Innovation and knowledge trends through standardisation of IT applications

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ARTICLE INFO

Article history:
Received 8 February 2013
Received in revised form 16 August 2013
Accepted 23 August 2013
Available online 30 August 2013

Keywords:
Innovations
Knowledge
Trends
Standards
IT applications

ABSTRACT

The paper presents part of a study on collective knowledge and innovations in IT as well as an extract segment from a comparative statistical analysis of trends in the global–local standardisation of the pathways of knowledge and IT innovations in IT applications. The aim of the paper is to provide and promote educational and financial resources for the quality of knowledge in IT application. ISO (global) and SRPS (local) documents on IT and IT applications have been extracted from this statistical sample and analysed. The main results of the research are presented with phases of the PDCA methodology.

1. Introduction

The paper deals with standardised pathways of knowledge and innovations in information technologies (IT), particularly in the subfields of IT application in industry. There is a growing problem in terms of the continuous improvement of individual knowledge in relation to standardised (partly public and collective) knowledge of new technologies. One aspect of the problem is the continuous improvement of product quality (education services), another concerns the price of knowledge, and a third pertains to the presentation of knowledge [1]. Analysis of the standardisation of collective or global knowledge in the subfields of IT innovations and IT applications is primarily based on ISO standardisation [2], supported by documents for the operationalisation of processes by virtue of individual knowledge. The study also encompasses the pathway of local knowledge in SRPS (SRPS is an abbreviation for the standards in Serbia [3]). Over the last few years SRPS have been created by using European norms (EN) on the local environment platform of the European Union (EU), a new concept.

The expansion of IT innovations and IT applications permanently widens the gap between collective and individual knowledge. With IT applications and IT innovations, the distance between the collective and individual becomes self-evident and manifests a tendency towards ever-increasing growth. With the globalisation of business and localisation of financial crises, additional state issues directly affect education. As in [4], this paper points to the fact that standards play a key role in the development of IT infrastructure in emerging economies and places further emphasis on the significance of IT standard innovation.

The global classification of IT innovation subfields, IT applications and the accompanying knowledge for organisational innovations has been applied. This classification is of both strategic and national importance for knowledge management. According to the International Classification of Standards (ICS), information technologies are classified in field 35, which comprises 12 segments. The paper focuses on IT innovations and IT applications (field 35.240, including 25.040) which are classified in 11 subfields, ICS-3 = 35.240.xy [2,3]:

35.240.01 – application of information technology in general
35.240.10 – computer-aided design (CAD)
35.240.15 – identification cards and related devices, including application of cards for banking, trade, telecommunications, transport
35.240.20 – IT applications in office work, including text processing systems, text communication, text presentation, Office Document Architecture (ODA)
35.240.30 – IT applications in information, documentation and publishing, including Standard Generalised Markup Language (SGML), automatic translation machines
35.240.40 – IT applications in banking, including automatic banking facilities, identification cards for banking purposes
Hypothesis 4

the paths to the adequate levels of the quality of product innovation, the standardisation process is becoming more important [6], the perspectives (including this one) aim at improving the exchange of knowledge on both global and local levels.

Hypothesis 3

1.1. Initial hypotheses, goals and (research significance) value of this research

The initial hypotheses express the need for clear answers to the acquisition of collective knowledge with the aim of improving the final product — IT services and IT products. The goals set in the paper are presented by way of interesting and important trends in IT applications, through the key results of knowledge management for IT applications, as well as through the answers to some pertinent issues (in PDCA) such as:

Hypothesis 1. Plan-phase

It is possible to plan (at the state level) the resources necessary for IT innovations and IT applications on the pathways of knowledge (collective and standardised knowledge, as part of social knowledge for individual results).

Hypothesis 2. Do-phase

To establish an adequate business organisation, it is necessary to determine the extent of available knowledge and IT innovations, or the size of quantity indices of: publications (Ip), new projects under development (Iq), Innovations (Iqi); collective/global–local (or national), or individual knowledge required for professional work, for improving the quality of services of IT applications and solving practical problems (for example, the problems encountered on the pathways to education).

Hypothesis 3. Check-phase

The critical aspects of knowledge and the possibility of anticipating the trends and necessary resources for individual updating of knowledge in the subfields or segments of IT applications according to the obtained results (price indices, innovation value indices – Ivin or Ivu = Ivis + Ivia ≈ Ivis).

Hypothesis 4. Act-phase

It is impossible to provide a single resource for discontinuous (cumulative $\sum$ Ip) and continuous improvement of knowledge on the paths to the adequate levels of the quality of product innovation, with the need to comply with innovated standards for IT applications and publications (Ivin; $\sum$ Ip; $\sum$ Iqv). Moreover, many papers (including this one) aim at improving the exchange of knowledge using IT innovations and implementing tools in IT applications.

In addition to providing the evidence for the given hypotheses, this paper strives to inform government, state institutions, faculties and individual innovators (both graduate students and teaching staff who, within the field of IT applications, should ask themselves the following question: what have we learned? [5]). In addition, since user participation in the standardisation process is becoming more important [6], the paper may be useful for innovators who are developing new standards (innovations) in the subfields of IT application.

The significance of this research lies in clustering the areas of IT application, determining the period necessary for updating the knowledge in PDCA, and explicitly defining the criteria which show the limited possibilities of knowledge innovation that require appropriate solutions. In short, the significance of the research is presented in the form of highlights.

2. Related work

Several surveys have accumulated an enormous amount of information on IT in previous years, over 10^12 books per year, which is about one exabyte of information or about 1.1 x 10^18 MB (or 1.15 x 10^18 bytes) [7]. This paper predominantly relied on ISO and SRPS standards as academic material for reliable and objective analyses of IT innovations in the relevant period.

A very small number of studies whose purpose entailed the understanding of investment in IT innovations on the platform of standardisation and PDCA have been carried out [8].

Some authors have analysed the effects of national culture, including individualism and collectivism [9]. There are numerous issues related to the adequacy of local knowledge and planning of company strategies in a particular country [10,11]. Most researches deal with the standards in developed countries, and just a few deal with the standards in developing countries, which leads to the ‘standardisation gap’ of ICT standards in these environments (Korea [12], Canada [13] India [14] — “the top 100 IT firms”: during the period of 1997–2009 from the European database and the United States). This paper analyses local knowledge and SRPS standards as well as IT innovations in Serbia.

According to some authors, progress towards a higher level of individual knowledge is figuratively portrayed as climbing the ladder of collective knowledge to the ‘phenomenological’, as in PDCA, phase D [15]. Rather than employing this principle, this paper endeavours to apply PDCA methodology to improve results in the quality spiral. Each year represents a separate step. Much as previously, in the last few years PDCA has been used as a method for improving web-based intelligent reports of an e-learning system as an intelligent system [16], or as a tool in the methodology based on Crosby’s philosophy [17], or for the harmonisation of multiple standards and models such as ISO 27001, ISO 20000 and ISO 9001 [18].

In this paper, IT applications and IT innovations have played a part in solving the issues regarding the scarcity of resources. Other authors assert that IT resources are used for the accumulation of wealth and achievement of capitalist priorities, as well as the suppression of social interests in favor of a ruthless rat race [19]. In addition, many authors have discussed the standardisation of IT applications, e.g. [20–22]. Therefore, a minimisation of costs and a cost-oriented approach are necessary for individual knowledge innovation in IT applications. Some authors have analysed the links between knowledge transfer and social capital for different types of networks [23] in order to facilitate knowledge transfer, reduce development costs, shorten the time between purchaser/user request and delivery, enhance the quality of delivery, react promptly to environmental changes and build steadfast and strategic relationships with suppliers. The goals set in this paper are virtually the same. The paper strives to analyse the relation between IT innovations and volume and value indices on both global and local levels.

Since this research predominantly encompasses standardised pathways of knowledge and IT innovations, it also provides an analysis of the aspects of knowledge management, such as knowledge management implementation and knowledge management technologies. All of this has been done with the aim of achieving excellence, such as according to the model from [24] or knowledge management from the paper [25,26]. In [27,28] the authors pointed out the effect of IT on the implementation of knowledge management systems. Moreover, relationships between knowledge management systems and IT were analysed. Similarly, the authors of [29] also explored the relationship
between information technology, information management and knowledge management. Innovation and knowledge trends were discussed in this paper as well.

3. Methodology and framework

The research employed PDCA methodology. Statistical methodology of dynamic analyses and deductive and inductive reasoning methods were used for predicting the future development and innovation of the pragmatic framework. Based on PDCA and defined values of the quantity indices of projects under development (IqI), i.e. the quantity indices of innovation (Iqi, phase Do), the index (or degree) of innovation in time dimension (Ity or It/year-per year) was determined. The period for checking the innovations (Check) in certain fields or subfields is dependent on the time index of innovation Ity. The index Ity was used for defining the groups or classes/clusters of innovation. The values of periodic checks (Check) of the research for practice (1–year, 2–month, 3–week or 4–day) were assigned to this index [8].

JAVA software was used for systematisation, analysis and presentation of the results [30]. This web application represents two IT innovations that have to be continually revised in accordance with all the changes to the ISO [2] and ISS [3] web sites. It is almost impossible to repeat the research without this software. The software enables all source data to be found online, in all respective fields or subfields, but experience shows that the most propitious time for comparative research is the end or the beginning of the calendar year, i.e. 31 December or 1 January. The analyses conducted over the years produced significant results (for example, the analysis carried out in early 2013). JAVA software allows for collecting reliable and valid data. In former research practice (from 1999 to 2013), the concepts of web sites [2] and [3] were created and web (Java) applications had to adopt all the changes. JAVA software (for data collection) is a web crawler specifically designed to parse HTML responses from ISO and SRPS web sites [2,3]. For each publicly available document standard data such as year of publication, type of document (Amendment, Corrigendum, etc.) and price are collected. These data are available for statistical analyses of published documents in some ICS areas/ subareas during the particular year and provide their total price.

Methodologically, statistical indices were formed for the comparison of ISO and SRPS relations in the subfield of IT applications (ICS-2 = 35.240) with other fields of human endeavour, including: quantity indices (IqI), value index (Iv) and index of qualitative variation (Iqv).

Quantity indices (IqI), defined and determined for both ISO and SRPS, refer to: samples (Iqs), published standards (Iqs), standards under development (Iqd), standards withdrawn from use (Iqw), deleted projects (Iqu), innovations in various stages of development (IqIyear = IqI/2012) for the full previous calendar year.

Value indices (Iv) follow quantity indices with results that are aggregated by trend for most of the 11 subfields. Graphs consist of two parts, (a) and (b):

(a) time aspects for the whole research period by year of publication, ∑ Iv/year
(b) regression trend lines (exponential, linear, logarithmic and polynomial), according to the data from the previous years (including 2012) and defined regression equations y = SRPS, Iv/year; P is Plan-phases in PDCA – general, or exactly: P0, P1, P2 to Pn, per research period: year, month, week or day).

The initial statistical sample comprised Iqs/ISO/35/year documents on 1 January 20xy (xy = 01, 02 to 12). This sample was extracted from a population of ΣIqs/ISO/35/year ISO standards, the first level of research for all scientific areas (for ICS-1 = 1 to 99, with value indices of innovated standards Iv = ISO/35/year; and for IT–Iv = ISO/35/year). Expressed in CHF [Swiss currency], whereby 1 CHF = 1.07 U. S. dollars and 1 CHF = 100 RSD [Serbian currency, SRPS].

Statistical analyses of innovations in all subfields of IT applications were conducted on a sample of Iqs/ISO/35.240/year = Iqs/ISO/35.240/2012 ISO documents in their entirety (for ICS-2 = 35.240, [2]).

Simultaneously, out of Iqs/SRPS/35/year samples in IT, Iqs/SRPS/35.240/year standards were analysed in the same subfield of IT application in Serbia [3] from a population of ΣIqs/SRPS/35/year Standards in all areas, for ICS-1 = 1 to 99.

The research results are presented graphically and tabularly, separately and aggregated as a whole, as well as by trend lines (figures) including: (1) time aspects for the whole research period by year of publication and (2) financial trend lines in the first decade of the twenty-first century.

4. Results

In this paper, potential innovations are analysed on the following levels: IqI/25.040 and comparable Iqs/ISO, from Iqs/35, from the total: ΣIqs/ISO/35/year = 42092 ISO/ISO/35/year = 4181, Ivs/ISO/35/year = 99878 CHF, and for IT–Iv = ISO/35/year = 37406 CHF (date: 2012.01.01 for P1, 2011.01.01 for P0 and 2013.01.01 for P2). In relation to the highest level, ΣIqs/ISO/35/year = 22098, for all areas, this paper analyses a significant percentage (Ivp = Table 1).

The term “pathways” shows alternative ways for the innovations and trends of knowledge: ISO (globally) or SRPS (locally). Further explanation of the term “pathways” of innovation partly derives from the published research [31]. This “path” of knowledge innovation through the area ICS-1 = 25 (“knowledge trends in the subfields of manufacturing engineering”), [31], leads to the subfield ICS-2 = 25.040-IT application in industry, Table 1, ICS-2 = 25.040 (comparatively with ICS-2 = 35.240), and Fig. 5 in this paper. On the other hand, “pathways” of knowledge innovation leads to the subfield of IT application in industry (ICS-3 = 35.240.50), through IT application, ICS-2 = 35.240, Fig. 4.

Table 1. Framework of a comparative multi-criteria analysis of pathways of innovations, 2012/01/01.

The results of the analysis of knowledge standardisation and innovations in IT application subfields are presented for many examples of global and local innovations:

(1) Ishikawa diagram of participants in the development of IT innovations in the subfields of IT applications Iqu = IqI (Std) + IqI (Amendment) + IqI (Cor) (2) Tables 1 and 2 show multi-criteria indices of quantity and value (quantity of publications – Iqs, aggregate values 2Iqv = Iqv + Iqw = Iqv + (Ivs (Std) + Ivs (Amendment))), the annual amount

Table 1

<table>
<thead>
<tr>
<th>Sub/field</th>
<th>Samples Iqs</th>
<th>Published Iqs</th>
<th>Under devel Iqs</th>
<th>Withdrawn Iqs</th>
<th>Del Iqs</th>
<th>∑ Iqv/year</th>
<th>ISO</th>
<th>SRPS</th>
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<tr>
<td>ICS-1/2</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
<td>(8)</td>
</tr>
<tr>
<td>1</td>
<td>∑ 35,240</td>
<td>1519</td>
<td>290</td>
<td>783</td>
<td>237</td>
<td>317</td>
<td>35</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>∑ 25,040</td>
<td>1362</td>
<td>196</td>
<td>807</td>
<td>193</td>
<td>63</td>
<td>1</td>
<td>492</td>
</tr>
<tr>
<td>3</td>
<td>∑ 35</td>
<td>5853</td>
<td>925</td>
<td>2975</td>
<td>782</td>
<td>799</td>
<td>99</td>
<td>2009</td>
</tr>
</tbody>
</table>
of innovation – $l_{qis}$, $l_{qia}$, $l_{qic}$, the annual value $l_{vis}$ of innovated Std and $l_{viva}$ of innovated Amd, withdrawal from initiated innovations in terms of new projects in the past 12 months – $l_{qd}$).

(3) Charts relating to examples of certain subfields; the best overview is achieved when the charts are composed of two parts:

(i) the first part includes overall analyses (of quantity – $l_{q}$ and value – $l_{v}$) of all current standards (Std), amendments (Amd), corrections (Cor) and new projects under development ($l_{qud}$ for NP)

(ii) the second part includes financial trend line diagrams, only for Std, with the exception of anything before the year 2000, because of innovations and the withdrawal of earlier documents – withdrawn category (non/applicability – $l_{qv}$).

In order to present graphical results (in the first part (4)) more clearly, only specific numerical values were shown.

Since corrections (Cor) are free of charge and the prices of amendments (Amd) are considerably lower than the prices of standards (Std), the number of presented Cor and Amd was minimised.

The fourth level of research (pathways of knowledge and IT innovations based on the degree of applicability, in one subfield) refers to IT applications in industry or industrial automation systems – 25.040, Table 2. Correlations between available pathways of knowledge and IT innovations, quantity indices ($l_{q}$), value indices ($l_{v}$), collective – global–local – individual, are presented in Table 2.

Table 2. Analysis of pathways of innovations (ISO in relation to SRPS) for ICS-2 = 35.240, 2013/01/01.

<table>
<thead>
<tr>
<th>Subfield</th>
<th>$l_{qis}$</th>
<th>$l_{qia}$</th>
<th>$l_{qic}$</th>
<th>$l_{p}$</th>
<th>$l_{q}$</th>
<th>$l_{v}$</th>
<th>$l_{qud}$</th>
<th>$l_{qv}$</th>
<th>$\Sigma l_{iv}$</th>
</tr>
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<tr>
<td>ICS-3</td>
<td>35.240.01</td>
<td>35.240.10</td>
<td>35.240.15</td>
<td>35.240.20</td>
<td>35.240.30</td>
<td>35.240.40</td>
<td>35.240.50</td>
<td>35.240.60</td>
<td>35.240.70</td>
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<td>12 1</td>
<td>8</td>
<td>1</td>
<td>8</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>35.240.10</td>
<td>15 10</td>
<td>7</td>
<td>10</td>
<td>1</td>
<td>7</td>
<td>0</td>
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<td>0</td>
</tr>
<tr>
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<td>35.240.15</td>
<td>272 77</td>
<td>109</td>
<td>59</td>
<td>45</td>
<td>117</td>
<td>18</td>
<td>1</td>
<td>9424</td>
</tr>
<tr>
<td>4</td>
<td>35.240.20</td>
<td>217 2</td>
<td>98</td>
<td>1</td>
<td>12</td>
<td>107</td>
<td>0</td>
<td>0</td>
<td>700</td>
</tr>
<tr>
<td>5</td>
<td>35.240.30</td>
<td>215 11</td>
<td>122</td>
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<td>15</td>
<td>67</td>
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<td>0</td>
<td>11390</td>
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<tr>
<td>6</td>
<td>35.240.40</td>
<td>73 17</td>
<td>19</td>
<td>2</td>
<td>10</td>
<td>44</td>
<td>15</td>
<td>0</td>
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<tr>
<td>7</td>
<td>35.240.50</td>
<td>48 47</td>
<td>26</td>
<td>41</td>
<td>19</td>
<td>2</td>
<td>6</td>
<td>1</td>
<td>2558</td>
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<tr>
<td>8</td>
<td>35.240.60</td>
<td>323 138</td>
<td>171</td>
<td>128</td>
<td>95</td>
<td>47</td>
<td>5</td>
<td>7</td>
<td>2365</td>
</tr>
<tr>
<td>9</td>
<td>35.240.70</td>
<td>93 38</td>
<td>66</td>
<td>25</td>
<td>21</td>
<td>1</td>
<td>5</td>
<td>2</td>
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<tr>
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<td>35.240.80</td>
<td>162 52</td>
<td>118</td>
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<td>49</td>
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<tr>
<td>11</td>
<td>35.240.90</td>
<td>184 24</td>
<td>102</td>
<td>22</td>
<td>49</td>
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<tr>
<td>$\Sigma$</td>
<td>35.240</td>
<td>1634 417</td>
<td>846</td>
<td>346</td>
<td>321</td>
<td>13</td>
<td>433</td>
<td>46</td>
<td>104672</td>
</tr>
</tbody>
</table>

4.2. Development of ISO/IEC innovations in IT applications

Global standardised pathways of knowledge and IT innovations (in examples of ISO/IEC), from the development of IT towards its application and the other way round, lead through technical committees and their subcommittees (Fig. 1) for each of the 11 segments (01/01/2013, for example).

- example (.30 section in Fig. 1) for ICS-3 = 35.240, IT applications in information, documentation and publishing: 15 projects under development have been entrusted to: JTC 1/SC 34 (6), TC 37/SC 3 (1), TC 46/SC 4 (3), TC 130 (4) and TC 171/SC 2 (1); JTC 1/SC 2 – last result of the 1998 development;

- example (.60) for ICS-3 = 35.240, IT applications in transport and trade: 98 projects under development have been entrusted to: TC 204 (90), JTC 1/SC 32 (3), TC 37/SC 3 (1), TC 8 (1), TC 8/SC 3 (1), TC 154 (1) and TC 22/SC 13 (1); TC 8/SC 11 – last result of the 2002 development, TC 20 and TC 8/SC 11 – last development in 2006;

- example (.99) for ICS-3 = 35.240, IT applications in other fields: 49 projects under development have been entrusted to: JTC 1/SC 25 (11), JTC 1/SC 36 (31) and TC 23/SC 19 (7); TC 159/SC 4 – last development 2008; TC 127/SC 3 – last development 2010; JTC 1/SC 6, TC 108/SC 5 and TC 205 – last development 2012.


4.2. Identification cards and related devices

The statistical sample consists of $l_{qis}$ = 349 ISO and SRPS documents, of which $l_{qis}$ = 168 are published, $l_{qis}$ = 45 are under development (all have been entrusted to JTC 1/SC 17), $l_{qis}$ = 135 have been withdrawn from use and five projects have been deleted in the last 12 months. Fig. 2 presents detailed results of the analysis:

(a) overall analyses for the period from 1990 to 01.01.2013, with an appreciable number of $l_{qis}$, $l_{qis}$ = 45 ongoing development projects–standards

(b) for the anticipated innovations of standards, the trend line according to Eq. (3.1) – (value indices $l_{vin}$, 35.240.15/2012/P3, see Table 3, column 3, row 3), $l_{vin}$ = 15 projects under development (3.4) and (3.5), according to Fig. 2b

$y_{35.240.15/ISO/2000–2010/P0} = 94.5x + 45$

$y_{35.240.15/ISO/2003–2011/P1} = 71.7x + 530.5$

$y_{35.240.15/SRPS/2004–2011/P1} = 14.235x$

The $l_{vin}$, 35.240.15/2013/p2 (Table 3, columns 10 and 11) is directed at relations (3.4) and (3.5), according to Fig. 2b

$y_{35.240.15/ISO/2003–2012/P2} = −6.636x + 821$

$y_{35.240.15/SRPS/2003–2012/P2} = 1.716x^2+494$

4.3. IT applications in information, documentation and publishing

The statistical sample consists of $l_{qis}$ = 226 ISO and SRPS documents, of which $l_{qis}$ = 125 are published, $l_{qis}$ = 67 have been withdrawn from use, $l_{qis}$ = 11 projects have been deleted and $l_{qis}$ = 19 are under development. $l_{qis}$, $l_{qis}$ = 15 projects under development “entrusted” or allocated to: TC 37/SC 3 (1), TC 130 (4), JTC 1/SC 34.
(6), TC 46/SC 4 (3) i TC 171/SC 2 (1), see Section 4.1, Fig. 1. Fig. 3 presents the results of standardisation analysis:

(a) overall analyses for the period from 1984 to 01.01.2013,
(b) trend line of anticipated annual requirements \( I_{\text{vin},35.240.30/2012/P0} \) according to Eq. (5.1)

\[
y_{35.240.30/2012/P0} = 126.1 \times 102
\]

(b) trend line of anticipated annual requirements \( I_{\text{vin},35.240.30/2012/P1} \) according to Eqs. (5.2) and (5.3)

\[
y_{35.240.30/2012/P1} = 272.2 \times 81.42
\]

(c) trend line of anticipated annual requirements \( I_{\text{vin},35.240.30/2013/P2} \) according to Eqs. (5.4) and (5.5), Fig. 3b

\[
y_{35.240.30/2013/P2} = 157.2 \times 213.4
\]

According to Eq. (5.1), approximately 1540 CHF should be provided for 2013. In reality, however, this figure would be twice as much.

4.4. IT applications in industry

The statistical sample consists of \( I_{\text{q}s} = 95 \) ISO and SRPS documents, of which \( I_{\text{q}p} = 67 \) are published, \( I_{\text{qu}} = 19 \) are under development (\( I_{\text{qu}/\text{ISO}} = 18 \) projects under development entrusted to TC 29), \( I_{\text{qw}} = 8 \) have been withdrawn from use and one project has been deleted. Fig. 4 presents the results of the standardisation analysis:

(a) overall analyses for the period from 1985 to 01.01.2013,
(b) trend line \( y_{35.240.50/2012/P0} \) of anticipated annual requirements \( I_{\text{vin},35.240.50/2012/P0} \) according to Eq. (7.1)

\[
y_{35.240.50/2012/P0} = 132 \times 149
\]
Knowledge innovation “path” leads through IT applications (ICS-2 = 35.240), to subfields of IT application in industry, Fig. 4 (ICS-3 = 35.240.50). In Fig. 5, “path” knowledge innovation to the subfields of IT application in industry encompasses a wider time frame for the analysis of available data (from 1977 to 2013), because in the ICS-1 = 25, standards from a wider time frame (from 1972) are available [31]. Special attention deserve trends of innovation and knowledge sharing (ICS-2 = 35.240 comparatively with subfields ICS-2 = 25.040, IT applications in industry — industrial automation systems, [31]), comparatively Fig. 4–Fig. 5 and accompanying indexes.

Results of the standardisation analysis for ICS-2 = 25.040 (in phases P1, 2012.01) according to Eqs. (7.6) and (7.7):

\[ y_{25.040/ISO/2004−2011/P1} = 2336x + 1444 \]  
\[ y_{25.040/SRPS/2004−2011/P1} = 235.4x − 58 \]

Fig. 5 presents the results of the standardisation analysis for 25.040 (in phases P2, 2013.01) with the trend of planned (annual and global) in Fig. 5b.

4.5. IT applications in transport and trade

There are numerous examples of IT applications in transport and trade. In this subfield of IT applications (and innovations), expectations management stands out as a model for e-commerce EDI and EDIFACT.

Fig. 6 presents the results of the standardisation analysis:

(a) overall analyses for the period from 1983 to 2013.01.01,
(b) trend line \( y_{35.240.60} \) of anticipated annual requirements
4.7. IT applications in healthcare technology

Numerous examples are available. Standardised knowledge in this subfield of IT applications is complemented with research on medical challenges and the costs of abuse as catalysts for transformation and crucial progress in the application of IT networks. The goal is overall health and well-being via: patient monitoring, data visualisation, decision-making for diagnostics, surgery.

Fig. 8 presents the results of the analysis:

(a) overall analyses for the period from 2001 to 01.01.2013,
(b) trend line \(y_{35.240.80}\) of anticipated annual requirements \(I_{vin,35.240.80/2012/P0}\) according to Eq. (10.1),
\[
y_{35.240.80/ISO/2001–2010/P0} = 304 \times -375
\]
\(I_{vin,35.240.80/2012/P1}\) according to Eqs. (10.2) and (10.3)
\[
y_{35.240.80/ISO/2004–2011/P1} = 225.1 \times -61.2
\]
\(I_{vin,35.240.80/2009–2011/P1}\) = 25.931 \(x\)
\(I_{vin,35.240.80/2012/P2}\) according to Eqs. (10.4) and (10.5), Fig. 8b.
\[
y_{35.240.80/ISO/2004–2012/P2} = 613.4 \ln (x) + 964.5
\]
\(y_{35.240.80/ISO/2012–2012/P2} = 24.77 x^{1.523}\)

4.8. IT applications in other fields

IT applications in other fields (ICS = 35.240.99): 49 new projects under development entrusted to: JTC 1/SC 25 (11), JTC 1/SC 36 (31) and TC 23/SC 19 (7).

There are numerous examples available (specifically in the E-learning sub-segment): nowadays, numerous surveys focus on the development of E-learning and the learning management system (LMS), as well...
as the standardisation of E-learning, etc. This paper presents some additional details relevant to the development and implementation of innovations.

Fig. 9 presents the results of the standardisation analysis:

(a) overall analyses for the period from 1988 to 01.01.2013,
(b) trend line \(y_{35.240.99}\) of anticipated annual requirements \(Ivin_{35.240.99/2012/P0}\) according to Eq. (11.1),
\[
y_{35.240.99/ISO/2000−2010/P0} = 216x−437
\]
(11.1)
\(Ivin_{35.240.99/2012/P1}\) according to Eqs. (11.2) and (11.3),
\[
y_{35.240.99/ISO/2000−2011/P1} = 215 x−295
\]
(11.2)
\(Ivin_{35.240.99/SRPS/2000−2011/P1} = 10.91 x
\]
(11.3)
\(Ivin_{35.240.99/2013/P2}\) according to Eqs. (11.4) and (11.5), Fig. 9b,
\[
y_{35.240.99/ISO/2006−2012/P2} = 900.5ln(x) + 613
\]
(11.4)
\(y_{35.240.99/SRPS/2006−2012/P2} = -23.91x + 396.5
\]
(11.5)

5. Discussion

In order to carry out a comparative analysis of ISO/SRPS, research on and evaluation of local (national-collective) knowledge according to SRPS standards in IT (as well as in the field of IT applications) were conducted.

In both this paper and [32] domestic standards were successfully introduced on a global level and national interests were more significant. In contrast to [33] and [34], which present a comparative analysis of two advanced IT nations, this paper provides analyses of the relations of the standards of a nation (SRPS) in parallel with the global (ISO). As shown in [35] there is a positive correlation between ICT competitiveness and economic growth, as well as international competitiveness. Compared with other papers, which deal with the existence of a standard framework for the creation of IT standards, ‘a framework for ICT standards creation’ [36], this paper deals with the possibilities of accessing IT standards to apply them in updating knowledge in PDCA.

5.1. Planning the innovation resources for IT applications (Plan–1 to Plan–2)

The previous chapter (Section 4) did not provide a detailed review of the results of all subfields of IT applications. The segments with declining trend lines and minimal or insignificant innovations were excluded (there are no problems in phase P). Details are as follows:

- the first and second segments were excluded (35.240.01 and 35.240.10), since only 10 and 8 ISO documents are available (and two and one project under development),
- no financial plans for ISO innovations are provided for these subfields: for example, theoretical \(Ivin_{35.240.10/2012/P1}\) according to Eq. (2.3), Table 3,
\[
y_{35.240.10/SRPS/2006−2011/P1} = 1.734 x
\]
(2.3)
- analysis results for ICS–3 = 35.240.20, IT applications in office work, with a trend line of anticipated annual requirements \(Ivin_{35.240.20/2011/P0}\), according to Eq. (4.1)
\[
y_{35.240.20/ISO/2000−2010/P0} = -25 x + 490
\]
(4.1)
or \(Ivin_{35.240.20/2012/P1}\) according to Eq. (4.2)
\[
y_{35.240.20/ISO/2000−2011/P1} = -29.255 x + 489.53
\]
(4.2)
- analysis results for ICS–3 = 35.240.40, IT applications in banking \(y_{35}\), with a trend line of anticipated annual requirements \(Ivin_{35.240.40/2011/P0}\), according to Eq. (6.1)
\[
y_{35.240.40/ISO/2001−2010/P0} = -5 x + 258
\]
(6.1)
5.2. Correlation of knowledge and IT applications: global and local world regions.

Table 3. IT innovations in P1D1C1A1: from P0D0C0A0 to P2D2C2A2 (from 1.2011 to 1.2013) for ICS-2 = 35.240.

Note: Time period for Do process: 2011 for Do/0 or D0, 2012 for Do/1 or D1 and 2013 for Do/2 or D2. For lty see Section 5.3.

Individual pathways have been considerably reduced because of local situation and personal income. Individual pathways of knowledge paths lead through: local knowledge and creative individuals, as well as expert teams whose task is to create local SRPS standards according to the international collective knowledge. The examples of SRPS in Serbia in the standardisation of IT applications attest to the fact that the pathways of knowledge are being reduced and amount to approximately 17% (quantitatively) and below 5% (financially) compared with ISO (Tables 1 and 2, columns 4, 6, 8, 10 and 13).

In order to attain local knowledge from all Serbian standards (SRPS) in the field of IT applications, it is necessary to allocate approximately \( \sum I_{V35.240/SRPS;2011/D0} = 8284 \text{ CHF} \), for Iqp + Iqu = 237 + 35 = 272 documents. Simultaneously, on the level spanning collective and local (national) level, i.e. ISO-SRPS, as well as the quantitative (Iqs35.240/2011/D0-1519 to 290) and financial level (\( \sum I_{V35.240/ISO;2011/D0} = 95380 \text{ CHF} \) to 8284 CHF is more than 90%), the number of pathways to ‘state knowledge’ is considerably lower. Fig. 10 presents a comparative analysis and financial details of knowledge innovation according to Serbian standards (SRPS) with respect to ICS-2 = 35.240/ISO and ICS-2 = 35.240/SRPS for all subfields of IT application. Total valued knowledge in IT applications according to SRPS (\( \sum I_{V35.240/SRPS;2011/D0} = 8284 \), for Iqp = Iqs = 237) is considerably lower (10 to 11 times as low) compared with ISO (\( \sum I_{V35.240/ISO;2011/D0} = 95380 \), for Iqp + Iqu = 783 + 317 = 1100, with the sample of Iqs = 1519 documents and \( \sum I_{V35.240/ISO;2011/D0} = 220442 \), Table 1 and \( \sum I_{V35.240/ISO;2012/D1} = 104672 \text{ CHF} \), Table 2).

The annual requirements for the specified field of IT applications, i.e. the maintenance of knowledge continuity in 2012, exceed \( I_{V35.240/ISO;2012/D1} = 13538 \text{ CHF} \). Cumulatively, without continuous or discontinuous innovation, all standardised pathways of ISO knowledge of IT applications require a considerably larger amount (\( \sum I_{V35.240/ISO;2012/D1} = 104672 \text{ CHF} \); \( \sum I_{V35.240/ISO;2011/D0} = 220442 \text{ CHF} \)).

5.3. Knowledge innovations in examples of IT applications

Which of the pathways of knowledge and innovations are critical and is it possible to predict the necessary resources for IT applications?

In this paper, original mathematical relations have been obtained on the basis of previous results and comparative standardisation analyses Eqs. (3) to (12). These relations can be used for anticipating expectations for IT applications and for other fields and subfields of expertise. In line with the presented analyses and the graphical presentation of trends, the coefficients of the direction of collective knowledge of standardisation have been defined (global – ISO and local – SRPS).

On the pathway to knowledge innovation it is necessary to provide a large number of new documents per year, Iqiso = Iqi (Std) + Iqi (Amd) + Iqu (Cor), and innovations Iqin = Iqi (Std) + Iqi (Amd) + Iqu (Cor).
A significant amount of development potential \(I_{qu}^{35.240/ISO/2012} = 321\) ISO new projects in 2012 is the basis for continuous improvement of knowledge. At the same time, new projects (NP, Fig. 1) are of paramount importance for the management of education projects and knowledge.

6. Conclusions

We conclude that the field of IT applications requires daily updating of knowledge, and some particular subfields on weekly or monthly basis. Studies provide additional practical benefits (globally and locally) in each country, especially in the member states of the ISO.

Contribution of this work to academic community is in practical monitoring of collective knowledge trends in IT applications with the goal of better organisation of the educational system: schools, universities, individuals (with individual knowledge), the wider community, all on the standardisation platform. The specific contribution of research (on the location of the author — in Serbia) has resulted in creation of a new module in the study program “IT applications in industry”. Newly created module “IT applications in industry” (with 240 ECTS) entered the accreditation procedure in 2013 and is going to be realized in the following five years. The first generation of these advanced studies will be enrolled in 2014, the fifth generation in 2019, therefore this study will be realized until the 2023 year at least. For the education of IT-teachers in future, studying program module “IT in Education” (300 ECTS) has been created. Expected long-term contribution in this area is reflected in the application of IT, so that the first generation of IT-teachers will complete their studies in 2019. After that period of time, they will educate younger generation on the platform of innovation and standardisation of IT trends.

It is possible to draw conclusions from the set goals, key results and answers to pertinent questions (e.g. resolving the dilemmas of the preliminary hypotheses in PDCA: Hypothesis 1 for Plan-phases — Section 5.1, Hypothesis 2 for Do-phases — Section 5.2, Hypothesis 3 for Check-phases — Section 5.3 and Hypothesis 4 for Advancement-phases — Section 5.4). On the basis of the presented results and analyses, the examples of IT applications in relation to all subfields, and the aggregate time index of innovation, it can be concluded that the IT application subfield requires daily knowledge updates.

6.1. Elimination of limited resources (finances) for more frequent innovation of knowledge

Both practice and the results of the analyses demonstrate that the standards of knowledge and IT innovations are not equally viable financially and organisationally (for resources planning, see Section 5.1). Consequently, results of individual work (without teamwork) are a drop in the bucket compared with social, strategically targeted results and the breadth of knowledge, on the way to sustained improvement of the quality of education and a higher level of social (collective) knowledge in relation to individual knowledge. The problem is even more pronounced in emerging economies, where decisions are expected at the highest level, the level of government. On the basis of these results (Sections 4 and 4.1 to Section 4.8, in phases: P0, P1 and P2), implicit conclusions can be drawn.

6.2. Future directions

The presented results of original analyses of one of the 12 areas of IT innovations enable a more precise determination of the quantitative (\(I_{qv}\)) and financial (\(I_{fv}\)) ‘gap’ between individual and collective — global (ISO) and local (or national SRPS) through social knowledge. Furthermore, they open up new possibilities for further research of IT innovations in education (E-learning), IT applications in industry and other fields as well. It has been established that it is necessary to continuously

5.4. Results of the analysis: IT applications (and future directions)

The procurement of new standards in 2013, as the basis for the knowledge and obligations that directly follow from these standards, requires a lot of money \((I_{viv/ISO/2013/P2})\) according to Eq. (12.1), \(I_{vin/ISO/2013/P1}\) according to Eq. (12.2) and (12.3):

\[
Y_{35.240/ISO/2000−2010/P0} = 993 \times 118
\]

\[
Y_{35.240/ISO/2000−2011/P1} = 957 \times 238.5
\]

\[
Y_{35.240/ISO/2004−2011/P1} = 102.3 \times x
\]

\[
I_{vin/35.240/ISO/2013/P2}\] according to Eqs. (12.4) and (12.5), Fig. 10b:

\[
Y_{35.240/ISO/2003−2012/P2} = 4925 \times e^{0.043x}
\]

\[
Y_{35.240/ISO/2003−2012/P2} = 0.701 \times x^{3/731}
\]

The difference between discontinuous and continuous improvement of the quality and level of individual knowledge is considerable (ranging from annual values \(I_{viv}\) — \(I_{viv/35.240/ISO/2013/P2} \approx 10000\) CHF, to values for several years, \(I_{viv/35.240/ISO/2011/D0}\) and \(I_{viv/35.240/ISO/2010/D0}\) — 92420 CHF and \(I_{viv/35.240/ISO/2010/D0}\) — 104672 (CHF), for Check 1 (or C1) and Act 1 (or A1) — 104672 CHF, Table 1 and Section 4.4). Thus, a cumulative financial \((I_{viv})\) and economic (\(I_{viv/35.240/ISO/2012/P1}\) and \(I_{viv/35.240/ISO/2010/P1}\)) contribution of research is important for the management of education projects and knowledge.

...
continuous checking of knowledge innovation in all subfields because of the need for future comparisons with the best.

What is critical is that the created pathways of standardised knowledge and financial resource (Iv), the corresponding organisation of human resources at the local level can produce better results. According to the trends present in the pathways of collective knowledge towards ISO documentation and projects under development, the obtained mathematical relations (presented trend lines, from the theoretical perspective), or individual knowledge of the stages of new project development (from the practical perspective), it is possible to anticipate future resources and financial requirements both as a whole and in terms of segments/subfields. The results of these analyses allow for the creation of an original methodology for the comparison of innovation in all technologies. This is achieved by defined indices which serve as criteria for grouping/clustering/ checking appropriate subfields and/or fields of human endeavour (see Section 5.3).

6.4. Future directions for improving knowledge and focus on IT applications in industry

The results of the analyses (for ICS-2 = 35.240 and ICS-2 = 25.040, see Section 5.4 and future directions for limiting aggregate criterion of value exceeds 30000 CHF! show an inability to access innovations for knowledge improvement: significant differences between discontinuous and continuous improvement of knowledge, the average annual requirement of new ISO SRPS documents under development, IT innovation on the pathway to knowledge innovation.

Although the subfield of IT applications has been extensively imbued with SRPS standards in recent years (because of Serbia's preparation for EU accession), it does not mean that the same trend will continue in the following years. On the other hand, the development trend of ISO standards is continuously supported by various technical committees.

Taking into consideration the criterion of value and the comparison of knowledge unit bases (ISO-SRPS), special attention should be given to future research in manufacturing engineering subfields with a focus on IT applications in industry (industrial automation systems; see Section 4.4).

Acknowledgements

The work presented here was supported by the Ministry of Education and Science of the Republic of Serbia (Project III 44006, http://www.mi.sanu.ac.rs/projects/projects.htm#interdisciplinary).

The author thanks Lena Tica for English language editing.

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