RĪGAS EKONOMIKAS AUGSTSKOLA
STOCKHOLM SCHOOL OF ECONOMICS IN RIGA

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MEASURING THE E-READINESS OF HIGHER EDUCATION INSTITUTIONS

Authors: Alexander Tarvid

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Measuring the e-Readiness of Higher Education Institutions

Alexander Tarvid

Supervisor: Juris Ulmanis

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Abstract

In this thesis, the author reviews some of the existing indices of measuring countries' e-readiness and some models proposed for higher education institutions (HEIs). Then, the author proposes the e-Readiness Framework as the (best?) model to apply to an HEI. He builds on the Framework so that it is (1) re-usable, i.e., consists of components not bound to a particular moment in time, and (2) includes all relevant variables. The author provides a detailed review of the Framework, showing all the formulas needed for analysing components. Finally, the author applies the Framework to three Latvian HEIs: the Stockholm School of Economics in Riga, the Transport and Telecommunication Institute, and the RTU Riga Business School. This application shows that the e-Readiness Framework works and that its variables are easily measurable and interpretable.

Introduction

Information and Communications Technology (ICT) has been a hot topic of discussion in the last decade. There have been many studies on the effect of ICT on a firm's productivity and innovations, which is connected with the concept of return on investment in ICT. Many companies have taken a broader look and measured the impact of ICT on the economy as a whole.

Then, researchers started to measure the "readiness" of an entity (in most cases, a country) to exploit benefits brought by ICT. Here, the author broadly refers to these studies as measuring "e-readiness[1]" of entities. Nevertheless, even if the measurement is applied to the same entity type—a country—the definition of "e-readiness" differs from researcher to researcher. Moreover, in view of the author, many of these indices are too broad and include irrelevant variables. On the other hand, some variables that actually could be relevant are not included.

To address these shortcomings, the author develops the e-Readiness Framework—a model of measuring e-readiness of a higher education institution (HEI). This entity has been touched by some researchers, but it is still a relatively new field to apply the e-readiness concept to. Thus, the author bases his model on a collection of models used when building different country e-readiness indices, as well as on models used when measuring e-readiness of HEIs. In addition, the author consults experts in the field of integrating ICT in HEIs, as well as IT experts, on the relevance and completeness of the model.

The purpose of this thesis is to evaluate the potential of application of the concept of e-readiness to an HEI by developing a model for measuring it. Thus, the research question is the following: **How can e-readiness of an HEI be defined and measured?**

The thesis is structured in the following way. First, the overview of some of the existing indices measuring e-readiness of countries and of HEIs is presented. Then, the author presents a detailed overview of the e-Readiness Framework. Finally, he analyses the results of the application of the model to three Latvian HEIs.

[1] The term "e-readiness" was taken from the Economist Intelligence Unit's "e-Readiness Rankings" country rankings research series.

1 Existing Indices Overview

In this section, the author first reviews some of e-readiness indices applied to countries and then presents the reader with some studies applying the e-readiness concept to HEIs.

1.1 e-Readiness Indices of Countries

The following table makes a quick overview of some of the existing indices measuring e-readiness of a country.

Purpose	Strengths / Weaknesses	Categories Measured	
Readiness for the Networked World: A Guide for Developing Countries by CID (2000)			
This is a guide for communities in the developing countries. "Readiness is the degree to which a community is prepared to participate in the Networked World," which could be measured by "assessing a community's relative advancement in the areas that are most critical for ICT adoption and the most important applications of ICT." *Source:* Information Technologies Group, Center for International Development at Harvard University, 2000	The framework is quite broad with five categories consisting of several factors each. Each factor can be in one of the four stages of advancement. **Strengths:** 1. A broad definition of categories allows to easily apply the framework to any community **Weaknesses:** 1. The definitions of stages of advancement can be applicable to developing countries only, as most of the developed countries already are in the fourth stage by each factor	Network Access	• Information infrastructure • Internet availability and affordability • Network speed and quality • Hardware & Software • Service & Support
		Networked Learning	• Schools' access to ICT • Enhancing education with ICT • Developing new ICT workforce
		Networked Society	• People & organisations online • Locally relevant content • ICT in everyday life • ICT in the workplace
		Networked Economy	• ICT employment opportunities • B2C and B2B e-commerce • e-government
		Network Policy	• Telecommunications regulation • ICT trade policy

<table>
<tr><th>Purpose</th><th>Strengths / Weaknesses</th><th colspan="2">Categories Measured</th></tr>
<tr><th colspan="4">Living in the Networked World by CSPP (2000)</th></tr>
<tr><td rowspan="4">This is a self-assessment tool designed to help communities understand where they are and where do they need to head to “reap the benefits of being connected in a Networked World.”

Source:
CSPP, 2000</td><td rowspan="4">The overall method is similar to the one of CID.

CSPP also provides five categories of variables that determine the readiness. Each category consists of factors, which are measured by variables (note that the variables relating to higher education are explicitly shown here). Again, each factor can be in one of four stages of development.

Strengths:
1. The concrete definition of stages allows to easily and quickly assess the readiness of a community

Weaknesses:
1. The definitions of stages of advancement do not take into account the needs of users—why should 100% of homes have e.g. DSL connection if the inhabitants do not use it at full capacity?
2. May become obsolete over time, as concrete numbers are given to reflect differences in some stages of advancement</td><td>Infrastructure</td><td>• Speed & Availability
  • Residential
  • Commercial
• Competition
  • Wired / fixed wireless
  • Mobile wireless</td></tr>
<tr><td>Access</td><td>• Business
• Government
• K-12
• Higher Education
  • Always-on connection to the Internet provided in:
    o Offices
    o Libraries
    o Labs
    o Dormitories
  • Wireless network availability
• Health
• Home</td></tr>
<tr><td>Networked Applications & Services</td><td>• Business
• Government
• K-12
• Higher Education
  • Online registration
  • Faculty trained to use digital content and web-based learning for instruction
  • Classes use digital content / web-based learning
• Health
• Home</td></tr>
<tr><td>Networked Economy</td><td>• Innovation
• Workforce
• Consumer</td></tr>
<tr><td>Networked World Enablers</td><td>• Ubiquity
• Security
• Privacy
• Policy</td></tr>
</table>

<table>
<tr><th>Purpose</th><th>Strengths / Weaknesses</th><th colspan="2">Categories Measured</th></tr>
<tr><td colspan="4">Digital Divide Report: ICT Diffusion Index by UNCTAD (2005)</td></tr>
<tr><td rowspan="2">The Index of ICT Diffusion is designed to evaluate ICT development using indicators of ICT diffusion across countries.

Source:
Press & Dumans, 2005</td><td rowspan="2">The index consists of two categories, each of which is measured by several variables.

Strengths:
1. Clearly-defined variables make the index easy to calculate and use

Weaknesses:
1. Too narrow measurement of infrastructure (Connectivity)
2. The variables measure the possibility to use ICT services, not the actual usage</td><td>Connectivity</td><td>• Internet hosts per capita
• PCs per capita
• Telephone mainlines per capita
• Mobile subscribers per capita</td></tr>
<tr><td>Access</td><td>• Number of Internet subscribers
• Literacy
• Cost of a local call (telephone, Internet)
• GDP per capita, measuring income</td></tr>
<tr><td colspan="4">Digital Access Index by ITU (2003)</td></tr>
<tr><td rowspan="5">To measure the overall ability of individuals in a country to access and use new ICT.

Source:
International Telecommunication Union, 2003</td><td rowspan="5">The index consists of five categories, each measured by one or two variables.

Strengths:
1. Clearly-defined variables make the index easy to calculate and use
2. All variables are directly measurable, as there are no qualitative variables

Weaknesses:
1. The variables measure the possibility to use ICT services, not the actual usage</td><td>Infrastructure</td><td>• Fixed telephone subscribers
• Mobile cellular subscribers</td></tr>
<tr><td>Affordability</td><td>• Internet access price</td></tr>
<tr><td>Knowledge</td><td>• Literacy
• School enrolment</td></tr>
<tr><td>Quality</td><td>• Broadband subscribers
• International Internet bandwidth</td></tr>
<tr><td>Usage</td><td>• Number of Internet users</td></tr>
</table>

<table>
<tr><th>Purpose</th><th>Strengths / Weaknesses</th><th colspan="2">Categories Measured</th></tr>
<tr><th colspan="4">Digital Opportunity Index by ITU (2007)</th></tr>
<tr><td rowspan="3">This index was designed “as a tool for tracking progress in bridging the digital divide and the implementation of the outcomes of the World Summit on the Information Society.”

Source:
International Telecommunication Union, 2007(1)

Alternatively, the Digital Opportunity Index is a composite index that measures “digital opportunity” or the possibility for the citizens of a particular country to benefit from access to information that is “universal, ubiquitous, equitable, and affordable.”

Source:
International Telecommunication Union, 2007(2)</td><td rowspan="3">The index consists of three categories, where each is measured by several variables. Each variable has a “goalpost” (desirable value).

Strengths:
1. Clearly-defined variables make the index easy to calculate and use
2. All variables are directly measurable, as there are no qualitative variables
3. Clear goalposts make it easy to assess how much each variable can be improved

Weaknesses:
1. The variables measure the possibility to use ICT services, not the actual usage</td><td>Opportunity</td><td>• Percentage of population covered by mobile cellular telephony
• Mobile cellular tariffs as a percentage of per capita income
• Internet access tariffs as a percentage of per capita income</td></tr>
<tr><td>Infrastructure</td><td>• Proportion of households with a fixed line telephone
• Mobile cellular subscribers per 100 inhabitants
• Proportion of households with Internet access at home
• Mobile Internet subscribers per 100 inhabitants
• Proportion of households with a computers</td></tr>
<tr><td>Utilization</td><td>• Internet users per 100 inhabitants
• Ratio of (Fixed) Broadband Internet subscribers to total Internet subscribers
• Ratio of (Mobile) Broadband Internet subscribers to mobile Internet subscribers</td></tr>
</table>

<table>
<tr><th>Purpose</th><th>Strengths / Weaknesses</th><th colspan="2">Categories Measured</th></tr>
<tr><th colspan="4">e-Readiness Rankings by Economist Intelligence Unit (2007)</th></tr>
<tr><td rowspan="6">e-readiness is the “state of play” of a country’s ICT infrastructure and the ability of its consumers, businesses, and governments to use ICT to their benefit.
The ranking allows governments to gauge the success of their technology initiatives against those of other countries. It also provides companies that wish to invest in online operations with an overview of the world’s most promising investment locations.

Source: Economist Intelligence Unit, 2007</td><td rowspan="6">The Economist Intelligence Unit in its last release of ERR builds its index on six categories, each measured by a set of qualitative and quantitative variables.

Strengths:
1. Categories allow to provide an assessment of e-readiness of a country from all perspectives
2. Addition of qualitative variables makes the assessment more realistic
3. Measures both possibility to use and actual usage

Weaknesses:
1. Qualitative variables make the assessment somewhat subjective</td><td>Connectivity & Technology Infrastructure</td><td>• Broadband penetration
• Broadband affordability
• Mobile-phone penetration
• Internet penetration
• PC penetration
• Wi-Fi hotspot penetration
• Internet security
• Electronic ID</td></tr>
<tr><td>Business Environment</td><td>• Overall political environment
• Macroeconomic environment
• Market opportunities
• Policy toward private enterprise
• Foreign investment policy
• Foreign trade and exchange regimes
• Tax regime
• Financing
• Labour market</td></tr>
<tr><td>Social & Cultural Environment</td><td>• Level of education
• Level of Internet literacy
• Degree of entrepreneurship
• Technical skills of workforce
• Degree of innovation</td></tr>
<tr><td>Legal Environment</td><td>• Effectiveness of traditional legal framework
• Laws covering the Internet
• Level of censorship
• Ease of registering a new business</td></tr>
<tr><td>Government Policy & Vision</td><td>• Government spend on ICT as a proportion of GDP
• Digital development strategy
• e-government strategy
• Online procurement</td></tr>
<tr><td>Consumer & Business Adoption</td><td>• Consumer spending on ICT per capita
• Level of e-business development
• Level of online commerce
• Availability of online public services for citizens and businesses</td></tr>
</table>

Purpose	Strengths / Weaknesses	Categories Measured	
Ready? Net. Go! By McConnell International (2001)			
The report tries to find the answer to the question: "Which countries and actions are enabling businesses, governments, and citizens to flourish in the networked economy?" *Source:* McConnell International, 2001	This index consists of five broad categories, each one of which is measured mainly by qualitative variables. **Strengths:** 1. Categories allow to provide an assessment of e-readiness of a country from all perspectives 2. Qualitative variables make the assessment more realistic **Weaknesses:** 1. Qualitative variables make the assessment somewhat subjective 2. Measure *possibility* to use ICT services, not their *actual* usage	Connectivity	• Affordability of wired & wireless communication services • Affordability & reliability of network access • Underlying infrastructure
		E-Leadership	• Priority of e-society on the government level • e-government • Partnerships between industry leaders & government to improve e-readiness • Effort to promote access for all citizens
		Information Security	• Legal protection of intellectual property rights • Protection of electronic privacy • Strength and effectiveness of the legal framework to address and prosecute computer crimes, authorize digital signatures, and enable public key infrastructures
		Human Capital	• Quality of and participation levels in the education system, with an emphasis on efforts to create and support a knowledge-based society • Penetration of ICT in schools and ability of educators to use and teach in accordance with the technologies • Culture of local creativity and information sharing within the society • Skills and efficiency of the workforce, and strength of efforts to retain skilled managers and technologists

<table>
<tr><th>Purpose</th><th>Strengths / Weaknesses</th><th colspan="2">Categories Measured</th></tr>
<tr><td></td><td></td><td>E-Business Climate</td><td>• Competition among communication and information services providers
• Transparency and predictability of regulatory implementation, openness of government, rule of law, and general business risk
• Openness to foreign investment in ICT
• Ability of the financial system to support electronic transactions
• Sponsorship of science and technology parks as hubs of innovation and support for new enterprises</td></tr>
<tr><th colspan="4">Networked Readiness Index by World Economic Forum, INSEAD, & infoDev (2003)</th></tr>
<tr><td rowspan="3">The NRI is defined as “the degree of preparation of community to participate in and benefit from ICT developments.” The attempt is to compute the relative development and use of ICT in countries and show a nation’s strengths and weaknesses with respect to ICT.

Source: Dutta et al., 2003</td><td rowspan="3">The index consists of three “component indices,” each of which in turn splits into three “subindices,” which are computed using a number of variables.

Strengths:
1. Use of both qualitative and quantitative variables allow to better capture the reality
2. Categories allow to provide an assessment of e-readiness of a country from all perspectives

Weaknesses:
1. Qualitative variables make the assessment somewhat subjective
2. Some of the variables have nothing to do with e-readiness (e.g. “number of radios per 100000 inhabitants”), according to the author</td><td>Environment</td><td>• Market
• Political / Regulatory
• Infrastructure</td></tr>
<tr><td>Readiness</td><td>• Individual readiness
• Business readiness
• Government readiness</td></tr>
<tr><td>Usage</td><td>• Individual usage
• Business usage
• Government usage</td></tr>
</table>

bridges.org has compared several e-readiness indices and compiled a table of "the levels of detail each tool or report includes in its assessment technology, economy, government, education, and social considerations of e-readiness." They map these levels on the [0,3] region where '0' means that "the tool or report fails to address a specific issue" and '3'—that it has "many related questions or indicators." According to their conclusions on the reviewed reports, infrastructure is covered by nearly all of the studies (average score of 2.57), while issues relating to education, usage, and other social factors remain nearly under-touched (average score of ~1). (bridges.org, 2005)

The author's general criticism of the above-presented indices can be summarized as follows:

- An index may quickly become obsolete if it
  - Includes a set of concrete numbers attached to variables' desirable values, and/or
  - Includes variables which are relevant only in a narrow period of time
- Not many indices measure the actual usage of ICT infrastructure
- Not many indices take into account whether people really *need* the best infrastructure to work efficiently

1.2 e-Readiness Indices of HEIs

The following table makes a quick overview of the models used in two reports on e-readiness of HEIs.

<table>
<tr><th>Purpose</th><th>Strengths / Weaknesses</th><th colspan="2">Categories Measured</th></tr>
<tr><th colspan="4">E-Readiness Assessment of 7 Higher Education Institutions in Ghana by Benjamin K. Addom (2004)</th></tr>
<tr><td rowspan="5">The purpose of this research project has been to investigate and assess the current state and usage of ICT in some Ghanaian universities and to evaluate the potential effectiveness of these technologies for teaching, research, and outreach.

Source:
Addom, 2004</td><td rowspan="5">This report used a framework developed by Colle (2004) and consists of five categories to be measured by variables.

Strengths:
1. A quite general framework that can be applied to any HEI

Weaknesses:
1. The variables are too simplistic and are not useful in more developed countries or more detailed assessment of e-readiness</td><td>Human Resources</td><td>• Existence of IT Support personnel</td></tr>
<tr><td>ICT Facilities</td><td>• Computers
• Networks
• Media production facilities</td></tr>
<tr><td>Academic Programmes</td><td>• Programmes that invite students to study and apply ICT
• Research & internship opportunities that thrust students and faculty members into the ICT-for-development environment</td></tr>
<tr><td>Outreach Policies</td><td>• Support for “university without walls”</td></tr>
<tr><td>Faculty Posture</td><td>• Faculty’s proficiency in ICT
• Faculty’s innovativeness and aggressiveness in application of ICT to learning and outreach</td></tr>
</table>

<table>
<tr><th>Purpose</th><th>Strengths / Weaknesses</th><th colspan="2">Categories Measured</th></tr>
<tr><th colspan="4">Developing an e-Readiness Model for Higher Education by Carlos Machado (2007)</th></tr>
<tr><td rowspan="4">The purpose is to reveal a “primary model of e-readiness for the specific context of higher education,” where e-readiness is defined as “the ability of HEIs and the capacity of institutional stakeholders to generate (e-) learning opportunities by facilitating computer-based technologies.”

Source:
Machado, 2007</td><td rowspan="4">Carlos Machado tested his conceptual framework of e-readiness of an HEI (presented in the first three rows on the right) on a focus group, which derived key stakeholders interested in development of e-readiness and their functions as mapped to the conceptual framework.

Strengths:
1. A quite general framework that can be applied to any HEI
2. Key stakeholders (human resources) identified and their functions mapped relative to e-readiness

Weaknesses:
1. The more concrete definition of variables is not given—however, it was not the purpose of the report</td><td>Ability of HEI Stakeholders</td><td>• HEI current policy
• HEI future strategy</td></tr>
<tr><td>Capacity of Learning Stakeholders</td><td>• Knowledge
• Teaching & learning styles
• Instructional methodology
• Techno-cultural acceptance</td></tr>
<tr><td>Facility by Learning Stakeholders</td><td>• Infrastructure
• Network services</td></tr>
<tr><td>Key Stakeholders (as defined by the focus group)</td><td>• Administration level
  ◦ Ability
  ◦ Facility (motivation, training, performance appraisal, provision of facility, access)
• Instructor level
  ◦ Capacity (way of thinking, resistance-acceptance, understanding new methods, skills)
• Student level
  ◦ Capacity (behaviour, resistance-acceptance, understanding new methods, computer skills, language skills)</td></tr>
</table>

2 The e-Readiness Framework

In this section, the author first presents the general Framework and explains the rationale of its components. Then, he provides a detailed review of the variables that could be used when measuring these components.

2.1 General Framework

First, let the author formally define e-readiness, as applicable to an HEI.

Definition: e-readiness—readiness to grant high-quality IT services that satisfy users of different IT proficiency levels, where IT services are described as infrastructure (consisting of hardware, software, telecommunication, and security), information, and IT support given to students by IT department workforce.

Figure 1 presents the general e-Readiness Framework developed by the author. It was derived based on the works reviewed in the Existing Indices Overview section and on additional sources of information, one of them being interviews with experts in the field of integrating ICT into academic environment and with IT experts.

When creating the Framework, the author had the following goals in mind:

1. The model should be re-usable; i.e., it should contain measures that are not linked to a particular moment in time. In other words, the author wants to disengage himself from technological contingencies by explicitly avoiding fixed infrastructure variables.[2] To do that, he introduces indirect component measurement:
    a. How much are the IT services provided used and how satisfactory they appear to users
    b. To what extent the IT department follows best practice recommendations and standards
2. One should include components not widely measured, but relevant—mainly, human capital (e.g., how educated is the IT department workforce)

As emphasized in Economist Intelligence Unit (2007) and by some of the experts, one needs to add dynamics to the measurement of each component. As the expert said, “The

[2] By fixed infrastructure variables, the author means variables such as Internet connection speed (in Mbit/s), number of computers, availability of a concrete technology (e.g., Wi-Fi), etc.

technology change is so rapid that today you may be e-ready, but the next week you already are not." One can view e-readiness as a function of time that is constant in a relatively narrow time period. Therefore, without a dynamics element, there is no sense in creating such a model. As one may note, including the indirect measurement just described fits perfectly the goal of creating measurements that are dynamic in themselves.

Microsoft (2004) provides some of statistics: "According to industry analysts, 50 percent (or more) of all IT budgets is spent operating IT systems, and 80 percent of unplanned system downtime is caused by people and process failures" and concludes that "it is vital that enterprise businesses augment technology with skilled IT staff having well-defined roles and responsibilities and using effective IT operations processes and management skills." As Baschab & Piot (2003) observe, "a major source of IT department inefficiency is poor organization of staff and lack of clear roles, responsibilities, and accountability. The resulting chaos causes responsibility gaps and overlaps, unclear roles, and difficulty holding individuals accountable for their results." These two sources speak about the need to implement best practices and make sure the IT staff is skilled enough. These moments are taken into account in the e-Readiness Framework, too.

During the process of writing this thesis, the author received comments from some students that e-readiness may be measured *only* by possibility to use some services (i.e., not measuring real usage of these services). The author, therefore, would like to provide some examples when he believes an HEI is *not* e-ready, despite some readers would (erroneously) say it *is* just because the *possibility* to use services exists:

- *An HEI has a file server where each student has a place of quoted size. However, most students do not use this server at all, and those that use have occupied space of no more than 10% of the quota.* The investment in ICT does not lead to anything positive—in this case, it is just waste of money. The fact that this case exists means that there is not enough analysis of usage of the infrastructure provided. It should be clear that absent analysis of usage does *not* lead to greater e-readiness.
- *An HEI provides students with access to a printer. However, students complain that one printer is not enough because of a too high workload of it. Nevertheless, the administration does not make any changes.* Interests of users are not taken into account. Maybe, management even does not know about the issue, as the helpdesk (to whom students complain) does not forward the information to senior IT staff.

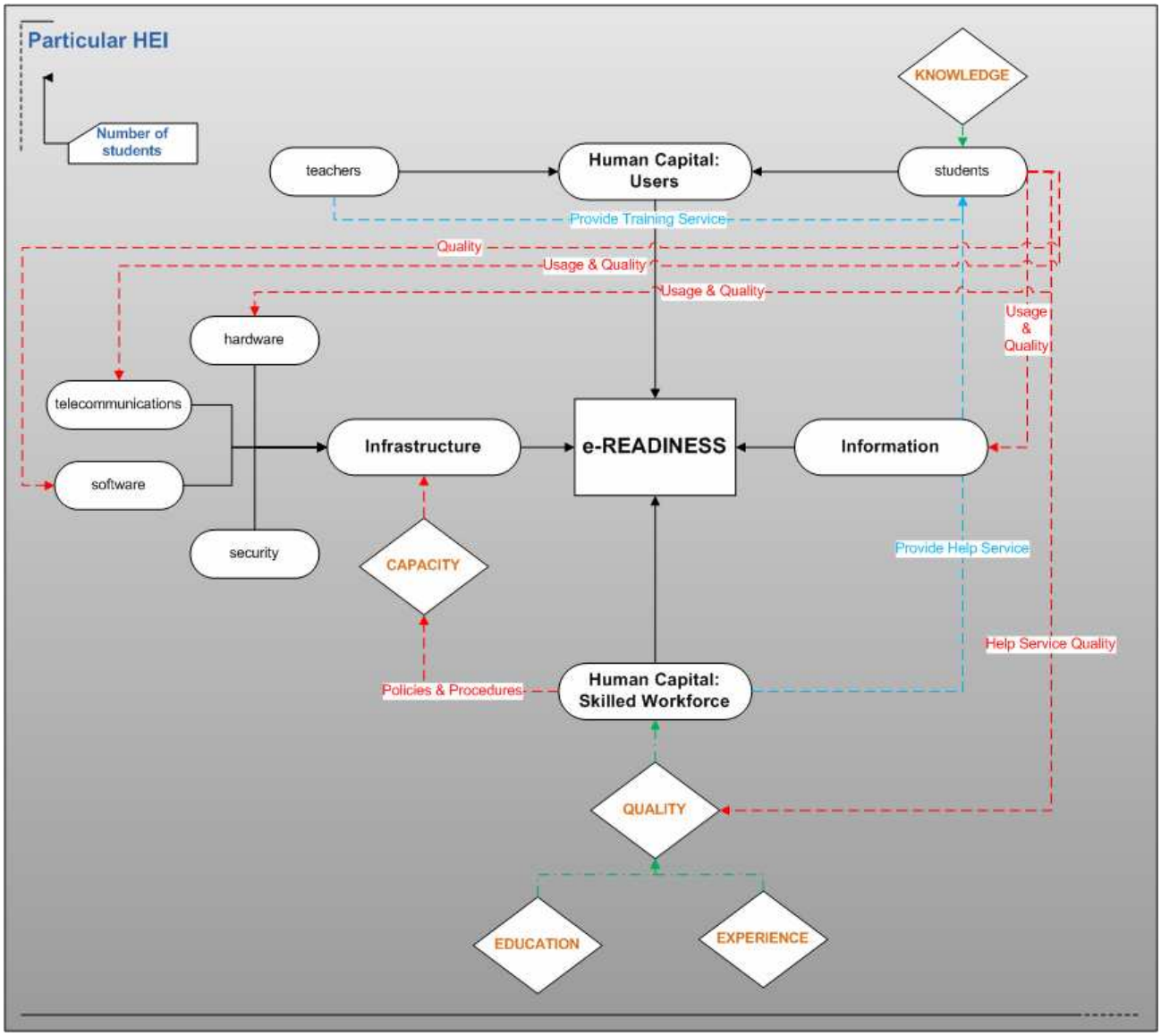

Figure 1. The general e-Readiness Framework. *Source*: Developed by the author.

The overall e-readiness index is proposed to be computed by *multiplying* the three components (human capital, infrastructure, and information) with appropriate weights, instead of summing them, as done in all indices described above. The rationale is the one that was described already by the Economist Intelligence Unit (2007): "In considering consumer and business adoption, we ask if these channels are proving useful enough. If yes, then they can begin to deliver added value, and create efficiencies of time, of money, of human resources. If individuals and businesses do not find the available channels useful in completing transactions, then the number of PCs or mobile phones in a country is a worthless measure." In other words, absence of any of the components automatically should lead to a verdict of *zero* electronic readiness.

2.2 Measuring Infrastructure

The author proposes to measure two aspects of infrastructure:

- Policies and Procedures that are employed by skilled workforce in administering the infrastructure of the HEI
- Usage and Quality of the infrastructure as perceived by users

2.2.1 Policies & Procedures

The most important item in this aspect is: Which policies and procedures to consider *appropriate*? Here, the author proposes to measure whether the HEI implements some of the international standards or best practices. In addition to explicitly asking to what extent the HEI IT department follows certain standards, the author asks more detailed questions whether *particular* policies and procedures are used and to what extent.

Gartner Group has developed a Hype Cycle—"a graphic representation of the maturity, adoption and business application of specific technologies." The graph shows five steps of the process of technology adoption: technology trigger, peak of inflated expectations, trough of disillusionment, slope of enlightenment, and plateau of productivity (Wikipedia, 2008(4)). Gartner Group's Hype Cycle for Higher Education has positioned COBIT in technology trigger step for the last two years, and ITIL—at the peak of inflated expectations in the same two years (Visible Procrastinations Blog, 2007). From the two just-mentioned frameworks, the author believes ITIL would be easier to use as a basis of detailed questions about policies and procedures implementation, as it is better known among IT professionals. The actual variables were taken from Microsoft Operations Framework, which is built on ITIL.

Figure 2 shows the overall scheme of classification of the variables measured in the questionnaire for IT department chiefs.

As the figure shows, the Policies & Procedures component evaluation comes from two broad sources: EDUCAUSE IT Studies and Microsoft Operations Framework (MOF).

EDUCAUSE is a "non-profit association whose mission is to advance higher education by promoting the intelligent use of information technology" (EDUCAUSE, n.d.). Thus, studies coming from this organisation can be used when assessing e-readiness of an HEI. From EDUCAUSE IT Studies, the author selected several questions from the questionnaire on help desk management (EDUCAUSE Centre for Applied Research, 2007(2)) and from the questionnaire on IT governance (EDUCAUSE Centre for Applied Research, 2007(1)).

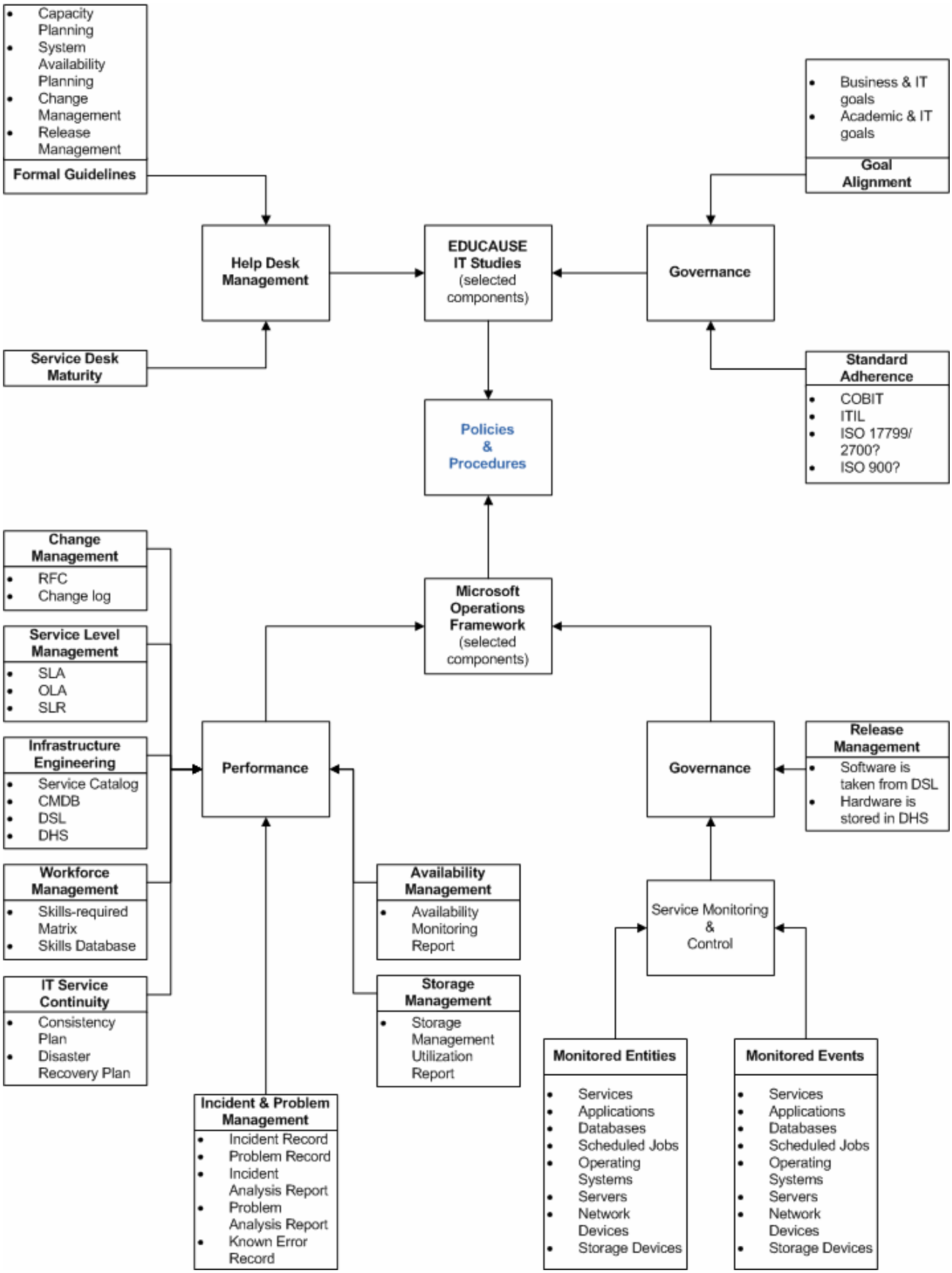

Figure 2. Scheme of variables measured to assess Policies & Procedures implemented in the IT department of an HEI. *Source*: Developed by the author.

From MOF, in turn, the author took the following two diagnostic elements: Performance and Governance. According to the author, the variables from these two diagnostics are the most relevant to e-readiness measurement and are the most easy-to-measure out of all seven diagnostics presented in MOF. In brief, Performance diagnostics should be used when "there is a need to examine whether base artefacts and practices exist, are performed, or are adequate, in order to further understand the problem / opportunity." Governance diagnostics, in turn, are used when "there is a need to understand the process metrics or other governance mechanisms of the problem / opportunity." (Microsoft, n.d.(2))

The formula for measuring Policies & Procedures is the following:

$$PP = \sum_i (score_i - 1), \text{ where}$$

- $score_i$ is the index number of the answer to question i the interviewee chose

To get percentage from the maximal score, the author scales *PP* in the following way:

$$PP\% = \frac{100}{136} PP$$

A detailed analysis of results could be performed according to categories of variables (i.e., storage management, formal guidelines, etc.).

2.2.2 Usage & Quality

Another part of Infrastructure component is Usage & Quality, as perceived by students. Questions on infrastructure usage and perceived quality are incorporated into student questionnaire.

When applying the framework, this part of student questionnaire was constructed specifically for each HEI. This was done for the reason that each HEI has its specific infrastructure, with specific component names by which teachers and students refer to them. Before constructing questionnaires, the author interviewed the management of each HEI to determine which infrastructure items the HEI provides to students. These items were then listed in a table and questions about frequency of use and perceived quality were asked.

The unique item that was formulated in the same way in each questionnaire was "Software (user-friendliness)." However, only quality (here, referred to by a publicly familiar concept of user-friendliness) of software was measured. Measuring frequency of using it has no sense, according to the author, for two reasons. Firstly, if one uses hardware provided by the HEI, it immediately follows that one uses software accessible from this hardware. One cannot use software provided by the HEI from computers not provided by the HEI, as HEIs

(normally) do not give licensed software for personal use. Therefore, to measure usage of HEI's software, it should be sufficient to measure usage of HEI's hardware. Secondly, there are many programmes, usage of which is required only during specific courses, and students might not use them outside these courses. The author believes that e-readiness should not be reduced if this software is not used "enough."

A single sub-component of infrastructure, on which students' opinions are not asked, is security. This is done for several reasons. Firstly, users are normally not informed on security mechanisms used in the company. Secondly, they do not have choice whether to use the security implemented or not. Therefore, the author believes their opinions on this sub-component are irrelevant.

The formula for measuring Usage & Quality is the following:

$$UQInfr_i = \frac{1}{2}\left[\frac{1}{n_1}\sum_{j=1}^{n_1}\left(5 - frequency_{ij}\right) + \frac{1}{n_2}\sum_{j=1}^{n_2}\left(quality_{ij} - 1\right)\right], \text{ where}$$

- n_1 is the number of infrastructure items for which frequencies are measured
- n_2 is the number of infrastructure items for which quality is measured
- *frequency* and *quality* are the corresponding scores of usage frequency and perceived quality of an item, as pointed by user i

Note: there are different quantities of infrastructure items for which frequency and quality is measured because of software component, as already described above.

Note that the first term of the sum needs to be reversed, as the frequency questions' answers are coded in such a form that the worst option ("Never") has the greatest index, while all quality questions' answers are coded in such a form that the worst option has the smallest index. Obviously, the author wants to obtain a *UQ* variable in the form "the greater the better."

Another issue to be noted is that if a respondent does not use a particular infrastructure item, he/she has two options: to provide his/her personal view on the quality of the item (for instance, if he/she has used it but found it useless or of a too low quality) or skip this question. When calculating the *quality* sub-component of the Infrastructure component, the author actually calculated average of items on which the user provided an answer.

To measure percentages from the maximal score, the author uses the following formulas:

$$frequency\% = \frac{100}{4}\, frequency$$

$$quality\% = \frac{100}{8}\, quality$$

$$UQInfr\% = 100 \cdot \frac{frequency + quality}{4 + 8} UQInfr \text{, where}$$

- *frequency* and *quality* are averages of reversed frequency and quality (subtracting one) scores by number of respondents

2.2.3 Overall Infrastructure Formula

The author proposes to take the two above-described variables each with 50% weight:

$$Infr = \frac{1}{2} PP + \frac{1}{2} UQInfr \text{, where}$$

- $UQInfr$ is average of $UQInfr_i$ by number of respondents

In percentage form, the formula looks in the following way:

$$Infr = 100 \cdot \frac{PP + UQInfr}{136 + 6}$$

2.3 Measuring Information

The author would like to measure the Information component the same way as the Infrastructure component, i.e., by measuring capacity and usage & quality. However, it is somewhat unclear how to measure information *as such*. Instead, the author proposes to measure Information Services (IS) as means by which users get access to the Information component—for instance, the HEI website or academic journal databases (if access to them is provided). In other words, by measuring IS, one indirectly assesses the Information component. The author further reduces the measurement by considering only usage & quality of IS.

The same algorithm that was used when measuring Usage & Quality of Infrastructure is applied when measuring Usage & Quality of Information, i.e.

$$UQInfo_i = \frac{1}{2}\left[\frac{1}{m}\sum_{j=1}^{m}\left[\left(5 - frequency_{ij}\right) + \left(quality_{ij} - 1\right)\right]\right] \text{, where}$$

- m is number of information services provided by the HEI
- *frequency* and *quality* have the same meaning as in Measuring Infrastructure section.

In the model, the average of $UQInfo_i$ by number of respondents, $UQInfo$, will be taken as input. The same comment about the *quality* sub-component that was made in Measuring Infrastructure section is also applicable here.

To measure percentages from the maximal score, the author uses the same formulas as for *UQInfr*.

2.4 Measuring Human Capital: Skilled Workforce

Human resources is the component not measured relatively widely in the indices. However, it is quite important—consider Brynjolfsson and Hitt (2003), for instance. They claim that investment in human capital is *complementary* to investment in ICT, whereas computers (in this case, infrastructure) are only a "general purpose technology." Another proof of the need to invest in human capital comes from Hempell (2003): "Firms that invest strongly in both training and ICT perform significantly better than competitors that pursue rather isolated investment strategies."

The author measures the Skilled Workforce component by its quality, which is measured using three variable groups:

- Education
- Experience
- Service quality

2.4.1 Education of Workforce

Education is measured by the grade a person has (Bachelor / Master / Doctorate), plus whether he/she is certified. Table 1 shows which scores attribute to which education in the e-Readiness Framework. The education score for degrees is measured as average per IT department employee.

Table 1. The correspondence between education levels of IT staff (measured in degrees) and experience scores in the e-Readiness Framework. *Note*: 'L' means that an employee is currently learning to obtain the corresponding degree.

	IT Education of IT Staff (Degree)					
	BSc (L)	**BSc**	**MSc (L)**	**MSc**	**DSc (L)**	**DSc**
Education Score	0.5	1	1.5	2	2.5	3

Source: Developed by the author

Besides having a degree, IT specialists usually get some additional certificates to show their proficiency in working with particular programmes / technologies. As Microsoft (n.d.(1)) put it, certification is needed to "demonstrate undeniable expertise" with corresponding products and platforms "to colleagues, employers, and" the certificate owners themselves. Therefore, the author also counts certificates of IT personnel as another way of

showing their education. As with academic degrees, the author measures the average number of certificates per IT department employee.

Thus, the formula for education is the following:

$$Edu = \frac{1}{k}\sum_{i=1}^{k}\left(D_i + NC_i\right), \text{ where}$$

- k is the total number of IT employees
- D_i is the degree of employee i (scales are provided in Table 1)
- NC_i is the number of certificates of employee i

2.4.2 Experience of Workforce

Experience is measured in years of working in any organisation (not only in the HEI under consideration) in IT department. To be consistent, the author measures experience as average by number of employees in the IT department. As experience is commonly treated more important than education, it has a greater weight in the quality formula. Table 2 shows which scores will be attributed to each IT department employee for his/her experience.

Table 2. The correspondence between experience levels of IT staff (measured in years) and experience scores in the e-Readiness Framework.

	Experience Levels of IT Staff (Years)				
	0-2	**3-10**	**11-20**	**21-30**	**>30**
Experience Score	1	2	3	4	5

Source: Developed by the author

The formula for experience is the following:

$$Exp = \frac{1}{k}\sum_{i=1}^{k} Exp_i \text{ , where}$$

- k is the total number of IT employees
- Exp_i is the experience score of employee i (scales are provided in Table 2)

2.4.3 Service Quality

To measure quality of service IT department provides (as perceived by users; in this case—students), the author proposes to use SERVQUAL instrument. As Kettinger & Lee (1997) note, “The practical value of SERVQUAL is twofold. First, SERVQUAL can be used as a benchmarking tool. Benchmarks, to establish service “best practice,” can be drawn by comparing the summary SERVQUAL scores of major “players” within the same industry. Second, SERVQUAL can be used as a diagnostic or prescriptive tool. In this way, periodic

measures of dimensional scores can identify problems within specific service processes." The author proposes to use SERVQUAL according to its first practical value—comparing the scores between different HEIs.

The actual SERVQUAL questionnaire the author uses was formulated and tested by Kettinger & Lee (2005). In their paper, the authors use zones-of-tolerance approach. The main idea is that users are asked to indicate their "zone of tolerance" (ZOT) of a particular aspect of IT service, by providing their minimum levels of service performance they consider adequate and desired levels of service performance. ZOT for each aspect is then given by the $[minimum,desired]$ interval. Then, relative to this interval, users indicate the actual level of service their HEI provides for this aspect. The authors used 18 aspects, overall, grouped in four categories: reliability (6 aspects), responsiveness (2 aspects), rapport (7 aspects), and tangibles (3 aspects). (Kettinger & Lee, 2005)

Nevertheless, one should be aware that SERVQUAL measures, in this case, the quality of *helpdesk* services of IT department—these are the only IT specialists who users directly interact with. Thus, in the formula of the quality component, it was given only 1/3 weight.

The author proposes to define SERVQUAL perceived by user *i* in the following way:

$$SERVQUAL\_rel_i = \frac{1}{18}\sum_{j=1}^{18}\frac{x_{ij} - des_{ij}}{des_{ij} - mi_{ij} + 1}$$

$$SERVQUAL\_abs_i = \frac{1}{18}\sum_{j=1}^{18} x_{ij}$$

$$SERVQUAL_i = \frac{1}{2}SERVQUAL\_rel_i + \frac{1}{2}SERVQUAL\_abs_i, \text{ where}$$

- summing goes by 18 aspects
- x_{ij} is the actual organisation's performance in question *j*, according to user i
- des_{ij} is the desired level of performance in question *j*, according to user i
- mi_{ij} is the minimum acceptable level of performance in question *j*, according to user i

Note: in the denominator, *one* is added to keep the observations where the minimum level of service is equal to the desired level (i.e., when ZOT length is zero).

$SERVQUAL\_rel$ measures the position of the actual performance relative to the desired performance, scaled with the width of the ZOT. In most cases (when the HEI has not surprised the user with IT service level), individual components of the sum will be negative.

However, the relative position scores will be appropriate for analysis.[3] $SERVQUAL\_abs$ shows the average absolute level of service. Both terms are taken with 50% weight each to obtain a service quality approximation.

One may be interested in observing through the three SERVQUAL variables the performance of the HEI in providing high-quality service. While it is obvious that to measure percentage of the maximum for *SERVQUAL_abs,* one needs to use the following formula: $SERVQUAL\_abs\% = \frac{100}{9} SERVQUAL\_abs$, for the other two variables the choice is not so obvious. One can show that the following always holds: $-8 \le SERVQUAL\_rel \le 8$. Therefore, to make an easily interpretable percentage formula for this variable, one can use the following: $SERVQUAL\_rel\% = \frac{100}{16}\left(SERVQUAL\_rel + 8\right)$. One can also show that the HEI:

- Heavily underperforms, as measured by this variable; i.e., its service level is lower than the minimum acceptable by students, when

  $$SERVQUAL\_rel\% \le \frac{100}{16}\left(-1+8\right) = 43.75$$

- Provides normal service; i.e., its service level is inside the interval $[mi, des]$, when $44.44 = \frac{100}{16}\left(-\frac{8}{9}+8\right) \le SERVQUAL\_rel\% \le \frac{100}{16}\left(0+8\right) = 50$

- Provides surprising service; i.e., its service level is higher than desired by students, when $\frac{100}{16}\left(0+8\right) = 50 < SERVQUAL\_rel\%$

The formula for the percentage equivalent to the *SERVQUAL* variable is then given by

$$SERVQUAL\% = 100 \cdot \frac{\left(SERVQUAL\_rel + 8\right) + SERVQUAL\_abs}{16+9}$$

[3] Let the author show it.

Let us denote each component of the sum by x_{ij}. Consider three possible cases:

A. $x_{ij} \equiv X_A < mi_{ij} < des_{ij}$ (the worst situation)

B. $mi_{ij} < x_{ij} \equiv X_B < des_{ij}$ (a normal situation)

C. $mi_{ij} < des_{ij} < x_{ij} \equiv X_C$ (the best situation)

Then, obviously, the following is always true: $X_A < X_B < X_C$. As $X_B < 0 < X_C$, if negative numbers are not recommended, one can add a constant positive number for average *SERVQUAL* for each HEI (naturally, average by the number of users) and then use this modified number for calculating e-readiness. This constant should be determined so that all average *SERVQUAL_rel*s are positive**.**

2.4.4 Overall Skilled Workforce Formula

For these reasons described above, the author proposes the following measurement of skilled workforce quality:

$$QWF = \frac{2}{3}\left(\frac{1}{3}Edu + \frac{2}{3}Exp\right) + \frac{1}{3}SERVQUAL$$, where

- *SERVQUAL* is the average SERVQUAL score by number of students who participated in the survey

2.5 Measuring Human Capital: Users

All experts interviewed by the author said that one of the most important aspects of e-readiness is the level of user proficiency in using IT services provided by the HEI.

The author sees two methods of measuring it:

1. Ask users what is their level of proficiency in using the infrastructure of their HEI
2. Take the average mark of the course in which students are introduced to the infrastructure of their HEI

However, both these measurements may be flawed. The first cannot be validated, as, usually, people that know less what the system is about tend to answer that they know the system well enough. On the contrary, people that understand the complexity of the system tend to say that they do not know the system well enough. Thus, if using this measurement, one can obtain results that cannot be interpreted at all.

The second leads to incomparable results for several reasons. The first is that HEIs might have different structures of the courses. The second is that some of the HEIs may disregard these courses at all—consider an example of an HEI providing MBA education.

It follows that both alternatives lead to flawed results and, therefore, the author chooses not to measure students' IT proficiency at all.

2.6 e-Readiness Formula

To remind the reader, the author proposes to multiply the three components measured to get an e-readiness score of the HEI under consideration:

$$eReadiness = Infr \cdot UQInfo \cdot QWF$$

3 Analysis of Results

Three higher education institutions were used to apply the e-readiness framework presented in the previous section:

- The Stockholm School of Economics in Riga (SSE Riga) provides an academic study programme in Economics and Business Administration, leading to a BSc degree, and a professional study programme, leading to the Executive MBA degree, for approximately 500 students
- The Transport and Telecommunication Institute (TTI) provides academic study programmes in Electronics and Telecommunications, Information Technologies and Computer Science, Management and Business Administration, Economics, Transport and Logistics, for approximately 4500 students
- The RTU Riga Business School (RBS) is an independent management-education institution within Riga Technical University (RTU), which provides Professional, Executive, and Full Time MBA, for approximately 400 students

Table 3 shows the summary of results for all three HEIs. Now, the author will briefly analyse the table.

3.1 Infrastructure Component

As one can observe from the table, SSE Riga has the greatest score in the Policies & Procedures sub-component—70 points (of the maximum of 136), while RBS follows with 59, and TTI closes with 50 points. These figures show that only SSE Riga follows slightly more than 50% of recommendations for the component, while the other two HEIs are below 50%. The most interesting situation, from the point of view of the author, is with TTI, which implements only 36.76% of recommendations, while it provides education in ICT and, thus, it would be more logical if its management was not only informed about the recommendations, but also followed them.

Usage & Quality of infrastructure is also highest in SSE Riga (4.5834 points), while the second place now is taken by TTI (3.9347 points). RBS is lagging behind the two with its 3.4472 points score. If taking percentage figures, then SSE Riga has infrastructure with usage & quality of 76.39%, TTI—65.58%, and RBS—57.45%. One should note that, while all three HEIs have infrastructure of approximately the same quality (66-70%), usage of it differs a

Table 3. Summary of measurement results for main components of the e-readiness framework for the three HEIs. *Note*: 'N' means number of respondents for the question and is included for informational purpose

	SSE Riga (~500 students)	TTI (~4500 students)	RBS (~400 students)
MOF Performance Score	14 (35%)	10 (25%)	14 (35%)
MOF Governance Score	48 (66.67%)	31 (43.06%)	30 (41.67%)
EDUCAUSE Governance Score	4 (33%)	6 (50%)	6 (50%)
EDUCASE Helpdesk Management Score	4 (33%)	3 (25%)	9 (75%)
PP	**70 (51.47%)**	**50 (36.76%)**	**59 (43.38%)**
Infrastructure Usage | N	3.8648 (96.62%) | 53	2.2688 (56.72%) | 93	1.5105 (37.76%) | 71
Infrastructure Quality | N	5.3019 (66.27%) | 49	5.6006 (70%) | 87	5.3838 (67.3%) | 68
UQInfr	**4.5834 (76.39%)**	**3.9347 (65.58%)**	**3.4472 (57.45%)**
Infr	**37.2917 (52.52%)**	**26.9674 (37.98%)**	**31.2236 (43.98%)**
Information Usage | N	3.6528 (91.32%) | 53	1.4698 (36.75%) | 91	2.0845 (52.11%) | 71
Information Quality | N	5.5139 (68.92%) | 49	5.1216 (64.02%) | 94	5.3646 (67.06%) | 72
UQInfo	**4.5834 (76.39%)**	**3.2957 (54.93%)**	**3.7246 (62.07%)**
Number of IT employees	5	18	4
D	0.6	1.2222	1.125
NC	0	0.3333	1
Edu	**0.6**	**1.5556**	**2.125**
Exp	**1.6**	**1.8889**	**1.5**
SERVQUAL_rel | N	-0.3995 (47.5%) | 23	-0.4878 (46.95%) | 61	-0.0981 (49.39%) | 10
SERVQUAL_abs | N	6.463 (71.81%) | 33	6.6873 (74.3%) | 70	7.0784 (78.65%) | 17
SERVQUAL | N	**3.0318 (56.25%)** | 23	**3.0998 (56.8%)** | 61	**3.4902 (59.92%)** | 10
QWF	**1.8550**	**2.2184**	**2.3023**
e-readiness score	**317.0665**	**197.1663**	**267.7437**

Source: Compiled by the author

lot—and this makes the difference in Usage & Quality scores. Note that SSE Riga students' usage of infrastructure is close to 100%, while in TTI it is slightly more than 50%, and RBS students positioned their use at only 37.76% level.

Overall, SSE Riga has the best-rated infrastructure of the three HEIs, having a score of 37.2917 points (or 52.52%—the only HEI of the three having the score greater than 50%). The middle position is occupied by RBS with 31.2236 score (or 43.98%). The lowest level of infrastructure is in TTI (26.9674 points or 37.98%).

3.2 Information Component

The first place in information usage is still occupied by SSE Riga (91.32%). However, compared with the usage of infrastructure, TTI and RBS swapped their places, and even the percentage levels. Now, the second is RBS with 52.11% of usage frequency, while the last is TTI with 36.75%.

Information quality, nevertheless, did not change much. Still, all three HEIs keep their information system quality in the region of 64-69%. However, TTI, the leader in infrastructure quality, now has the last position with 64.02%.

Overall, the positioning of HEIs in this component is the same as in the previous one: SSE Riga (4.5834 points or 76.39%), followed by RBS (3.7246 points or 62.07%), closed by TTI (3.2957 points or 54.93%).

3.3 Skilled Workforce Component

The difference between the three HEIs is that, while both SSE Riga and TTI have in-house IT administration staff, RBS outsources everything from Riga Technical University (RTU), keeping only helpdesk in-house. Nevertheless, the RTU staff that administers RBS infrastructure is taken into account by the author. Thus, the HEIs are still comparable by this component.

As also was expected, TTI has the greatest score of academic education (*D* variable) among the three HEIs analysed—1.2222 points. The second result is shown by RBS (& RTU) IT departments—1.125 points. The least academically educated staff works in SSE Riga—its score is only 0.6 points. What is more, only staff at RTU and TTI have IT certificates—RTU's score is 1, but TTI's—0.3333. Thus, the education score (as the reader may recall, it is obtained by summing *D* and *NC* variables) leader place goes to RBS, with 2.125 points. TTI occupies the second position, with 1.5556 points score, while SSE Riga has only 0.6 points.

As the table shows, TTI has the most experienced staff, compared to the two other HEIs—its experience score is 1.8889, while SSE Riga follows with 1.6. RBS IT staff experience score is slightly lower than SSE Riga's—1.5.

Regarding service quality, all three HEIs have their relative SERVQUAL scores inside the "normal" level, i.e., the level of service is inside the students' [minimum, desired] interval. Nevertheless, while SSE Riga and TTI are close to one another by relative SERVQUAL position (47.5% and 46.95%, correspondingly), RBS leads here with its

position being nearly at the border of students' desired level of service (49.39%—recall that any score above 50% means that the HEI surprises its students with the above-expected level of service).

The absolute SERVQUAL scores also position RBS at the top (78.65%), followed by TTI now (74.3%), and closed by SSE Riga (71.81%). Note two facts here. The first is that although SSE Riga had the score greater than TTI in *relative* SERVQUAL score, it did not guarantee it the leading position over TTI in *absolute* score. The second is that all three HEIs have their absolute SERVQUAL scores inside the band of 70-80%, which can be considered quite good.

In overall SERVQUAL score, the three HEIs appear quite similar: RBS leads with 59.92%, while TTI and SSE Riga follow closely (56.8% and 56.25%, correspondingly).

Overall, RBS leads in the Skilled Workforce component, as it has the greatest scores in education and service quality sub-components (component score is 2.3023). It is closely followed by TTI with its score of 2.2184 points. SSE Riga is lagging behind the two with the score of 1.855 points only.

3.4 Overall e-Readiness

Of the three HEIs considered in this paper, the most e-ready is SSE Riga (317.0665 points overall). This HEI got its first place because of implementing infrastructure and information services that are of the greatest quality, adherence to standards, and usage, and despite it loses in all skilled workforce sub-components to the other two HEIs.

The second position is occupied by RBS (267.7437 points overall). All three components of the e-Readiness Framework are between SSE Riga and TTI levels, which also guaranteed it the second place.

TTI, despite providing ICT education, has the lowest e-readiness score—only 197.1663 points. The only variables where TTI is the best is infrastructure quality and average academic education of IT department. Otherwise, most often it occupies the last position.

Conclusions

The author has defined e-readiness of a higher education institution (HEI) and developed a model—the e-Readiness Framework—for measuring it. The Framework performs assessment of e-readiness from three possible ways: Infrastructure, Information, and Human Capital. The components of the Framework are easily measurable and interpretable, which is an obvious advantage. Most individual components of the Framework contain sub-components measurable in percentage terms of the maximal level, which allows an HEI to assess how much it is possible to improve them. Another advantage is that the model is based on variables that are not bound to a particular moment in time and, thus, it is free of having to be reconsidered after a short time period. Rather, the foundation of the Framework is best practices and standards, as well as logics.

The author has also proved that the model is applicable by testing it on three Latvian HEIs: the Stockholm School of Economics in Riga, the Transport and Telecommunication Institute, and the RTU Riga Business School.

Thus, the e-Readiness Framework proved itself as a ready-to-use tool of assessing e-readiness of an HEI.

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