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Contents

DESIGN OF A WORKFLOW SYSTEM TO IMPROVE DATA QUALITY USING ORACLE WAREHOUSE BUILDER[1]

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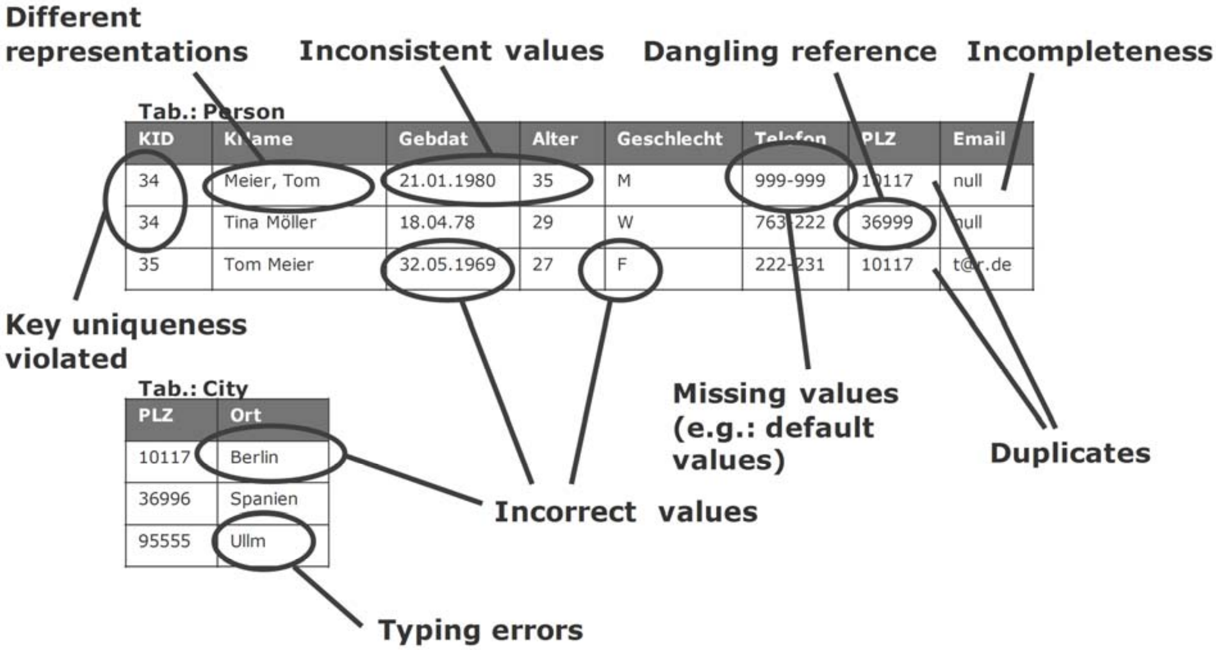
Abstract: We are concerned with the development of a workflow system for data quality assurance. The approach is based on the Oracle Warehouse Builder (OWB) in its latest available version. We motivate the data quality problem mainly companies are faced to, discuss some basics about data quality assurance of (mostly) non-metric data, and introduce our proposal for a workflow machine. We very shortly present some striking features, i.e. the architecture and data quality cycle of the Oracle Warehouse Builder having set the "Data Quality Option". Next we report about our software DaRT , an acronym representing Data Quality Reporting Tool. We close with some remarks and perspectives for ongoing research.

Key words: data quality; Oracle Warehouse Builder; OWB; DaRT

1. Motivation and Basics

Given a database and/or data at the data entry a data conflict exists if the data collected is not fit for use related to purposes and quality targets of a given company. Such data conflicts are represented in Table 1 below.

Table 1. Typical data conflicts arising in the business domain



The big trouble makers are errors, missing values as a kind of incompleteness and duplicates. We can classify the data conflicts according to conflicts which exist in the schema, i.e. exist as schema conflicts in the database schema – even before any data entry, and data conflicts which are bounded to the data set itself. We can summarize the "problem sphere" according to the following so called dimensions of data quality; cf. Batini & Scannapieco (2006):

- Accuracy;
- Completeness;
- Time related dimension:
  - currency;
  - volatility;
  - timeliness;
- Consistency.

While computer scientists like Chrisman (1984) coined the slogan "Data Quality is Fitness for use", we prefer the extended version saying "Data Quality is Fitness for use given a purpose". Alternatively, we may stick to Wertz (1915): "Quality reflects the ability of an object to meet the purpose". The purpose of data quality control is mandatory. It would be rubbish to first compute business or economic aggregates and then locate errors in the derived figures and reject them. Validation rules are a generic part of metadata management and are mandatory for any modern statistical information system or, synonymously, data warehouse.

2. Design of a Workflow System for Data Quality Improvement

There exists a lot of experience and self-evidence that data quality of economic or business information systems based on modern relational databases can be achieved by data quality checks, i.e. semantic rules, statistical tests, and validation rules (logical and numerical edits).

- Semantic Checks
  - Inspection /Comparing of real data against metadata
  - Ex.: Estimation of the completeness of an attribute (simple ratio)

$$Q_V(A) := 100 \cdot \frac{\sum_{i=1}^{|A|}(null(w_i))|}{|A|}$$

$$null(w) := \begin{cases} 0, & \text{falls w = Null} \\ 1, & \text{sonst.} \end{cases}$$

- Statistical Measures
  - Exploration and Analysis of a data set or database by descriptive statistics like (Minimum, Maximum, arithmetic Mean, Median, Standard Deviation, (quite obscure) Six Sigma Rule as preferred by non statisticians etc.)

- Validation Rule Sets
  - Checking of real data using business or economic rules of type „if…then…"

- Edits as simple, logical or numerical statements, cf. Boskovitz (2008), as well as statistical or fuzzy logic based edits, cf. Köppen and Lenz (2006).

The coding of checks, statistical measures and edits for DQ reporting is simple but very tedious. We give below an example of the PL/SQL source code for a very quick and dirty outlier detection of attribute x using a three-sigma rule as $|x\text{-avg}| > 3\sigma$.

```
DECLARE
        l_prj VARCHAR2(4000) := NULL;
        l_sql VARCHAR2(4000) := NULL;
BEGIN
l_sql := 'SELECT *
         FROM '|| :P_TABLENAME ||'
         WHERE '|| :P_COLUMN ||' >
         (
             SELECT AVG_VALUE + (3 * STDDEV_VALUE)
             FROM ALL_IV_PROFILE_COLUMNS          /* Public View */
             WHERE COLUMN_ID = '|| :P_COLUMNID ||'
         )
```

```
                OR '|| :P_COLUMN ||' <
                (
                        SELECT AVG_VALUE - (3 * STDDEV_VALUE)
                        FROM ALL_IV_PROFILE_COLUMNS          /* Public View */
                        WHERE COLUMN_ID = '|| :P_COLUMNID ||'
                )
                ';
RETURN l_sql;
END;
```

If any data quality management is trying to do so the question arises how to proceed, and what kind of road map exists to "produce data quality. The straight fort answer to this question is using a workflow machine for data quality improvements. We sketch in Figure 1. a taxonomy of data quality (DC) criteria which forms the basement of our proposal of such a workflow.

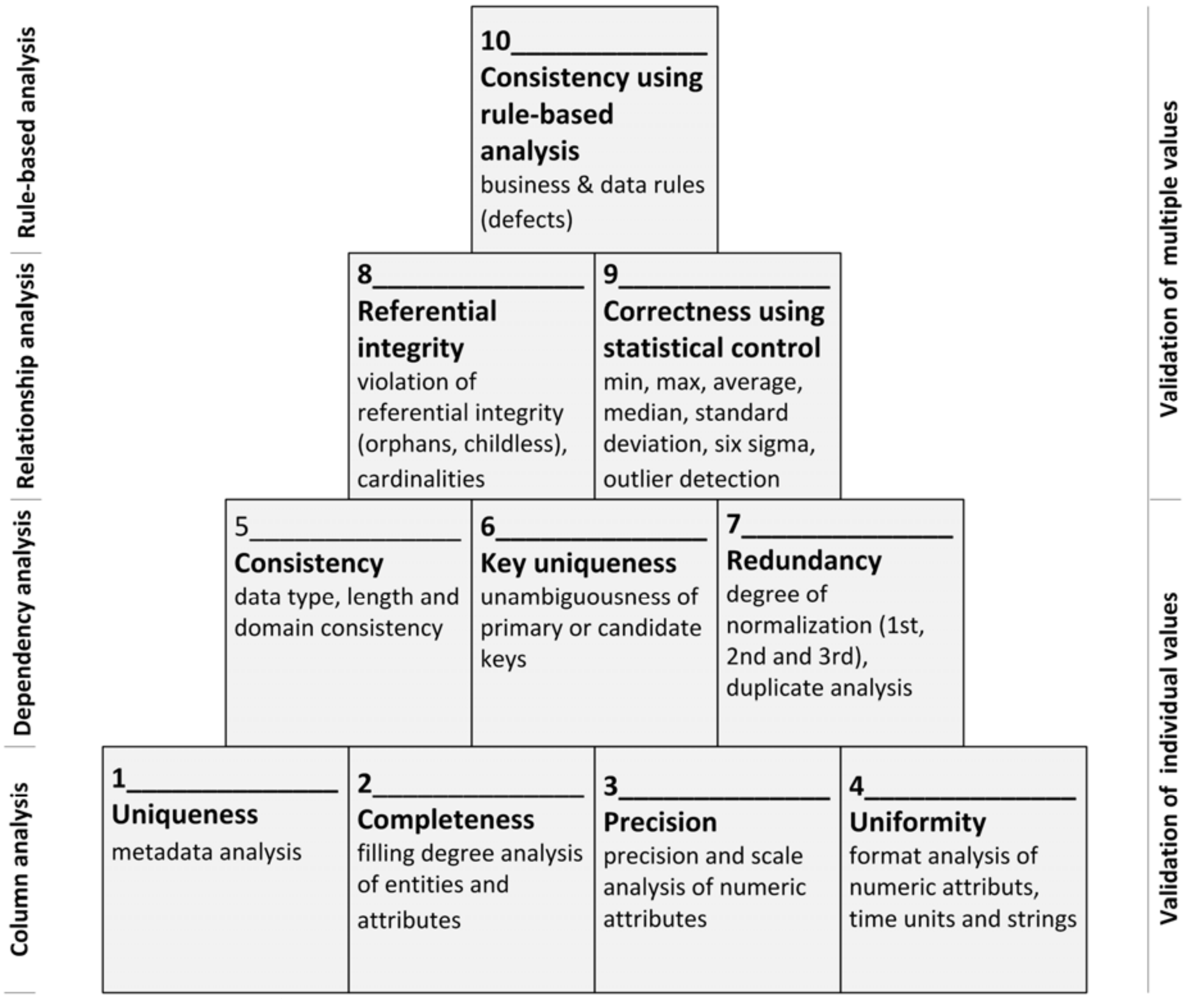


Figure 1. Taxonomy of data quality criteria used in DaRT – a new data quality reporting tool

3. Oracle Warehouse Builder (OWB) with "Data Quality Option"

As our DQ workflow machine is an added-on to the Oracle Warehouse Builder we show below a diagram which explains the architecture to some degree. Of course, further details would need more pages which are limited in this paper due to given restrictions.

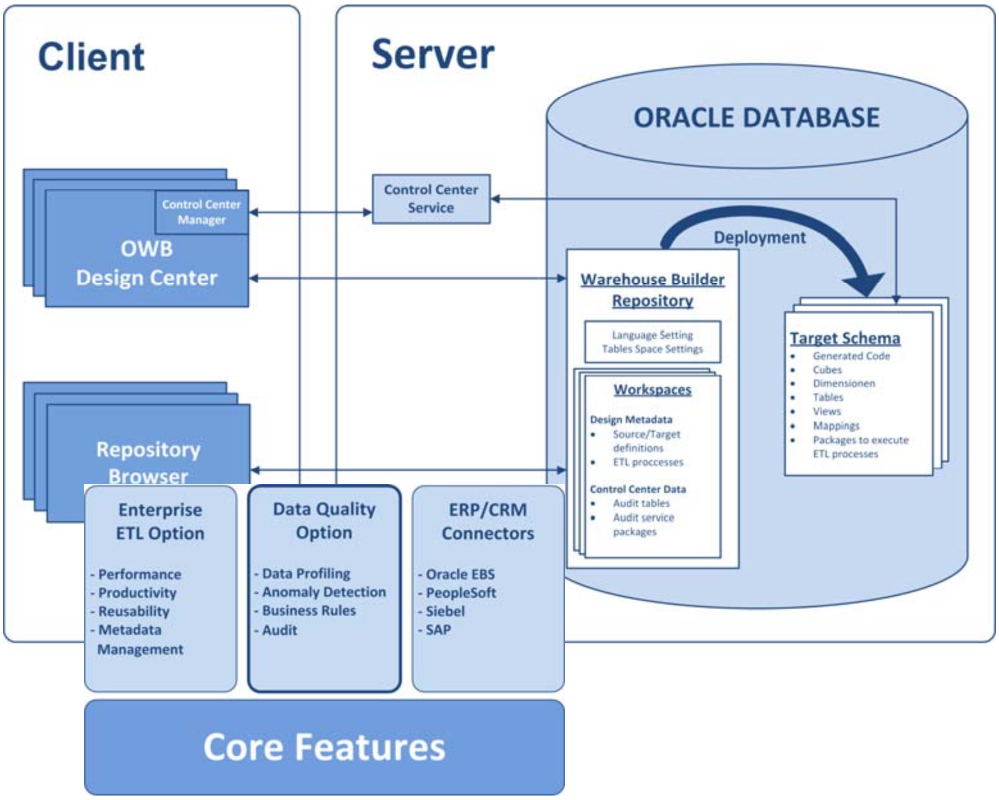
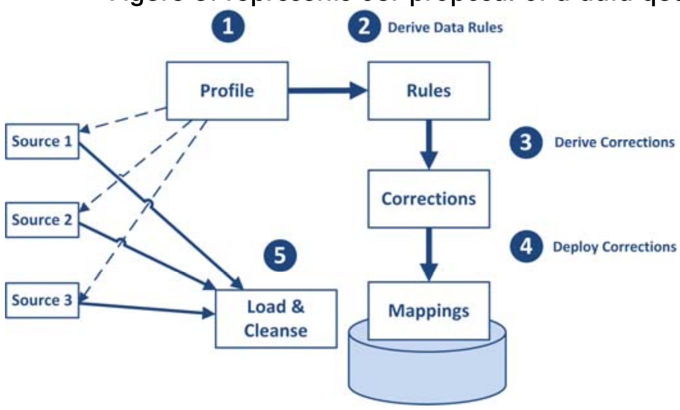


Figure 2. OWB Architecture with Data Quality Option (Source: Oracle 2007a)

It is evident from Figure 2. that DaRT is embedded into a client server architecture. This does not give any hints which steps are necessary for data quality improvement. Moreover, the archi-tectture is perpendicular on how these steps are sequenced. This view on our DQ engine is represented in the following chapter**.**

4. The Data Quality Cycle

Figure 3. represents our proposal of a data quality circle.



.
Figure 3. Data Quality Cycle of DaRT within OWB

The five steps are to some extent self evident. According to our definition of DQ as "Fitness for use given a Purpose" we start with a target and profiling on stage 1. Then the rules to be used come in a stage 2, followed by error location and correction in step 3-4, and finally by loading and cleansing data in step 5.

5. The Data Quality Reporting Tool - DaRT

The next point we have to consider is the extent of data quality activities or the functionality of DQ covered by DaRT. For the sake of compactness of discussion we present just a diagram which, as we believe, says more than one thousand words.

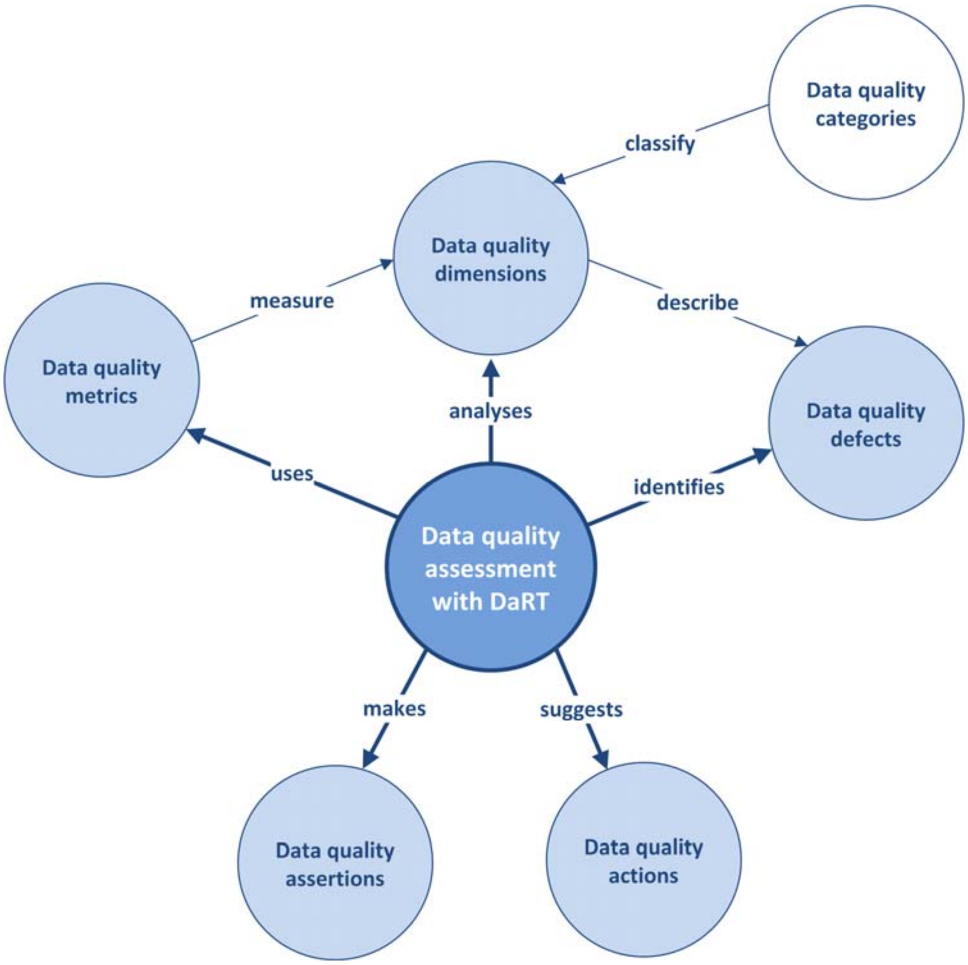


Figure 4. DaRT – Data Quality Reporting Tool

6. The Meta Database Model for Data Quality

Our workflow engine "DaRT" is not completely explained without displaying the conceptual schema of the underlying meta database system. The entity types are to some extent self evident. We have a relation with attributes, quality characteristics and quality dimensions or categories. The quality indicators have a so called "quality metric", and are used for metering data quality, accordingly. Of course, data quality specifications ("purpose" of data quality above), statements or judgements about current data quality of a table, and quality actions are to be considered further. We collect these views together in the conceptual schema as "DaRT inside" underpinning the data quality engine in Figure 5.

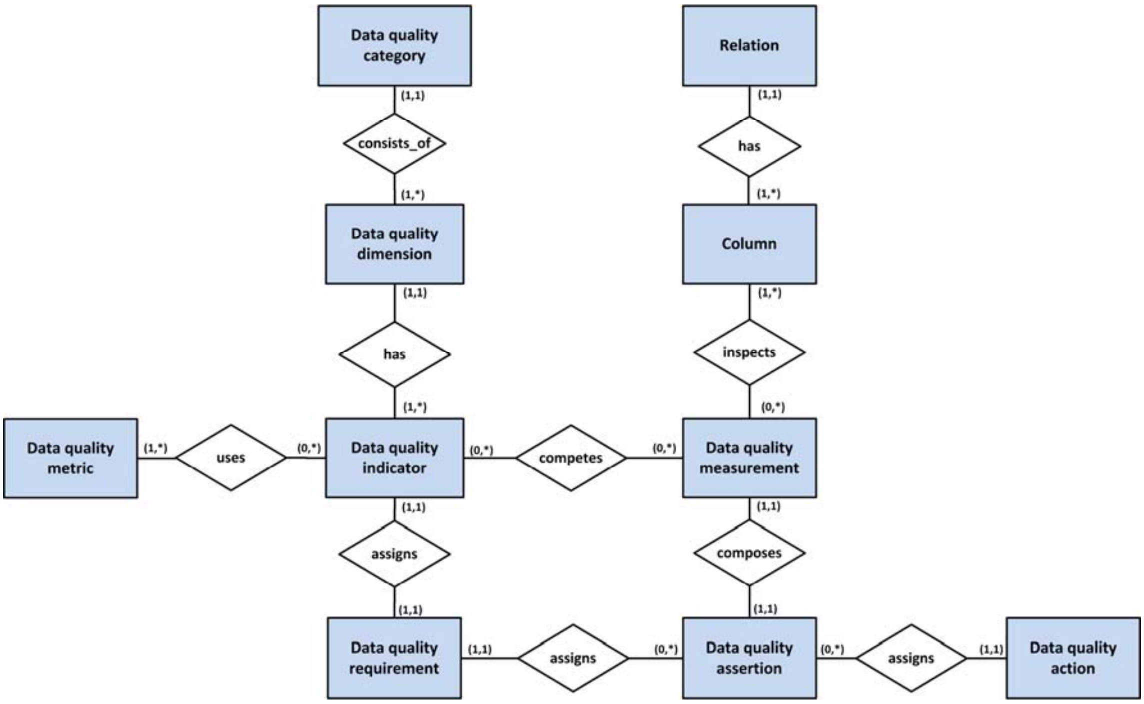


Figure 5. The Conceptual Schema of the Data Quality Meta Model used in DaRT

The last question the interested reader may raise is about the IT technologies used so far. Figure 6 represents what was used to implement DaRT.

7. The used IT Tools of DaRT

The used IT tools for DaRT are the followings:

- ETL-Tool (Data Extraction, Integration, Loading)
  - Oracle Warehouse Builder
- Web Application Framework
  - Application Express (APEX)
- Programming Languag
  - PL/SQL
- Database Developer
  - SQL Developer (incl. SQL*Plus)

8. The frontend for the data quality analyst

We limit ourselves with respect to the user interface (GUI) to present only part of the frontend devoted to the functionality of data quality reporting. The semantics of the reports is concer-ned wit a table “Customer” which has attributes house no, contact person, type of customer clients file, customer id etc all printed in German language in this sequence.

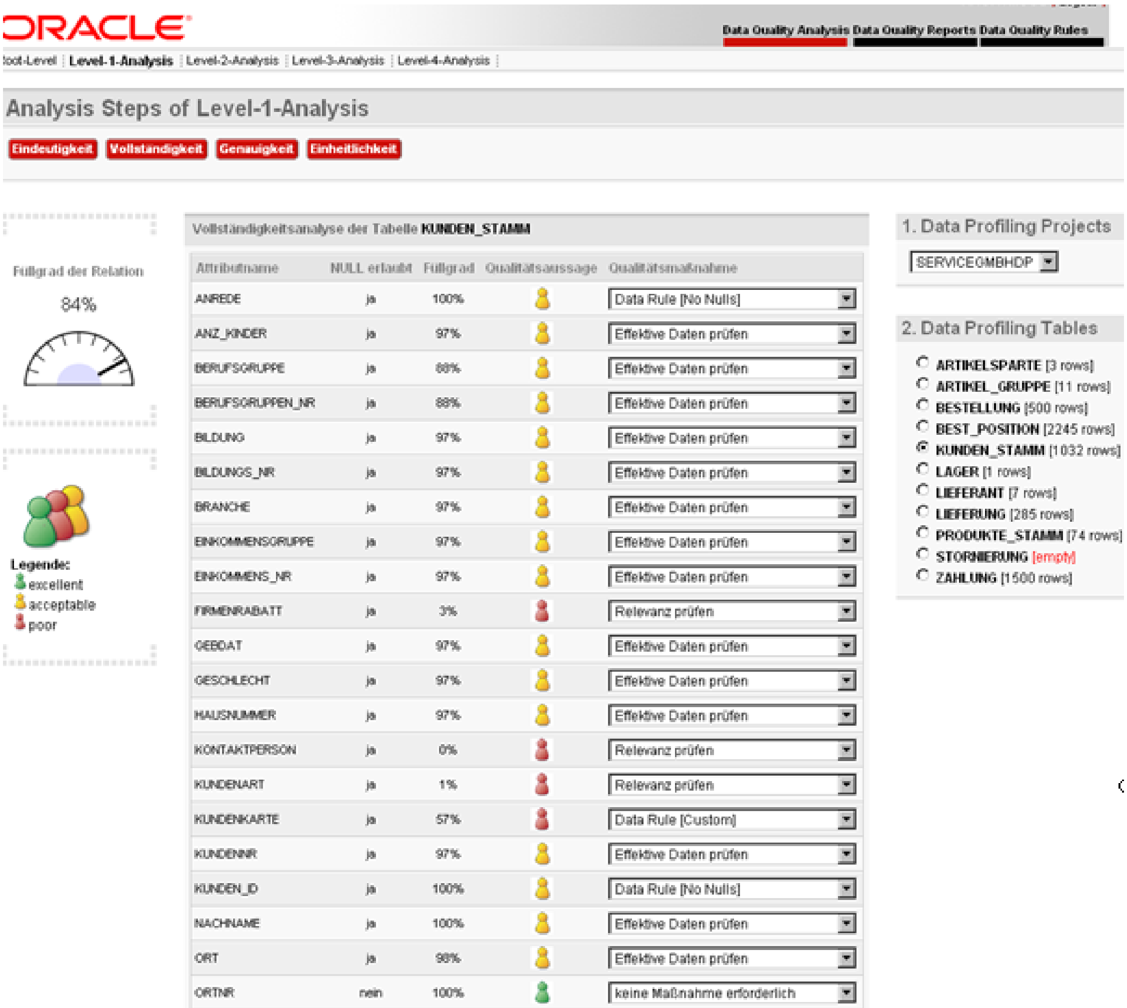


Figure 6. DQ Report on customer data using DaRT

It may be worthwhile mentioning that the default sequencing of DQ steps may be changed according to real environments and use cases. The flexibility given by DaRT is reflected by its update capabilities as represented in Figure 7.

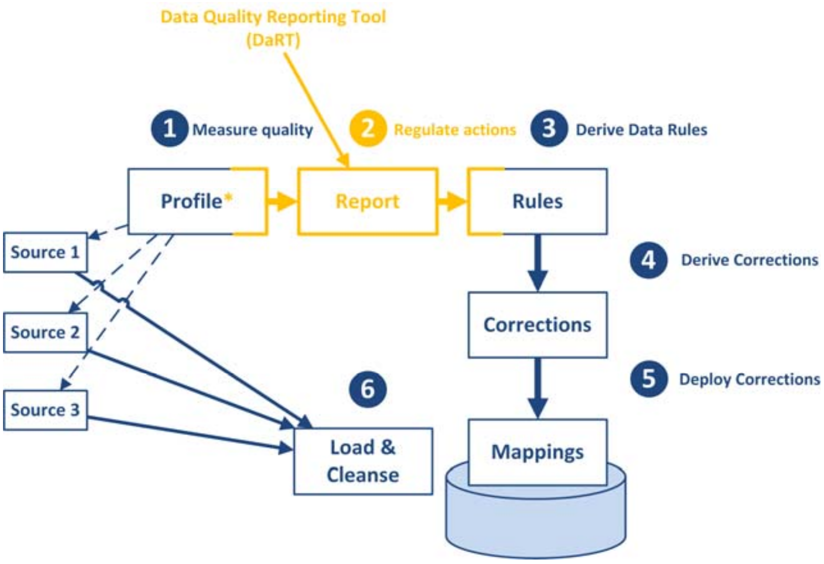


Figure 7. Updating the data quality cycle of DaRT

9. The main Results and Perspectives for DQ

The main results of designing and implementing DaRT are as follows:

- Fixing of data quality attributes (indicators) which can be measured
- Sequencing of steps of DQ analyses
- Designing a conceptual meta database model
- DQ Analysis cockpit as GUI
- Web based workflow engine.

Our perspective after completing the development of a first data quality workflow engine but before any shop floor evaluation is:

- Expanding the workflow engine wit respect a large range of edits
- Improving the conceptual Schema
- Capturing the semantics of various application scenarios
- Transferring our prototype "DaRT" into an Oracle product added on OWB.

We close with a statement coined in German language by Albert Einstein: „Es ist leichter, Datenqualitätsprobleme zu lösen, als mit Ihnen zu leben."

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VALIDITY EXAMINATION OF EFQM'S RESULTS BY DEA MODELS

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Abstract: *The European Foundation Quality Management is one of the models dealing with the assessment of an organization's function using a self-assessment for measuring the concepts, some of which are more and more qualitative. Consequently, the complete understanding and the correct use of this model in an organization depend on the comprehensive recognition of that model and of the different strategies of self - assessment. The process of self – assessment on the basis of this model in an organization needs using experienced auditors. This leads to reducing the wrong privilege, obeying the criteria and sub-criteria.*
In this paper, firstly there are studied some of the weaknesses of the EFQM model, then, by using the structure of input-output governing of the model and also using the Data Envelopment Analysis, a method is offered to recognize the lack of proportion between Enablers and the results of organization, which may occur due to problems and obstacles hidden in the heart of organization.

Key words: *European Foundation Quality Management; Data Envelopment Analysis*

1. Introduction

The European Foundation for Quality Management (EFQM) was founded by the presidency of 14 major European companies in 1988. Its purpose was designed as to stimulate and assist organizations throughout Europe to participate in improvement activities leading ultimately to excellence in customers' and employees' satisfaction, to influence society and business results and to support the managers of European organizations in accelerating the process of making Total Quality Management (TQM) (Besterfield & Besterfield - Michna 1999) a decisive factor for achieving global competitive advantage.

Until 1995, almost 60% of the European organizations were using the EFQM model to assess their organization. Many papers in this area have been published, while each of them was trying to complete this model. For example, EFQM (1999b) describes the Radar

Logic which is known as the heart of the excellence model. EFQM (2000) is considering the aspects of Deployment and Assessment and Review within the Radar Logic. Lascelles and Peacock (1996) have studied the area of scoring the aspects of Deployment and Assessment and Review and their results are being considered in EFQM (2000). In 2003, a new edition of the model was presented, which in comparison with the previous edition, had considerable amendments in the sub-criteria and in the guidance points (EFQM 2003).

In contrast, Charnes, Cooper and Rhodes (1978) developed data envelopment analysis (DEA) as a methodology aimed at evaluating the relating efficiency between the decision making units (DMUs) solely on the basis of their noticed performance.

In recent years, a growing number of researchers have been looking for ways to incorporate judgment into DEA. Golany and Roll (1997) suggested an alternative approach for introducing judgment into the DEA methodology by allowing incorporation of engineering standards into the analysis. The present study uses the method proposed by Golany and Roll (1997).

This paper has been organized in five sections. The next section presents a brief review of the CCR model and structure of EFQM. The suggested methods are presented in section 3. The theoretical finding of a numerical example is solved in section 4. Finally, section 5 draws some concluding remarks.

2. Background

2.1. CCR Model

Since the seminal paper by Charnes, Cooper and Rhodes in 1978 (CCR), a variety of DEA models have appeared in the literature. Two of the DEA models that are most often associated with the DEA methodology are the CCR and BCC (Banker, Charnes and Cooper 1984) models. Let inputs x_{ij} (i=1,…, m) and outputs y_{rj} (r=1,…,s) be given for DMU$_j$ (j=1,…,n).

The linear programming statement for the (output oriented) CCR model is:

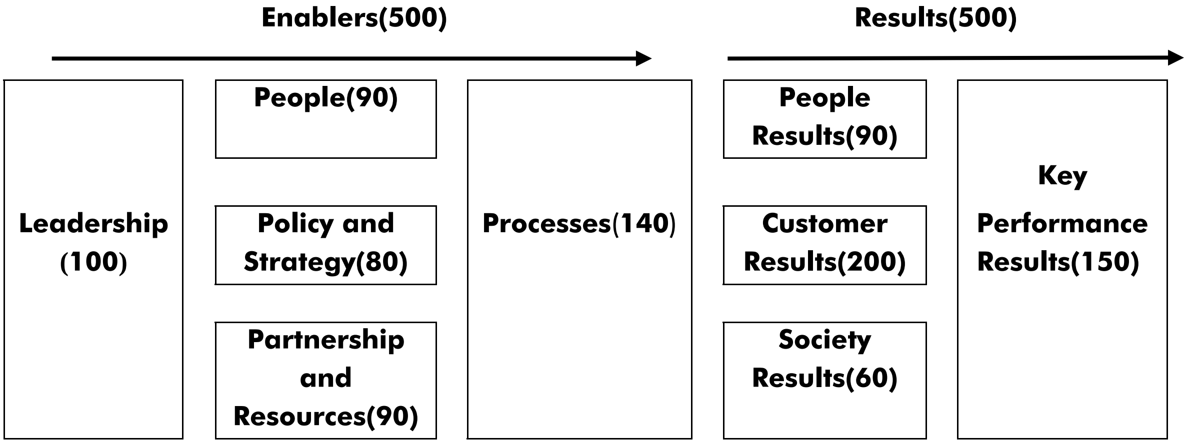
$$\begin{aligned} \min \quad & Z=\sum_{i=1}^{m} v_i x_{ip} \\ \text{s.t:} \quad & \sum_{r=1}^{s} u_r y_{rp}=1 \\ & \sum_{r=1}^{s} u_r y_{rj}-\sum_{i=1}^{m} v_i x_{ij} \le 0 \qquad j=1,\dots,n, \\ & u_r, v_i \ge \varepsilon \qquad i=1,\dots,m,\ r=1,\dots,s. \end{aligned} \tag{1}$$

Where, ε is a non-Archimedean infinitesimal and, x_{ip} and y_{rp} denote, respectively, the ith input and rth output values for DMU$_p$, the DMU under consideration.

2.2. EFQM

The EFQM Excellence model is a non-prescriptive framework recognizing that there are many approaches to achieving sustainable excellence. The model's framework is based on nine criteria. Five of these are "Enablers" and four are "Results". The "Enablers" criteria cover what an organization does. The "Results" criteria cover what an organization achieves.

"Results" are caused by "Enablers" and the feedback from "Results" help to improve "Enablers". The link between these criteria is illustrated below:



The model recognizes that there are many approaches to achieving sustainable excellence in all aspects of performance. It is based on the premises that excellence results with respect to Performance, Customer, People and Society, which are achieved through Leadership driving Policy and Strategy, which is delivered by People, Partnerships, Resources and Processes.

3. DEA and Errors of Assessment in EFQM

As it has been mentioned in the previous section, some of the criteria recognized in the EFQM model are qualitative, so measuring these criteria cannot be easily made. As the incorrect assessment may give an unreal image of the organization and so the organization would fall into non-existence, it deems necessary to design a control system for such situations, which may alarm and warn the organization that the assessment is not real.

Because some of the nine criteria in the model are so qualitative that their measurement needs experienced individuals and experts, there is this probability of arising errors in the self-assessment on the basis of EFQM. With regard to difficult scoring to "Enablers", probability of mistaken scoring in this area is very high. So, it seems necessary to design a system to control the accuracy of the results. With that end in view, we propose the method designed by Golany and Roll (1997) in order to standardize through DEA. For more description, we assume that the assessment criteria in the organization include one Enabler criteria and one Result criteria. We collect the results of the assessment obtained by expert assessors in the past from different organizations as to make the standard level. In figure (1), the DMUs A, B, C, D, E and F are representing such units. Efficiency frontier is represented by A, B, C and D. The gained frontier indicates that we expect to obtain the scale of "Results" in the organization by using the specified scale of "Enablers". With regard to the criteria of a qualitative EFQM, the assessment error may be more or less ignored. For example, the units E and F which are not on the efficiency frontier, but related closely to the efficiency frontier, result in acceptable evaluation. Thus, inefficient units are divided in two groups. The first group consists of inefficient DMUs or the organizations whose assessments are not acceptable and second group contains efficient units or organizations whose assessment result is acceptable. In figure (1), the units G and H are DMUs which are scored by expert assessors. For DMU G, there are two possibilities to be taken into consideration:

1) The error has occurred in scoring.

2) There are problems in the organization, which are not being noticed by the managers.

If we accept that the assessment of the organizations A and B has been realistic, the expectation is that the organization G, with use of amount x_2 Enabler achieves amount y_2 result, whilst this organization has achieved to y_1 result. As it has already been mentioned, this could be due to an assessment error or to a problem within the organization that caused this situation. Therefore, it seems necessary to re-study the assessment, in order to find the cause and, in the case of finding an error, scores should be amended. If the second situation has happened, the cause should be studied. In order to distinguish the organizations whose assessment results are not acceptable, it is used the method proposed by Golany and Roll (1997). Organizations which have been assessed by EFQM model are considered as DMU. The five criteria of "Enablers" are Inputs and the other four results criteria are considered as Outputs. We collect the information relating to these units which were successfull or not in the past, but the scores have been awarded by expert assessors. We evaluate these units by the DEA. Some of them are situated on the efficiency frontier. These units will make the standard DMUs. After the standard units are recognized again by adding the DMUs which gave the scores in a certain period to the aforementioned units, it means that the evaluation is made again by using the CCR model? If a DMU causes an inefficient DMU standard, then the data of the organization is questionable and therefore it should be studied again. In the case of accuracy being confirmed, the relevant data should be presented as belonging to a standard organization. Otherwise, the given scores will not change the standard frontier. Again, the organization is being studied by ignoring the standard units, then calculating the ratio of two efficiencies for each organization (DMU) and finding the average of the obtained numbers. Again, we calculate the distance between each number and the average and we calculate the average of these distances; by subtracting the average from the obtained number, we will have the number which will represent the basis for accepting the results of EFQM. If the gained result of assessment of a DMU would be lower than this number, either it has not been calculated correctly or the obstacle factors which the assessment indexes fail to recognize have played their role in giving this results. Because we expect that the organization is using its leadership with certain power, policy and strategy, people, partnerships and resources and processes, each of them has been illustrated by a number, thus achieving series of related results.

4. Numerical Example

We consider the table 1 from the appendix section. The decision making units D1 until D25 in this table are the units that have been assessed in the past by experienced assessors and they were assigned scores which confirmed. Hereafter, these units should be called standard units. The columns 2 up to 10 are nine criteria relating to the areas of EFQM. In the evaluation made by the CCR model, there are seen the efficiency units in column 11. It is made the efficiency frontier of these units. Certainly, this doesn't mean that the other units have unreal scores, as the existence of some errors is more or less acceptable. The proposed method specifies the area of such errors. The units D27 up to D35 are the organizations which have been assessed in a certain period, and the accuracy of their results must be studied. With this end in view, we compare them with the standard units. Table 2 shows the results of using the method for recognizing the organizations which have been wrongly assessed. The value 0.979 in the last row of table 2 is the average of the values in the last column. By calculating the average of the distance of each value from the last column, it is obtained the value of 0.019.The value 0.967 is the difference between 0.979 and 0.012, and it represents an accepted criteria for accuracy of data relating each DMU. As the values allocated to units 30, 31, 32 and 35 are less than the aforementioned number, the results of the assessment of these units are doubtful, and restudying of these units is recommended. For example, we consider the D31. The criteria of Enabler of this unit compared with D21 is bigger, while the results are lower. In other words, there have been obtained weaker results from greater Enabler. This means that either the assessment is unreal or there are some problems within the organization which need a specific study.

Table 2. The results of the proposed method

DMUs	Efficiencies of inefficient standard DMUs and under evaluation {1}	Efficiencies of standard DMUs and under evaluation {2}	$\frac{\{2\}}{\{1\}}$
D3	1	0.992	0.992
D13	1	0.999	0.999
D16	1	0.977	0.977
D17	1	0.988	0.988
D18	1	0.983	0.983
D19	1	0.986	0.986
D20	0.998	0.963	0.965
D21	1	0.972	0.972
D22	0.987	0.976	0.989
D23	1	0.996	0.996
D24	1	0.985	0.985
D26	1	0.989	0.989
D27	1	0.986	0.986
D28	1	0.998	0.998
D29	1	0.990	0.990
D31	0.998	0.945	0.947
D32	0.981	0.943	0.961
D33	1	0.976	0.976
D30	0.853	0.809	0.948
D34	0.887	0.869	0.980
D35	0.957	0.921	0.962
0.012 Variance		0.979 average	

The second column shows the efficiency and the third column shows the reference units suitable to each decision making unit. In order to specify the scale of cumacy of the data results in case of each decision making unit under assessment, we compare this unit with the standard unit having at least one common reference. In the event that the figure of efficiency of this unit is at least bigger than the figure of efficiency of one of these units, the results of the assessment by EFQM model are confirmed. Otherwise, the restudying of the points in nine areas is recommended. For example, we consider the unit Q28. The units D15

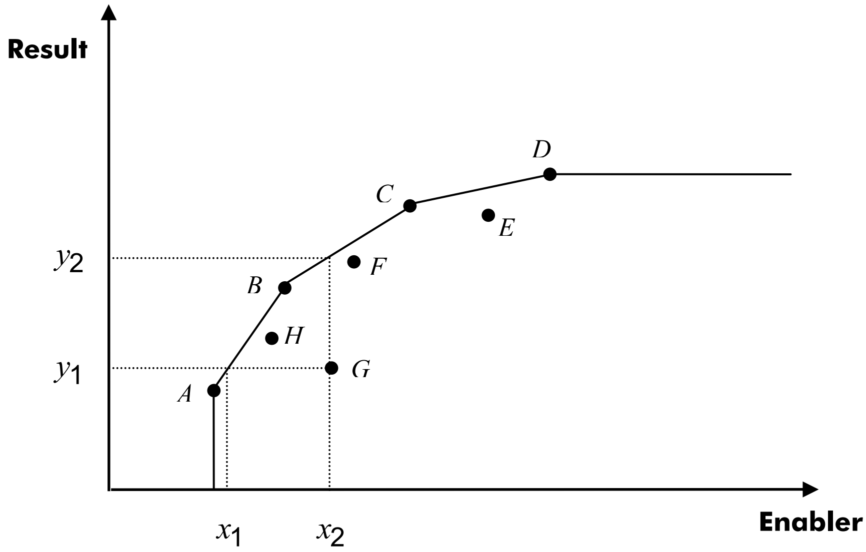


Figure 1. The efficiency of decisions

and D4 have been recognized as references for this unit. D9, D4, D11, D13, D15,D16, D17, D18, D21, D22, D23, and D24 have at least one common reference with D28 decision – making unit. The figure of the efficiency of this decision – making unit is bigger that the figure of the efficiency of unit19 (0.986) and its result is confirmed. In turn, the results obtained from point – awarding in the EFQM model for D30 demand a more precise study, as this unit, in comparison to all other reference connected decision – making standard units, has a lower figure of efficiency. The units 20, 21, 23, and 26 have at least one common reference with the decision – making unit 30. For this reason, the results of the units 31, 32, 34, and 35 need to be studied. The complete understanding and correct use of the EFQM model since its origin requires the comprehensive interpretation of this model and the different strategies of self – assessment of the organization and its proportion, as the experienced assessors need a quite qualitative approach of the current assessment criteria. Consequently, there are too many possibilities for errors to occur in the process of awarding point to the criteria and to the sub–criteria. On the other hand, it is necessary to have a coordination between the decision-makers and the awareness of their results, because this implies recognizing the failures and allowing the organization to take the appropriate measures. In this article, it is used the structure of the input-output governing EFQM model which has been taken from nine criteria and with the support of the CCR model, by using technical efficiency it is likely to detect the existence of possible errors in assessment and/or the possible non- coordination between the decision - makers and their results, items that have been studied carefully.

5. Conclusions

The complete understanding and correct use of the EFQM model in an organization required the comprehensive knowledge of this model, as the experienced assessors need a quite qualitative approach of the current assessment criteria in order to give a valuable contribution. Consequently, there are many possibilities for errors to occur in scoring the criteria and the sub-criteria. On the other hand, sometimes, it could be possible that coordination between Enablers and the results has not been made, due to some problems within the organization, and so it needs the recognition of this failure in order to be aware of it and take the appropriate steps.. In this paper it is used the structure of the input-output governing EFQM model which has been taken from nine criteria used and with the support of the CCR model, by using technical efficiency it is more likely to detect the existence of possible errors in assessment and/or the possible non- coordination between Enablers and their results, items that have been studied carefully.

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Appendix A.

Table 1. Data used in the numerical example

DMUs	Leadership	Policy& Strategy	People	Partnership& Resources	Processes	Customer Results	People Results	Society Results	k ey Performance Results
D1	50	40	44	45	70	105	44	31	74
D2	65	49	55	57	68	129	56	38	97
D3	70	53	65	67	80	141	63	40	103
D4	55	42	45	46	73	112	43	34	83
D5	60	47	52	54	75	119	52	37	92
D6	70	50	64	68	79	142	64	41	101
D7	74	53	70	73	83	150	74	43	112
D8	80	65	76	77	90	159	79	47	118
D9	75	63	72	74	80	151	75	43	114
D10	55	45	46	49	69	110	47	35	80
D11	64	49	53	54	69	127	55	39	95
D12	85	68	80	82	110	169	82	52	126
D13	80	63	77	79	95	161	79	47	121
D14	40	31	35	37	62	75	38	22	63
D15	35	24	30	33	51	71	31	22	53
D16	51	40	45	46	71	104	43	30	73
D17	65	51	56	58	69	128	55	37	96
D18	71	52	64	69	79	141	63	40	100
D19	65	49	54	55	69	126	54	38	94
D20	86	63	78	80	96	160	79	46	120
D21	36	25	31	34	51	70	30	21	53
D22	83	67	79	81	108	163	80	48	122
D23	42	31	36	37	63	74	37	22	63
D24	57	43	46	48	69	110	45	34	79
D25	75	54	73	75	83	149	77	43	113
D26	32	26	29	28	45	45	28	19	48
D27	65	49	54	55	69	126	54	38	94
D28	71	50	64	69	79	140	63	41	99
D29	65	50	52	56	73	125	52	35	90
D30	49	45	42	45	76	63	37	20	53
D31	37	25	35	39	56	70	25	21	50
D32	87	73	75	80	109	156	75	48	121
D33	51	41	46	46	70	104	42	29	74
D34	72	54	64	69	80	126	53	37	93
D35	35	27	29	30	46	44	27	20	47

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GENERALIZED BURR-HATKE EQUATION AS GENERATOR OF A HOMOGRAPHIC FAILURE RATE

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Abstract: *Starting from a generalized form of Burr-Hatke differential equation namely* $\mathrm{d}\varphi/\mathrm{d}x = u(x)\cdot\varphi^a + v(x)\cdot\varphi^b$ *(see for details [18]), we obtain – for peculiar choices of u, v, a and b – as a solution, a reliability function* $\varphi(x)$ *which provides a homographic failure rate (HFR)* $h(x) = \theta + 1/x$*, where* $\theta > 0$*. Some statistical inferences on the variable X having such a hazard rate are performed. Main indicators are evaluated and it is proved that the maximum likelihood method of estimation cannot furnish a solution for the parameter involved. A moment estimator is deduced which is used in the construction of some special sampling plans for durability testing.*

Key words: *Burr-Hatke equation; HFR –homographic failure rate; exponential integral; moment estimator; log-likelihood equation; (n, 0) - sampling plan*

1. Preliminaries and some historical remarks

In statistical distribution theory, the so-called Burr-Hatke differential equation, namely

$$\frac{\mathrm{d}F}{\mathrm{d}x} = F(1-F)\,g(x,F) \quad \text{with } F_0 = F(x_0),\ x_0 \in R \qquad (1.1.)$$

where $F(x) = \mathrm{Prob}\{X \le x\}$ is the c.d.f. (cumulative distribution function) of a continuous random variable X and $g(x,F)$ is an arbitrary positive function for any $x \in R$ – is considered by many authors as a system of c.d.f.(s) generator or simply a **system of frequency curves** (see Rodriguez [16[1], page 218] or Johnson et al. [13, page 54]).

Burr [4] and (Sister) Hatke [11] presented a list of twelve such cdf(s) – denoted from I to XII, the most famous being probably the form II, which is just the "logistic curve" introduced by the Belgian scientist François Pierre VERHULST (1804-1849) – see *Iosifescu et all* [12, page 285]).

The majority of cdf(s) are deduced from (1.1.) by taking $g\left(x,F\right)=g\left(x\right)$ – that is a simpler choice. The form XII – for which Rodriguez elaborated even a "guide" (see [15]) has received more attention than the other ones in this family.

The form XII, that is $F(x;c,k)=1-\left(1+x^{c}\right)^{-k},\quad x\geq 0,\ c,k>0$ has been used in sampling inspection theory (Zimmer and Burr [20]). Burr also showed that for $c\approx 4.874$ and $k\approx 6.158$ we find that $E(X)\approx 0.6447$ and $\sqrt{Var(X)}\approx 0.1620$ (where *X* is the Burr-type XII variable) and the normed variable $U=\left[X-E\left(X\right)\right]/\sqrt{Var(X)}$ approximates quite well the standardized normal variable *N* (0,1) – see further developments on this subject matter in Burr [6], Burr and Cislak [7] and Burr [8].

In the last two decades, the Burr-type X distribution, that is

$$F\left(x;a,b\right)=\left[1-\exp\left(-ax^{2}\right)\right]^{b},\quad x\geq 0,\quad a,b>0 \qquad (1.2.)$$

has attracted the interest of reliability engineers as well as of statisticians since if "can be used quite effectively in modeling strength data and also modeling general lifetime data" as Raqab and Kundu [14] claimed.

In fact, (1.2/) is a generalization of Rayleigh cdf: for *b* = 1we obtain the classical form proposed in 1880 by Lord Rayleigh (1842-1919), as the distribution of the amplitude resulting from the harmonic oscillations. Since $F(x;a,1)$ provides a linearly increasing failure (hazard) rate $h(x)=F'/\left(1-F\right)=2ax,\quad x\geq 0, a>0$ this peculiar Burr-type X distribution is suitable to describe the irreversible wear-out processes which take place in metalworking (grinding and cutting-tool durability analysis).

The Burr-type XII distribution has been used as a failure model especially in the case of censored and multicensored / progressively censored data (Wingo [19]).

The form (1.1.) has been generalized (see the second author [18]) as below

$$\frac{\mathrm{d}\varphi}{\mathrm{d}x}=u(x)\varphi^{a}+v(x)\varphi^{b} \qquad (1.3.)$$

where $\varphi(x)$ is a positive function for every $x\geq 0,\ u(x)$ and $v(x)$ are continuous functions and *a* and *b* are two arbitrary real numbers. If φ is a cdf and $u(x)=1,\ v(x)=-1,\ a=1$ and $b=2$, **one recovers the Burr-Hatke form (1.1).**

The above proposal (1.3.) has the advantage that it can provide not only cdf(s) – as (1.1) does – but also pdf(s) – probability density functions and reliability ones. In other words, it is more flexible.

For instance, if we take $u(x)=v(x)=kx^{k-1}/\theta,\ x\geq 0,\ \theta,k>0, a=0$ and $b=1$, we shall get $\varphi(x)=1-\exp\left(-x^{k}/\theta\right)$ which is the famous cdf proposed in 1951 by the Swedish scientist Waloddi WEIBULL (1887-1979) – see Johnson et al. [13, page 628].

If we choose $u(x) = (x / 2\pi)\exp\left(-x^2\right), x \in R,\ v(x) = 0, a = -1$, for any $b \in R$ we shall obtain the standardized normal pdf $\varphi(x) = \left(1/\sqrt{2\pi}\right)\exp\left(-x^2/2\right)$.

Let us take now a = b = 1, u(x) = -1/x, x ≥ 1, v(x) = - θ, with θ > 0 and consequently, from (1.3.) we shall get

$$\varphi(x) = \frac{1}{x}\exp\left[-\theta\left(x-1\right)\right], \quad x \geq 1, \theta > 0 \tag{1.4.}$$

which is a **reliability function** ($\varphi(1) = 1$, $\varphi(\infty) = 0$).

The purpose of this paper is to perform a statistical analysis on the random variable having (1.4.) as its survivor function.

2. Straightforward consequences

From (1.4) we can deduce immediately the cdf and pdf of the underlying variable.

$$F(x;\theta) = 1 - x^{-1}\cdot\exp\left[-\theta\left(x-1\right)\right], \quad x \geq 1, \theta > 0 \tag{2.1.}$$

$$f(x;\theta) = \left(\theta x^{-1} + x^{-2}\right)\cdot\exp\left[-\theta\left(x-1\right)\right], \quad x \geq 1,\ \theta > 0\,. \tag{2.2.}$$

Since $f'(x;\theta)$ is always strictly negative, $f(x;\theta)$ is strictly decreasing: the curve associated to *f* has the starting point of coordinates $\left(1, 1+\theta\right)$ and a horizontal asymptote $y = 0$.

The density curve is therefore of an exponential type which decreases faster than the classical exponential pdf.

The associated hazard rate is:

$$h\ (x;\theta) = \frac{f(x;\theta)}{1 - F(x;\theta)} = \theta' + \frac{1}{x} = \frac{\theta x + 1}{x}, \quad x \geq 1, \theta > 0 \tag{2.3.}$$

with $h'\left(x;\theta\right) = -1/x^2 < 0$, that is *h* is decreasing and in fact it is a peculiar form of the general homographic function. Therefore, we investigate a HFR-type variable.

Another form of a homographic hazard function, namely $h_1\left(x;\theta\right) = \theta^2 x / \left(1 + \theta x\right)$, $x \geq 0, \theta > 0$ has been studied by Bârsan-Pipu et al. [2] but this is strictly increasing since $h_1' = \theta^2 / \left(1+\theta x\right)^2 > 0$.

Therefore our form (2.3.) is adequate for modeling the "burn-in" process (or "infant mortality" in demographic terms), meanwhile $h_1(x;\theta)$ is suitable for fatigue and wear-out cases.

3. Main indicators and parameter estimation

First, we shall compute the first four raw moments of our HFR-variable – let it be *X*. To this purpose, we shall state

Property 1. The non-central m^{th} moment of X , with $m \geq 2$ can be expressed explicitly as

$$E\left(X^m\right)=1+\frac{m}{\theta}\cdot\sum_{j=0}^{m-2}\frac{(m-2)!}{(m-j-2)!}\theta^{-j},\quad m=2,3,... \tag{3.1.}$$

The mean-value (the first raw moment) implies a special function – namely the exponential integral with negative argument, $Ei(-u)$.

$$E\left(X^2\right)=\int_1^\infty x^2 f(x;\theta)\mathrm{d}x=\int_1^\infty e^{-\theta(x-1)}\mathrm{d}x+\theta\int_1^\infty xe^{-\theta(x-1)}\mathrm{d}x \tag{3.2.}$$

Proof. We shall reach (3.1.) sequentially. For *m* = 2 we have

$$\theta\left[-\frac{x}{\theta}e^{-\theta(x-1)}\Big|_1^\infty+\frac{1}{\theta}\int_1^\infty e^{-\theta(x-1)}\mathrm{d}x\right]=\frac{1}{\theta}+1+\frac{1}{\theta}=1+2/\theta.$$

The expression is the same if we take *m* = 2 in (3.1.).

After some more similar integration by parts we shall get

$$E\left(X^3\right)=1+3(1+1/\theta)/\theta \tag{3.3.}$$

$$E\left(X^4\right)=1+4\left(1+2/\theta+2/\theta^2\right)/\theta \tag{3.4.}$$

For *m* = 3 and *m* = 4 in (3.1.) one obtains easily (3.2.) and (3.3.). A simple induction will validate (3.1.).

For *m* = 1, we have

$$E(X)=\int_1^\infty xf(x;\theta)\mathrm{d}x=\int_1^\infty\left(\theta+\frac{1}{\mathrm{x}}\right)e^{-\theta(x-1)}\mathrm{d}x=\theta\int_1^\infty e^{-\theta(x-1)}\mathrm{d}x+e^\theta\int_1^\infty\frac{e^{-\theta x}}{x}\mathrm{d}x=$$

$$=1-e^\theta\cdot Ei(-\theta) \tag{3.5.}$$

– see Abramowitz-Stegun [1, page 56] or Smoleanski [17, page 121] where the indefinite integral generating this special function is provided as

$$\int\frac{e^{-ax}}{x}\mathrm{d}x=\ln|x|+\frac{ax}{1!}+\frac{a^2x^2}{2\cdot 2!}+\cdots+\frac{a^nx^n}{n\cdot n!}+\cdots \tag{3.6.}$$

(here $a\neq 0$ could be positive or negative).

The straightforward consequence is following: one cannot use $E(X)$ in order to estimate θ by applying method of moments proposed in 1891 by Karl PEARSON (1857-1936). Nevertheless we may state

Property 2. The moment estimator for θ has the below form

$$\hat{\theta}_M=\frac{2}{n^{-1}\sum x_i^2-1} \tag{3.7.}$$

where $x_i, i=\overline{1,n}$ are sample values on X $\left(x_i\geq 1,\forall i\right)$.

The proof is immediate: we have to equate $E\left(X^2\right)$ with the empirical raw second order moment $n^{-1}\sum x_i^2$.

Property 3. The log-likelihood equation associated to $f(x;\theta)$ has all its roots negative ones, therefore there is no MLE – Maximum Likelihood Estimator for θ.

Proof. We may write successively

$$L=\prod_{i=1}^{n} f\left(x_i;\theta\right)=\left[\prod_{i=1}^{n}\left(x_i^{-2}+\theta\cdot x_i^{-1}\right)\right]e^{-n\theta}\cdot\exp\left(-\theta\sum_{i=1}^{n}x_i\right) \quad (3.8.)$$

$$\ln L=\prod_{i=1}^{n}\ln\left(x_i^{-2}+\theta\cdot x_i^{-1}\right)-\theta\sum_{i=1}^{n}x_i+n\theta \quad (3.9.)$$

$$\frac{\partial \ln L}{\partial\theta}=\sum_{i=1}^{n}\frac{x_i}{1+\hat{\theta}x_i}-\sum_{i=1}^{n}x_i+n=0 \quad (3.10.)$$

If we denote $u_i=1/x_i$ we shall have

$$\sum_{i=1}^{n}\frac{1}{\hat{\theta}+u_i}+n-\sum_{i=1}^{n}\frac{1}{u_i}=0 \quad (3.11.)$$

Since $1/x_i<1$, the quantity $\left(n-\sum_{i=1}^{n}\frac{1}{u_i}\right)$ is always positive and hence the equation (3.11.) has real roots but all negative ones. Indeed, the function

$$\psi\left(\hat{\theta}\right)=\sum_{1}^{n}\frac{1}{\hat{\theta}+u_i}+n-\sum_{1}^{n}\frac{1}{u_i} \quad (3.12.)$$

is a decreasing one, since $\psi'\left(\theta\right)<0$. It has a horizontal asymptote

$$\hat{\theta}=n-\sum_{i=1}^{n}\frac{1}{u_i}\ \in\left[0,n\right) \quad (3.13.)$$

For $\hat{\theta}=$ 0, we have $\psi\left(0\right)=n$, that is the point (0, *n*) is on the vertical coordinate axis. There exists also *n* vertical asymptotes, namely $\hat{\theta}=-u_i<0,\quad i=\overline{1,n}$ since $\lim_{\hat{\theta}\to u_i}\psi\left(\hat{\theta}\right)=\pm\infty$ and therefore there are *n* "cuts" on the horizontal axis that is we have *n real negative roots.*

It follows that the maximum likelihood method (MLM) does not provide an estimator for θ.

Remark: this situation is not unique; for the so-called power law $F\left(x;\delta,b\right)=\left(x/b\right)^{\delta},\quad \delta>0,\ 0\le x\le b$, the MLM cannot give MLE(s) for δ and *b* (such an estimator exists only if *b* is assumed to be known) – see Bârsan-Pipu et al. [3, pages 73-75].

4. Special sampling plans

In this section we shall construct a sampling plan of (*n*, 0) type for durability testing in the case that the time-to-failure obeys the law $F\left(x;\theta\right)$ given by (2.1.).

The problem is in this case to establish the sample size *n* when the acceptance number is A = 0. We have a lot of size *N* with a given fraction defective *p* and we fix a testing time T_0 for a sample of *n* product units submitted to a durability test. We have hence (see Derman and Ross [10])

$$p = F(T_0;\theta) = 1 - \frac{1}{T_0} \cdot \exp\left[-\theta(T_0 - 1)\right] \quad (4.1.)$$

$$1 - p = T_0^{-1} \cdot \exp\left[-\theta(T_0 - 1)\right]. \quad (4.2.)$$

Then, the probability (β) to accept the batch during the T_0 testing period, via *n* tested elements is

$$\beta = (1-p)^n = T_0^{-n} \cdot \exp\left[-n \cdot \theta(T_0 - 1)\right] \quad (4.3.)$$

and by taking the logarithm we have

$$\ln \beta = -n\theta(T_0 - 1) - n \ln T_0 \quad (4.4.)$$

which gives

$$n = \left[\frac{-\ln \beta}{(T_0 - 1)\theta + \ln T_0}\right], \ [m] - \text{the nearest integer to } m. \quad (4.5.)$$

In (4.5.) θ has to be replaced by its moment estimator given by (3.7.), where $E(X^2)$ – that is the mean-durability of square failure times represented by X^2 has a previous specified value.

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TEN TIPS FOR PROMOTING AUTONOMOUS LEARNING AND EFFECTIVE ENGAGEMENT IN THE TEACHING OF STATISTICS TO UNDERGRADUATE MEDICAL STUDENTS INVOLVED IN SHORT-TERM RESEARCH PROJECTS[1]

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Abstract: *This article seeks to present some of the key challenges in facilitating autonomous learning and effective engagement in the teaching of statistics to undergraduate medical students involved in short-term research projects. With a view to addressing these challenges, recommendations for good practice are presented in the form of ten tips for teachers of medical statistics. The ten tips are justified by appeal to the more general educational literature on self-directed learning and engagement. Practical suggestions for the implementation of these tips are provided on the basis of the author's own experience of teaching statistics to medical students who have embarked on 14-week clinical research projects within the 4th year of their undergraduate curriculum.*

Key words: *autonomous learning; effective engagement; online resources; self-directed; quality of statistical practice; undergraduate medical students*

1. Introduction

The educational literature is replete with alternative interpretations of what is meant by autonomous learning (Benson and Voller 1997). More extreme interpretations of this notion are based on the idea of the individual being resistant to external influence at all stages of their learning. In such extreme cases, the implications for subverting the individual's capacity to construct their own meaning in relation to experiences and concepts are clear. It is understandable why, from this perspective, autonomy may be frowned upon by educational theorists and practitioners as a state of inertia rather than a goal to aspire to.

Consequently, it is important to stress at the outset that whilst autonomous learning as I intend it in the current work is *ultimately* experienced exclusively by the individual learner, it may also be informed through interaction with peers or by reflection on the views of the educator. Socially constructed knowledge, however, must for the autonomous learner in the end be filtered through a personal construct system whereby there is scope for further development of personal nuances and insights.

Thus, I choose to define autonomous learning as a type of learning which is characterized by personalization, self-directedness and less *dependency* on the educator for affirmation, and which therefore enhances rather than hinders the capacity for constructive collaborative participation in the workplace.

The idea that self-directed learning is central to effective engagement with the learning process is well-recognized (see, for example, Ramsden 1992, Bryson and Hand 2007). Nevertheless 'effective engagement' is itself a term which is open to interpretation (Bowen 2005). Thus, I shall take the liberty of using this form of engagement to mean a quality of participation in the learning experience which is transformative. More precisely, the learner is empowered to re-construct what they already knew or believed into a system of beliefs, conceptualizations, values and forms of reasoning which are symptomatic of a more mature state of cognitive development. The sense of authenticity which is derived from autonomous learning as defined above contributes to this process by liberating the learner to view their own perspectives as valid and to embark on a personal learning journey whereby these perspectives must inevitably change over time.

Autonomous learning and effective engagement are not intended here to be ends in themselves. Rather, they are indispensable to responsible decision making in the workplace wherever specialist knowledge needs to be applied within a variety of complex problem-solving contexts. In turn, they ought to reflect transferable graduate skills which are to be fostered in ensuring that the field of learning is practiced soundly and hence with reputable quality.

On the other hand, given the plethora of highly commendable literature by trained statisticians critiquing statistical blunders in the medical literature (such as Goodman and Berlin 1994, Senn and Harrell 1997, Senn and Harrell 1998, Bland and Peacock 2000, Altman 2002), it may seem surprising that any statistician should wish to entertain the notion of a clinician safely engaging with, or worse still, becoming a self-directed learner within, the field of medical statistics! Poor interpretation of statistics can cause much damage to the reputation of statistics and tensions can run high as statisticians become increasingly aware that pleas for greater caution are ignored under the misguided assumption that statisticians, and statisticians alone, are pathologically pre-conditioned to find statistics hard.

Having acknowledged these frustrations, I would argue that statisticians' expectations regarding the potential of medical students to engage effectively and responsibly with statistics at the undergraduate stage need to be raised considerably and that opportunities must be provided within the curriculum to meet these expectations. Irrespective of whether or not they should choose to pursue a career in research within the workplace, all practicing clinicians will be faced with the challenge of making clinical decisions through "interpreting the evidence" in the available literature with a considerable degree of autonomy and with confidence. The requirements to differentiate between good and bad evidence and to be able to empower patients to make informed decisions based on good communication of findings are unavoidable. The General medical Council (GMC), which is the regulatory body for the medical profession in the UK, has placed an increasing emphasis on the optimization of patient safety as a driving force for quality assurance of medical teaching (GMC 2006), thus reinforcing the importance of the above recommendations.

Moreover, undoubtedly, teachers of medical statistics will wish their students to be effectively engaged. Optimistically speaking, this quality of learning will have a long-term impact on the learner so as to enhance the quality of the study design and the interpretation of statistics in future clinical publications. It is with this sense of optimism and with a view to disseminating current knowledge and illustrations for practice that the following ten tips for *promoting* autonomous learning and engagement are presented below.

TIP 1

Face the facts concerning inhibitions and the need for stamina in the student's own learning of statistics.

Irrespective of the subject area concerned, an essential part of transformative learning entails maintaining contact with one's true self (Palmer 1998). During one-to-one sessions, the educator is in a prime position to facilitate this through encouraging authenticity on the part of the learner. As Rogers presents it,

> *"the teacher who can warmly accept, who can provide an unconditional regard, and who can empathize with the feelings of fear, anticipation, and discouragement, which are involved in meeting new material, will have done a great deal toward setting the conditions for learning." (Rogers 1967)*

In the learning of statistics in particular, a key message which needs to be communicated is that it is okay, even normal, to find the subject matter difficult. Students accustomed to learning other subjects more progressively or who are less inclined to reason mathematically for a number of possible reasons, including genetic make-up or lack of practise, may need particular reassurance in this respect. Frequently, such students will have been in the habit of performing well and may therefore not have developed the emotional stamina to handle the inevitable time lag which must elapse before they grasp the fundamental concepts and processes relating to the statistical procedures which apply to their research.

Questions regarding levels of confidence, motivation and enjoyment can be incorporated into a pre-meeting questionnaire, as has frequently been the case in the author's own work with undergraduate medical students engaged in 14-week clinical research projects in the form of Student-Selected Components (SSCs) within 4th year (SSC4s). This approach to self-expression can facilitate discussion in relation to improving student comfort levels regarding the idea of engaging with statistics. For example, within this context, an emphasis can be placed on the need for progressive learning and pointers can be provided to exemplar reports submitted by students who commenced their study experience from an entirely similar perspective.

An emphasis on the setting of realistic goals is critical at this early stage so as to ensure that the focus for the student can be on what they have accomplished rather than on what has been left undone. Otherwise, the educator is at risk of being designated the role of a 24/7 Accident and Emergency unit, with an unfathomable cost to the depth of understanding for the student and their capacity to engage in lifelong learning in statistics.

TIP 2

Validate the student's capacity to know.

As Baxter Magolda observes (Baxter Magolda 2001), use of current knowledge and experience is perceived as a "sign of respect" and simultaneously furnishes the learner with an awareness of their capacity to enhance their own learning. Likewise, citing medical diagnosis as one of several examples, Boyer observes (Boyer 1990) that the application of one's existent knowledge is a vehicle for "[n]ew intellectual understandings".

The pre-meeting questionnaire referred to earlier may, for example, also include a question on student perceptions of their ability to calculate and know when to use a variety of measures of central tendency and spread. With some careful prompting, follow-up discussions will regularly lead to some degree of recognition on the part of the student as they begin to recognize concepts which they have applied at secondary school level. Invariably, this knowledge will require to be complemented with a sound appreciation of how to choose between different measures according to different characteristics of the data and indeed as to relevant contexts for their application. Nevertheless, it is helpful at this stage to emphasize the value of summary statistics in explaining the characteristics of a study cohort to the reader of the project report, thus reassuring the student that they are already in a position to make a useful statistical contribution to their study.

Much can also be said in favour of validating students' capacities to contribute to their own and others' existing knowledge. The latter validation process can be facilitated by implementing the strategies recommended under Tip 1, above and through adapting more didactic style teaching sessions to incorporate video snapshots of previous students describing key transitions, disproved misconceptions and conquests in their personal learning experiences.

Trusting their judgements as a means of validating undergraduate medical students' capacity to know (Baxter Magolda 2001) may not be a realizable maxim within the field of statistics *per se*. Nevertheless, it is certainly feasible that the foundation can be laid for enabling the same students to select the correct tools to make informed judgements concerning the appropriate choice of statistical methodology. This may occur, for example, when the Bland-Altman procedure is used to compare the interchangeability of cardboard and plastic measuring devices. The student on obtaining their results may be concerned that they have 'failed to' validate the cardboard surrogate in keeping with the aspirations of their supervisor. However, within this context, the student has been introduced to the world of uncertainty where the views of the more experienced clinician are not sacrosanct and hypothesis testing may lead to theory revision. Equipped with the correct statistical tools and skills of interpretation to furnish their evidence base, they are now in a position to use their *own* yardstick of experience to engage in knowledge construction within their chosen clinical field and beyond, whilst sensing that their contribution is capable of being valued.

TIP 3

Provide a comprehensive online Data Preparation Tutorial to counteract psychological barriers to learning created by a formidable data file.

A consistent and often central issue for the student in commencing their statistical analysis is the arrangement of their data in spreadsheets in such a way that these data can be

a) regarded as an efficient and effective means of accessing information which was previously only available in questionnaires, patient records or in an overly comprehensive database

b) readily explained to a statistician

and

c) conveniently analysed using a suitable statistical package such as Minitab or SPSS[3].

(McAleer 1990) advises that when "confronted with statistics" the clinician should "[p]lan well in advance a method that will transfer raw data into a form suitable for statistical analysis." It is often at the stage of data preparation, however, that the greatest scope for anguish in using a statistical package takes place. All too often, spreadsheets involve individual columns containing *conglomerates* of variables such as *presence or absence of analgesic* combined with *type* and *dosage of analgesic used*. Furthermore, this scenario frequently occurs within a context where the student has been encouraged to collect additional data which is not required for their own needs but is of value to future projects. Within this context, it is difficult for the student to embark on the fundamental tasks of identifying questions for investigation and defining related hypotheses (which regrettably but typically takes place after the data have been collected). Moreover, students are often unaware of the value of including a group variable to differentiate between cases and controls for example and therefore have a tendency to create multiple spreadsheets with variations in which columns are included depending on the subgroup to be considered. This adds to the complexity of the preliminary datasheets, and unnecessarily so, leaving the student with an inflated view of what is genuinely required in transferring their data from a package such as Excel to SPSS or Minitab.

With such observations in mind, the author has designed an online Data Preparation tutorial for preparation of data for analysis in SPSS. The Data Preparation Tutorial involves a highly comprehensive PowerPoint presentation covering a wide range of anomalies in Excel spreadsheets based on several years of prior experience in working with students on a one-to-one basis. The anomalies are representative of those which would normally prevent the data from being amenable to analysis in SPSS or be likely to cause obstacles to sub-group analyses or recognition of meaningful research questions once the data had been saved in SPSS format. The presentation is accompanied by sequential spreadsheets in Excel (initial and intermediary stages) and SPSS (later stages) and students are encouraged to prepare their data using this tutorial prior to attending their first appointment.

Where the nature of a student-selected project is such that data need to be collected prospectively and are not therefore prepared in advance, students may also be concerned that they are at a disadvantage relative to their peers in advancing with their project. However, such students are invited to prepare some sample data in Excel using the above tutorial to take them at least to the intermediary stages of data preparation. In turn, further to their first appointment, they are encouraged to use online 'Spreadsheets for Practice' which have been made available to enable them to practice the techniques they can expect to be implementing with their future data. They are also encouraged to touch base again with the statistician should any resultant queries emerge.

Such interventions carry several advantages which are directly related to promoting student autonomy. These include:

i) less repetitive work on the part of the educator in providing individualized support in fine detail regarding alterations which require to be made to satisfy requirements a) to c), above;

ii) empowering the student to use further online resources for analysis of their data prior to arranging their first appointment;

and hence

iii) helping to eliminate the misconceptions that defining hypotheses for 'my data' and statistically analysing these data are formidable or even insurmountable tasks.

TIP 4

Ensure that the student maintains ownership of their own project.

The GMC introduced SSCs in 1993 (GMC 1993) with the intention of ensuring that between a quarter and a third of the UK undergraduate medical curriculum should be devoted to components which are non-optional but within which students could exercise choice in terms of their areas of specialisation.

Thus, the GMC placed an emphasis on the unique capacity of these projects to allow students to "have greater control over their own learning and develop their self-directed learning skills."

In practice, the majority of students choose their SSC projects and corresponding supervisors from an available list, with a target in some institutions of 90% for the proportion of students being allocated their first choice (Riley, Ferrell, Gibbs, Murphy and Smith 2008). In other cases, the student may be allowed to self-propose the topic of the project and approach a clinician who is considered to have considerable expertise in the corresponding field. Moreover, there is considerable scope for flexibility in terms of where to study, although this can vary according to the existing partnerships between universities and industry.

Thus, at the earliest stage of the SSC process there are opportunities for students to take responsibility for their own learning and indeed to become fully engaged with this activity, provided that choice is based on motivation to learn. Nevertheless, the process from initiation into the SSC experience to submission of the final report is a complex one, ideally involving responsible planning.

Without some early guidance, students, more out of naivety than indolence, can expect to arrive for their first consultation armed with the solitary question, "Here is my data; how do I analyse it?" In making this query, the student is already assuming that the statistical component of their project is a separate entity to be tagged onto their project proper and that the imagination of the statistician may prove an asset in putting the final icing on the cake when the project report is presented for assessment.

In this common scenario, the teacher of medical statistics may be confronted with a plethora of powerful forces enticing them to meet the student's perceived need. At this stage, therefore, it is extremely tempting to offer suggestions as to meaningful associations to test for and effective and efficient means of presenting relationships graphically. If student autonomy is to be realized, this temptation is best eliminated by a pragmatic approach rather than conquered by mere will power.

The author has developed an electronic booking form with individual sections for students to complete when requesting their first appointment. By means of these sections the student is invited to specify their own support needs (thus requiring them to consider in advance what they anticipate getting out of their appointment). They are also advised to provide a comprehensive project summary, specifying their key objectives and hypotheses. The electronic form, which has been developed with the support of an experienced Learning Technologist, is designed to arrive via email as an MS Word document and thus in a suitable format for future updating and editing by the statistician during consultations. On submission of the form, the student also receives an automatic reply providing them with their personal electronic copy.

The statistician is then in a position to advise the student in advance of their appointment if further information is required or if the style in which the project details have been presented is inadequate for a meaningful discussion. The scene is therefore set for a productive first session in which the student can be encouraged to set the agenda regarding the subject matter and priorities for the meeting.

More recently, the success of this intervention has been greatly enhanced by the inclusion of an exemplar request form within the system.

TIP 5

Make use of readiness for autonomous learning inventory and self-efficacy questions to assess the preparedness of students for self-directed learning and effective engagement.

For multifarious reasons, students vary considerably in their individual degrees of self-direction (Pratt 1988). In measuring readiness for autonomous learning or engagement, the educator is acknowledging that good teaching requires versatility. Nevertheless, it needs to be emphasized that the type of versatility required here is not to be measured in terms of statistical knowledge transmission but rather, in terms of pedagogical groundwork that requires to be performed to successfully direct the learner towards more effective engagement or a more self-directed style of learning.

The Self-Directed Learning Readiness Scale (SDLRS) was designed in 1977 (Gugielmino 1977) as a mechanism for quantifying adult readiness for self-directed learning. Since then, its construct validity has been confirmed through numerous studies involving a wide variety of cohorts of adult learners and different statistical techniques (see, for example, Mourad and Torrance 1979, Long and Agykekum 1983, Finestone 1984, Long and Agykekum 1984a, 1984b, Bentley and West 1989, Jones 1992, Baxter Magolda 2001) and is generally accepted as the most valid and widely used instrument of its kind.

The score forthcoming from this inventory is categorized into five classes from low to high, relating to the readiness of the individual for self-directed learning. Based on prior research, it is also regarded as a measure of preparedness for activities involving a high degree of problem-solving, creativity or change. The SDLRS can serve as a diagnostic test for the educator to identify students who are likely to exhibit resistance or disorientation when confronted with a learning programme which requires a high or even moderate level of personal self-management. It may also aid the student in aspiring to more advanced forms of learning provided the necessary teaching resources are in place to facilitate progression to a higher level of self-directed learning (Figure 1).

A further important measurable component in explaining an individual's level of engagement in learning, however, is self-efficacy. Self efficacy has been defined in a number of ways, including as the belief that one can perform a novel or difficult task, or cope with adversity (Scholz, Gutierrez-Dona, Sud and Schwarzer 2002) and as a measure of "people's judgements of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura 1986). Thus, measures of self-efficacy are understood to be predictors of whether individuals are likely to set high goals and how they are likely to respond emotionally and organizationally to a desirable but potentially challenging activity, such as becoming acquainted with statistics. They are also possible predictors of levels of stamina and commitment in the face of discouragements, relapses and challenges.

The commonly accepted measurement of self-efficacy is the General Self-Efficacy Scale (GES) of (Schwarzer and Jerusalem 1995). Like the SDLRS, the construct validity of the GES has withstood scrutiny from a number of sources (Schwarzer and Luszczynska).

Whilst the SDLRS inventory acknowledges self-efficacy in terms of self-concept as an effective learner, important items from the GES are omitted, particularly those relating to the capacity to handle unforeseen difficulties, solve difficult problems and remain focused on personal goals. As the GES comprises only 10 items, with a total average response time of about four minutes, it could conveniently be merged with the SDLRS inventory. However, the change in available response categories for this add-on would need to be highlighted for the benefit of the respondent and would preclude the possibility of conveniently combining scores from the SDLRS and GES in any meaningful sense.

Low self-efficacy scores can assist in promoting positive behavioural changes in individuals identified as being particularly vulnerable to discouragement. In designing a self-efficacy scale which is more effective in the preparation of students for a deeper approach in the learning of *medical statistics* and in maintaining this quality of learning, it is noteworthy that guidelines are available ((Schwarzer and Luszczynska) and (Schwarzer and Fuchs 1996)) for adaptation or extension of the GES to incorporate subscales representative of beliefs about the ability to perform target behaviours within specific contexts. The call for a revised version of the GES in assessing readiness of medical students for self-directed learning in statistics is implicit from Little's observation that "the learner who displays a high degree of autonomy in one area may be non-autonomous in the other." (Little 1991)

Moreover, to optimize the use of such a scale in improving student learning it is advisable to ensure that it is itemized to capture the specific type of task to be performed and that it is adapted accordingly as this task is changed. In making such distinctions, however, it is important that the level of specificity is not so high as to preclude its utility beyond the level of an individual institution.

TIP 6

Where constraints on time are considerable ensure that dependency is not a *necessity* of efficiency.

The limitation of time is frequently the precursor to increased dependency on others. For example, to avoid being late for an engagement, we will pursue the most accessible individual who is qualified to provide directions to the train station or to the appropriate aisle in the department store. The same is true within the domain of student learning.

It is not necessarily the case that comprehensive contents lists for eLearning materials can provide a sufficiently transparent medium for helping the inexperienced learner to know *exactly where* relevant information should be accessed from.

Ironically, attention to level of detail in catering for the varied needs of the masses can result in a formidable spectacle at the level of the *individual* learner. Indeed, for those with lower levels of self-efficacy, a highly comprehensive resource may be perceived as an obstacle to rather than an opportunity for engaging with statistics at a deeper level.

Within this context, the scope for student autonomy and engagement may be severely constrained by the need for the learner to consult the statistician for far more detailed advice than may seem appropriate if the student is ever to appreciate their individual role in knowledge construction. If online knowledgebases are to serve their original purpose, therefore, supplementary work needs to be done to assist the student along the pathway towards more self-directed learning.

Such observations have prompted the author to work with staff from the Learning Technology Section at her home university to develop two online searchable indexing systems for use within EEMeC (the web-based virtual learning environment for the Edinburgh Undergraduate Medical Programme). The indexes are defined separately for her online resources on Questionnaire Design and Statistics (including those relating to Frequently Asked Questions on Statistical Design and Analysis). Each index enables students to create a window of URLs to match their own enquiries involving key word searches. These indexes also contain an inbuilt system to enable automatic searching for related terms (including synonyms) based on previously selected key words and can be conveniently updated as new materials are added to the original knowledgebase. Furthermore, the students are encouraged to regard the indexes as being mutually constructed by the educator and the learner. To this end, free text search options are provided to supplement the listed search terms. The free text search options are linked to an automatic reply message for failed searches encouraging the student to specify terms they would like to see added to the online lists of index terms. A record of failed searches is also automatically generated within each of the two indexing systems. These records can be checked and updated by the statistician once new terms are added to the indexes.

TIP 7

Be sensitive to the notion that student autonomy is a process which can be represented by a staging model.

On embarking on a research project, undergraduate medical students are typically unable to gauge the potential level of difficulty and the workload associated with the statistical content of their work. Supervisor aspirations can often be a problem in this context. Recommendations to consult the statistician in retrospect regarding instructions on how to replicate a multivariate analysis discovered in a peer-reviewed journal are wholly unrealistic within a context where students have little recollection or prior knowledge of very basic statistics. Moreover, the process of model building, including the careful screening of potential predictors to include in a multivariate model, and the additional requirement of testing the goodness-of-fit of the model are essential steps for which the student has insufficient time within the context of a short research project.

If common sense is to have any place here, the teacher of medical statistics must take the bull by the horns and develop a learning programme for the student with meaningful learning goals representative of small wins. Where appropriate, these wins should be presented as possible foundation stones for larger successes involving more sophisticated statistical techniques. The student can then be provided with multiple stages at which to exit, where all such stages allow them to attribute meaning to the interpretation of their data but afford progressively greater insights into, for example, what can or cannot be inferred about the population based on the sample studied.

Whilst such an approach to teaching statistics can assist in preventing the student learning curve from spiralling out of control and in maintaining student momentum, the difficulty still remains of lack of prior statistical knowledge and in implementing such a strategy, the educator is still very much in control of student learning. This fact is an inevitable consequence of the student having a lack of prior information to process from earlier learning experiences which could provide illumination on their own options. *To ensure that undergraduate medical students are able to choose or even use statistics responsibly in a research project they ought to have had some fundamental experience of how to think statistically but the scene is rarely set to make this ideal a realizable one*. Without intervening through the provision of explicit guidance the educator would therefore succumb to the key pedagogical problem of mismatch between teaching style in terms of control of learning and student preparedness for self-directed learning.

(Grow 1991) usefully highlights the various contexts in which such mismatch can arise with reference to a Stages of Self-Directed Learning Model of the sort represented in Figure 1. Mismatch can occur when ellipses on the left and right of the figure are aligned in a different manner to that shown. In the teaching of statistics to medical students it may be the case that the educator is employed to assume the role of the facilitator when due to their lack of preparedness in the area of statistics in particular, students are still at the *dependent* stage.

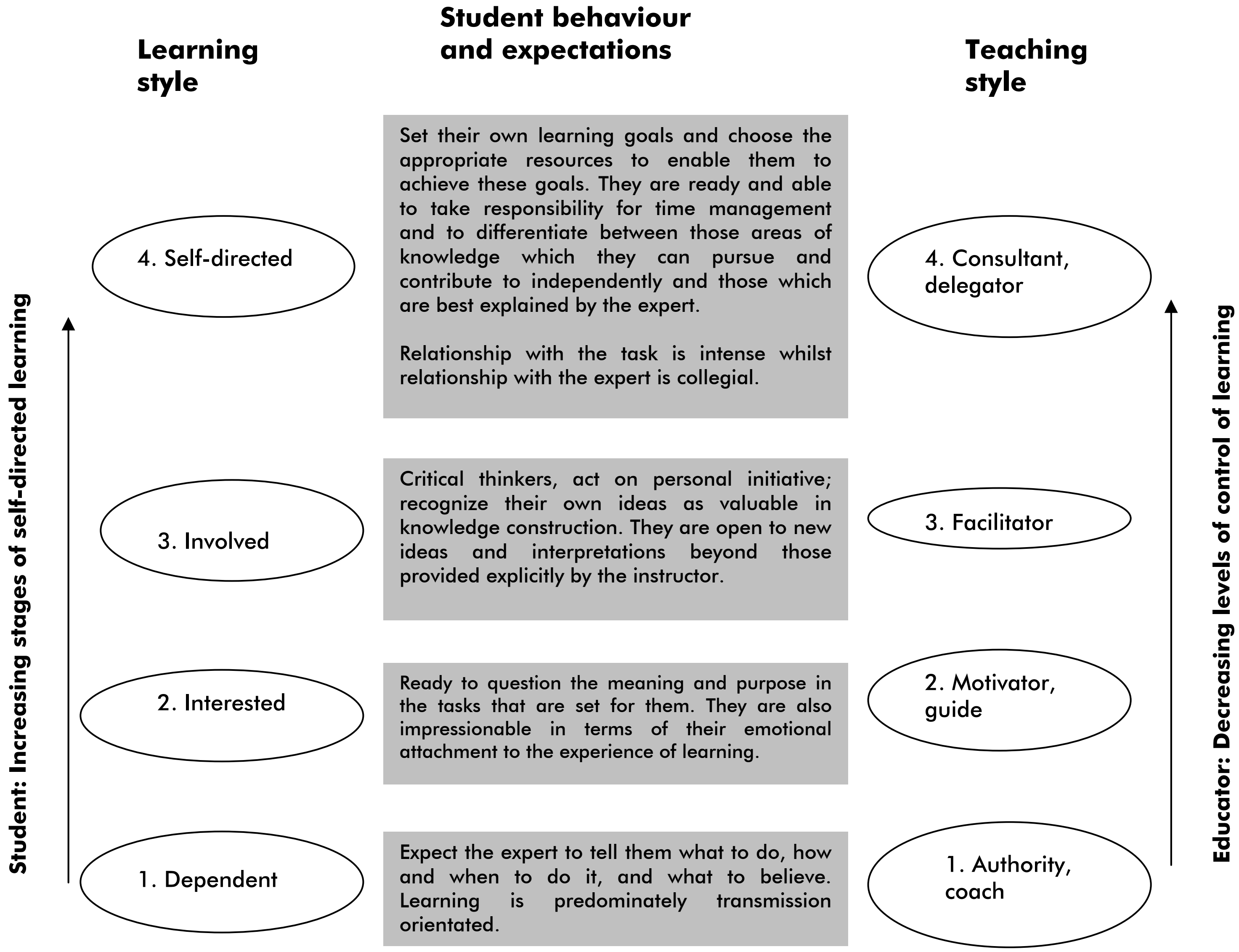

Figure 1. Corresponding learning and teaching styles and student roles in Grow's Stages of Self-Directed Learning

According to Grow's model, it is the responsibility of the educator to adapt their teaching style in such a way that the student's ability to manage their own learning increases.

His underlying philosophy of education includes the doctrines that "[t]he goal of the educational process is to produce self-directed, lifelong learners." The doctrine itself rests on the seemingly paradoxical assumption that "teachers can be vigorously influential while empowering students toward greater autonomy."

Invariably, however, students within any given cohort do not demonstrate the same degree of readiness for self-directed learning. For example, British students from overseas have in some studies shown a tendency to assume that ownership of academic knowledge lies mainly with the host country (Elsey and Kinnell 1990). In turn, they have perceived their responsibility as that of becoming acquainted with British ways of thinking concerning their fields of study. Consequently, they have been less inclined to question the objectivity of beliefs and practices within their host institution and recognize their own capacity for ownership or construction of knowledge. Moreover, in some East Asian countries conformity to popular beliefs and practice is seen as a cultural norm (Ho 2001), (Ming and Alias 2007) and (Alder-Collins and Ohmi 2006) and thus the idea of personalization of learning requires some explaining. Whilst for students from this type of cultural background, adaptation to learning in higher education in Western countries may ultimately prove liberating and intellectually rewarding, it may also prove more challenging due to less preparedness for self-directed learning.

As explained below, the associated need for identifying appropriate teaching and learning styles at an individual level can be addressed through the implementation of context specific inventories based on previously validated designs.

TIP 8

Ensure that statistical activities are fully integrated with core learning material rather than bolted on in the form of additional modules with only the appearance of clinical relevance.

In his description of scholarly activities, Boyer (1990) highlights the *application of knowledge* as an activity which promotes student engagement by prompting the student to ask the questions, "How can knowledge be responsibly applied to consequential problems?" and "How can it be helpful to individuals as well as institutions?" In depositing knowledge in the learner's brain, it can be implicitly assumed all too often that the brain then becomes a repository for future consultation. However, even where learners are exposed to multiple perspectives, adding richness to their insights and imparting freedom of choice regarding personal beliefs, it is highly unlikely that the knowledge transmitted will be retained unless it is "situated in the learners' experiences" (Baxter Magolda 2001) so as to lift the "barriers between learning and living" (Little 1991).

Application of knowledge is fundamental not only to retention but also to the quality of the learning experience in terms of level of engagement. In order to promote autonomous learning which is not purely assessment driven, it is necessary to protect the student from finding it convenient to treat the statistical content of their course as a separate entity (Entwistle 2005) and from endeavouring to learn without a justification for depth of understanding. Indeed, it has been recognized (Bryson and Hand 2007) that even students with an intrinsic interest in a subject can feel alienated if they are conditioned to focus on the "output orientation" of their degree, including exam performance without a sense of personal commitment. Where statistical assignments are presented simply as an extension to an already highly demanding workload, this sense of alienation can be compounded, and students may resort to procrastination as a temporary means of escape.

It is fundamental, therefore, that the theoretical content being assessed is explicitly presented as part of a process which every student can expect to use in their future professions. In terms of applying this principle to learning approaches, Ramsden observes with reference to Medicine in particular that:

> *"a deep approach typically appears as the establishment of a complex chain of associations which links symptoms to theoretical knowledge." (Ramsden 1992)*

Ramsden's observation is generalizable in Medicine beyond the topic of diagnosis and may in particular be used to refer to the linkage of risk-based concepts in statistics (*including number needed to treat* or *harm*, *absolute risk difference*, *relative risk and odds ratio*) with decision making relating to the correct choice of treatment or indeed whether a new treatment ought to be introduced or withdrawn. Through her Higher Education Academy funded project, "Statistics in medicine: a risky business?", the author is currently developing Computer Assisted Learning objects (CALs) which foster a deep approach to learning in Ramsden's sense. The CALs involve integration of real-life case scenarios from recent medical literature with explanations of statistical concepts, structured examples and exercises which provide detailed immediate feedback on understanding.

TIP 9

Ensure that the principle of integration of statistics with core learning material is carried over to formal assessment.

Under Tip 8, above, an emphasis has been placed on promoting a deep approach to the learning of statistics. The intention here, is not only to guard against a more surface approach to learning but also, to prevent a purely strategic approach according to which the single intention is to optimize exam performance.

Nevertheless, the undergraduate medical curriculum is typically very demanding in terms of student workload. Moreover, all medical school graduates must complete a two-year Foundation Year training programme in order to practice medicine in the UK. On account of the use of ranking based on student exam performance in current application procedures for UK postgraduate Foundation Year programmes, medical students have the additional pressure of competing with their peers for selection for their preferred programme and associated clinical attachments.

Conseqeuntly, students who set out with the full intention of becoming model learners, fully engaged with learning processes for all of their course content, may be compelled to transfer to 'efficiency mode' to manage their own learning packages (Baxter Magolda 2001). During exam preparation, for example, they may be tempted to dissect their carefully integrated body of knowledge so as to eliminate the non-assessable parts, thus sabotaging the original objectives of the educator.

The teacher of medical statistics is therefore obliged not merely to recognize assessment as an essential means of maintaining student momentum in engaging with statistics. Rather, they should also ensure that assessments measure an advanced form of learning according to which the parts are understood in relation to the whole.

Assessment tools should therefore be designed to reinforce the marriage between clinical case scenarios and application of statistics evident in preparatory learning tools. As recommended under Tip 8, above, this can be facilitated in the form of formative assessment through the development of CAL materials involving explicit and immediate feedback to student responses to structured questions. It is important, however, to ensure that subsequent online materials for formal summative assessment are presented in an environment with which the student has already become familiar in the absence of any technological barriers which may impede the validity of the assessment of statistical knowledge.

TIP 10

Engender critical thinking and a sense of uncertainty regarding the presentation of statistics in the medical literature.

By the time they have entered 4th year or ideally, much earlier, one would hope that most medical students will have grown tired of the maxim, "don't believe all that you read."

It is typical and natural, however, for senior students to revert back to a more naïve perspective when presented with a subject area in which they lack the necessary experience to detect conceptual blunders or misapplications of techniques based on reasonably intuitive arguments. They must therefore acquire the art of being legitimately tentative towards the interpretation of data presented in medical publications.

In his list of defining features of a deep approach, as opposed to a surface approach, to learning (Entwistle 2005) includes, amongst others, those of "Checking evidence and relating it to conclusions" and "Examining logic and argument cautiously and critically". For the inexperienced student, the acquisition of these skills can seem so much more worthwhile when presented in an interactive learning environment where misguided conclusions can be seen as a direct hindrance to deriving optimal pathways for patient care. Such an environment is facilitated by the approaches to teaching outlined under Tips 8 and 9, above.

As is the case with the author's own CAL development work, the student can be introduced to Simpson's paradox within the context of erroneous approaches to aggregating risk estimates across studies in the comparison of two competing methods of operative repair. This approach may prove a particularly useful aid to lifelong learning for those who would otherwise have insufficient training to recognize bad practice in the application of meta-analysis techniques to patient data. Moreover, within this context, the educator has the opportunity to encourage the learner to recognize the importance of *fully* enlisting a specialist medical statistician at the early stages of a project where statistical work involving a higher level of expertise than that expected from a medical graduate is anticipated. The importance of disseminating this message cannot be over-estimated as a means of reducing opportunities for the compromise of personal professional integrity. Where the statistician is consulted casually, retrospectively or as a mere formality, instances can arise where papers are pushed forward to the submission stage irrespective of concerns raised about the validity of the conclusions they contain in relation to clinical findings.

Even where clinicians have opted for appropriate statistical procedures, concerns remain regarding how the results forthcoming from these procedures are carried forward into the interpretation of clinical outcomes. There is an evident need to train medical undergraduates to critically assess the logical coherence of arguments which formulate the conclusions of a study in a published paper. Such considerations should not be limited to highlighting the well-known distinction between association and cause-and-effect. There is also a critical need for highlighting the importance of differentiating between sufficient and necessary conditions, and valid and invalid forms of logical argument and for demystifying the notion of confounding. These needs become particularly apparent where efforts are made to distinguish between the predictor and response variables in affording clinical explanations for the results of hypothesis tests.

Conclusion

Ironically, autonomous learning does not take off autonomously but rather is dependent on the initiative of the educator. Within the context of teaching statistics to undergraduate medical students involved in short research projects, there is incredible scope for addressing the mismatch between students' prior experiences in learning statistics and the role of the educator as a facilitator. Moreover, through the implementation of structured learning strategies, students can be encouraged to engage effectively with statistics. Such strategies can be used to develop the capacity to differentiate between good and bad practice. However, they may also be presented as a means of enabling learners to appreciate the complexity of statistics and make responsible decisions regarding the involvement of a professional statistician in more complex work. Furthermore, having a heightened awareness of the potential for misunderstandings concerning less familiar types of analyses should provide an incentive for the statistically trained clinician to consult a medical statistician prior to the start of a project wherever more specialist knowledge may be required at the planning stage.

In the longer term, exposure of medical students to worked examples contrasting good and bad statistical practice ought to have a positive effect on patient care. It is therefore anticipated that the additional time spent by the educator in designing resources which promote effective engagement and autonomous learning will be of value, not only in enhancing the quality of statistical practice in medical graduates but more generally to society as a whole.

The need is also recognized, however, to make provision for the training of undergraduate medical students in the use of sound logical reasoning as a means of ensuring that appropriate inferences are being drawn once suitable statistical procedures have been implemented.

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[3] "SPSS" denotes "Statistical Package for the Social Sciences".

TESTING: FIRST STEP TOWARDS SOFTWARE QUALITY

Quality is never an accident; it is always the result of high intention, sincere effort, intelligent direction and skillful execution; it represents the wise choice of many alternatives.
(William A. Foster)

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Abstract: *This article's purpose is to present the benefits of a mature approach to testing and quality activities in an engineering organization, make a case for more education with respect to software quality and testing, and propose a set of goals for quality and testing education.*

Key words: *software testing; course curricula; quality assurance; testing tools*

1. Introduction

IT managers and professionals may have varied opinions about many software development principles, but most agree on one thing above all – the software you deliver must be accurate and reliable. And successful software development groups have long recognized that effective testing is essential to meeting this goal.

In a recent survey of software development managers, the most often cited top-of-mind issue was software testing and quality assurance [Zeich05][1]. Testing is not quality assurance—a brilliantly tested product that was badly conceived, incompetently designed and indifferently programmed will end up a well-tested, bad product. However, software testing has long been one of the core technical activities that can be used to improve the quality of software. Many organizations invest heavily in testing and many software developers work as testers. For example, most Microsoft projects employ one tester per programmer [Cusum98]; [Gates97]

Despite testing's well-established benefits, however, many IT organizations, especially in the Romanian newly-developed software market, still give the practice short shrift, considering thorough testing impractical; as expected from a fairly new software engineering culture, the approach and mentality are development-centric. The limited testing most of the IT organizations do conduct is often haphazard and painfully cumbersome, an effort with little if any gain. Also, most notable is the small, if any at all, presence of the quality-related education in the engineering / computer science schools and universities.

2. Software management, quality assurance, and testing

Before we dive into the details, let's look at where testing fits in the larger world of software management and why it is a valuable practice.

2.1. Software systems context

Software systems are an increasing part of life, from business applications to consumer products. Most people have had an experience with software that did not work as expected. Software that does not work correctly can lead to many problems. We can mention here loss of money, loss of time or business reputation.

A human being can make an error, which produces a fault in the code, in software or a system, or in a document. If a defect in code is executed, the system will fail to do what it should do or even do something it shouldn't, causing a failure. Defects in software, systems or documents may result in failures, but not all defects do so.

Defects occur because human beings make mistakes and also because of time pressure, complex code, complexity of infrastructure, changed technologies, and many system interactions, including environmental conditions

2.2. Software management

Software management is a set of practices that attempt to achieve the following goals:

- Deliver software products with the expected functionality and quality;
- Deliver in the expected timeframe;
- Deliver for the expected cost;
- Meet expected levels of service during the software's use.

Effective software management is a matter of setting and meeting expectations, which requires a software development process that is ***predictable*** and that produces consistent outcomes. Testing is one of the software management practices that helps improve predictability and consistency.

2.3. Quality assurance

The overall goal of QA is to deliver software that minimizes defects and meets specified levels of function, reliability, and performance. Quality Assurance makes sure the project will be completed based on the previously agreed specifications, standards and functionality required without defects and possible problems. It monitors and tries to improve the development process from the beginning of the project to ensure this. A good, healthy quality assurance process should be overall oriented to "prevention".

2.4. Testing general issues

Testing is a collection of techniques used to measure, and thereby improve, software quality. Testing fits in the broader category of software management practices known as quality assurance (QA), along with other practices, such as defect tracking and design and code inspections. Software testing is oriented to "detection" [KaPe02].

A common perception of testing is that it only consists of running tests, i.e. executing the software. This is part of testing, but not all of the testing activities.

Test activities exist before and after test execution, activities such as planning and control, choosing test conditions, designing test cases and checking results, evaluating completion criteria, reporting on the testing process and system under test, and finalizing or closure (e.g. after a test phase has been completed). Testing also includes reviewing of documents (including source code) and static analysis.

Both dynamic testing and static testing can be used as a means for achieving similar objectives, and will provide information in order to improve both the system to be tested, and the development and testing processes.

There can be different test objectives:

- finding defects;
- gaining confidence about the level of quality and providing information;
- preventing defects.

The thought process of designing tests early in the life cycle (verifying the test basis via test design) can help preventing defects from being introduced into code. Reviews of documents (e.g. requirements) also help to prevent defects appearing in the code.

Debugging and testing are different. Testing can show failures that are caused by defects. Debugging is the development activity that identifies the cause of a defect, repairs the code and checks that the defect has been fixed correctly. Subsequent confirmation testing by a tester ensures that the fix does indeed resolve the failure. The responsibility for each activity is very different, i.e. testers test and developers debug.

The most visible part of testing is executing tests. But to be effective and efficient, test plans should also include time to be spent on planning the tests, designing test cases, preparing for execution and evaluating status.

The fundamental test process consists of the following main activities:

- planning and control;
- analysis and design;
- implementation and execution;
- evaluating exit criteria and reporting;
- test closure activities.

Although logically sequential, the activities in the process may overlap or take place concurrently.

2.5. Motivation for testing

By understanding the root causes of defects found in other projects, processes can be improved, which in turn should prevent those defects reoccurring and, as a consequence, improve the quality of future systems.

Effective testing before production deployment achieves three major benefits:

- Discovering defects before an application is deployed allows you to fix them before they impact business operations. This reduces business disruptions from software failure or errors and reduces the cost of fixing the defects.
- You can estimate the extent of remaining, undiscovered defects in software and use such estimates to decide when the software meets reliability criteria for production deployment.
- Test results help you identify strengths and deficiencies in your development processes and make process improvements that improve delivered software.

Considering the first benefit, your own experience probably confirms what software researchers have discovered: The later a "bug" or other defect is found, the more troublesome and expensive it is as is depicted in Figure 1.

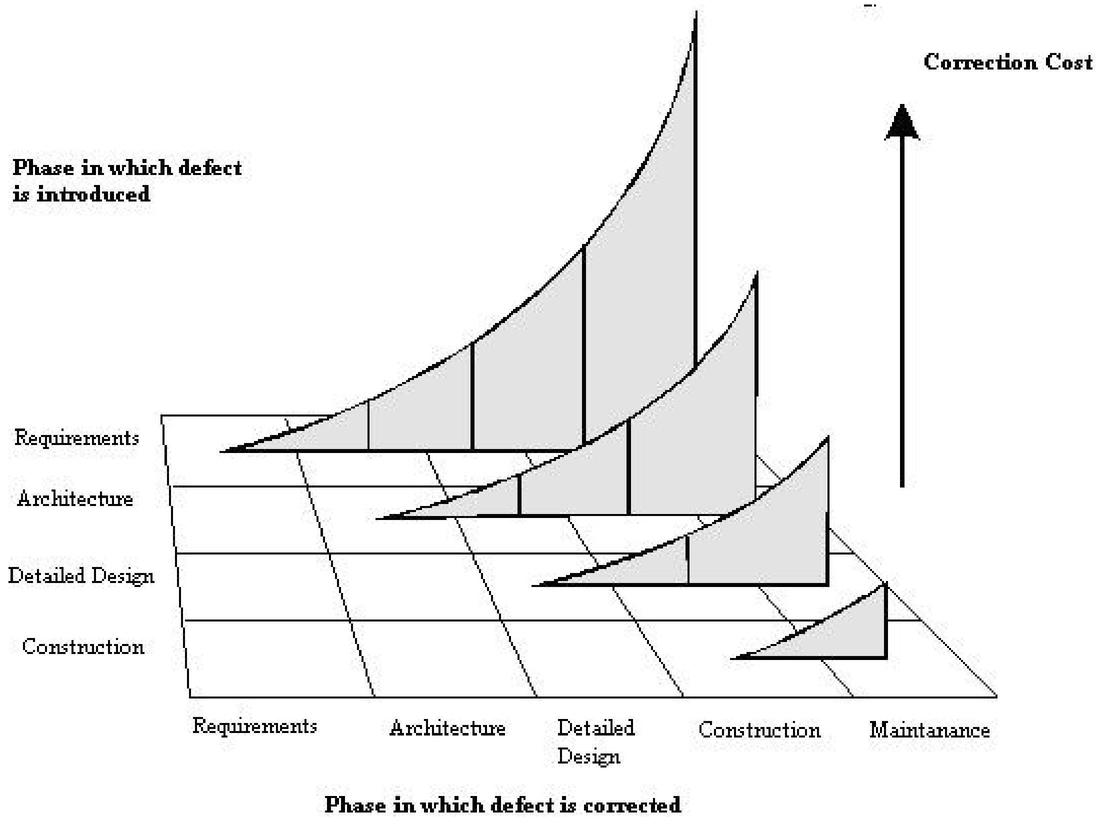

Figure 1. Cost of defects in development phases [McCon97]

Defects in production software can severely disrupt business operations by causing downtime, customer complaints, or errors. Software researchers have found that defects discovered in production can be as much as one hundred times more expensive to fix than those found early in the design and implementation process. Excessive numbers of defects also disrupt the software development process, because the development group "thrashes" as they try to manage the cycle of fixing defects in production code while adding new features or making other planned changes required by the business.

Test execution is just one way to discover defects earlier in the development process. Various studies indicate that well-conducted testing by itself may identify somewhere around 50 or 60 percent of the defects present in an application. Design and code inspections are another technique for discovering defects; and, interestingly, research indicates inspections can achieve error detection rates as high as 90 percent. [Kaner04]; [KaNg93]

With the help of testing, it is possible to measure the quality of software in terms of defects found, for both functional and non-functional software requirements and characteristics (e.g. reliability, usability, efficiency and maintainability).

Thorough testing of systems and documentation can help to reduce the risk of problems occurring in an operational environment and contribute to the quality of the software system, if defects found are corrected before the system is released for operational use.

Another benefit of testing (which applies to code inspections, as well) is that you gain some measures of how "buggy" a piece of software is before you decide to deploy it. For example, if your experience with testing reveals that, on average, about as many defects are found after deployment as are found during testing, then you can project a similar relationship for future projects.

Software testing may also be required to meet contractual or legal requirements, or industry-specific standards.

2.6. Testing principles

A number of testing principles have been suggested over the past 40 years and offer general guidelines common for all testing. These should be the fundament for a healthy testing organization approach. [GrVe06]

a) Principle 1 – Testing shows only presence of defects

Testing can show that defects are present, but cannot prove that there are no defects. Testing reduces the probability of undiscovered defects remaining in the software but, even if no defects are found, it is not a proof of correctness.

b) Principle 2 – Exhaustive testing is impossible

Testing everything (all combinations of inputs and preconditions) is not feasible except for trivial cases. Instead of exhaustive testing, risks and priorities are used to focus testing efforts.

c) Principle 3 – Early testing

Testing activities should start as early as possible in the software or system development life cycle, and should be focused on defined objectives.

d) Principle 4 – Defect clustering

A small number of modules contain most of the defects discovered during pre-release testing, or show the most operational failures.

e) Principle 5 – Pesticide paradox

If the same tests are repeated over and over again, eventually the same set of test cases will no longer find any new bugs. To overcome this "pesticide paradox", the test cases need to be regularly reviewed and revised, and new and different tests need to be written to exercise different parts of the software or system to potentially find more defects.

f) Principle 6 – Testing is context dependent

Testing is done differently in different contexts. For example, safety-critical software is tested differently from an e-commerce site.

g) Principle 7 – Absence-of-errors fallacy

Finding and fixing defects does not help if the system built is unusable and does not fulfill the users' needs and expectations.

3. High-level issues for building an effective quality/testing organization

3.1. Test organization and independence

A critical issue with testing is independence. [ISTQB05] The effectiveness of finding defects by testing and reviews can be improved by using independent testers. Options for independence are:

- Independent testers within the development teams.
- Independent test team or group within the organization, reporting to project management or executive management.
- Independent testers from the business organization, user community and IT.
- Independent test specialists for specific test targets such as usability testers, security testers or certification testers (who certify a software product against standards and regulations).
- Independent testers outsourced or external to the organization.

For large, complex or safety critical projects, it is usually best to have multiple levels of testing, with some or all of the levels done by independent testers. Development staff may participate in testing, especially at the lower levels, but their lack of objectivity often limits their effectiveness. The independent testers may have the authority to require and define test processes and rules, but testers should take on such process-related roles only in the presence of a clear management mandate to do so.

The benefits of independence include:

- Independent testers see other and different defects, and are unbiased.
- An independent tester can verify assumptions people made during specification and implementation of the system.

Drawbacks include:

- Isolation from the development team (if treated as totally independent).
- Independent testers may be the bottleneck as the last checkpoint.
- If proper communication is not insured, developers may lose a sense of responsibility for quality.

3.2. Testing staff education

Even though erratic testing could provide "some" results, delivering quality software cannot be achieved without the testing personnel having the appropriate knowledge for approaching testing in a more scientific way. We should address this topic further in the 3rd section of this paper.

3.3. Tools for testing activities

There are tools available to support many activities in the test processes. Some of them are purely the basis for a well-established testing organization (such as defect tracking tools), others provide improvements in testing efficiency. Irrespective of that, providing the correct set of tools to the testing organization can be critical to its success.

Tools can be classified in according to the testing activities that they support [GrVe06]. Some tools clearly support one activity; others may support more than one activity, but are classified under the activity with which they are most closely associated.

Management tools apply to all test activities over the entire software life cycle:

- Test management tools.
- Requirements management tools.
- Incident management tools.
- Configuration management tools.

The major benefit of **static testing tools** is the cost effectiveness of finding more defects at an earlier time in the development process. As a result, the development process may accelerate and improve by having less rework. Tools to support static testing are:

- Review process support tools.
- Static analysis tools.
- Modeling tools.

Test specification tools support testing activities prior to test execution:

- Test design tools.
- Test data preparation tools.

Probably the broadest set of tools is the category that provides support for the actual testing activities: test execution, monitoring and logging:

- Test execution tools (functional).
- Test harness/unit test framework tools.
- Test comparators.
- Coverage measurement tools.
- Security tools.
- Dynamic analysis tools.
- Performance testing/load testing/stress testing tools.
- Monitoring tools.

Other tools might appear to provide support for **specific application areas**.

4. Proposed education goals

The intent of this section is to pinpoint some very specific information that should be part of any tester's knowledge, information that could be provided, for example, as part of a university curriculum or professional training for testing specialists. The main topics of the course would be:

- Testing fundamentals.
- Testing within the software life cycle context.
- Static testing techniques.
- Test design techniques.
- Test management.
- Tools support for testing.

4.1. Testing fundamentals

A good tester should understand his role in the organization and the responsibility this role assumes. A trained tester should:

- Understand the way in which a defect in software can cause harm to a person, to the environment or to a company.
- Distinguish between the root cause of a defect and its effects.
- Be aware of his role as part of quality assurance.
- Understand how testing contributes to higher quality.
- Understand the terms mistake, defect, failure and corresponding terms error and bug.
- Understand the purpose of testing in software development, maintenance and operations as a means to find defects, provide confidence and information, and ultimately prevent defects.
- Live his professional life by the principles of testing
- Know the fundamental test activities from planning to test closure activities and the main tasks of each test activity:
    - test planning;
    - test control;
    - test analysis and design;
    - test implementation and execution;
    - evaluate exit criteria;
    - reporting;
    - test closure activities.
- Be aware that the success of his job is influenced by psychological factors:
    - clear objectives;
    - a balance of self-testing and independent testing;
    - recognition of courteous communication and feedback on defects.

4.2. Testing within the software life cycle context

Testing does not exist in isolation. Testing activities are related to software development activities. Different approaches to testing are needed for different development life cycle models. In this context, a tester should:

- Understand the relationship between development, test activities and work products in the development life cycle model of the environment, product characteristics and context.
- Know and use test levels:
    - Component testing.
    - Integration testing.
    - Systems testing.
    - Acceptance testing (user, operational, contract, field).
- Know and use the four testing types:
    - functional,
    - non-functional,
    - structural,
    - change-related
- Apply functional and structural tests occur at any test level.

- Identify non-functional test types based on non-functional requirements.
- Identify test types based on the analysis of a software system's structure or architecture.
- Understand the purpose of confirmation testing and regression testing
- Make the difference between maintenance testing (testing an existing system) and testing a new application with respect to test types, triggers for testing and amount of testing.
- Identify reasons for maintenance testing (modification, migration and retirement) and apply this in his job.
- Know the role of regression testing and impact analysis in maintenance.

4.3. Static testing techniques

Static testing techniques do not execute the software that is being tested; they are manual (reviews) or automated (static analysis). A test engineer should:

- Apply the different static techniques to examine software work products, using specific phases, roles and responsibilities, and success factors for each type of technique:
  - informal review;
  - technical review;
  - walkthrough;
  - inspection.
- Be aware of the importance and value of considering static techniques for the assessment of software work products.
- Understand the objective of static analysis.
- Be familiar with typical defects and errors identified by static analysis
- Acknowledge both typical and organization specific benefits of static analysis.
- Know typical code and design defects that may be identified by static analysis tools.

4.4. Test design techniques

The purpose of a test design technique is to identify test conditions and test cases. Accumulated knowledge should allow a test engineer to:

- Identifying test conditions and design test cases.
- Know and apply concepts like: test design specification, test case specification and test procedure specification.
- Write test cases:
  - showing a clear traceability to the requirements;
  - containing an expected result.
- Translate test cases into a well-structured test procedure specification at a level of detail relevant to the knowledge of the testers.
- Write a test execution schedule for a given set of test cases, considering prioritization, and technical and logical dependencies.
- Be familiar with categories of test design techniques.
- Recall reasons that both specification-based (black-box) and structure-based (white-box) approaches to test case design are useful, and be aware of the common techniques for each.

- Know the characteristics and differences between specification-based testing, structure based testing and experience-based testing.
- Be familiar with and apply specification-based or black-box techniques
- Write test cases from given software models using test design techniques like:
  - equivalence partitioning;
  - boundary value analysis;
  - decision tables;
  - state transition diagrams.
- Understand the main purpose of each of the four techniques, what level and type of testing could use the technique, and how coverage may be measured.
- Understand the concept of use case testing and its benefits.
- Be familiar with and apply structure-based or white-box techniques
- Understand the concept and importance of code coverage.
- Understand the concepts of statement and decision coverage, and understand that these concepts can also be used at other test levels than component testing (e.g. on business procedures at system level).
- Write test cases from given control flows using test design techniques like:
  - statement testing;
  - decision testing.
- Assess statement and decision coverage for completeness.
- Apply experience-based techniques
- Be able to write test cases based on intuition, experience and knowledge about common defects, and specific areas where defects are prone to appear.
- Be able to make a decision choosing test techniques
- Identify the factors that influence the selection of the appropriate test design technique for a particular kind of problem, such as the type of system, risk, customer requirements, models for use case modeling, requirements models or tester knowledge.

4.5. Test management

Due to the more independent nature of the testing activities, issues of test management should be well known to a member of the testing team [Black02]; [Black07], who should:

- Show proficiency in test organization:
  - Understand the importance of, and advocate for independent testing.
  - Understand the benefits and drawbacks of independent testing within an organization.
  - Recognize the different team members to be considered for the creation of a test team.
  - Recall the tasks of typical test leader and tester.
- Display good skills in test planning and estimation
  - Use the different levels and objectives of test planning.
  - Be familiar with the purpose and content of the test plan, test design specification and test procedure documents according to the 'Standard for Software Test Documentation' (IEEE829).
  - Be aware of the typical factors that influence the testing-related effort.

- Be familiar with the two conceptually different estimation approaches: the metrics-based approach and the expert-based approach.
- Be able to devise, or at least be familiar with various documents types, such as test planning for a project, for individual test levels (e.g. system test) or specific test targets (e.g. usability test), and for test execution.
- Know the test preparation and execution tasks that need planning.
- Use and justify adequate exit criteria for specific test levels and groups of test cases.

- Be able to run test progress monitoring and control activities:
  - Use common metrics for monitoring test preparation and execution.
  - Understand and interpret test metrics for test reporting and test control (e.g. defects found and fixed, and tests passed and failed).
  - Be familiar with the purpose and content of the test summary report document according to the 'Standard for Software Test Documentation' (IEEE 829) or organization specific standard.
- Understand how configuration management interacts with and supports testing.
- Be able to take a risk-based approach to testing
  - Understand risks as a possible problem that would threaten the achievement of one or more stakeholders' project objectives.
  - Prioritize risks by likelihood (of happening) and impact (harm resulting if it does happen).
  - Distinguish between the project and product risks.
  - Identify typical product and project risks.
  - Use risk analysis and risk management for test planning.
- Write incident reports covering the observation of a failure during testing.
- Use the 'Standard for Software Test Documentation' (IEEE 829) incident report or organization specific standard.

4.6. Tools support for testing

There are a number of tools that support different aspects of testing. A proficient member of the testing organization should be able to:

- Be familiar with the different types of test tools according to the test process activities.
- Know the tools that may help developers in their testing.
- Understand the potential benefits and risks of test automation and tool support for testing.
- Recognize that test execution tools can have different scripting techniques, including data driven and keyword driven.
- Know and understand the main principles of introducing a tool into an organization.
  - Use the goals of a proof-of-concept/piloting phase for tool evaluation.
  - Identify factors (other than simply acquiring a tool) that are required for good tool support.

5. Conclusions

Efficiency and quality are best served by approaching testing activities in a structured and scientific way, instead of the, unfortunately, usual 'monkey-testing'. The effectiveness of testing effort can be maximized by selection of appropriate testing strategy, good management of testing process, and appropriate use of tools to support the testing process. The net result would be an increase in the produced software quality and a decrease in costs, both of which can only be beneficial to a software development organization.

However, in order to be able to put quality processes into place, the appropriate knowledge is needed. The quality engineering should be recognized as a standalone area of study and treated as such in the computer science universities and faculties curricula in the emergent software development market that Romania is. Taking the right path can never be too early; it can only be too late.

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STATISTICAL MODELING OF THE GROUNDWATER ARSENIC CONTAMINATION LEVEL IN BANGLADESH DUE TO CHEMICAL ELEMENTS

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Abstract: *This paper intends to offer a modeling of the magnitude of arsenic, by using 54 variables of chemical elements based on secondary data. The samples are collected from 113 wells from different areas of Bangladesh. The study shows that 9 variables are significantly related with the arsenic variable. Analysis also claims that arsenic variable can be modeled with three principal components (a linear combination of independent variables). The study also considered the latitude and longitude variables but there is no spatial autocorrelation between them.*

Key words: *regression model; principal component; spatial autocorrelation; arsenic contamination; chemical elements*

1. Introduction

Arsenic contamination of the groundwater is a major threat to public health in Bangladesh and West Bengal. Groundwater often provides water supply that is more reliable in quantity and more stable in quality than the surface water and thus it has economic and operational advantages due to reduced treatment requirements [8][6]. Until the early 1970s, more than 100 million inhabitants of Bangladesh and the neighbouring West Bengal drank from shallow hand-dug wells, rivers and ponds. These sources of water are generally polluted and account for various water-borne diseases such as diarrhoea, polio, typhoid, amebiasis etc. In order to provide safe drinking water, the government of Bangladesh, international agencies such as UNICEF and various non-government organizations (NGO's) were engaged in setting up tube wells - steel pipes fitted for simple hand pumps in order to tap the plentiful and apparently clean water in the sand and silt of the Ganges flood plain. There are about 3-5 millions tube wells present today, whereas they were only about 50,000 during the British colonial rule [10]. Groundwater provides safe drinking water to over 97% of the rural population in Bangladesh. This extensive coverage is an indication of the country's successful attempt as to provide safe drinking water to its main population. However, the recent discovery of arsenic in the groundwater has ruined this decade-long success, so the access to safe drinking water has dropped to almost 80% [10].

Arsenic is well-known for its toxicity and carcinogenicity. Clinical effects of arsenic mainly include Keratosis and Melanosis. Other clinical manifestations include body related disturbances, cerebral inffection, cangrene, muscular atrophy, depressive state, auditory problem and various neurological symptoms. The acceptable source of arsenic is the geological route, as it was transported by rivers from the sedimentary rocks in the Himalayas during tens of thousands of years. On the other hand, the anthropogenic sources are other unwanted sources of arsenic. In average, 27% of the shallow tube wells in Bangladesh are producing water with arsenic in excess in comparison to the Bangladesh standard of 0.05mg/l for drinking water.

Non-cancer effects of arsenic can include thickening and discoloration of the skin, stomach pain, nausea, vomiting, diarrhoea, blindness, partial paralysis and numbness in hands and feet. Arsenic has been linked to cancer of the bladder, lungs, skin, kidney, nasal passages, liver and prostate

Bangladesh is a very small country with a total area of 147,570 sq.km and the total population accounts for about 150 millions people. It is the most densely populated country in the world. It is bordered on most sides by India and by Myanmar in the Southeast. Bangladesh has a tropical monsoon climate with a high annual rainfall of 1000-2000 mm or more, falling mainly during the period June- September. Bangladesh has a large area of surface waters taking the form of the major Padma (Ganges), Jamuna (Brahmaputtra), Meghna Rivers and their tributaries. [12]

The number of estimated tube-wells in Bangladesh is around 6-11 millions. The vast majority of these are private tube-wells that penetrate the shallow alluvial wells to depths typically of 10-60 m. In the south and in the Sylhet Basin from northeast Bangladesh, deep tube-wells abstract groundwater from depth of 150m or more. In the south, the tube wells have been installed as to avoid high salinity at shallower levels [1]. Shallow hand- dug wells occur in some areas although they are less common than tube wells.

Arsenic presence in the drinking water is a new, unfamiliar problem to the population in Bangladesh, including concerned professionals. There are millions of people who may be affected by drinking arsenic-rich water. The fear for future adverse health effects is a major concern because of the water already being consumed. It has been suggested by WHO that there are between 8-12 million shallow tube-wells in Bangladesh. Piped water supplies are available only to a little more than 10% of the total population living in the large agglomerations of some district towns while up to 90% of the Bangladesh population prefer to drink well water. Until the discovery of arsenic in the groundwater in 1993, well water was regarded as safe for drinking. It is now generally agreed that the arsenic contamination of groundwater in Bangladesh is of geological origin. The arsenic derives from the geological strata underlying Bangladesh. Over the next decade, skin and internal cancers are likely to become the principal human health concern arising from arsenic. According to one estimate, at least 100,000 cases of skin lesions caused by arsenic have occurred and there may be many more. [9]

The number of people drinking arsenic-rich water in Bangladesh has increased dramatically since the 1970s due to well-drilling and population growth. The impact of arsenic extends from immediate health effects to extensive social and economic hardship that affect especially the poor. The costs of health care, the inability of the affected persons to engage in productive activities and the potential social exclusion are important factors to be taken into account.

Several factors, significantly related to arsenic, need to be selected through our proposed model. The level of arsenic in the ground water varies from region to region, in relation with the depth of the tube wells and of other factors, such as the presence of different elements in the ground water, like aluminium, iron, phosphorus, manganese etc. Our interest is to identify the factors that are accountable for the magnitude of arsenic. Although the dimensions of the problems associated with arsenic in Bangladesh are enormous, public awareness of the overall extent of contamination is limited.

The objective is to study the relationship among extent of arsenic, region, depth of tube-wells and other elements in groundwater, and then to conceive a model describing this relationship.

Lot of works have been done on various dimensions of arsenic-related problems at home and abroad, but only few of them are related with fitting the model for the relationship with arsenic magnitude in groundwater and chemical elements. Arsenic, lead, and cadmium contamination in soil samples show strong and statistically high significant correlations for all contaminant pairs. Spearman rank correlations (a nonparametric approach to correlation analysis, applicable to any data distributions) are all significant at $p < 0.0001$; the rank correlations are 0.86 for arsenic and lead, 0.74 for arsenic and cadmium, and 0.74 for lead and cadmium. (The results involving cadmium are, of course, affected by the substitution of one-half of the detection limit for all not detected results). [2]

Arsenic, which is naturally present in soil, can be mobilized and transported, leading to increased concentrations of As in aquifers, that are sources of drinking water [3]. The largest contemporary known mass exposure to it is occurring due to the consumption of tube-well water throughout the Ganges-Brahmaputra Delta in Bangladesh and India. In Bangladesh alone, this exposure is affecting approximately 25–30 million residents. A survey of roughly 6,000 contiguous wells in Araihazar, Bangladesh, reported well-water As concentrations ranging from less than 5 to 860 μg/L. [11]

An approach is described for viewing the interrelationship between different variables and also tracing the sources of pollution of groundwater of north Chennai (India). It was applied the linear regression model (LRM) with correlation analysis in order to to check its validity for prediction of metal speciation and to apply LRM for rapid monitoring of water pollution [6]. An important component of quantitative risk assessment involves characterizing the dose-response relationship between an environmental exposure and adverse health outcome and then computing a benchmark dose, or the exposure level that yields a suitable low risk. This task is often complicated by model choice considerations, because risk estimates depend of the model parameters. A study proposed by the Bayesian methods is meant to address the problem of the model selection and to derive a model-averaged version of the benchmark dose. They illustrate the methods through application to data on arsenic-induced lung cancer in Taiwan. [7]

2. Data and variables

Secondary sample data have been downloaded from the Bangladesh Water development Board web site *http://www.bgs.ac.uk/arsenic/bangladesh/Data/BWDBSurvey Data.csv*. The data were collected from different areas of Bangladesh excepting the hilly regions.

There were 56 variables and 113 wells. Most of the variables are geological elements in ground water in Bangladesh. The dependent variable was Arsenic which was censored at 0.05 ug/l. The independent variables are latitude, longitude, depth, and geological elements in ground water including Al-Aluminum, As- Arsenic, B-Boron, Ba-Barium, Be-Beryllium, Ca-Calcium, Cd-Cadmium, Ce-Cerium, Cl-Chlorine, Co-Cobalt, Cr-Chromium, Cs-Cesium, Cu-Copper, Dy-Dysprosium, Er-Erbium, Eu-Europium, Fe-Iron, F-Fluorine, Gd-Gadolinium, HCO3- Bicarbonate, Ho- holmium, I-Iodine, K- Potassium, La-Lanthanum, Li-Lithium, Lu-Lutetium, Mg- magnesium, Mn- Manganese, Mo- Molybdenum, Na- Sodium, Nd- Neodymium, $_{NH4N}$, N- Nitrogen, i NO_2N, NO_3N, P- Phosphorus, Pb- Lead, Pr- Praseodymium, Rb- Rubidium, Sb- Antimony, Si- Silicon, Sm- Samarium, Sn- Tin, SO_{4-} Sulphate, Sr- Strontium, Tb- Terbium, Tl- Thallium, Tm- Thulium, U- Uranium, V- Vanadium, Y- Yttrium, Yb- Ytterbium and Zn- Zinc. Some of the independent variables were also censored, but in this analysis we will consider them as the observed value at censored limit. For example, cadmium (Cd) has a censored value of 0.02 ug/l but we will take 0.02 ug/l as an observed value.

3. Methodology

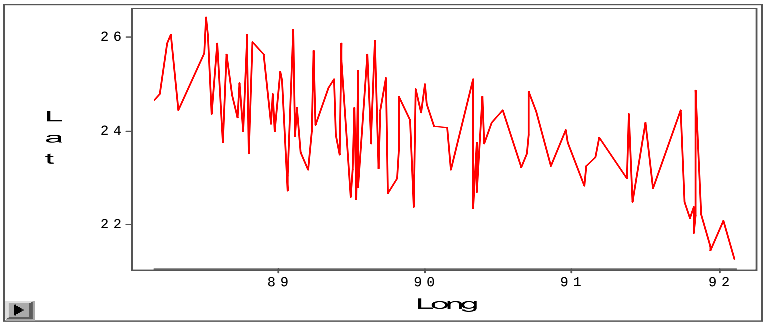
There is a moderate portion of missing values in the data set. To avoid this difficulty, the expectation–maximization (EM) method is used for inputing missing data. The multiple linear regression technique has been applied to modelling the extent of arsenic with various independent variables. There are too many input variables in comparison to the total number of observations in the data set. Regression based on Principal Component Analysis is used to overcome the problem of the large number of input variables. The spatial autocorrelation technique has been performed to find out the possible spatial correlations between the positions of the wells.

There were used automatic model selection procedures, such as the backward elimination method. The software used throughout the analysis was *Microsoft Excel, SAS* and the *S-Plus* module *Spatial*. Excel was used for simple data transformation (i.e. from Mg/L to μ_g/L). The SAS was used for modeling – as there are the Principal Component Analysis and the Multiple Regression. The main procedures from the *SAS* software system were *Lifereg*, *Princomp* and *Reg* procedures. The module *Spatial* in *S-Plus* was used for analyzing spatial correlation, Spatial Autocorrelation and for filling in the missing data by using the Expectation- Maximization Method.

4. Results and Discussions

Possible Spatial Autocorrelation

Spatial data is different when comparing with standard data analysis, especially when spatial information and predictions in the model are being included. Data are often correlated with space. Spatial structure can arise from several different sources, such as measurement error, continuity effects including spatial heterogeneity and space-dependent processes or mechanisms.



The graphic above shows the relationship between latitude and longitude.

The data set contains the latitudes and longitudes of the tested wells. The data have been analyzed for testing autocorrelation, by using the Moran and Greay test statistic. Depending on the outcome of the test, we would decide to either apply spatial modeling or disregard it in case the spatial autocorrelation turns out to be negligible. In the former case, we would fit a Spatial Linear Model describing the dependence of arsenic on the spatial locations [5]. After fitting the model, we would consider the residuals and would fit a standard regression model describing the effects of the remaining dependent variables on the residuals. However, in the alternative case that there was no significant autocorrelation exhibited, we would just include the latitude and longitude variables along all other variables in our regression model without trying to eliminate first their spatial autocorrelation effect.

In our analysis, firstly we have calculated the spatial neighbour and then, with this spatial neighbour, we calculated spatial correlation on arsenic and found that there was no spatial autocorrelation (i.e. spatial autocorrelation is 0.002 and it is statistically insignificant). Therefore, latitude and longitude variables were left in the model, like all the other variables.

The Multiple Regression Model

In our data there are not too many censored variables. This motivated us to also use the standard Multiple Regression Analysis as to the effect of the independent variables on Arsenic and to compare the results. The multiple regression model has the general form:

$$Y = X\beta + \varepsilon$$

where:

-*X* it is a *n x p* matrix of observation on the predictor variables

-*Y* it is a *n x 1* vector of response measurement

-ε it is a *n x 1* random vector; the error term. [4]

The output of the model by using SAS is as follows:

Table 1. Analysis of variance

Source	Degrees of Freedom (df)	Sum of Squares	Average Sum of Squares	F- value	p- value
Model	9	339739	37749	13.05	<0.0001
Error	103	297838	2891.63060		
Corrected total	112	637577			

Table 2: Estimation of parameters and its test result

Variable	Parameter Estimate	Standard Error	Type II SS	t-value	p- value
Intercept	-22.79033	18.18662	4540.87759	1.57	0.2130
B	-0.19611	0.04764	49001	16.95	<0.0001
Dy	-18525	2947.58734	114215	39.50	<0.0001
Er	19816	3536.06507	90814	31.41	<0.0001
Fe	0.00348	0.00123	22979	7.95	<0.0058
K	-0.00362	0.00068856	79710	27.57	<0.0001
Mg	0.00102	0.00026434	43075	14.90	<0.0002
Mn	-0.03408	0.00786	54294	18.78	<0.0001
Mo	39.93068	5.41908	157002	54.30	<0.0001
P	0.06359	0.01133	91059	31.49	<0.0001

The final fitted model based on the multiple regression approach is

As = -22.790 – 0.196B -18525Dy + 19816Er + .0035Fe - .0036K + .00102Mg – 0.0341Mn + 39.931Mo + 0.064P

From this model it clearly results that out of 54 variables 9 of them are highly significant for the arsenic contamination level.

Multiple Linear regression with PC variables

When using principal components regression, we transform first the predictor variables into principal components. Then we regress the output on the principal components. The scaling option for PC is Z = *X U*

where $U'U = I$.

To implement principal components regression, we first transform the original data into PC's. Then we obtain

$Y = Zb_z$

where b_z denotes the regression coefficient obtained by using principal components. [4]

The reason to use principal components is that many of the predictors exhibit multicollinearity, which has an effect on the rank of the design matrix and it causes difficulties in the calculation of the inverse of $X'X$ when calculating the smallest squares estimators. Another related reason is that when there are too many potential independent variables (like in our case 56 of them), we would like to reduce the dimensionality of the problem by involving only a small number of principal components as regressors, instead of using the large number of all independent variables.

Since the new predictors based on the principal components are not correlated, the resulting regression coefficients will be not correlated also. PCR will predict the response with the exact same precision as OLS when all of the pc's are used. However we are interested only in including a relatively small number of relevant principal components.

As already pointed out, further benefit of using PCR is the simplification of the model since a small number of pc's are used, because the pc's are so readily interpretable that they became the new variables in the prediction model. In case they are not interpretable at all, one can still relate the responses to the original prediction, as follows:

$$Y = Zb_z = XUb_z$$

Since $Z = XU$ and therefore

$$b = Ub_z$$

and

$$b_z = \left[U'X'XU\right]^{-1}U'X'Y$$

then

$$b = U\left[U'X'XU\right]^{-1}U'X'Y \quad [4]$$

The output of the model by using SAS is as follows:

Table 3. Analysis of variance

Source	Degrees of Freedom (df)	Sum of Squares	Average Sum of Squares	F- value	p- value
Model	3	192835	64278	15.75	<0.0001
Error	109	444742	4080.20423		
Corrected total	112	637577			

Table 4. Estimation of parameters and its test result

Variable	Parameter Estimate	Standard Error	Type II SS	t-value	p- value
Intercept	30.66283	6.00899	106244	26.04	<0.0001
Prin3	8.68376	2.87639	37188	9.11	<0.0032
Prin12	23.41578	5.523.4	73340	17.97	<0.0001
Prin13	-25.91756	5.77055	82307	20.17	<0.0001

There are 54 variables in our analysis. By Using Princomp command in SAS we get 20 principal components which cover more than 91% of the variation of the output. Again, with 20 principal components we ran multiple regression model in SAS by Reg command with Backward eliminations method and the first 8 principal components were found significant at 5% level of significance and finally got only three of them as highly significant at 1% level of significance. The fitted model is

As = 30.663+ 8.684prin3 + 23.416prin12 – 25.918prin13

5. Conclusion

In this study two regression models (multiple regression and multiple regression with PC variables) have been applied in order to study the effect of some chemical components on groundwater arsenic contamination level. The two models are found to be highly significant. Only 9 variables in the multiple regression model and 3 principal components in the multiple regression with PC variables are highly significant. So, further research focusing on these variables will be helpful to explore the groundwater arsenic contamination problem related with chemical elements.

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THE ESTIMATION OF MAXIMUM EFFORT IN WEIGHT LIFTING PROCESSES

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Abstract: *Starting from defining the processes connected to lifting weights this article wishes to accomplish a quantitative analysis applied to the lifting processes. Also, based on the data collected at the recently ended Olympic Games (Beijing 2008) we build several models of analyzing the effects that some factors can determine during these processes.*

Key words: *estimation; effort; metric; processes*

1. Lifting processes

There are many fields in which the lifting force of objects characterized by weight, shape and volume intervenes. In most of the activities that meet the human factor is important to establish overlapping maximum effort that a certain person is submitting.

Effort is characterized by:

- intensity; is the degree of application of the body during activities of lifting, is expressed differently depending on the sport considered;

- duration, means the time frame during which effort is made;
- repeat frequency; is the number of activity repeats in a time unit;
- way of pursuit; represents all the conditions in which the activity is unfolding; for cycling, a track and favorable atmospheric conditions are needed, for gymnastics a covered gym and matrices are need.

For clarifications situations in which lifting processes occur are presented.

In sport branches there are:

- weight lifters who try to lift a maximum weight in one attempt; presently there are two types of lifting methods "clean and jerk" and „the snatch";
- the weight throwers use when throwing metallic balls with a weight of 7,248 kg;
- the hammer throwers; are similar to the weight throwers the only difference being that they use metallic balls attached with a cable to the handle, and the throw is made after several turns around their axis;
- the javelin throwers launch a spear; the antic trial requested that the javelin will stick into the ground otherwise the throw would have been null;
- the disc throwers are appreciated for the distance they throw the disc as for their precision.

In the current activity the weight lifting and transport processes are frequent:

- in constructions brick lifting, concrete bags, water buckets, beams, gravel, sand.
- in the wood industry log lifting, cupboards, wastes, boards, sawdust.
- in sports there are branches that assume lifting weights, own body, weights in extreme sports.

The lifting process has associated a formalization which includes:

- variables;
- driving or driving systems;
- objects meant for lifting;
- defining the conditions.

This approach considers the characteristics of the human factor, the one that executes the lifting processes. Taking in account the industrial growth, human strength is replaced by different mechanical, electrical equipments or for a short time now the computer assisted coordination of movements and lifting force. The development of robots assumes lifting force establishment models, which are treated distinctly in robotic science.

2. Factors that influence the lifting process

Persons are different from one another considering:

- age;
- sex
- height;
- weight;
- conformation;
- training;
- race;
- abilities.

In a certain context a person executes a lifting process successfully if:

- it fulfils the set objective;
- after committing its state is good and has the capacity of doing other activities;
- the lifting process took place in the established time frame;
- the movement of the object on the agreed upon trajectory was done without interruption.

The lifting effort is defined as being the minimum quantity of energy that needs to be consumed by a person on order to lift an object of a certain weight. Because persons are different, for the same weight of an object the efforts are different. Because of this an effort measurement based on the size of the produced effect, meaning based on the weight of the lifted object is needed.

To compute the effort the formula is used:

Effort = a_0 + a_1*Person weight + a_2*Person height + a_3*Person age

It results that the factors that influence the effort must be extended to include the particularities of the persons.

The following variables are defined

v – age because experimentally it is known that the lifting capacity is reduced until the person becomes an adult, reaches a peak when the person is mature, and decreases as the person ages;

g – the weight influences the degree of effort that a person makes in the lifting process, because in normal conditions the muscular mass has a significant weight in the body mass, and considering an adequate training that muscular mass develops and increases the weight lifting capacity of the person;

i – height is a characteristic strictly tied to the biological traits of a person, making a tight correlation with the bone system, which forms components that define drives in the lifting processes; the bone system has a specific consistency, influenced by the accumulation of basic organism components.

It means that the effort a person can realize is given by a relationship.

e = f(v,g,i)

In order to build effort estimation models the following hypothesis are considered:

- measurements are made based on the same procedures for all persons; the procedures define instruments with the help of which measurements are made, the conditions a person must fulfill to be measured, the optimal position of the person when the person is measured and the result processing method; the procedures must ensure result reproducibility for the persons measured in a collectivity; it means that by comparison, when the procedures are well defined the obtained results must not differ significantly if two teams make measurements independently for the same person collectivity;
- a homogenous community is considered, formed from persons that correspond to restrictions or filters which oversee belonging to an age group, a weight group, the duration of executing several activities which suppose weight lifting effort belonging to a specific interval, it is imposed to make measurements and build models separately for men and women;
- the weight and height are measured using the well established and validated procedures for persons from the homogenous community; the homogeneity is determined empirically using an estimation set given by specialists and adapted to any other characteristic defined for the elements of the collectivity, a collectivity formed from persons with an average height of 185 centimeters, is considered by specialists to be homogenous is the persons have heights ranging in [182,5; 187,5]; by elementary computation the correspondence is made such that these empiric results are considered for age and weight; average weight is 100 kg and the interval that ensures homogeneity is [97,3; 102,7]; average age is 30 years meaning 360 months which means that in order to form a homogenous collectivity the age must be in the interval [355;365] months;

- only the persons that don't use helping substances are considered, which respect a certain effort and recovery program; considering the fact that during the day the physiological characteristics of a person are changed, the capacity to sustain effort varies; it is important to make a study in order to determine the way in which effort and rest are alternating to maximize the efficiency of each person.

Considering the fact that in order to collect personal data for the persons that make up the homogenous collectivity are dispersed in the territory, the ones that operate the selection process must prove that they understand the measuring procedures and it will not be needed to redo the process to have the needed data for the estimation.

The data must be complete, correct and reproducible. The completeness assumes that in the table that contains the identification code of the person, height, weight, age must be marked as numeric values corresponding to the above characteristics. Empty spaces or lines that mark the lack of measurements for a person won't be allowed.

Correctitude assumes the use of calibrated measuring tools according to the existing standards, ensuring the correct position of the person in agreement with the information provided in the procedure and reading the data from the measuring tool. Reproduction requests that for the same characteristic of a person, regardless of who makes the measuring the result will be the same.

Considering the fact that the objective is to estimate the maximum lifting effort, it is carried on to processing the data for the persons that belong to a sport collectivity, specialized in lifting weights. To ensure the homogeneity of a sport collectivity in report to the maximum level of training, the collectivity is formed by the weight lifters who participated at the Olympic Games in Beijing 2008.

3. Building the models

In a general form, the technology for building estimation models assumes establishing the influence factors F_1, F_2, ..., F_k associated to lifting processes. The number of K factors is given by the capacity of the specialist which analyzes the process and by his experience. For example K=3, F_1 is the age, F_2 is the height and F_3 is the weight.

The interdependencies of the factors F_1, F_2, ..., F_k are analyzed by computing the correlation coefficients between the factors F_i and F_j.

$$r(Fi,Fj) = \frac{\sum (f_i - \bar{f}_i)(f_j - \bar{f}_j)}{\sqrt{\sum (f_i - \bar{f}_i)^2 \sum (f_j - \bar{f}_j)^2}}$$

where *f* denotes the values recorded for each factor.

Table 1. Correlation matrix for considered factors where $r(F_i, F_j)$ $1 \geq i > j \geq k$

	F_1	F_2	...	F_i	...	F_k
F_1	1	$r(F_2, F_1)$	...	$r(F_i, F_1)$	...	$r(F_k, F_1)$
F_2		1	...	$r(F_i, F_2)$	...	$r(F_k, F_2)$
...			...	...	...	...
F_i				$r(F_i, F_i)$	...	$r(F_k, F_i)$
...				...	...	...
F_k						1

When the linear correlation coefficients are grater then 0,5 between the variables there is a linear correlation and a model for estimating the effort is built:

$Effort = a_0+a_1*f_1+a_2*f_2+...+a_k*f_k$

In (Visoiu 2005, 94-100) the linear regression model generator is presented. The technology oversees the way in which from a set of generated models a small subset is selected, and after a severe filtering only one model is selected.

A specific structure is needed in such that the model is simple and representative.

4. Software structure used for building effort estimation models

The software product for effort estimation is built as an online software application and it is available at: www.estimaresarcinamaxima.somee.com

Now the software product is using as input a text file with the following structure:

M
K
$X_{11}, X_{12}, \ldots, X_{1k}$
$X_{21}, X_{22}, \ldots, X_{2k}$
...
$X_{m1}, X_{m2}, \ldots, X_{mk}$

where:

M – no. of persons
K – no. of variables
X_1 – dependant variable
$X_2, \ldots, X_k$ – independent variables

In the near future an interface will be defined such that users will input the data interactively.

The product computes the correlation coefficients between the independent variables.

Based on the correlation coefficients and the inputted options by the user the product develop effort estimation models.

Models like the following are generated:

Efort1= a1*Weight+b1
Effort2=a2*Age +b2
Effort3=a3*Height+b3
Effort4=a4*Weight+c4*Age+b4
Effort5=a5*Weight+c5*Height+b5
Effort6=a6*Age+c6*Height+b6
Effort7=a7*Weight+c7*Age+d7*Height+b7

For each the difference between the squares sum is computed like;

$$Dif = \sum_{j=1}^{N} abs(Effort(F_{ij}) - EffectiveEffort(j))$$

where N represents the number of elements in the collectivity.

The model is selected based on which one has the minimum square sum difference.

5. Maximum effort estimation for weight lifters

Data is collected regarding the results at the weight lifters trial at the Olympic Games in Beijing 2008, the results are given in table 2 (Appendix 1.).

The correlation coefficients are computed as shown in figure 1:

	X1	X2	X3	X4
X1	1	-0.0758218238303701	0.829045833400274	0.708383990616877
X2		1	0.0398851733925065	0.0398314524693218
X3			1	0.812910316100301
X4				1

Figure 1. Correlation coefficients matrix

The coefficients of the model which has as dependent variables X3 and X4 are computed. X2 is not considered because the correlation coefficient indicates a weak relation with the dependent variable. The resulting model is:

$$Y = 10.49757 + 1.144350*X3 + 0.295702*X4$$

By applying the created model to the data set an average error of 10.156 is obtained.

With the model:

M_1: Effort = 10.49757 + 1.144350*Weight + 0.295702*Height

other weight lifters H_{n+1}, H_{n+2} information is introduced in the model. The results of the model are compared with the real results obtained by the weight lifters in competitions as shown in Table 3.

Table 3. Comparation of estimated and effective results for a new dataset with heavier weightlifters

Weight	Height	Estimated result	Obtained result	Difference
145,93	183	231.606	203	28.61
124,13	187	207.842	210	-2.16
144,97	181	229.916	206	23.92
144,09	185	230.091	207	23.09
130,25	190	215.733	201	14.73
142,89	190	230.197	196	34.20
131,16	177	212.93	185	27.93
132,16	183	215.848	188	27.85
154,15	183	241.013	165	76.01
148,48	175	232.158	175	57.16
130,04	185	214.013	171	43.01
135,13	180	218.36	140	78.36

It is observed that the subset of weight lifters belonging to 105+ category increases the level of non-homogeneity of the collectivity, this requests they be processed separately. For them:

- the correlation matrix is given in Table 4
- the models that highlight the connections between effort and the weight lifters characteristics are generated using a linear generator.

Table 4. Correlation between results and factors considered for heavy weight lifters

	Result	Weight	Height
Result	1	-0,45645	0,504417
Weight		1	-0,29538
Height			1

The list of generated models is given below along with the performance expressed as the sum of squared differences between real and estimated values denoted as SS:

M2: Y=-193,6968 +0,0513 Weight +2,0400 Height SS :3969,9226
M3: Y=-181,4013tl +2,0117 Height SS:3972,2177
M4: Y=218,8667tl -0,2281Weight SS:4871,1639

where Y is the resultative variable as denoted in the output obtained from the generator.

Using the model with the least sum of squared differences, which includes the both factors, the values are estimated again and the results compared with the anterior model, as shown in table 5.

Table 5. Comparison between initial model and model built specially for heavy weight lifters

Effective results	Estimated results using M1	M1 differences	Estimated results using M2	M2 model differences
203	231.606	28.61	187,1094	-15,8906
210	207.842	-2.16	194,1511	-15,8489
206	229.916	23.92	182,9802	-23,0198
207	230.091	23.09	191,095	-15,905
201	215.733	14.73	200,585	-0,41497
196	230.197	34.20	201,2335	5,233457
185	212.93	27.93	174,1117	-10,8883
188	215.848	27.85	186,403	-1,59699
165	241.013	76.01	187,5311	22,5311
175	232.158	57.16	170,9202	-4,07978
185	214.013	43.01	166,1221	-18,8779
180	218,36	78.36	103,1051	-76,8949

It is observed that the medium difference using M2 is 17,59 which makes this second model more suitable for heavy weight lifters.

In order to study the stability of the model, the data set is divided in two groups. The first group contains the weight lifters with a height smaller or equal to 165 cm (165 = Hmin + (Hmax-Hmin)/2). The first group has 46 records, and the second one 64.

Generating models for the two sets the following results are obtained:

For the first group the generated model is:

M5: Result = -94.5945 + 1.040276*Weight + 0.992316*Height

For the second group the generated model is:

M6: Result = 153.3072 + 1.312025*Weight - 0.61078*Height

Estimations of the results of the athletes belonging to the first group are made using the generated model of the second set as shown in table 6 (Appendix 2).

The sum of the absolute values given by the differences between the real results and the estimated ones is 531.88, so the average result prediction error is 11.5626087 kg.

The average of real results is 131.9782609 and the average of estimated results is 141.0154348, the difference between them is 9.037173913.

Estimations are made for the second weight lifters group using the model generated by the first group as shown in table 7 (Appendix 3.).

The absolute value sum of the differences for the second data set is 771.99, so the result estimation is made with an average error of 12.06234375. The average of the real results is 161.0625 and the average of the estimated results is 167.3745781, the difference between the two is 6.312078125. The difference between the two averages is positive which means most of the athletes don't manage to lift the maximum weight that they should for their height and weight.

A new model is computed based on the existing ones to improve prediction quality. The coefficients of the new model are obtained as an arithmetic mean of the coefficients of the previous models.

The model for the first weight lifters group is:

M5: Result = -94.5945 + 1.040276*Weight + 0.992316*Height

The model for the second weight lifters group is:

M6: Result = 153.3072 + 1.312025*Weight - 0.61078*Height

The new model is:

M7: Result = 29.35635 + 1.1761505*Weight + 0.190768*Height

The new model tested using the initial data as shown in table 8 (Appendix 4.).

By applying the new model on the complete data set an average error of 10.33209091 is obtained, smaller than the arithmetic mean of the average error obtained in the two models built based on the two data sets which were equal to 11.81247622. The average of the results is 148.9, and the average of the estimated results with the new model is 152.626, the difference between them is 3.73.

This value is two times smaller then the average of the values computed for the first two models.

The model created based on the two previous models is better because it minimizes the error thus giving more precise estimations.

Comparing with the initial model on the full data set, this model is less efficient because the error average (10.33209091) is grater then the one of the initial model (10.159).

The capacity of an entity represents a maximum level of which the entity has the capability of reaching in normal evolution conditions. The maximum lifting effort is highlighted for a specialized category of athletes. If it is desired to translate to other typologies of specializations it is important to collect data related to the lifting effort orientated to maximum. Contrary, the maximum estimated level is error prone when a lot of persons in the collectivity succeed in accomplishing it. The maximum effort must be a desiderate, without the need of correcting it periodically.

For a person P outside the collectivity the maximum effort is estimated using the selected model. If person P is characterized by:

- age 25 years;
- weight 97Kg
- height 179cm

it results that by applying the model
M7: Result = 29.35635 + 1.1761505*Weight + 0.190768*Height
the maximum effort associated to person P is
Fmax = 177 Kg.

If person P unfolds a lifting process which has R lifting actions of weight of mass G1, G2,… G_R Kg, it results that in average P lifted G_{avg} Kg, meaning $(G_1+G_2+…+G_R)/R$ Kg obtained based on the relationship:

$G_{avg}=(G_1+G_2+…+G_R)/R$

In order to estimate the activity made it is necessary to compute:

- the relative effort given by

$G_{rel} = G_{avg}/F_{max}$

- the maximum relative effort given by

$G_{relmax} = max\{G_1G_2…G_K\}/F_{max}$

When performance structural modification occur at collectivity level it is necessary to recalculate the maximum effort such that G_{rel} and G_{relmax} must always be smaller then 1.

6. Conclusions

Human collectivities are suitable for extracting large datasets with a large number of records and a large number of variables.

The study of large datasets has advantages over studying only small samples and is aided by the new directions in recording, storing and processing data. Data is collected automatically, powerful databases store it and processing power is increasing every day. There is also a strong vector for distributed applications, distributed storage and distributed processing which improve such processes.

The developed models are stored in modelbases and are subject to reestimation, validation and refinement.

Development assumes:

- moving towards other domains;
- maximum effort for equipment, cars;
- including new variables.

Defining a maximum thereshold for the studied variables as the effort is in this article is important for comparison between activities. Accurate models include more significant independent variables from the dataset but exclude insignificant ones. This is achieved by model generation and refinement.

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Appendix 1.

Table 2. The results obtained by weight lifters and their description characteristics.

Weight lifer code	Result (kg) – X_1	Age (in years) – X_2	Weight (kg) – X_3	Height (cm) – X_4	Estimated result	Difference
H001	132	18	55.37	156	119.99	12.01
H002	130	23	55.97	152	119.494	10.51
H003	130	19	55.91	155	120.312	9.69
H004	128	21	55.85	157	120.835	7.17
H005	120	29	55.67	155	120.037	-0.04
H006	115	32	55.53	157	120.469	-5.47
H007	121	27	55.77	161	121.926	-0.93
H008	106	28	55.84	155	120.232	-14.23
H009	116	22	55.64	162	122.073	-6.07
H010	114	28	55.79	155	120.175	-6.17
H011	112	24	55.74	159	121.3	-9.30
H012	114	33	55.94	164	123.008	-9.01
H013	110	26	55.99	161	122.178	-12.18
H014	109	32	55.63	154	119.696	-10.70
H015	143	25	61.91	161	128.952	14.05
H016	138	28	61.47	163	129.04	8.96
H017	135	21	61.9	161	128.941	6.06
H018	130	18	61.66	161	128.666	1.33
H019	132	19	61.6	165	129.78	2.22
H020	132	24	61.75	157	127.586	4.41
H021	126	22	61.96	161	129.01	-3.01
H022	130	25	61.97	158	128.134	1.87
H023	128	25	61.95	163	129.589	-1.59
H024	120	30	61.69	145	123.969	-3.97
H025	115	31	61.67	160	128.382	-13.38
H026	158	21	68.97	168	139.101	18.90
H027	151	27	68.38	167	138.13	12.87
H028	148	30	68.92	162	137.27	10.73
H029	146	29	68.86	165	138.088	7.91
H030	146	30	68.64	158	135.767	10.23
H031	145	25	68.41	167	138.165	6.84
H032	147	24	68.99	164	137.941	9.06
H033	145	19	68.68	162	136.995	8.00
H034	135	27	68.76	168	138.861	-3.86
H035	135	20	68.85	166	138.373	-3.37
H036	139	27	68.23	165	137.367	1.63
H037	135	32	68.79	167	138.6	-3.60
H038	128	27	68.9	168	139.021	-11.02
H039	131	21	68.97	170	139.693	-8.69
H040	135	25	68.92	160	136.678	-1.68
H041	130	17	68.85	153	134.528	-4.53
H042	123	24	68.86	160	136.61	-13.61
H043	114	31	68.67	163	137.28	-23.28
H044	110	21	68.14	163	136.673	-26.67
H045	115	25	66.06	170	136.363	-21.36
H046	163	23	76.46	165	146.785	16.21
H047	168	28	76.91	168	148.187	19.81
H048	165	25	76.77	165	147.14	17.86
H049	155	26	76.86	165	147.243	7.76
H050	162	33	76.8	165	147.174	14.83
H051	157	25	76.53	163	146.274	10.73
H052	162	26	76.78	172	149.222	12.78
H053	161	24	76.71	167	147.663	13.34
H054	160	24	76.86	170	148.722	11.28
H055	157	20	76.56	172	148.97	8.03
H056	153	27	76.92	168	148.199	4.80
H057	154	20	76.52	165	146.854	7.15
H058	156	21	76.83	175	150.166	5.83
H059	143	27	75.83	160	144.586	-1.59
H060	144	26	76.24	168	147.421	-3.42
H061	140	22	76.9	164	146.993	-6.99
H062	140	20	76.69	175	150.006	-10.01
H063	140	24	76.93	180	151.759	-11.76
H064	145	28	76.38	171	148.468	-3.47
H065	130	25	76.57	167	147.503	-17.50
H066	135	23	76.98	172	149.45	-14.45
H067	124	29	76.15	178	150.275	-26.27
H068	110	23	75.53	175	148.678	-38.68
H069	180	22	84.41	172	157.953	22.05
H070	185	26	84.69	172	158.273	26.73
H071	177	25	83.78	175	158.119	18.88
H072	180	20	84.54	173	158.397	21.60
H073	169	26	84.84	174	159.036	9.96

H074	162	24	84.55	172	158.113	3.89
H075	165	25	84.71	174	158.888	6.11
H076	160	22	84.14	168	156.461	3.54
H077	166	23	84.52	170	157.487	8.51
H078	155	25	84.62	172	158.193	-3.19
H079	152	32	84.74	172	158.331	-6.33
H080	148	24	84.97	165	156.524	-8.52
H081	153	23	82.77	172	156.076	-3.08
H082	115	25	82.67	152	150.048	-35.05
H083	200	20	104.76	172	181.24	18.76
H084	193	25	104.72	182	184.152	8.85
H085	190	29	102.13	175	179.118	10.88
H086	182	23	102.48	179	180.701	1.30
H087	181	22	102.03	180	180.482	0.52
H088	184	31	104.27	181	183.341	0.66
H089	176	22	103.36	173	179.934	-3.93
H090	180	27	104.34	185	184.604	-4.60
H091	177	22	104.64	181	183.764	-6.76
H092	170	24	104.9	170	180.809	-10.81
H093	166	33	104.39	176	182	-16.00
H094	163	33	104.64	182	184.06	-21.06
H095	150	24	103.76	175	180.983	-30.98
H096	150	31	104.45	180	183.251	-33.25
H097	180	20	93.64	175	169.402	10.60
H098	185	23	92.99	178	169.546	15.45
H099	176	21	93.69	176	169.755	6.24
H100	181	27	93.83	170	168.141	12.86
H101	178	28	92.3	178	168.756	9.24
H102	180	26	92.32	170	166.413	13.59
H103	175	25	93.9	177	170.291	4.71
H104	173	24	93.74	175	169.517	3.48
H105	173	27	93.09	172	167.886	5.11
H106	170	21	93.97	176	170.076	-0.08
H107	168	36	93.69	179	170.642	-2.64
H108	170	27	93.71	176	169.778	0.22
H109	160	27	93.01	172	167.794	-7.79
H110	155	21	93.9	168	167.63	-12.63

Appendix 2.

Table 6. Estimation for first group using M6

Weight lifter code	Result	Age	Weight	Height	Estimated result	Difference
H001	120	30	61.69	145	145.683	-25.68
H002	130	23	55.97	152	133.903	-3.90
H003	115	25	82.67	152	168.934	-53.93
H004	130	17	68.85	153	150.191	-20.19
H005	109	32	55.63	154	132.235	-23.24
H006	130	19	55.91	155	131.992	-1.99
H007	120	29	55.67	155	131.677	-11.68
H008	106	28	55.84	155	131.9	-25.90
H009	114	28	55.79	155	131.834	-17.83
H010	132	18	55.37	156	130.672	1.33
H011	128	21	55.85	157	130.691	-2.69
H012	115	32	55.53	157	130.271	-15.27
H013	132	24	61.75	157	138.432	-6.43
H014	130	25	61.97	158	138.11	-8.11
H015	146	30	68.64	158	146.861	-0.86
H016	112	24	55.74	159	129.325	-17.33
H017	115	31	61.67	160	136.495	-21.49
H018	135	25	68.92	160	146.007	-11.01
H019	123	24	68.86	160	145.928	-22.93
H020	143	27	75.83	160	155.073	-12.07
H021	121	27	55.77	161	128.143	-7.14
H022	110	26	55.99	161	128.432	-18.43
H023	143	25	61.91	161	136.199	6.80
H024	135	21	61.9	161	136.186	-1.19
H025	130	18	61.66	161	135.871	-5.87
H026	126	22	61.96	161	136.265	-10.26
H027	116	22	55.64	162	127.362	-11.36
H028	148	30	68.92	162	144.786	3.21
H029	145	19	68.68	162	144.471	0.53
H030	138	28	61.47	163	134.4	3.60

H031	128	25	61.95	163	135.03	-7.03
H032	114	31	68.67	163	143.847	-29.85
H033	110	21	68.14	163	143.151	-33.15
H034	157	25	76.53	163	154.159	2.84
H035	114	33	55.94	164	126.534	-12.53
H036	147	24	68.99	164	143.656	3.34s
H037	140	22	76.9	164	154.034	-14.03
H038	132	19	61.6	165	133.349	-1.35
H039	146	29	68.86	165	142.875	3.13
H040	139	27	68.23	165	142.048	-3.05
H041	163	23	76.46	165	152.846	10.15
H042	165	25	76.77	165	153.253	11.75
H043	155	26	76.86	165	153.371	1.63
H044	162	33	76.8	165	153.292	8.71
H045	154	20	76.52	165	152.925	1.08
H046	148	24	84.97	165	164.011	-16.01

Appendix 3.

Table 7. Estimation for second group using M5

Weight lifter code	Result	Age	Weight	Height	Estimated result	Difference
H001	135	20	68.85	166	141.753	-6.75
H002	151	27	68.38	167	142.256	8.74
H003	145	25	68.41	167	142.288	2.71
H004	135	32	68.79	167	142.683	-7.68
H005	161	24	76.71	167	150.922	10.08
H006	130	25	76.57	167	150.776	-20.78
H007	158	21	68.97	168	143.862	14.14
H008	135	27	68.76	168	143.644	-8.64
H009	128	27	68.9	168	143.79	-15.79
H010	168	28	76.91	168	152.122	15.88
H011	153	27	76.92	168	152.133	0.87
H012	144	26	76.24	168	151.425	-7.43
H013	160	22	84.14	168	159.643	0.36
H014	155	21	93.9	168	169.797	-14.80
H015	131	21	68.97	170	145.847	-14.85
H016	115	25	66.06	170	142.82	-27.82
H017	160	24	76.86	170	154.055	5.95
H018	166	23	84.52	170	162.023	3.98
H019	170	24	104.9	170	183.224	-13.22
H020	181	27	93.83	170	171.708	9.29
H021	180	26	92.32	170	170.138	9.86
H022	145	28	76.38	171	154.548	-9.55
H023	162	26	76.78	172	155.956	6.04
H024	157	20	76.56	172	155.727	1.27
H025	135	23	76.98	172	156.164	-21.16
H026	180	22	84.41	172	163.894	16.11
H027	185	26	84.69	172	164.185	20.82
H028	162	24	84.55	172	164.039	-2.04
H029	155	25	84.62	172	164.112	-9.11
H030	152	32	84.74	172	164.237	-12.24
H031	153	23	82.77	172	162.187	-9.19
H032	200	20	104.76	172	185.063	14.94
H033	173	27	93.09	172	172.923	0.08
H034	160	27	93.01	172	172.84	-12.84
H035	180	20	84.54	173	165.021	14.98
H036	176	22	103.36	173	184.599	-8.60
H037	169	26	84.84	174	166.325	2.67
H038	165	25	84.71	174	166.19	-1.19
H039	156	21	76.83	175	158.985	-2.99
H040	140	20	76.69	175	158.84	-18.84
H041	110	23	75.53	175	157.633	-47.63
H042	177	25	83.78	175	166.215	10.78
H043	190	29	102.13	175	185.304	4.70
H044	150	24	103.76	175	187	-37.00
H045	180	20	93.64	175	176.472	3.53
H046	173	24	93.74	175	176.576	-3.58
H047	166	33	104.39	176	188.648	-22.65
H048	176	21	93.69	176	177.517	-1.52
H049	170	21	93.97	176	177.808	-7.81
H050	170	27	93.71	176	177.537	-7.54
H051	175	25	93.9	177	178.727	-3.73
H052	124	29	76.15	178	161.255	-37.25
H053	185	23	92.99	178	178.773	6.23

H054	178	28	92.3	178	178.055	-0.06
H055	182	23	102.48	179	189.638	-7.64
H056	168	36	93.69	179	180.494	-12.49
H057	140	24	76.93	180	164.051	-24.05
H058	181	22	102.03	180	190.162	-9.16
H059	150	31	104.45	180	192.679	-42.68
H060	184	31	104.27	181	193.484	-9.48
H061	177	22	104.64	181	193.869	-16.87
H062	193	25	104.72	182	194.945	-1.94
H063	163	33	104.64	182	194.861	-31.86
H064	180	27	104.34	185	197.526	-17.53

Appendix 4.

Table 8. Estimations using M7 model

Weight lifter code	Result	Age	Weight	Height	Estimated result	Difference
H001	120	30	61.69	145	129.574	-9.57
H002	130	23	55.97	152	124.182	5.82
H003	115	25	82.67	152	155.585	-40.59
H004	130	17	68.85	153	139.522	-9.52
H005	109	32	55.63	154	124.164	-15.16
H006	130	19	55.91	155	124.684	5.32
H007	120	29	55.67	155	124.402	-4.40
H008	106	28	55.84	155	124.602	-18.60
H009	114	28	55.79	155	124.543	-10.54
H010	132	18	55.37	156	124.24	7.76
H011	128	21	55.85	157	124.995	3.01
H012	115	32	55.53	157	124.619	-9.62
H013	132	24	61.75	157	131.934	0.07
H014	130	25	61.97	158	132.384	-2.38
H015	146	30	68.64	158	140.229	5.77
H016	112	24	55.74	159	125.247	-13.25
H017	115	31	61.67	160	132.412	-17.41
H018	135	25	68.92	160	140.94	-5.94
H019	123	24	68.86	160	140.869	-17.87
H020	143	27	75.83	160	149.067	-6.07
H021	121	27	55.77	161	125.664	-4.66
H022	110	26	55.99	161	125.923	-15.92
H023	143	25	61.91	161	132.885	10.11
H024	135	21	61.9	161	132.874	2.13
H025	130	18	61.66	161	132.591	-2.59
H026	126	22	61.96	161	132.944	-6.94
H027	116	22	55.64	162	125.702	-9.70
H028	148	30	68.92	162	141.321	6.68
H029	145	19	68.68	162	141.039	3.96
H030	138	28	61.47	163	132.75	5.25
H031	128	25	61.95	163	133.314	-5.31
H032	114	31	68.67	163	141.218	-27.22
H033	110	21	68.14	163	140.594	-30.59
H034	157	25	76.53	163	150.462	6.54
H035	114	33	55.94	164	126.436	-12.44
H036	147	24	68.99	164	141.785	5.22
H037	140	22	76.9	164	151.088	-11.09
H038	132	19	61.6	165	133.284	-1.28
H039	146	29	68.86	165	141.823	4.18
H040	139	27	68.23	165	141.082	-2.08
H041	163	23	76.46	165	150.762	12.24
H042	165	25	76.77	165	151.126	13.87
H043	155	26	76.86	165	151.232	3.77
H044	162	33	76.8	165	151.161	10.84
H045	154	20	76.52	165	150.832	3.17
H046	148	24	84.97	165	160.771	-12.77
H047	135	20	68.85	166	142.002	-7.00
H048	151	27	68.38	167	141.64	9.36
H049	145	25	68.41	167	141.675	3.32
H050	135	32	68.79	167	142.122	-7.12
H051	161	24	76.71	167	151.437	9.56
H052	130	25	76.57	167	151.272	-21.27
H053	158	21	68.97	168	142.524	15.48
H054	135	27	68.76	168	142.277	-7.28
H055	128	27	68.9	168	142.442	-14.44
H056	168	28	76.91	168	151.863	16.14
H057	153	27	76.92	168	151.875	1.13

H058	144	26	76.24	168	151.075	-7.08
H059	160	22	84.14	168	160.367	-0.37
H060	155	21	93.9	168	171.846	-16.85
H061	131	21	68.97	170	142.906	-11.91
H062	115	25	66.06	170	139.483	-24.48
H063	160	24	76.86	170	152.186	7.81
H064	166	23	84.52	170	161.195	4.80
H065	170	24	104.9	170	185.165	-15.17
H066	181	27	93.83	170	172.145	8.85
H067	180	26	92.32	170	170.369	9.63
H068	145	28	76.38	171	151.812	-6.81
H069	162	26	76.78	172	152.473	9.53
H070	157	20	76.56	172	152.215	4.79
H071	135	23	76.98	172	152.709	-17.71
H072	180	22	84.41	172	161.447	18.55
H073	185	26	84.69	172	161.777	23.22
H074	162	24	84.55	172	161.612	0.39
H075	155	25	84.62	172	161.694	-6.69
H076	152	32	84.74	172	161.835	-9.84
H077	153	23	82.77	172	159.518	-6.52
H078	200	20	104.76	172	185.382	14.62
H079	173	27	93.09	172	171.656	1.34
H080	160	27	93.01	172	171.562	-11.56
H081	180	20	84.54	173	161.791	18.21
H082	176	22	103.36	173	183.926	-7.93
H083	169	26	84.84	174	162.335	6.67
H084	165	25	84.71	174	162.182	2.82
H085	156	21	76.83	175	153.104	2.90
H086	140	20	76.69	175	152.94	-12.94
H087	110	23	75.53	175	151.575	-41.58
H088	177	25	83.78	175	161.279	15.72
H089	190	29	102.13	175	182.861	7.14
H090	150	24	103.76	175	184.778	-34.78
H091	180	20	93.64	175	172.875	7.12
H092	173	24	93.74	175	172.993	0.01
H093	166	33	104.39	176	185.71	-19.71
H094	176	21	93.69	176	173.125	2.87
H095	170	21	93.97	176	173.454	-3.45
H096	170	27	93.71	176	173.149	-3.15
H097	175	25	93.9	177	173.563	1.44
H098	124	29	76.15	178	152.877	-28.88
H099	185	23	92.99	178	172.683	12.32
H100	178	28	92.3	178	171.872	6.13
H101	182	23	102.48	179	184.036	-2.04
H102	168	36	93.69	179	173.697	-5.70
H103	140	24	76.93	180	154.176	-14.18
H104	181	22	102.03	180	183.697	-2.70
H105	150	31	104.45	180	186.544	-36.54
H106	184	31	104.27	181	186.523	-2.52
H107	177	22	104.64	181	186.958	-9.96
H108	193	25	104.72	182	187.243	5.76
H109	163	33	104.64	182	187.149	-24.15
H110	180	27	104.34	185	187.368	-7.37

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THE AUTOMATED SYSTEM OF THE RHYTHM ANALYSIS IN THE EDUCATIONAL PROCESS OF A HIGHER EDUCATIONAL INSTITUTION ON THE BASIS OF APRIORISTIC DATA

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Abstract: *In this article we consider the problems of algorithm functioning development for the system of automated analysis of the educational process rhythm in a higher educational institution. Using devices of experimental planning in conducting the scientific researches, adapted methodologies, which were received by authors in their dissertations regarding the decision of similar problems for continuous and discrete mass productions, there are offered variants of constructing corresponding algorithms for the automated analysis of rhythm in a higher educational institution in conducting the educational process.*

Key words: *automated system; rhythm; educational process; quality*

1. Introduction

The preparation of experts with higher education in the CIS countries in the last 15 years is still accompanied by a decreasing interest in exact and engineering sciences and by an increasing demand for economic and legal specialties.

The planned number of students in educational groups of one specialty usually decreases, but for other specialties the number of groups and students in a group increase, which leads to the infringement of educational process rhythm, with all resulting consequences. First of all, it influences the quality of the educational process. Finding variants of the automated rhythm analysis of one educational process or another is the important and actual problem. Using planning techniques for the experiment, it is obviously possible to calculate the general dispersion of the rhythm factor. In the beginning, by means of Kohren criterion, the performance of a hypothesis regarding the static uniformity of a selective dispersion is checked. The heterogeneity of each step is also established. Both the size of displacement, and the number of other operations are defined, while the picture of dispersion is also revealed. For a quantitative estimation of the rhythm factor we use the technique presented in [1,2][1]. In establishing the mathematical dependence between a rhythm parameter and the time we draw by analogy the sequence of actions applied in [3]. The moments of one-dimension numbers of the distribution [4], the mixed moments paid off, factors of correlation and the correlation attitude are calculated, in the end, the factors and direct regression equation, offered by P.L.Chebyshev [4] are defined. The received model can be used as a basis for the construction of the automated system of the analysis of rhythm in conducting the educational process by preparation of experts with higher education in modern conditions.

2. The analysis of rhythm of educational process

Let's assume, that there are rhythmical and spasmodic educational processes. Rhythmical processes are stable, the quantity of trained students and the quantity of let out experts in unit of time B_f basically corresponds to the in-advance established plan B_p, i.e. $B_f = B_p$. Graphically, rhythmical educational institutions can be presented in the form of some linear dependences (1) as shown in figure 1 and 2.

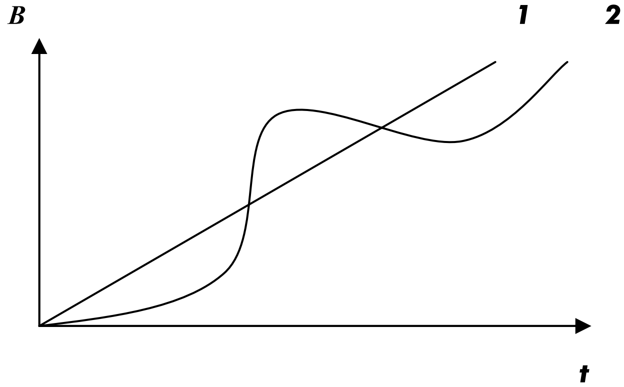

Figure 1. The schedule of dependence between the quantity of trained students and graduate experts from time at rhythmical (1) and spasmodic (2) educational process

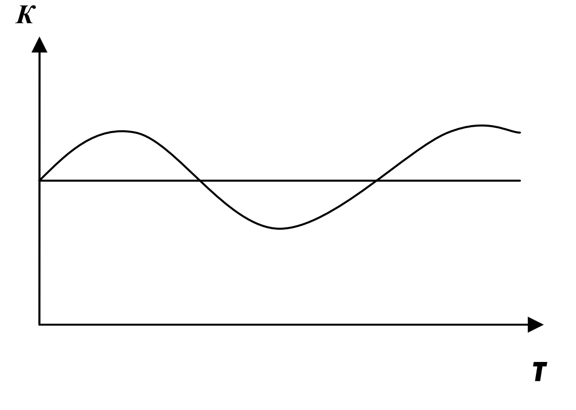

Figure 2. The dependence between the rhythm factor and time at rhythmical (1) and spasmodic (2) educational process

In spasmodic educational institutions the number of trained students and the quantity of graduate experts with higher education in current time changes under the casual law. For them deviations from planned targets, both in negative, and in the positive party are characteristic. Generally, they can be described in the form of some curves (2) presented on figure 1 and 2.

To quantitatively estimate both rhythmical, and spasmodic educational processes is possible by means of factor of rhythm. According to [1,2,5, etc.] it is possible to define factor of rhythm K_r a parity of the sum of actual release of experts and/or quantities of students simultaneously trained in the certain period of time B_f to the general scheduled volume of experts release B_p for the similar period of time:

$$K_r = \frac{\sum_{i=1}^{n} B_f}{\sum_{i=1}^{n} B_p} \qquad (1)$$

In view of both positive, and negative deviations of actual release of young experts and/or simultaneous training of students on corresponding specialization B_f from scheduled B_p, the rhythm factor suggests to count according to the following formula:

$$K_r = 1 - \frac{\sum_{i=1}^{n} \left| B_p - B_f \right|}{\sum_{i=1}^{n} B_p} = 1 - \frac{\sum_{i=1}^{n} a}{\sum_{i=1}^{n} B_p} \qquad (2)$$

where, $a = | B_p - B_f |$ - absolute (both positive, and negative) a deviation of scheduled and actual release of experts and/or quantities of students simultaneously trained during the certain period of time, ***n*** – number of the periods in which the rhythm of educational process (educational weeks, semester, educational years) is analyzed.

The rhythm factor expressed by means of formulas (1) and (2) is equal to unit at rhythmical work of an educational institution and less then one in all other cases.

Development-wise according to the present article, there is a necessity to consider possible fluctuations of educational process which can lower its quality considerably.

It is possible to consider these fluctuations as long as the corresponding algorithms in calculating the rhythm factor will be included. However, the formulas resulted in [4] regarding the rhythm factor definition are not so convenient for their account in corresponding algorithms because the inclusion in formulas (1) and (2) post value B_f in defining the rhythm factor which are not always convenient [3]. Positive results for calculating the rhythm factor on the basis of aprioristic data have been received in [3] but have not yet been published, while as object of research there were data about production of the enterprise with discrete mass character of manufacture. Therefore we were required additional researches for the acknowledgement of an opportunity of use received in [3], and for defining the rhythm factor on the basis of aprioristic data about a course of educational process in a higher educational institution.

For this purpose we used data about a number of students from one of the educational institutions at the beginning and the end of each educational semester, in an autumn and spring semester, a number of graduates in the period 1998-2002. Parameters B_f were compared, as well as in [3], with the plan B_p (a defined contingent of students accepted on the first rate) by means of the following formula

$$K^1 = \frac{B_f}{B_p}$$

The variable K^1, received in relative units, has appeared convenient for carrying out the corresponding researches with the purpose of defining the aprioristic rhythm factor of functioning of a higher educational institution. Values K^1 are accepted as initial for constructing trend components, describing the modification tendency in the quantity of graduates in time, i.e. rhythm of educational process on the basis of aprioristic data.

In defining the dispersion of trend components it is convenient to take advantage of the methods of dispersive analysis [4] which represent methods of processing the experimental data, allowing the check up a hypothesis about presence of effect, inserted by the investigated factor, by allocation and comparison of two dispersions: a dispersion defined by effect of level change in the investigated factor, and a dispersion describing distance, connected with a experimental mistake.

Considering that the planning and the control over an educational institution is conducted on results of each semester, academic year, on each release in a cut of each of educational groups, it would be logical to analyse a share of the dispersion at each stage in the general dispersion by means of the device of step planning experiment [4] about which we already made some remarks in the 1st section of this presentation.

3. Conclusions

Calculating the rhythm factor by time in an educational institution on the basis of aprioristic data, on quantity of trainees, on a contingent of graduates, and its use for constructing algorithms for the automated system of rhythm analysis during the preparation of experts, enables us to predict more accurately the behavior of a course of educational process during the subsequent periods of time, more precisely to count an academic load of teachers, allowing the reducing of financial losses of an educational institution, as well as the quality increase in the educational process as a whole.

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RESEARCH ON ELABORATION AND TESTING OF AN INTEGRATED SYSTEM BASED ON XML DATA ANALYSIS

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Abstract: This paper approaches the importance of XML for better organizing and managing plain text data. This document provides the architecture and testing plan for a data model describing organization metadata as a collection of networked information. As an important result, we propose a new model of an integrated system based on XML, using the data analysis. It also provides some steps we must follow for this data model - using XML, the Extensible Markup Language.

Key words: XML; Integrated System; Database; Testing Models

Introduction

XML is a standard language for data description, widely used for sharing business information without taking in discussion the incompatible programs, computer networks, data structures or operating systems. XML provides structural and syntactical data interoperability. Because all the exchanged files contain the same XML mark-up, indexing, searching, combining, and re-using text-based information, they are easily accomplished. XML is text-based, thus allowing the information interchange between systems that are not natively compatible. Many companies have implemented XML as a standard for transactions involving extended systems and have invested in networks and Web services for offering the necessary support. However, employees are rarely using XML labelling office systems for the structure and content of their documents. The opportunities to capture and further re-use such data are missed, or the companies have difficulties in migrating data to an enterprise level system.

Purpose of the study

This study gathers information in order to determine answers to important questions about ERP systems and XML databases, because currently there is no effective approach to test methods of an ERP system's prototype based on XML. The purpose of this study is to support businesses and software companies which desire to implement or upgrade their ERP base system, enhance competitive capacity and actively sustain a global strategy, especially regarding the current trend of communication and collaborative data discovery.

Materials and Methods

After a few years of work and studies in e-Commerce, Database Design, ERP Systems and Software Engineering, we arrived to an important stage of research. The prototype of an ERP system based on XML was proposed in previous researches and we reached the point of prototype testing.

- First of all, we have studied the theoretical concepts on Software Engineering and Programming Engineering;
- During the study of the ERP concepts we collaborated with two important software companies from Cluj-Napoca;
- The documentation base is being provided by multiple sources, one of them being the free articles and academic magazines offered by the Central University Library "Lucian Blaga"; at the same time, the Central University Library in collaboration with "Babes-Bolyai" University in Cluj-Napoca offers free access to on-line databases like PROQUEST, SPRINGERLINK, JSTOR.

Results

We define a new model of an integrated system based on XML and data analysis. The advantages of this model are the following [4][1]:

- The work-process is adaptable, it can be modified and adjusted to the projects' and customers' requirements;
- The capacity to process a big amount of data in a short period of time;
- The efficient communication with the customer and the quick reaction to his requirements, obtaining them with a superior flexibility;
- The externalization of data processing services;
- We need to design different levels of gave through which the processes can assure these levels.

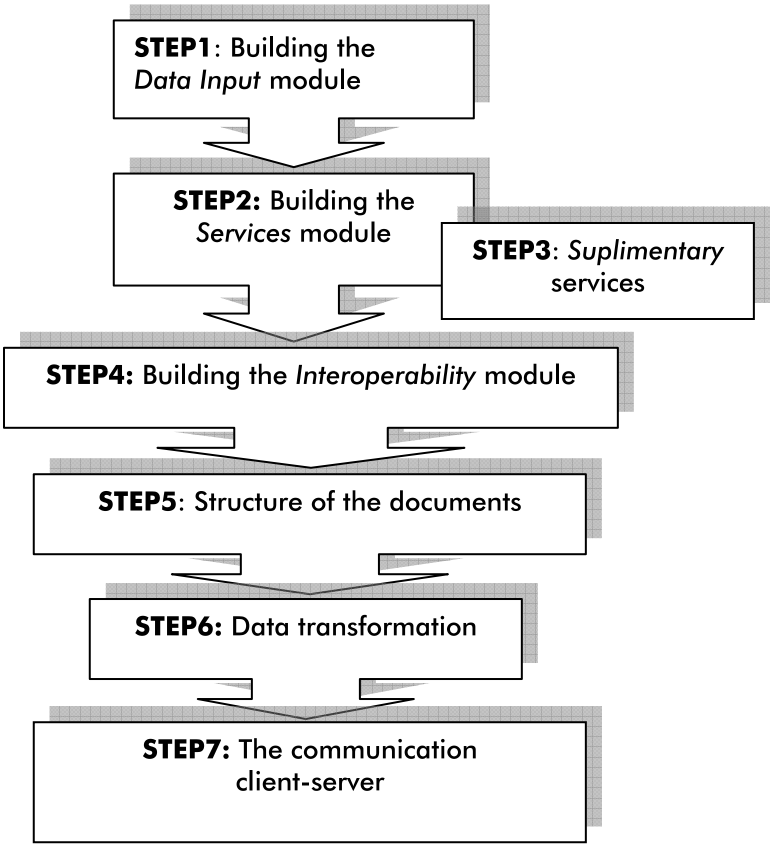

Figure 1. The steps followed in the elaboration of the model

The system's testing activities are [2]:

1. *The Modular testing* - is testing a module to see if it achieves the associated function of the module. The test is executed through some dedicated scripts (test drivers) which must have predictable behaviour, or manually. All discrepancies between the estimated results and the obtained results are collected in a test summary and are being tracked as errors;
2. *The Integration testing* - is a test phase involving two or more modules linked by the internal logic of the application. It assumes that the modular testing has already been executed and the reported errors were debugged. A great emphasis falls on testing the module interface;
3. *The Application testing* regards the application as a whole. It assumes that previous testing phases are completed and it's based on a test stub that automatically runs the application, feeds input and records output. Automated stubs are implemented with the AutoIt language and include random testing that simulates random user behaviour;
4. *The Integration application testing* - its goal is to check the application's functioning along its modules and through compatibility involving use cases;
5. *The Acceptance testing* - the goal is to validate the system in relation to the user's requirements.

In the following paragraphs, we will describe the steps in building the model and the proposed testing activities, for each building step.

Step 1: Data Input

When we design the module of *Data Input*, we have to include the following build activities:

a. Specialized teams on different formats of data and specialized teams in different programming environnements must build the data input. The data must be delivered in the following formats: XML/HTML (*.xml, *.htm), Comma Separated Values (*.csv), Word (*.doc, *.rtf, *.txt), Excel (*.xls), Portable Document File (*.pdf), Access (*.mdb).[12]

b. The data input specifications will be related to the online or offline Help, data indexes, e-books, databases, market studies, etc; of these services may benefit commercial banks, financial institutions, insurance companies, educational instititutions, universities and other institutions which work with a big volume of data.

c. We will implement some data validation procedures, including validation in relation to the XML Scheme, as to assure data quality and data structures integrity.

d. The data input will also be provided by alternative data capture methods, paper documents, microfilms or scanned images via OCR software able to convert scanned data in plain text markable data.

As testing activities, we propose the activities shown in table 1.

Table 1. The testing activities implemented in the first step: *Data Input*

Testing activities/Building activities	a	b	c	d
Modular testing	√	√		
Integration testing		√	√	√
Application testing				
Integration of application testing				
Acceptance testing			√	

Step 2: Services for the model

Our model must contain several modules which offer the following:

a. Verifying and adjusting the data.
b. Data analysis.
c. Data processing in structured or unstructured format as XML.
d. Creation and modification of XML Scheme.
e. Description of converting specifications.
f. Processsing of data input through OCR.
g. Structure and conversion of data formats.
h. By an efficient use of the conversion tools based on the DOM technology, our model must offer data conversion in XML, SGML, HTML and another structured formats, departing from different data formats: Word, Notepad, Textline, QuarkXPress, PageMaker, Mediaview etc.
i. Automatic data conversion.

As testing activities, we propose the activities shown in table 2.

Table 2. The testing activities implemented in the second step: *Services*

Testing activities/Building activities	a	b	c	d	e	f	g	h	i
Modular testing	√	√						√	√
Integration testing		√	√	√	√		√		√
Application testing					√	√		√	
Integration of application testing						√	√		
Acceptance testing			√		√	√		√	√

Step 3: Suplimentary services

We want to implement other modalities of data processing such as:

a. Images processing.
b. Creation and processing of the forms.
c. Design and support of databases.
d. The assurance of Total Quality Management.

As testing activities, we propose the activities shown in table 3.

Table 3. The testing activities implemented in the third step

Testing activities/Building activities	a	b	c	d
Modular testing	√	√	√	√
Integration testing		√	√	√
Application testing		√		
Integration of application testing			√	√
Acceptance testing	√			√

Step 4: The Interoperability enlargement between different platforms

We want to implement modalities of communication between different platforms. We follow these steps:

a. The analysis and possibility of communication within a heterogenous infrastructure: Windows platform, Linux platform etc.

b. The analysis and possibility of communication between different clients/servers databases: SQL server database, Oracle server database, SQL client database, Oracle server database etc.

c. We must assure communication of all clients with different servers based on different protocols of communication such as TCP/IP, SOAP etc.

d. We must build the XML common standards of communication.

e. We must ensure the transformation of the results of queries in XML format; XML offers a high abstraction level of the platform.

f. The implementation on each computer needs a XML client parser.

Table 4. The testing activities implemented in the fourth step: *Interoperability*

Testing activities/Building activities	a	b	C	d	e	f
Modular testing	√	√				
Integration testing		√	√	√	√	
Application testing						√
Integration of application testing						√
Acceptance testing			√			√

Step 5: Structure of XML documents

In [3] we presented a methodology for mapping relational data structure to XML vocabularies, which can be grouped in three phases:

a. Creation of the XML Scheme represented by the XSD document.
b. Definition of structures with a clear semantic specification.

With the help of XML Schema or DTDs we can define the contractual basis for data interoperability within the database system.

Table 5. The testing activities implemented in the fifth step: *Structure*

Testing activities/Building activities	a	b	c
Modular testing	√	√	
Integration testing		√	√
Application testing		√	
Integration of application testing		√	
Acceptance testing			√

Step 6: Data transformation

The XML offers some important services of data transformations (Data Transformation Services [13]).

We must go through the next steps:

a. Identify the data types, which sometimes do not have a clear equivalent in the translation step.

b. The enforcement by XML vocabularies of a set of common data.

c. The adoption of a standard where a common vocabulary convention is difficult to establish.

d. Use of advanced standards for changing the XML documents (XSLT).

Table 6. The testing activities implemented in the sixth step: *Data Transformation*

Testing activities/Building activities	a	b	c	d
Modular testing	√	√		
Integration testing		√	√	√
Application testing	√	√		√
Integration of application testing			√	
Acceptance testing			√	

Step 7: The client-server communication

a. We choose from a wide variety of Java-based XML and HTTP tools.

b. We use a prepacked set of XML-RPC tools.

c. With the help of XML-RPC tools we debug and establish connection between systems located in different environments.

d. We make the installation of XML-RPC servers.

e. We make the installation of ADO or ADO.net client/server communication technology.

Table 7. The testing activities implemented in the seventh step: *Communication Client-Server*

Testing activities/Building activities	a	b	c	d	e
Modular testing	√	√			
Integration testing		√	√	√	√
Application testing		√		√	
Integration of application testing					
Acceptance testing			√		

Some important things we must rely on, when we build and test the system

We must remember that XML, although a very strong technology, can lead to certain risks, if it not used properly, as follows:

- XML can bring a penalization for the performance, partially because of generation/parsing/validation, especially in the case of an abusive DOM parsing (SAX being the alternative use of a smaller memory window but with disadvantages regarding the element reference);

- XSLT transformations also affect performance.
- XML is not fit for the representation of amorphous systems of unstructured data because it contains only a limited set of characters.
- We can transport XML binary data, but only after a previous conversion in a text file format; this means an important restriction, especially for a type of applications like the wireless applications.
- XML data fills a greater space than in binary format, therefore we must think about the efficiency transportation of the documents XML through the network, especially because of the possible emergence of strangleholds.
- XML format can be canonicalized and compressed with the classic algorithms for superior performance.

The test cases used in our testing phases are following the recommendations of standards such as IEEE 829 regarding testing documentation. Each test case is documented on three levels [2]:

- The test case specification, a general description and an identification of each test case
- The test case design, a more detailed description, including instruments, input partitioning and the expected result.
- The test case procedure, of an algorithmic nature, with an m-n relationship to test cases (the same test case may use more than one testing procedure).

Conclusions

Our system has a performant database for the post-relational era, it is based on a new generation of technologies, combining a multidimensional data server with a versatile applications server. We use an advanced object technique, fast development for Internet, an advanced programming language, a unique data stock technology, etc. Our system must support all traditional methods for Web pages development, a unique technology named *Cache Server Pages* (CSP), optimized for improved access to the database system.

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