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AN EXAMPLE OF THE INFORMATICS COURSES PARALLEL FREQUENCY & QUALITATIVE ANALYSIS

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The paper presents the complex method of the selected curriculum's quantitative and qualitative analysis and comparison. In the period of research, this method was tested by analysis/comparison of the selected Croatian Information systems curriculum with selected 1) Abroad curriculum model and 2) Croatian recommendation. The goals of the research are: a) to investigate quality and consistency more usual usage of the selected Croatian informatics graduate curriculum, and b) to present those processes as a method. Initial hypotheses are: a) as the compound category, the study/education quality primarily depends on curriculum quality, and b) quantitative/qualitative curriculum analysis and its comparison with selected model always can help with its improvement. The results of research were confirmed, and defined the hypothesis through following main conclusions: A) In comparison with both the selected Abroad curriculum model and Croatian recommendation, quantitative analysis has been showing a quite high quality on the selected Croatian Information systems university curriculum, and B) Detailed syllabus analysis confirmed results of the qualitative analysis. On several discussed examples, it was demonstrated how the sensitive points should be located of direct influence on curriculum improvement. Finally, it was concluded, that the presentation of complex method for curriculum quantitative analysis and comparison was successful. It was confirmed that proposed method always could be used in the proving of curriculum quality.

Keywords: information education, parallel frequency analysis, qualitative analysis.

1. INTRODUCTION

Information Sciences are a rather young and very dynamic scientific field. It's not easy to compose its education processes, especially those on the high level. Informatics education should be professional, stable and well defined, but at the same time modern, creative and flexible for any modification.

The solution of this problem is to establish a curriculum that will be a perfect compromise between classical education and global, contemporary tutorial study. This paper should be a first step to a final purpose.

The paper consists of four parts: *Introduction*, *Research*, *Results* and *Conclusion*. The introduction generally describes the work. The basic problem, hypothesis and goals of research are placed at the beginning of the second part. After that comes a description of employed methods/techniques of data collecting, preparing and processing. The second part finishes with the quantitative and qualitative indicators, i.e. data processing results review. The third part is concerned with interpretation and evaluation of results. As the synthesis of the whole work, the conclusion contains condensed presentation of procedures, results and suggestions for any possible improvements in the future.

2. RESEARCH

2.1. Problem, hypothesis and goals

Research, analysis and evaluation of an example of Informatics Graduate Curriculum; that are the basic problems which should be solved. This solution should give an answer to some questions, for instance:

- Is this curriculum good?
- How can we improve it?

In these terms, there are *two goals* of the research:

- to investigate the quality and consistency of the selected Croatian informatics graduate curriculum, and
- to present those processes as a method for objective analysis and evaluation of the curriculum,

and *two affirmative hypothesis*:

- as the compound category, the study/education quality primarily depends on curriculum quality, and
- quantitative/qualitative analysis of current curriculum and its comparison with selected optimal model can always help to its improvement or in making a new one.

2.2. Methods and techniques

Usually, for high-level curriculum evaluation we take *the curriculum objective analysis and evaluation method*, which consists of two subordinate methods: 1) *frequency subject's analysis method* and 2) *comparative analysis method*.

The best is to use both of them, but the first one is always basic. The other method has the role for a) comparison of the analysed curriculum with the selected optimal model, and b) control method for result's verification.

Ad 1)

The frequency subject's analysis method is a method for classification and quantification of several verbal and non verbal messages and their substantial and formal characteristics. It serves as the method for providing qualitative and quantitative examination of a document. For frequency analysis, the following should be determined 1) analysis unit, 2) subject's elements and 3) subject's categories, i.e. quantitative and qualitative classification criteria [14].

In context of this research, document (analysis unit) is the selected Croatian high-level curriculum we'll analyse. Its courses are analysis elements. The quantitative criteria are frequency (number of appearances). The qualitative criteria are relations between good, bad and neutral attributes of analysed curriculum.

This information should be the basis for 1) curriculum quality and acceptability evaluation and 2) suggestions for it's possible improvement.

Ad 2)

The goals of this research are identical to goals of Croatian university education: structure and quality of study have to be globally good and near worldwide noun development of the same scientific field - information sciences in this case. Therefore we will compare the selected Croatian curriculum with the abroad one, because we wish to know a) how good we in Croatia are and b) of any advantage or deficiency in our curriculum.

Usually, comparative analysis gives the answers of sophisticated questions, for instance:

- Subject and object of observation - how identical they are?
- What are the good points?
- Where are the weak points?
- Our curriculum - how can we improve it, if necessary.

In this research were used usual statistic techniques of 1) preparation: data grouping, counting recording, classification and categorization; 2) representation and processing: tables, percents, central values (median), χ^2-test (deviation degree of distribution), median-test and correlation coefficient; and 3) analysis: quantitative, qualitative, causal [2].

2.3. Data processing

For research and presentation of the curriculum objective analysis and evaluation method, two programs were needed: (a) one Croatian curriculum for analysis, and (b) one curriculum from abroad for comparison.

From Croatia, a curriculum of *Information sciences*, i.e. *Information systems* was chosen. From abroad, eleven studies were examined - eight American and three British. After detailed analysis, as the best one, the *University of Cambridge, U.K., Information systems education* was chosen.

Also, for internal structure examination, the Croatian curriculum was compared with *University of Zagreb Recommendation* about maximal acceptable teaching periods and proportional presence of required, elective and optional courses.

To ensure compatibility, data were prepared. After counting and recording both add comma instead of dash Croatian and Cambridge curriculums[1] were prepared and courses classified by relationship in three categories: *informatics*, *mathematics*, *others*. *CROATIA* was also classified by obligatoriness in: *required*, *elective*, and *optional* courses.

Finally, *CROATIA* was encoded. A course code (a letter plus 5-digits code) has following significance: (a) a letter: *course category*[2]; (b) first and second digit: *two semesters sign*[3]; (c) third digit: *course category*[4] and (d) fourth and fifth digit: *cur-*

[1] Because of need for objective and impartial access to results evaluating, those curriculums will be refened to as *Croatia* and *Cambridge*.
[2] A ⇒ informatics, B ⇒ mathematic, C ⇒ *others*
[3] 10=1. semester, 20=2. semester, 12=1. and 2. semester, and so far...
[4] 1=required, 2=elective, 3=optional

ricula appearance ordinal course number. Use of the course code makes possible - among other things - simple data understanding and sorting[5].

For *quantitative analysis*, some basic tables were prepared. In the first place, there are four tables (table 1 to 4) which represent *CROATIA* curriculum in the form of academic year teaching periods and category course overview. From their facts were composed the next four tables (table 5 to 8).

Tables 9 to 11 represent *CROATIA* and *CAMBRIDGE* compatible course lists. They were a source for tables 12 and 13 for the purpose of proportional and structural comparison between the above mentioned studies.

Data processing for *qualitative* syllabus[6] analysis was more complicated. No standard method exists for this step of research. Therefore, composed first was a database drawn *CROATIA* course syllabuses, i. e. theirs key subjects/words and their course codes. From this base were composed four tables, each for one academic year. They include relevant subjects classified by month of realisation, which made possible a horizontal (inside one year) and vertical (during all study) analysis. After that, those tables were sublimated to a new one with all the repeated and significant subjects. Because of their large size, it wasn't possible to present them here. Therefore - as illustration of sample data for qualitative analysis - the next four tables were combined:

a) - *Examined syllabus list* (table 14),
   - *Number of examined syllabus and noticed key subjects* (table 15)
b) - *Horizontal* (table 16) and
   - *Vertical* (table 17) *qualitative analysis: some significant key subjects.*

3. RESULTS

3.1. Quantitative analysis

CROATIA curriculum has a total of 54 courses 4155 teaching periods (tables 5 to 8). Most of them (66.7%) are required and 27.8% are elective courses The rest (5.6%) are optional. One academic year has on average 1038.75 teaching periods or 13.5 courses[7]. Courses are also classified in three categories

- *Informatics:* 33 courses (61.3%) with a total of 2475 teaching periods (56.2%), between them
  - 18 one-semester courses (1215 teaching periods) and 15 two-semester courses (1269 teaching periods), or
  - 22 required courses and 11 elective courses

[5] Here are some examples: (1) *System theory,* code A12106 means: category *informatics*, first and second semester, required, course number 06; (2) *Foreign language I.*, code C12235: category *others*, first and second semester, elective, number 35; and (3) *Introduction to technical & scientific work*, code C30350: category *others*, third semester, optional, number 50.

[6] Teaching program, curriculum

[7] 9 required, 3.75 elective and 0.75 optional

- *Mathematics:* 6 courses (10.9%) with a total of 600 teaching periods (14.5%): 1 one-semester course (90 teaching periods), 5 two semester courses (510 teaching periods) - all required, and
- *Others:* 15 courses (27.7%) with a total of 1530 teaching periods, between them
  - 7 one-semester courses (450 teaching periods) and 8 two-semester courses (1080 teaching periods), or
  - 8 required courses, 4 elective courses and 3 '*others*' courses

CAMBRIDGE curriculum course list (table 10) has altogether 43 courses; 26 (approximately 60%) informatics, 7 (approximately 16%) mathematics and 10 (approximately 23%). It was the base - together with table 8 for table 12 which was provided comparison from Croatian and Cambridge data. As we can see, those curriculum structures proportional are similar. It was attested by computed statistical values: percents, median and, especially χ^2-value, which is under permitted. But, correlation coefficient isn't quite high. On the scale of correlation[8] it means a 'small correlation'.

Because of obligatoriness structure of the proofing course, *CROATIA* has been compared also with *University recommendation* (table 13). Let us say something of this recommendation. It was implemented a few years ago. Its intention was global modernisation of study. It should be realised, among others, across the introduction of as many as possible elective and optional courses. In this direction, statistical results of comparison are plausibly negative. In fact, they should be explained as very good, because *CROATIA* proportional structure is much better than recommended.

It all means, in context of this research:

1. There are not important statistical distinctions between *CROATIA* and *CAMBRIDGE* curriculum structures. Applied to proportional share of each category, the curriculum mentioned are comparably good.
2. *CROATIA* obligatoriness structure is better than recommended.
3. It may be concluded:
   - In comparison with both *CAMBRIDGE curriculum* and *University recommendation*, quantitative analysis has shown a the higher quality of *CROATIA curriculum*.

3.2. Qualitative analysis

PART I.

Of greatest importance for a qualitative analysis were detailed *CROATIA* syllabus analysis, and horizontal and vertical comparison and analysis of their interdependence. Quantitative analysis gives us information on curriculum quality in general. As a supplemental method, qualitative analysis gives us more sophisticated information about details.

[8] 0-0.2 = none, 0.2-0.4 = small, 0.4-0.7 = middle, 0.7 and more = high correlation

Let us start with *CROATIA/CAMBRIDGE* course list comparison. There are 21 course groups (table 11). Only 6 of them[9] are completely identical. The rest of them were constituted by similarity. That is almost all we can conclude quantitatively. Qualitatively, there is much more.

The *Mathematics* category is a very good example. Because of through ness in mathematics fundamentals[10], it seems at first sight, that *CROATIA Mathematics* category is generally better than *CAMBRIDGE*. But, on the other hand, British specialized mathematics[11] are almost identical and practical aspects of *Mathematics* are even better than Croatian[12].

Informatics are also very interesting, especially subjects of *IS projecting and designing*. There are only two courses on the left, and eight on the right side, so it can be concluded that *CAMBRIDGE Informatics* is better than *CROATIA*. But, teaching periods (table 4) of *IS projecting & designing* discipline shows us that here is a question of the most important course of the IV academic year of *CROATIA*. Therefore, it isn't good to conclude anything before detailed analysis. It may be possible that this one discipline covers all the subjects of eight disciplines on the right.

Category *Others*, i.e. general-education subjects have two groups: economics and organization. There is nothing to say about similarity between *CROATIA* and *CAMBRIDGE curriculum*. It's rather good, but the placement of some *Others* inside *CROATIA* may be a little more to the benefit of initial informatics subjects and techniques.

Often, compared separate categories can be rather similar, but their internal structure can be different. Often, there are some quite unsymmetrical groups[13]. That is indicative but doesn't have to be negative. More complicated are those groups[14] which, without the detailed syllabus analysis, can be evaluated only by title. All expected answers can't be given by simple comparison of two curriculums. It has to be deepened through s detailed internal analysis, such as horizontal and vertical analyses of syllabuses. That is the role of the second part of the qualitative analysis.

PART II.

It was already explained how syllabuses were processed and why it wasn't possible to present whole results. As a model of analysis method, the illustrative examples will be discussed here (table 14 to 17).

Examined all together were 27 informatics and mathematics syllabuses (table 14.) with 628 key subjects. Table 15 illustrate their appearances inside this study. Most of them (237 or 37.7%) are, logically, from IV academic year.

[9] Informatics, Information theory, Software engineering, System theory, Deciding theory, Operational research and Probability & statistics
[10] Mathematics, Mathematics methods
[11] Decision theory may be more accurate – not familiar with subject, Operational researches
[12] More concrete aspects of Modelling and simulations, for instance no comma before ellipsis...
[13] Like this with IS economics. It has 5 courses on the left and only 2 courses on the right side
[14] The 6. group, for instance the 6. group with Operational systems, Data structures etc.

Tables 16 and 17 presents some significant key subjects prepared for horizontal and vertical qualitative analysis. That means: 1) horizontal: analysis of those subjects who appeared many times in *several courses of the particular year*, sometimes at the same time; and 2) vertical: analysis of those subjects who appeared many times in *several courses of several years*, sometimes also at the same time. On the basis of course code we know which course is a question about and when this subject was referred to. It's always important, but it hasn't been serious. Let us discuss presented examples.

Here is a discussion of 13 examples presented in tables 16 and 17. They were divided into 2 groups:

A) NECESSARY EXAMINATION

1. *CASE tools: introduction, Object analysis: basics* and *IS, classes and objects: attributes* (IV year): *IS projecting & designing* (November, December), *Special methods of IS projecting* (May, April). Checking. Possible overlap, but perhaps is here a question of teaching material linking.
2. *Dynamic allocation* (I. and II year): 1) *Programming I.* (April, I year), 2) *Programming II* (October, II year), 3) *Operational systems* (Mart, II year) and 4) *Computer architecture* (Mart, II year). Possible overlap, but, perhaps is here a question of presentation from different aspects.
3. *Dynamic lists, trees* (II year): appearing at the same time (November, December) in: 1) *Data structures* and 2) *Programming.* That can be a real problem, which has to be examined.
4. *Memory of computer* (II year): 1) *Operational systems* (November, Mart) and 2) *Computer architecture* (Mart, May). Checking.
5. *Models: Shannon, von Neumann* (II year): 1) *Information theory* (October), 2) *Computer architecture* (April). It has to be proved[15].
6. *Networks* (I year): word appears in three courses: 1) *INDOK* (November), 2) *Informatics* (January), and 3) *System theory* (June). Perhaps there is no problem here, however, an examination of this case is recommended, especially the relationship of *Informatics* and *System theory*. Both of them are introductory courses, perhaps here is the question of overlap.
7. *Operators, relational* (I and III year): 1) *Programming I.* (May, I year), and 2) *Data bases* (October, III year). This is probably a question of using (*Data bases)* something basic for many courses which already had to be learned earlier (*Programming I*). Case has to be examined.
8. *Sorting: algorithms and methods* (I and II year): 1) *Programming I* (May, I. year), 2) *Data structures* (January, II year). Possible overlap.
9. *Text and picture processing* (I, II and IV year): 1) *INDOK* (April, I year), 2) *Picture & text styling* (Mart, April, II year) and 3) *IS of production* (December, IV year). Possible overlap. That may be examined.

[15] Remark: there are many problems beetwen those two courses.

B) GOOD EXAMPLES

1. *Dynamic allocation* (II year): *Programming* (October) and *Operational systems* (April). That is probably good. First, *Programming* tech about handling techniques, then *Operational systems* about using.
2. *Object models:* (II and IV year): 1) *Operational systems* (November, II year) and 2) *IS projecting & designing* (October, IV year). A good example of study development: object systems researched in *Operational systems* have been in use in *IS projecting & designing.*
3. *Relations* (II year): word appears in two courses: 1) *Mathematics* (November) and 2) *Informatics* (December). By all indications, these are all right, because here is the question of different introductory categories which tackled a problem in a different manner.
4. *Systems* (I, II, III and II year): 1) *Informatics* (November, January, I year), 2) *System theory* (January, I year), 3) *Operational systems* (October to June, II year), 4) *Information theory* (October, II year), 5) *Office Automation* (October, II year), 6) *Software engineering* (October, March, June, III year), 7) *Expert systems* (October, December, June, III year), 8) *Data bases* (Mart, III year), 9) *Modelling & simulations* (March, IV year), 10) IS of production (April, IV year), 11) *Information technology on complex IS management* (March, IV year) and 12) *Special methods of IS projecting* (May, IV year). Keyword *Systems* is perhaps the best example that testifies the whole study integrity and quality. It may be used as control word for result's verification.

As the conclusion of qualitative analysis, comparison and mutual co-ordination was proposed for the following syllabus:

- *Informatics* and *System theory,*
- *Computer architecture* and *Information theory,*
- *Programming II*, *Operational systems* and *Data structures,*
- *IS projecting & designing* and *Special methods of IS projecting,*
- *Programming I*, *Computer architecture*, *Data structures, Operational systems* and *Programming I.*
- *Programming I* (I year), and *Data bases* (III year) and
- *INDOK* (I year), *Picture & text styling* (II year) and *IS of production* (IV year)

Because of multiple appearance of some disciplines[16], the possibility of their better placement inside study should be proved. It seems that they shouldn't be performed in the same time.

[16] *Programming*, *Operational systems* and *Data str*uctures, for example,

TABLES

Table 1. *CROATIA*: the I academic year course list

COURSE	Semester: teaching periods per week				TOTAL (semester = 15 weeks)
	AUTUMN		SPRING		
	Lectures	Exercises	Lectures	Exercises	
Required					
Informatics (A)	4	2	-	-	90
Mathematics (B)	2	2	2	2	120
Probability & statistics (B)	2	1	1	2	90
Fundamentals of economy (C)	3	3	-	-	90
Company/business organization (C)	2	1	2	1	90
System theory (A)	2	1	1	2	90
Programming I (A)	-	-	3	3	90
Communicology (A)	1	2	2	1	90
English for informaticians I (A)	1	1	1	1	60
Sports I (C)	-	2	-	2	60
Elective (minimal 90 teaching periods)					
Foreign language I (C)	2	1	1	2	90
Information/documentation systems(INDOK) (A)	3	1	-	-	60
Law for informaticians (A)	-	-	3	1	60
Minimal teaching periods (required+90 teaching periods elective)					*960*
Maximal teaching periods (required + all elective)					*1080*

Table 2. *CROATIA*: the II academic year course list

COURSE	Semester: teaching periods per week				TOTAL (semester = 15 weeks)
	AUTUMN		SPRING		
	Lectures	Exercises	Lectures	Exercises	
Required					
Data structures (A)	2	2	-	-	60
Business economics (C)	2	1	1	2	90
Operational systems (A)	2	1	1	2	90
Information theory (A)	2	2	-	-	60
Programming II. (A)	2	2	-	-	60
Mathematics methods for informaticians (B)	2	2	2	2	120
Computer architecture (A)	-	-	2	2	60
Communication on organization (C)	2	2	-	-	60
Technological systems (C)	-	-	3	1	60
English for informaticians II (A)	1	1	1	1	60
Sports II (C)	-	2	-	2	60
Elective (minimal 120 teaching periods)					
Foreign language II (C)	1	2	1	2	90
Office Automation (A)	2	2	-	-	60
Picture & text styling (A)	-	-	3	1	60
Optional					
Introduction to technical & scientific work (C)	2	2	-	-	60
Speech & writing culture (C)	2	2	-	-	60
Minimal teaching periods (required+120 teaching periods elective)					900
Maximal teaching periods (required + all elective + all optional)					1110

Table 3. *CROATIA*: the III academic year course list

COURSE	Semester: teaching periods per week				TOTAL (semester = 15 weeks)
	AUTUMN		SPRING		
	Lectures	Exercises	Lectures	Exercises	
Required					
Data communications & computer networks (A)	2	1	1	2	90
Software engineering (A)	2	2	2	2	120
Expert systems (A)	2	1	1	2	90
Operational researches (A)	2	1	1	2	90
Organizational theory (C)	2	2	-	-	60
Data bases (A)[17]	2	1	1	2	90
Formal methods for information technology (B)	2	1	1	2	90
Elective (minimal 180 teaching periods)					
Geographical information systems (GIS) (A)	2	2	-	-	60
Strategic management (A)	2	2	-	-	60
State & administrative IS (A)	-	-	2	2	60
Electronic data exchange (A)	-	-	2	2	60
Optional					
Foreign language III (C)	1	1	1	1	60
Minimal teaching periods (required + 180 teaching periods elective)					*810*
Maximal teaching periods (required + all elective + all optional)					*930*

Table 4. *CROATIA*: the IV academic year course list

COURSE	Semester: teaching periods per week				TOTAL (semester = 15 weeks)
	AUTUMN		SPRING		
	Lectures	Exercises	Lectures	Exercises	
Required					
IS of production (A)	2	1	1	2	90
IS projecting & designing (A)	2	2	2	2	120
Modelling & simulations (B)	3	3	-	-	90
Deciding theory (B)	2	1	1	2	90
Organizational projecting (C)	2	1	1	2	90
Informatical marketing (A)	2	1	1	2	90
Accounting IS (A)	2	1	1	2	90
Organization of IS development (A)	2	1	1	2	90
Elective (minimal 165 teaching periods)					
IS economics (A)	-	-	2	2	60
IS security (A)	-	-	2	2	60
IS of finances (A)	-	-	2	2	60
Special methods of IS projecting (A)	-	-	1	2	45
Information technology on complex IS management (A)	-	-	2	2	60
Minimal teaching periods (required + 165 teaching periods elective)					*915*
Maximal teaching periods (required + all elective + all optional)					*1035*

[17] it means Relational data bases

Table 5. *CROATIA*: courses per obligpertoriness

YEAR	NUMBER OF COURSES																TOTAL	
	REQUIRED				ELECTIVE				OPTIONAL				SUM					
	1-sem		2-sem		1-sem		2-sem		1-sem		2-sem		1-sem		2-sem			
	nr	%	nr	%	nr	%	nr	%	nr	%	nr	%	nr	%	nr	%	nr	%
I	3	5.5	7	13	2	3.7	1	1.8	-	-	-	-	5	9.2	8	14.8	13	24.1
II	6	11.1	5	9.2	2	3.7	1	1.8	2	3,7	-	-	10	18.5	6	11.1	16	29.6
III	1	1.9	6	11.1	4	7.4	-	-	-	-	1	1,9	5	9.3	7	13	12	22.2
IV	1	1.9	7	13	5	9.3	-	-	-	-	-	-	6	11.1	7	13	13	24.1
Σ	11	20.4	25	46.3	13	24.1	2	3.7	2	3,7	1	1.9	26	48.1	28	51.9	54	100

nr=number of courses

Table 6. *CROATIA*: teaching periods per obligatoriness

YEAR	TEACHING PERIODS																TOTAL	
	REQUIRED				ELECTIVE				OPTIONAL				SUM					
	1-sem		2-sem		1-sem		2-sem		1-sem		2-sem		1-sem		2-sem			
	h	%	h	%	h	%	h	%	h	%	h	%	h	%	h	%	h	%
I	270	6.5	600	14.4	120	2.9	90	2.2	-	-	-	-	390	9.4	690	16.6	1080	26
II	360	8.7	420	10.1	120	2.9	90	2.2	120	2,9	-	-	600	14.4	510	12.3	1110	26.7
III	60	1.4	570	13.7	240	5.8	-	-	-	-	60	1.4	300	7.2	630	15.2	930	22.4
IV	90	2.2	660	15.9	285	6.8	-	-	-	-	-	-	375	9	660	15.9	1035	24.9
Σ	780	18.8	2250	54.1	765	18.4	180	4.4	120	2,9	60	1.4	1665	40	2490	60	4155	100

h=teaching periods

Table 7. *CROATIA*: teaching periods per category

YEAR	TEACHING PERIODS																TOTAL	
	INFORMATICS(A)				MATHEMATIC(B)				*OTHERS* (C)				SUM					
	1-sem		2-sem		1-sem		2-sem		1-sem		2-sem		1-sem		2-sem			
	h	%	h	%	h	%	h	%	h	%	h	%	h	%	h	%	h	%
I	330	7.9	150	3.6	-	-	210	5.1	150	3,6	240	5,8	480	11.5	600	14.5	1080	26
II	360	8.7	150	3.6	-	-	120	2.8	240	5.8	240	5.8	600	14.5	510	12.2	1110	26.
III.	240	5.8	480	11.5	-	-	90	2.2	60	1.4	60	1.4	300	7.2	630	15.1	930	22.
IV	285	6.9	480	11.5	90	2.2	90	2.2	-	-	90	2.2	375	9.1	660	15.9	1035	24.
Σ	1215	29.3	1260	30.2	90	2,2	510	12.3	450	10.8	630	14.8	1755	42.1	2400	57.7	4155	100

h=teaching periods

Table 8. *CROATIA*: courses per category

YEAR	NUMBER OF COURSES																TOTAL	
	INFORMATICS(A)				MATHEMATIC(B)				*OTHERS* (C)				SUM					
	1-sem		2-sem		1-sem		2-sem		1-sem		2-sem		1-sem		2-sem			
	nr	%	nr	%	nr	%	nr	%	nr	%	nr	%	nr	%	nr	%	nr	%
I	3	5.6	3	5.6	-	-	2	3.7	2	3.7	3	5.6	5	9.3	8	14.9	13	24.1
II	6	11.1	2	3.7	-	-	1	1.8	4	7.4	3	5.6	10	18.5	6	11.2	16	29.6
III	4	7.4	5	9.3	-	-	1	1.8	1	1.8	1	1.8	5	9.3	7	13	12	22.2
IV	5	9.3	5	9.3	1	1,8	1	1.8	-	-	1	1.8	6	11.1	7	13	13	24.1
Σ	18	3.4	15	27.9	1	1,8	5	9.1	7	12.9	8	14.8	26	48.2	28	52.1	54	100

nr=number of courses

Table 9. *CROATIA*: course list: categories/alphabet

Course	*Code*
Informatics	
1. Accounting IS	A78133
2. Communicology	A12108
3. Computer architecture	A40117
4. Data bases	A56125
5. Data communications &computer networks	A56120
6. Data structures	A30111
7. Electronic data exchange	A60244
8. English for informaticians I, II	A12109
9. Expert systems	A56122
10. Geographical information systems (GIS)	A50241
11. Informatical marketing	A78132
12. Informatics	A10101
13. Information technology on complex IS management	A80249
14. Information theory	A30114
15. Information/documentation systems (INDOK)	A10236
16. IS economics	A80245
17. IS of finances	A80247
18. IS of production	A78127
19. IS projecting & designing	A78128
20. IS security	A80246
21. Office Automation	A30239
22. Operational systems	A34113
23. Organization of IS development	A78134
24. Picture & text styling	A40240
25. Programming I	A20107
26. Programming II	A30115
27. Software engineering	A56121
28. Special methods of IS projecting	A80248
29. State&administrative IS	A60243
30. Strategic management	A50242
31. System theory	A12106
Mathematics	
1. Deciding theory	B78130
2. Formal methods for information technology	B56126
3. Mathematics	B12102
4. Mathematics methods for informaticians	B34116
5. Modelling & simulations	B70129
6. Operational researches	B56123
7. Probability & statistics	B12103
Others	
1. Business economics	C34112
2. Communication on organization	C30118
3. Company/business organization	C12105
4. Foreign language I	C12235
5. Foreign language II	C34238
6. Foreign language III	C56351
7. Fundamentals of economy	C10104
8. Introduction to technical & scientific work	C30350
9. Law for informaticians	C20237
10. Organizational projecting	C78131
11. Organizational theory	C50124
12. Speech & writing culture	C30352
13. Sports I and II	C12110
14. Technological systems	C40119

Table 10. *CAMBRIDGE* course list: categories/alphabet

Course	*Category*
Informatics	
1. Applied communicology	A
2. Communicology	A
3. Company IS	A
4. Computer networks & communications	A
5. Data processing methods	A
6. Designing IS, methodology	A
7. Designing IS, problems	A
8. Designing IS, technics	A
9. Expert systems	A
10. Fundamentals of informatics	A
11. Fundamentals of informatics	A
12. Hardware & software systems	A
13. Information processing	A
14. Interface	A
15. IS application: selected areas	A
16. IS design	A
17. IS organization	A
18. Office automation	A
19. Planning & policy of IS	A
20. Programming	A
21. Projecting IS	A
22. Science, information, data	A
23. Software engineering	A
24. Special techniques	A
25. Storage, research & managing information	A
26. System theory	A
27. Technological computer development	A
Mathematics	
28. Deciding	B
29. Discrete mathematics & logic	B
30. Introduction to operational researches & statistics techniques	B
31. Modelling: application	B
32. Practical aspects of modelling & simulation	B
33. Principles of modelling & simulation	B
34. Probability & statistics	B
Others	
35. Company modifications	C
36. Designing	C
37. Economics	C
38. Philosophy, policy & economics of IS	C
39. Finances & accounting	C
40. Management principles	C
41. Organization theory approach	C
42. Society goals & tasks	C
43. Sociology	C
44. Technology & society	C

Table 11. *CROATIA/CAMBRIDGE* course list: comparison

	CROATIA	*CAMBRIDGE*
INFORMATICS	Accounting IS IS of finances	Finances & accounting
	Communicology Communication on organization	Applied communicology Communicology
	Computer architecture Information technology on complex IS management	Technological computer development Hardware & software systems
	Geographical information systems (GIS) Informatical marketing IS economics IS of production State & administrative IS	Company IS Company modifications
	Data communications & computer networks Electronic data exchange	Computer networks & communications
	Operational systems Data structures Data bases IS security	Data processing methods Information processing Special techniques Storage, research & managing information
	Informatics	Fundamentals of informatics
	Information theory	Science, information, data
	IS projecting & designing Special methods of IS projecting	Designing Designing IS, methodology Designing IS, problems Designing IS, technics IS application: selected areas IS design Planning & policy of IS Projecting IS
	Office Automation Picture & text styling Information/documentation systems	Office automation Interface
	Programming I Programming II	Programming
	Software engineering	Software engineering
	System theory	System theory
MATHS	Deciding theory	Deciding
	Formal methods for information technology Mathematics Mathematics methods for informaticians	Discrete mathematics & logic
	Modelling & simulations	Practical aspects of modelling & simulation Modelling: application Principles of modelling & simulation
	Operational researches	Introduction to operational researches & statistics techniques
	Probability & statistics	Probability & statistics
OTHERS	Business economics Fundamentals of economy Law for informaticians Technological systems	Economics Philosophy, policy & economics of IS Society goals & tasks Sociology Technology & society
	Company/business organization Organizational theory Organization of IS development Organizational projecting Strategic management	IS organization Organization theory approach Management principles
	Introduction to technical & scientific works English for informaticians I and II Foreign language I, II and III Speech & writing culture Sports I and II	None

Table 12. *CROATIA/CAMBRIDGE*: curriculum structure

STUDIES	NUMBER OF COURSES						TOTAL	
	INFORMATICS		MATEMATICS		*OTHERS*			
	freq[18]	%	freq	%	freq	%	freq	%
CROATIA	33	34	6	6.2	15	15.5	54	55.7
CAMBRIDGE	26	26,8	7	7.2	10	10.3	43	44.3
TOTAL	59	60,8	13	13.4	25	25.8	97	100
Central value (median) $\Rightarrow$ 12,5; $\chi^2 \Rightarrow$4,528; marginal $\chi^2 \Rightarrow$5,991; correlation coefficient=0,35								

Table 13. *University recommendation/CROATIA*: teaching periods per obligatoriness

CATHEGORY	TEACHING PERIODS PER YEAR											
	UNIVERSITY		*CROATIA*									
			I YEAR		II YEAR		III YEAR		IV YEAR		AVERAGE	
	freq	%	freq	%	freq	%	freq	%	freq	%	freq	%
R	747	83.0	870	80.6	780	70.3	630	67.7	750	72.5	757	73
E	117	13.0	210	19.4	210	18.9	240	25.8	285	27.5	236	22.7
O	36	4.0	-	-	120	10.8	60	6.5	-	-	45	4.3
TOTAL	900	100	1080	100	1110	100	930	100	1035	100	1038	100
median $\Rightarrow$176,5; $\chi^2 \Rightarrow$62,389; marginal $\chi^2 \Rightarrow$5,991												

R=Required, E=Elective, O=optional

Table 14. *CROATIA*, qualitative analysis: examined syllabus list

Syllabus	*Code*
I year	
1. Informatics	A10101
2. Information/documentation systems (INDOK)	A10236
3. System theory	A12106
4. Communicology	A12108
5. Mathematics	B12102
6. Programming I.	A20107
II year	
1. Data structures	A30111
2. Information theory	A30114
3. Programming II.	A30115
4. Office Automation	A30239
5. Operational systems	A34113
6. Computer architecture	A40117
7. Picture & text styling	A40240
III year	
1. Geographical information systems (GIS)	A50241
2. Data communications & computer networks	A56120
3. Software engineering	A56121
4. Expert systems	A56122
5. Data bases	A56125
6. Operational researches	B56123
7. Formal methods for information technology	B56126
IV year	
1. Modelling & simulations	B70129
2. IS of production	A78127
3. IS projecting & designing	A78128
4. IS economics	A80245
5. IS security	A80246
6. Special methods of IS projecting	A80248
7. Information technology on complex IS management	A80249

[18] frequency

Table 15. *CROATIA*, qualitative analysis: examined syllabus and noticed key subjects

Category	I YEAR		II YEAR		III YEAR		IV YEAR		TOTAL	
	freq	%	freq	%	freq	%	freq	%	freq	%
Courses	6	22.3	7	25.9	7	25,9	7	25.9	27	100
Subjects	128	20.4	131	20.9	132	21	237	37.7	628	100

Table 16. *CROATIA*, HORIZONTAL qualitative analysis: some significant key subjects

SUBJECTS	COURSE CODE							
	Oct	Nov	Dec	Jan	Mar	Apr	May	Jun
I year								
Networks		A10236		A10101				A12106
Relations		B12102	A10101					
II year								
Dynamic data	A30115							
Lists		A30111						
Lists		A30115						
Trees			A30111					
Trees			A30115					
Dynamic allocation	A30115					A34113		
Models: Shannon, von Neumann	A30114				A40117			
IV year								
CASE tools: introduction		A78128					A80248	
Object analysis: basics			A78128			A80248		
IS, classes and objects: attributes			A78128			A80248		

Table 17. *CROATIA*, VERTICAL qualitative analysis: some significant key subjects

SUBJECTS	COURSE CODE							
	OCT	NOV	DEC	JAN	MAR	APR	MAY	JUN
Memory								
of computer		A34113			A34113		A40117	
of computer					A40117			
dynamic allocation						A20107		
dynamic allocation	A30115					A34113		
dynamic allocation						A40117		
Models: object	A78128		A34113					
Processing								
picture			A78127			A40240		
text						A10236		
text/picture					A40240			
Operators, relational	A56125						A20107	
Sorting: algorithms and methods				A30111			A20107	
Systems, I year								
operation		A10101						
numeric				A10101				
technique						A12106		
Systems, II year								
operational (general),	A34113							
operational (examples)								A34113
of communication	A30114							
office	A30239							
multiprocessing		A34113						
of data			A34113					
of computers				A34113				
of files							A34113	
Systems, III year								
of programs	A56121							
expert	A56122							
of production			A56122					
of management					A56121			
formal					A56125			
development								A56121
intelligent								A56122
Systems, IV year								
dynamic				B70129				
Just-in-time					A78127			
C^2, C3 and C^3I					A80249		A80248	

4. CONCLUSION

It is very difficult to develop a new curriculum. Nor is it easy to improve an existing one. It has to be[19] in accordance - inside one academic year, as during the study - with law, university recommendation and global science development. Syllabuses, teachers, literature and equipment have to be excellent.

The situation is even more difficult with the question of dynamic sciences such as Informatics. There is always a contradiction between education and theory on the one side and praxis on the another. If praxis is too fast, education has problems to catching up with. It's like closed circle: first 1) people wish to satisfy their own needs, that 2) result in new solutions, which 3) are the basis for scientific development, which 4) de-

[19] Primarily on teaching periods per one academic year

livers it's cognition to education/students, who 5) start working to satisfy people's needs.....

This paper occupied with similar problems. Starting with two hypotheses[20], the paper presents the complex method of selected curriculum's quantitative and qualitative analysis and comparison.

In the period of research, the mentioned method was tested by analysis/comparison of the selected Croatian *Information systems* curriculum. The results of research confirmed the defined hypothesis through following main conclusions:

I. In comparison with both selected *Abroad curriculum model* and *Croatian recommendation*, quantitative analysis has been showing a quite high quality of selected Croatian *Information systems* university curriculum.

II. As method of verification and obtaining refined recommendations for curriculum improvement, detailed syllabus analysis confirmed results of qualitative analysis. On several discussed examples, it was demonstrated how the sensitive points of direct influence on curriculum improvement should be located.

Opposite the quantitative analysis results, which ordinarily are obligatory, the results of detailed syllabus analysis often have only an advisory purpose which, because of the university teacher's intellectual independence, usually are not prescriptive. Their purpose is, at best, to identify the problem. It is the teacher's decision, often in consultation with his colleagues, to discuss, evaluate and accept the advice.

Finally, it may be concluded, that the presentation of the complex method for curriculum quantitative analysis and comparison was successful. It was confirmed that the proposed method could always be used in proving curriculum quality. Its general references were given in this paper.

4. REFERENCES

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[20] a) Quality of study primarily depends of the curriculum quality and b) curriculum analysis/comparison always can help in its improvement

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PRIMJER PARALELNE ANALIZE FREKVENCIJA I KVALITATIVNE ANALIZE INFORMATIČKIH PREDMETA

Sažetak

U radu se primjenjuje kompleksna metoda kvantitativne i kvalitativne analize izabranih nastavnih programa. U dijelu istraživanja, spomenutom metodom izabrani domaći predložak kurikuluma u području informacijskih sustava analiziran je i uspoređen s izabranim 1) inozemnim modelom kurikuluma istog područja i 2) sveučilišnim preporukama za ustroj kurikuluma u Hrvatskoj. Ciljevi istraživanja bili su: a) ispitivanje kvalitete i konzistentnosti izabranog visokoškolskog hrvatskog kurikuluma i b) primjena postupka analize/usporedbe u svojstvu metode objektivne analize i vrednovanja. U radu su postavljene slijedeće hipoteze: a) kvaliteta studija/edukacije kao složena kategorija ovisi u prvom redu o kvaliteti kurikuluma i b) kvantitativna/kvalitativna analiza kurikuluma i njegova usporedba s izabranim modelom doprinosi detekciji slabijih dijelova i uvijek može pomoći u postupku poboljšanja promatranog kurikuluma. Rezultati istraživanja potvrdili su postavljene hipoteze: A) u dijelu kvantitativne i kvalitativne analize, usporedba promatranog sveučilišnog kurikuluma s izabranim inozemnim modelom i sveučilišnim preporukama, pokazana je njegovu visoku kvalitetu, B) detaljna analiza programa pojedinačnih kolegija potvrdila je dobivene rezultate, C) na osnovi konkretnih primjera pokazano je na koji način se analizom mogu locirati slabe točke i njihovim otklanjanjem direktno utjecati na poboljšanja kurikuluma. Potvrđeno je da je metoda kvalitativne analize i uspoređivanja uspješno primijenjena i da se ponovljeno može koristiti u postupku ispitivanja kvalitete kurikuluma u i drugih područja.

Ključne riječi: informatičko obrazovanje, paralelna analiza frekvencija, kvalitativna analiza.