, 2, 3, \dots, m \\ y = \text{const.} \\ z = \text{const.} \end{array}$$



This set, "column x" represents the set of all process groups according to specified subgroups of sub-processes and their associated parameters or parameter values through IS or ICT support.

**CONCLUSION**

The Knowledge Society becomes a basis for development of any society. Higher education is a generator of development of any society. Functioning of higher education is increasingly reliant on information systems and information and communication technology. IS and ICT are used to support different types of processes within higher education. Given the diversity of the needs of a specific segment analysis of IS or ICT in support of "doing business" of a faculty as a business system, described and presented sets in multidimensional system can be used for very complex, detailed and sophisticated analysis, not only for measuring the quality of IS and ICT in higher education, but also with certain adjustments for other operating systems. The realization of concrete software solution (based on the proposed conceptual model) for entering and displaying data, monitoring and measuring the quality of IS and ICT in business processes according to the presented model

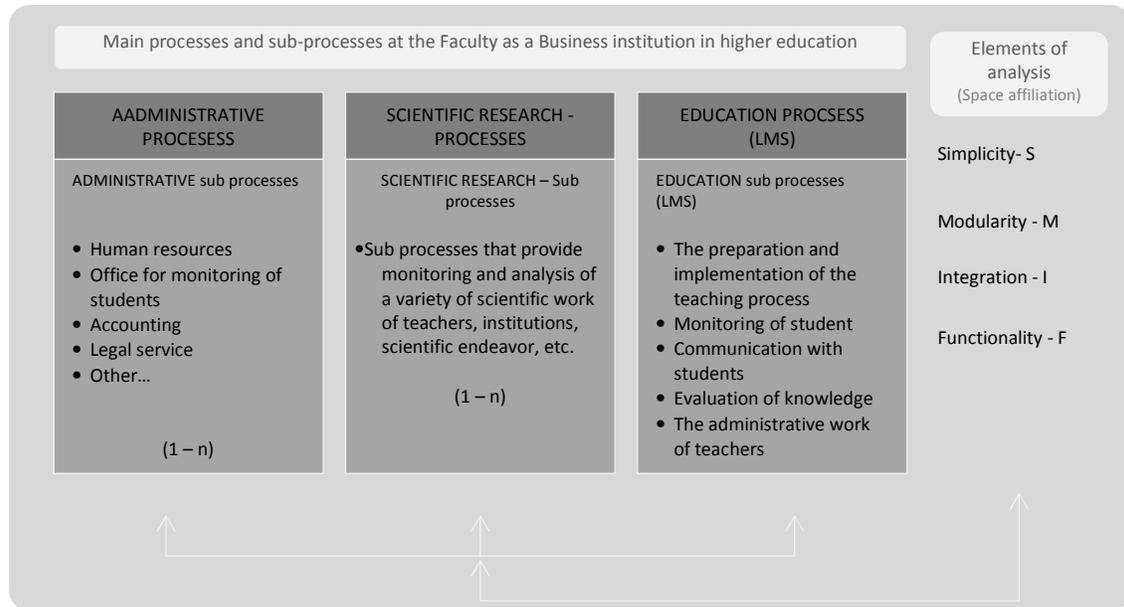
with showed "3D outputs" would make a significant step in addressing this very timely topic. According to the defined inputs a systematic qualitative quantitative review of content of interest in all planes and columns in the observed multidimensional system would be received. In this way, a clear picture of the quality of IS and ICT support for business processes of all kinds would be presented.

## REFERENCES

- Hong, K.S. and Songan, P. (2011), ICT in the changing landscape of higher education in Southeast Asia, Universiti Malaysia Sarawak, Malaysia, *Australasian Journal of Educational Technology*, 27 (Special issue 8), 1276-1290.
- Šimunić, M., Hutinski, Ž., Čubrilo, M. (2005), WEB log Explorer Control of Multidimensional Dynamics of WEB pages, *Journal of information and organizational sciences*, Vol. 29, No. 2. 1-95, 39-53, ISSN 0351804
- UNESCO »Bangkok Office» Education » ICT in Education » ICT in Education, Projects » Higher Education » Use of ICT in Higher Education - <http://www.unescobkk.org/education/ict/ict-in-education-projects/higher-education/use-of-ict-in-higher-education-institutions/> (15.02.2013.)
- UNESCO Institute for statistics, Guide to measuring information and communication technologies (ICT) in education, 2009, ISBN 978-92-9189-078-1.
- Valcke, M. (2004), ICT in higher education: An uncomfortable zone for institutes and their policies, In R. Atkinson, C. McBeath, D. Jonas-Dwyer & R. Phillips (Eds), *Beyond the comfort zone: Proceedings of the 21st ASCILITE Conference (20-35)*, Perth, 5-8 December.
- Weske, M. (2012), *Business Process Management - Concepts, Languages, Architecture*, Springer Berlin Heidelberg, ISBN: 978-3-642-28615-5 (Print) 978-3-642-28616-2 (Online).
- Wong, E.M.L. & Li, S.C. (2008), Framing ICT implementation in a context of education change: a multilevel analysis, *School Effectiveness and School Improvement*, 19(1), 99-120.

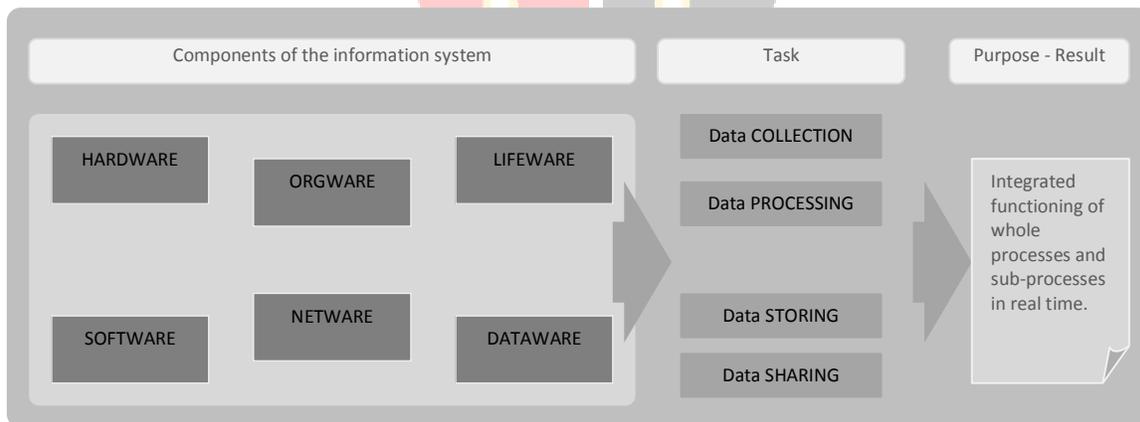
**APPENDIX**

**Figure 1: The division of the operational processes in higher education and the elements of multidimensional analysis**



Source: Authors

**Figure 2: IS components and their role in business information systems**



Source: Authors

**Table 1: The structure of process parameters within the H, S, L, D, O, N - IS components and ICT Support in "business-operational processes" of higher education**

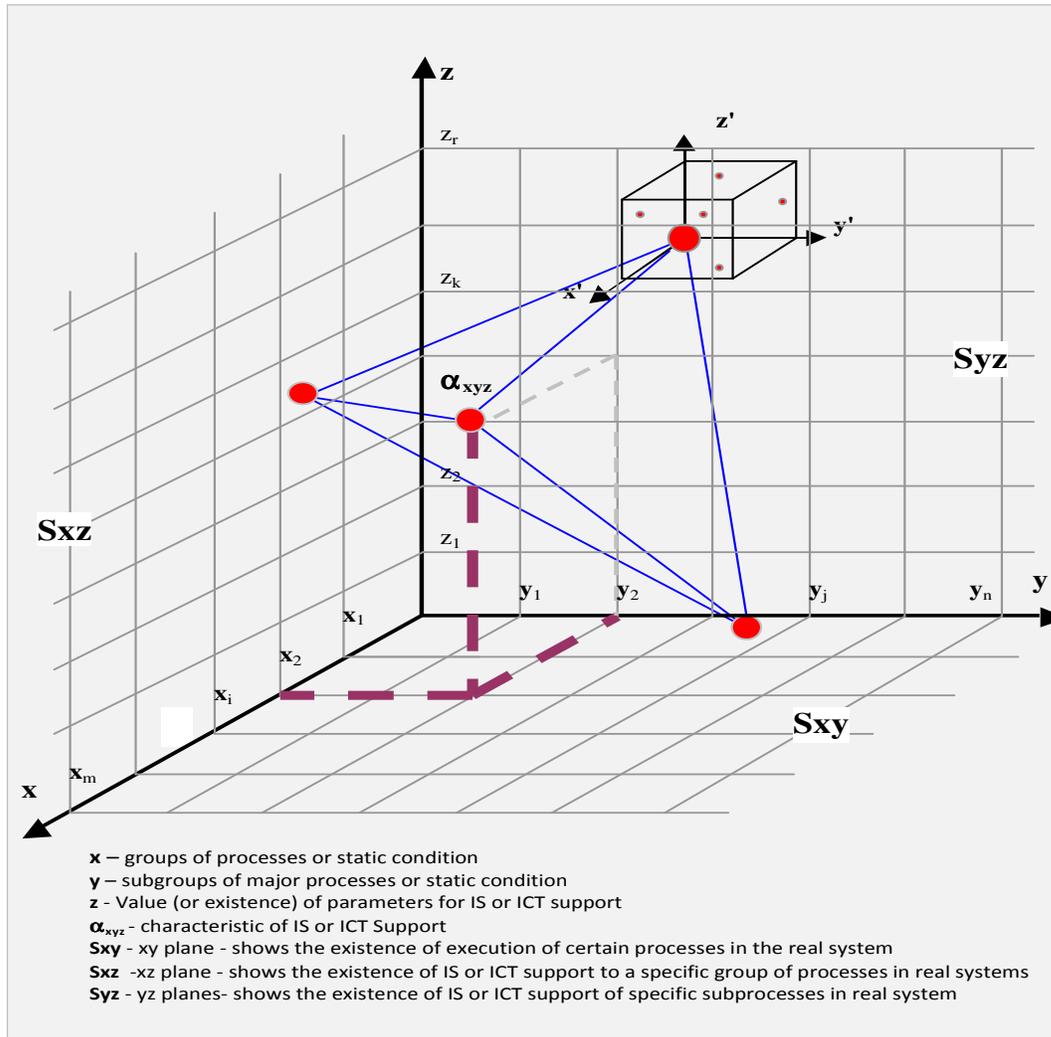
IS component	Label	axisX		axisY		axisZ	
		Group of process	Label	Subprocesses (data-information, apparatus, functions, ...)	Label	Value (or existence) of parameter for support through IS or ICT	Label of space affiliation
HARDWARE	<b>H</b>	Administrative processes	AP	from1 2 3 ... to n	from AP1 AP2 AP3 ... to APn	Yes - No (✓)  or 0,1,2, ..., 100% (✓)	F, ili S, ili M, ili I (Hi, VI)
		Scientific - research processes	SP	from 1 2 3 ... to n	from SP1 SP2 SP3 ... to SPn	Yes - No (✓)  or 0,1,2, ..., 100% (✓)	F, ili S, ili M, ili I (Hi, VI)
		Education processes	EP	from 1 2 3 ... to n	from EP1 EP2 EP3 ... to EPn	Yes - No (✓)  or 0,1,2, ..., 100% (✓)	F, ili S, ili M, ili I (Hi, VI)
SOFTWARE	<b>S</b>	-    -	-    -	-    -	-    -	-    -	-    -
LIFEWARE	<b>L</b>	-    -	-    -	-    -	-    -	-    -	-    -
DATAWARE	<b>D</b>	-    -	-    -	-    -	-    -	-    -	-    -
ORGWARE	<b>O</b>	-    -	-    -	-    -	-    -	-    -	-    -
	<b>N</b>	- ...    -	-    -	-    -	-    -	-    -	-    -

Source: Authors

Note:

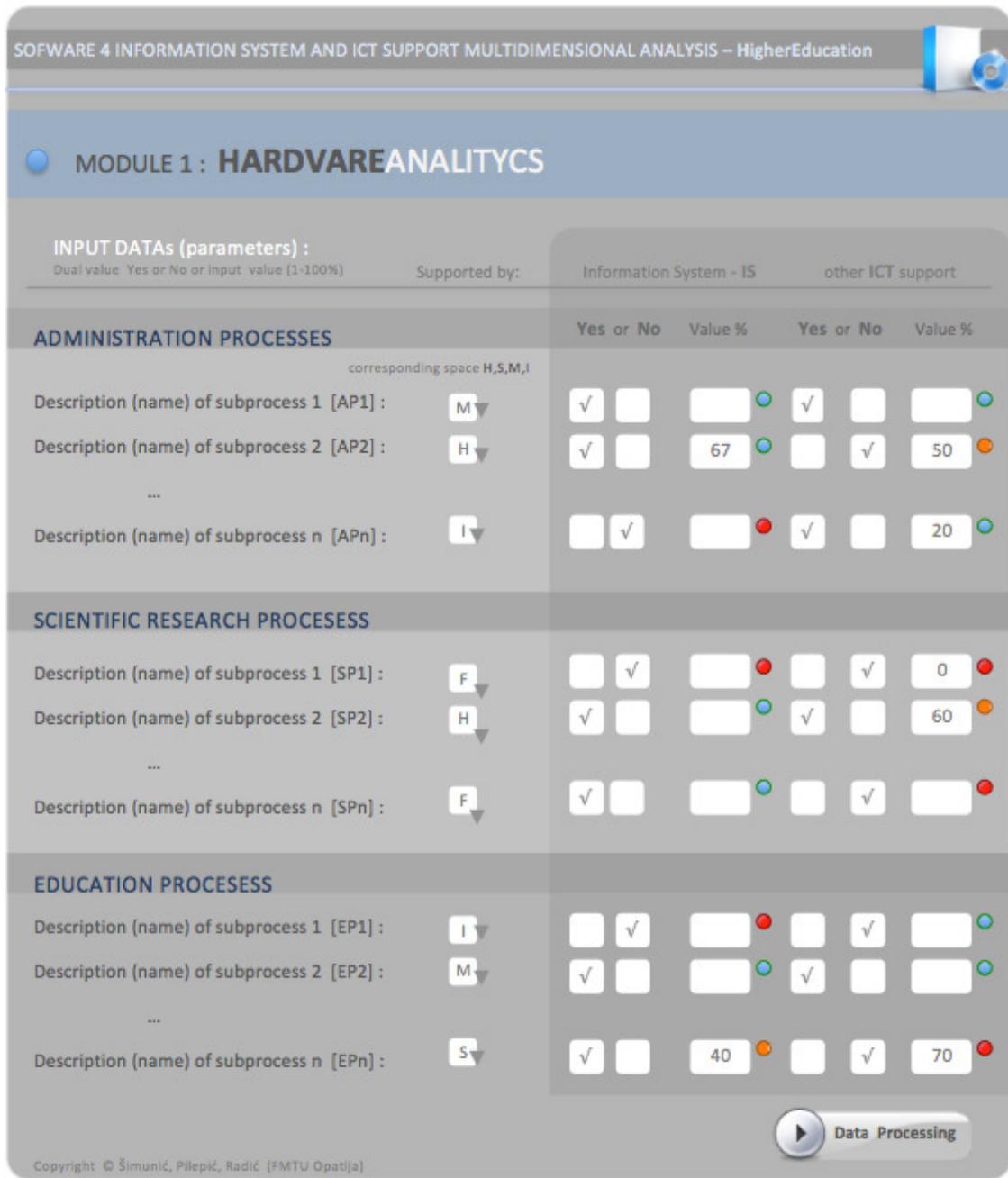
A mark of the parameter space is very useful in terms of reporting as data filtering criteria. Such a "filter" allows displaying analysis results to the space background where could be seen which part is the IS or ICT Support is satisfactory or unsatisfactory, and to what extent.

Figure 3: **Multidimensional analysis of the quality of IS and ICT Support in Higher Education**



Source: Authors

Figure 4: **Conceptual suggestion of software interface for the data entry of multidimensional analysis**



Source: Authors vision and design (based on research)

Note: in the same way should be analyzed other information system components; SOFTWARE, LIFEWARE, DATAWARE, ORGWARE, NETWORK. Indicators ● ● ● show if the particular kind of support through the IS and ICT is at a satisfactory, partly satisfactory or at unsatisfactory level