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Comparative Analysis of the Development and Application of Standards for Software Development in Serbia and BiH

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Abstract: *The paper analyzes and crosses the state of local SRPS and standardization from the neighboring state of Bosnia and Herzegovina BAS, in the field of information technologies. The accent is given on published standards; i.e. the standards currently in use in the field of Information Technology - ICS1 = 35; Substance Software - ICS2 = 35.080.*
Presented in the paper are the current standards in the field of software development as well as the organizations dealing with them, with reference to the state of local standardization in relation to the standardization of the neighboring country.
The aim of the research is to look at the status quo from several different aspects in the field of software development.
The results of the research indicate the current state and the position of local standardization in relation to the neighboring country and serve as an indicator of the necessary financial resources for software standards; and their mutual differences in number per year.

Keywords: *Software; Trend; Standardization; SRPS; BAS*

1. INTRODUCTION

Software Engineering is the youngest engineering discipline and, as such, still contains a high degree of arbitrariness and individuality. The process of software design itself is largely lacking in methods and techniques, as well as in appropriate tools to make it more efficient. Lack of development standards is even more pronounced. The significance of the problem is multiply emphasized by the need to ensure software quality and software-based systems.

The success of projects in each business, including in software engineering, is conditioned by the application of appropriate standardization. Software projects are becoming more and more complex, and there is a need for defining a formal project management process. Project management and the application of standardization aim at the efficient use of resources, the equal distribution of jobs and the establishment of a plan so that the project can be implemented within the deadline, as it is intended, with the envisaged way of execution and expected results. Although various standards have been developed, the percentage of unsuccessful projects is high. This tells us that further development and improvement of existing standards is needed in the future.

The presented research deals with comparative analysis of local (SRPS) and standards from the neighboring state of Bosnia and Herzegovina (BAS) in the field of Information technology - ICS1 = 35, sub-content Software - ICS2 = 35.080. The Information Technology area is standardized by the International Organization for Standardization (ISO) and the International Electrotechnical Commission for (IEC) [1].

The aim of the paper is to analyze the situation in the stated field of standardization and forecast future financial requirements for standards in the field of software.

2. METHODOLOGY AND FRAMEWORK OF RESEARCH

In this paper, a dynamic analysis methodology was used, as well as statistical methods for comparing groups of standards using the t - test.

The tasks and framework can be presented in the shortest terms through the PDCA concept:

P (Plan) - software development planning based on neighboring country (BAS) and local (SRPS) standardization

The collection of data on standardization of the neighboring state (BAS) and local (SRPS) standardization was done with the web presentations of the Institute for Standardization of Bosnia and Herzegovina and the Republic of Serbia.

During the selection, data related to standards in the field of Information technology were separated - ICS1 = 35 subclass Software - ICS2 = 35.080 with emphasis on current standards.

D (Do) - Comparison of group of standards

SRPS-BAS for Software Development in Information Technology. Comparison of the SRPS - BAS standard group for software development in the field of Information Technology was done using the t - test method.

C (Check) - check the intensity of innovation

The original methodology that quantifies the intensity in BAS-SRPS innovation can be applied to the standards in the field of Information Technology - ICS1 = 35; Substance Software - ICS2 = 35.080.

A (Act) - Analysis of results and improvement of application

Improving the application of the standard in the field of Information technology - ICS1 = 35 subaltern Software - ICS2 = 35.080 in Serbia implies the improvement of the methodology of innovating standards.

3. RESULTS AND DISCUSSION

Differences in the arithmetic mean of the sample $(\bar{x}_1\text{-}\bar{x}_2)$ will follow the t - test law if two independent independent sets of the size of N_1 and N_2 units whose variances are equal $\sigma_1^2 = \sigma_2^2$ are observed. Their unique value is estimated based on the variance. [2]

The value of the parameters t_0 is calculated based on the relation [3]:

$$t_0 = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{S_{(\bar{x}_1 - \bar{x}_2)}} \quad (1)$$

The estimate of the standard error of the difference in the arithmetic mean of the sample $S_{(\bar{x}_1 - \bar{x}_2)}$ is calculated as follows [4]:

a) If the data in the sample is ungrouped:

$$S_{(\bar{x}_1 - \bar{x}_2)} = \sqrt{\frac{\sum_{i=1}^{n_1} x_{i_1}^2 - n_1 \bar{x}_1^{\,2} + \sum_{i=1}^{n_2} x_{j_2}^2 - n_2 \bar{x}_2^{\,2}}{n_1 + n_2 - 2} \left(\frac{1}{n_1} + \frac{1}{n_2}\right)} \quad (2)$$

b) If the data in the sample is grouped:

$$S_{(\bar{x}_1 - \bar{x}_2)} = \sqrt{\frac{\sum_{i=1}^{n_1} x_{i_1}^2 f_{i_1} - n_1 \bar{x}_1^{\,2} + \sum_{i=1}^{n_2} x_{j_2}^2 f_{j_2} - n_2 \bar{x}_2^{\,2}}{n_1 + n_2 - 2} \left(\frac{1}{n_1} + \frac{1}{n_2}\right)} \quad (3)$$

In this case, the hypothesis reads:

$H_0 : (\mu_1 - \mu_2) = (\mu_1 - \mu_2)_0$; $H_1 : (\mu_1 - \mu_2) \neq (\mu_1 - \mu_2)_0$ (4)

$H_0 : (\mu_1 - \mu_2) \geq (\mu_1 - \mu_2)_0$; $H_1 : (\mu_1 - \mu_2) < (\mu_1 - \mu_2)_0$ (5)

$H_0 : (\mu_1 - \mu_2) \leq (\mu_1 - \mu_2)_0$; $H_1 : (\mu_1 - \mu_2) > (\mu_1 - \mu_2)_0$ (6)

The table value $t_{(\alpha, r)}$ reads the error rate α and r of the number of degrees of freedom, according to the formula [5]:

$$r = n_1 + n_2 - 2 \quad (7)$$

In order to examine the average annual number of standards in the field of software development, in two different countries, in this case in Serbia and BiH, in the random way from the first and second groups, they were selected for ten years, in which they were published, with the total number .

With a probability of 95%, it was tested:

1. Can the zero hypothesis H_0 be accepted that the difference in the average annual number of standards, by years, is incidental or statistically significant and depends on the country in which it is issued?
2. Can the zero H_0 hypothesis be accepted that the difference in the average number of standards in the above-mentioned area is not higher than 15 standards in the listed countries?

Table 1. *Overview of current SRPS / BAS standards on 20th March 2018, according to the number [6, 7]*

Year	Number of standards	
	SRPS	BAS
1998	1	2
2002	0	18
2004	1	16
2008	1	13
2010	10	28
2011	2	9
2012	15	9
2013	0	12
2015	17	5
2017	20	30
Total	67	142

Taking into account that the number of standards is at the level of one year, the frequency value f = 1 will be used.

The average annual number of standards is calculated as follows:

$$\bar{x}_{\text{SRPS}} = \frac{\sum_{i=1}^{n} x_i \cdot f_i}{\sum_{i=1}^{n} f_i} = \frac{67}{10} = 6.7 \text{ standards} \quad (8)$$

The average annual number of standards in the field of software development in Serbia on a sample of ten years is 6.7 standards.

$$\bar{x}_{\text{BAS}} = \frac{\sum_{i=1}^{n} x_i \cdot f_i}{\sum_{i=1}^{n} f_i} = \frac{142}{10} = 14.2 \text{ standards} \quad (9)$$

The average annual number of standards in the field of software development in BiH for a sample of ten years is 14.2 standards.

The estimate of the standard error of the arithmetic mean difference is calculated on the basis of formula (3):

$$S_{(\bar{x}_{SRPS}-\bar{x}_{BAS})} = \sqrt{\frac{1021 - 10 * 6.7^2 + 2768 - 10 * 14.2^2}{10 + 10 - 2} \cdot \left(\frac{1}{10} + \frac{1}{10}\right)}$$

$$S_{(\bar{x}_{SRPS} - \bar{x}_{BAS})} = 3.83 \quad (10)$$

Hypotheses are tested:
$H_0 : (\mu_1-\mu_2) = (\mu_1-\mu_2)_0$; $H_1 : (\mu_1-\mu_2) \neq (\mu_1-\mu_2)_0$, and the assumed difference $(\mu_1 - \mu_2) = 0$;
The value of parameters t_0 is calculated according to formula (1) and it is:

$$t_0 = \frac{6.7-14.2-0}{3.83} = -1.96 \quad (11)$$

For the risk of error a = 0.05 and the number of degrees of freedom r = 10 + 10 – 2 = 18 value $t_{(0.05;\ 18)} = \pm 2.101$.

Since $t_0 = -1.96 > t\ (0.05;\ 18) = -2.101$, the hypothesis H_0 is accepted at the risk of error a = 5% and it can be considered that the difference in the average annual number of standards in software development in Serbia and BiH coincidental and can be attributed to random variation of data in samples. The difference $\bar{x}_{SRPS} - \bar{x}_{BAS}$ = 6.7 - 14.2 = -7.5 is random. This means that the average annual number of standards does not depend on the country in which it is published.

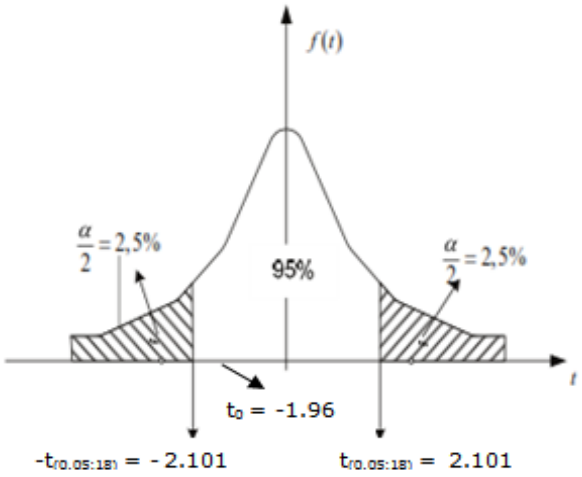

Figure 1. *Acceptance and rejection*
$H_0 : (\mu_1 - \mu_2) = 0$;
$H_1 : (\mu_1 - \mu_2) \neq 0$

2) The hypotheses in this case are:

$H_0 : (\mu_1 - \mu_2) \leq 15$ standards;

$H_1 : (\mu_1 - \mu_2) > 15$ standards;

This is a one-way test, the table value $t_{(0.10;\ 18)} = \pm 1.734$; (2α = 10%).

The value of parameters t_0 is calculated according to formula (1) and it is:

$$t_0 = \frac{6.7 - 14.2 - 15}{3.83} = -5.84 \quad (12)$$

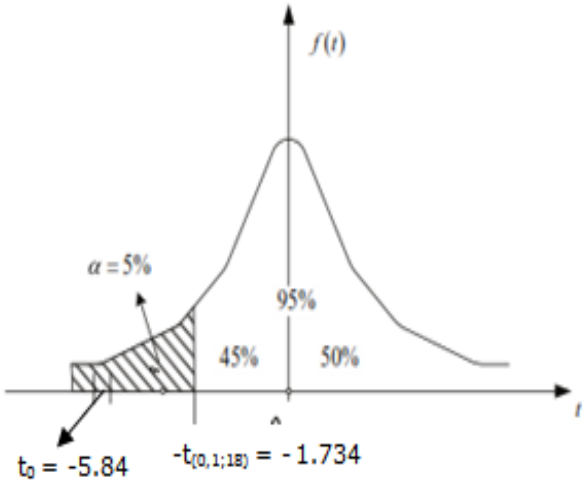

Figure 2. *Acceptance and rejection*
$H_0 : (\mu_1 - \mu_2) \leq 15$;
$H_1 : (\mu_1 - \mu_2) > 15$

Since $t_0 = -5.84 < t_{(0.10;\ 18)} = -1.734$, the H_0 hypothesis is not accepted, with the risk of error a = 5%, and it can not be considered that the difference in the average annual number of standards in software development in Serbia and BiH, less than 15 standards per year. The difference $\bar{x}_{SRPS} - \bar{x}_{BAS}$ = 6.7 - 14.2 - 15 = -22.5 is statistically significant and can not be attributed to the random variation of data in the samples.

In order to examine the average annual price of software development standards, in two different countries, in this case in Serbia and BiH, in the random way from the first and second groups, they were selected for ten years, in which they were published, with the total values standards.

With a probability of 95% testing:

1. Can the zero hypothesis H_0 be accepted? Is the difference in the average annual value of the standard, by age, random or statistically significant, and depends on the country in which it is issued?
2. Can the zero hypothesis H_0 be accepted that the difference in the average value of the standard in the above-mentioned area is not greater than 10 CHF;

Table 2. *Overview of current SRPS / BAS standards on 20th March 2018, by number and average value* [1]

Year	SRPS		BAS	
	Average value (CHF)	Number of standards	Average value (CHF)	Number of standards
1998	45.09	1	31.47	2
2002	0	0	35.95	18
2004	38.33	1	47.25	16
2008	42.7	1	31.41	13
2010	39.65	10	58.35	28
2011	31.82	2	66.87	9
2012	32.88	15	41.57	9
2013	0	0	48.88	12
2015	37.6	17	25.05	5
2017	36.87	20	49.08	30
Total	304.94	67	435.88	142

The average annual value of the standard is calculated using the data in Table 3, as follows:

Table 3. *Worksheet for calculation of SRPS standardization parameters*

Year	SRPS			
	Average value x_i	Number of standards f_i	x_i*f_i	$x_i^2*f_i$
1998	45.09	1	45.09	2033.108
2002	0	0	0	0
2004	38.33	1	38.33	1469.189
2008	42.7	1	42.7	1823.29
2010	39.65	10	396.5	15721.23
2011	31.82	2	63.64	2025.025
2012	32.88	15	493.2	16216.42
2013	0	0	0	0
2015	37.6	17	639.2	24033.92
2017	36.87	20	737.4	27187.94
Total	304.94	67	2456.06	90510.11

$$\bar{x}_{\text{SRPS}} = \frac{\sum_{i=1}^{n} x_i \cdot f_i}{\sum_{i=1}^{n} f_i} = \frac{2456.06}{67} = 36.66 \text{ CHF} \qquad (13)$$

[1] Average values are calculated on the middle exchange rate NBS on 20th March 2018, and the values are:

1 CHF = 100.8167 RSD = 1.67237 BAM

The average annual value of software development standards in Serbia for a sample of ten years is 36.66 CHF.

Table 4. *Worksheet for calculation of BAS standardization parameters*

Year	BAS			
	Average value x_i	Number of standards f_i	x_i*f_i	$x_i^2*f_i$
1998	31.47	2	62.94	1980.72
2002	35.95	18	647.1	23263.2
2004	47.25	16	756	35721
2008	31.41	13	408.33	12825.6
2010	58.35	28	1633.8	95332.2
2011	66.87	9	601.83	40244.4
2012	41.57	9	374.13	15552.6
2013	48.88	12	586.56	28671.1
2015	25.05	5	125.25	3137.51
2017	49.08	30	1472.4	72265.4
Total	435.88	142	6668.34	328994

$$\bar{x}_{\text{BAS}} = \frac{\sum_{i=1}^{n} x_i \cdot f_i}{\sum_{i=1}^{n} f_i} = \frac{6668.34}{142} = 46.96 \text{ CHF} \qquad (13)$$

The average annual value of software development standards in BiH for a sample of ten years is 46.96 CHF.

The estimate of the standard error of the arithmetic mean difference is calculated on the basis of formula (3):

$$S_{(\bar{x}_{\text{SRPS}}-\bar{x}_{\text{BAS}})} = \sqrt{\frac{90511.11-67*36.66^2+328944-142*46.96^2}{142+67-2} \cdot \left(\frac{1}{142}+\frac{1}{67}\right)}$$

$$S_{(\bar{x}_{\text{SRPS}}-\bar{x}_{\text{BAS}})} = 1.31 \qquad (14)$$

The average mean deviation of the difference in arithmetic mean in arithmetic mean samples in the basic set is 1.31 CHF.

Hypotheses are tested:

$$H_0 : (\mu_1 - \mu_2) = (\mu_1 - \mu_2)_0;$$
$$H_1 : (\mu_1 - \mu_2) \neq (\mu_1 - \mu_2)_0,$$

and the assumed difference $(\mu_1 - \mu_2) = 0$;

The value of parameters t_0 is calculated according to formula (1) and it is:

$$t_0 = \frac{36.66 - 46.96 - 0}{1.31} = -7.86 \qquad (15)$$

For the risk of error a = 0.05 and the number of degrees of freedom r = 67 + 142 - 2 = 207 value $t_{(0.05;\ 207)} = \pm 1.96$.

How is $t_0 = -7.86 > t_{(0.05;\ 207)} = \pm 1.96$, the hypothesis H_0 is not accepted at the risk of error a = 5% and it can not be considered that the difference in the average annual value of the standards in the field of software development in Serbia and BiH are random and can not be

attributed to random variation of data in samples. Difference $\bar{x}_{\text{SRPS}} - \bar{x}_{\text{BAS}}$ = 36.66 - 46.96 = -10.3 CHF is not a coincidence. This means that the average annual value of the standard is dependent on the country in which it is published in the specified area.

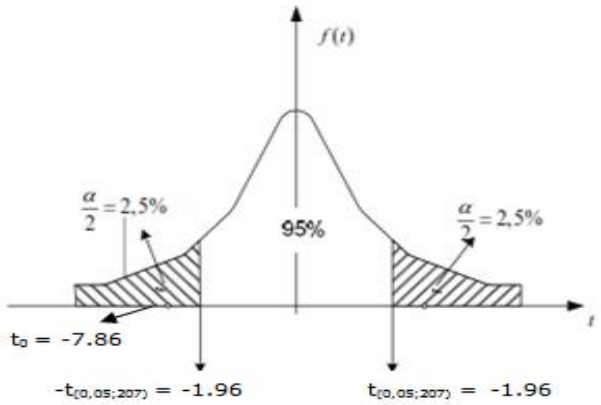

Figure 3. *Acceptance* and rejection

$H_0 : (\mu_1 - \mu_2) = 0;$

$H_1 : (\mu_1 - \mu_2) \neq 0$

2) The hypotheses in this case are:

$H_0 : (\mu_1 - \mu_2) \leq 10$ CHF;

$H_1 : (\mu_1 - \mu_2) > 10$ CHF;

This is a one-way test, the table value $t_{(0,10;\ 207)} = \pm 1.6448$; ($2\alpha$ = 10%).

The value of parameters t_0 is calculated according to formula (1) and it is:

$$t_0 = \frac{36.66 - 46.96 - 10}{1.31} = -15.5 \qquad (16)$$

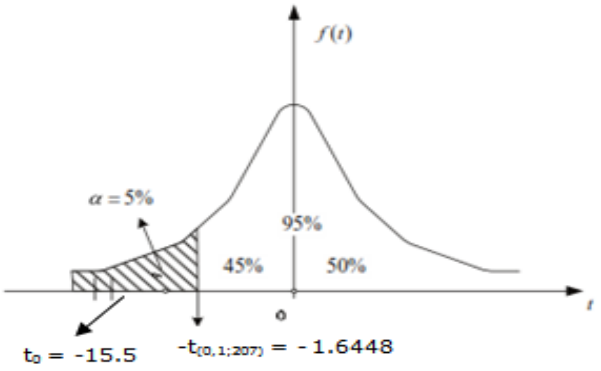

Figure 4. *Acceptance and rejection*

$H_0 : (\mu_1 - \mu_2) \leq 10;$

$H_1 : (\mu_1 - \mu_2) > 10$

How is t_0 = -15.5 < $t_{(0.10;\ 18)}$ = -1.6448, the H_0 hypothesis is not accepted, with the risk of error *a* = 5%, and the difference in the average annual number of standards in software development in Serbia and BiH, less than 15 standards per year. The difference

$$\bar{x}_{SRPS} - \bar{x}_{BAS} = 36.66 - 46.96 - 10 = -20.3$$

is statistically significant and can not be attributed to the random variation of data in the samples.

4. CONCLUSION

Concluding considerations can be presented in the shortest terms through the PDCA concept:

(P) Planning the necessary resources (only for access to standards and annual innovations goes beyond individual frameworks).

(D) Development of national standards in the field of Information Technology - ICS1 = 35, Substance Software - ICS2 = 35.080 implies continuous teamwork, as well as representation of innovation in accordance with the BAS / SRPS standardization platform with current projects of the neighboring country.

(C) The trend of local SRPS standardization should be in line with the standardization of neighboring BAS.

(A) Improving (development, application and accessibility of standards in Serbia) includes the development of software for on-line access to SRPS standardization.

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