

*e-learning, distance learning,
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Robert KRÓL^{*}, Adrian OLSZEWSKI,
Jan PIECHA^{*,**}

THE ADVANCED VALIDATION FORMULAS FOR INTERACTIVE CONTROL OF E-LEARNING APPLICATIONS

The quality of interactivity within the Computer Aided Learning packages depends on quality of implemented measures [1], [2]. These factors provide the user with various validation formats and methods allowing controlling the study progress and knowledge quality analysis of the application progress [3]. They provide the users with powerful monitoring facilities indicating the user self education level and his ability of working as a Virtual University member. The specific distance learning interfaces were implemented not only for educational resources development but also for special services of Internet databases distribution.

1. INTRODUCTION

The problem discussed in this paper concerns the knowledge level measures effectiveness increase. This knowledge is checked to certify the application user qualification. The given interaction formats make possible to set an individual path through the application units. Various validation formulas are available for the application developer [4], [5].

Many educational units work today for a new virtual services development, expecting to simplify the process of education and to make it cheaper.

The distance learning (via Internet) [6] model of education implies new challenges for studying methodology of teaching and for methods of the application structure development. The paper shows the recent solution developed in the Department of Computer Systems, at the University of Silesia.

The e-learning processes are under control of the application management engine called Multimedia Applications Management Shell (MAMS) [2] supported by Quality Repetition Unit (QRU). These two shells are used for applications development and for controlling of the application flow.

* University of Silesia in Katowice, Poland, Institute of Informatics, Dept of Computer Systems,
e-mail: krol@zsk.tech.us.edu.pl

** Silesian University of Technology, Faculty of Transport

The application runs at the user workstation where his interactivity record is produced. The application structure has been presented in Fig.1 and widely described in other papers [2]. [3], [4].

The application interactivity results are recorded in a personal file of the user. That is why very effective measures of these interactions have been elaborated. The database contains not only the teaching units (micro presentation units) with their identifiers. They are also recorded with the user status, as: date and hour of the user actions, login into the system, log-out from the system and other activities of the user works.

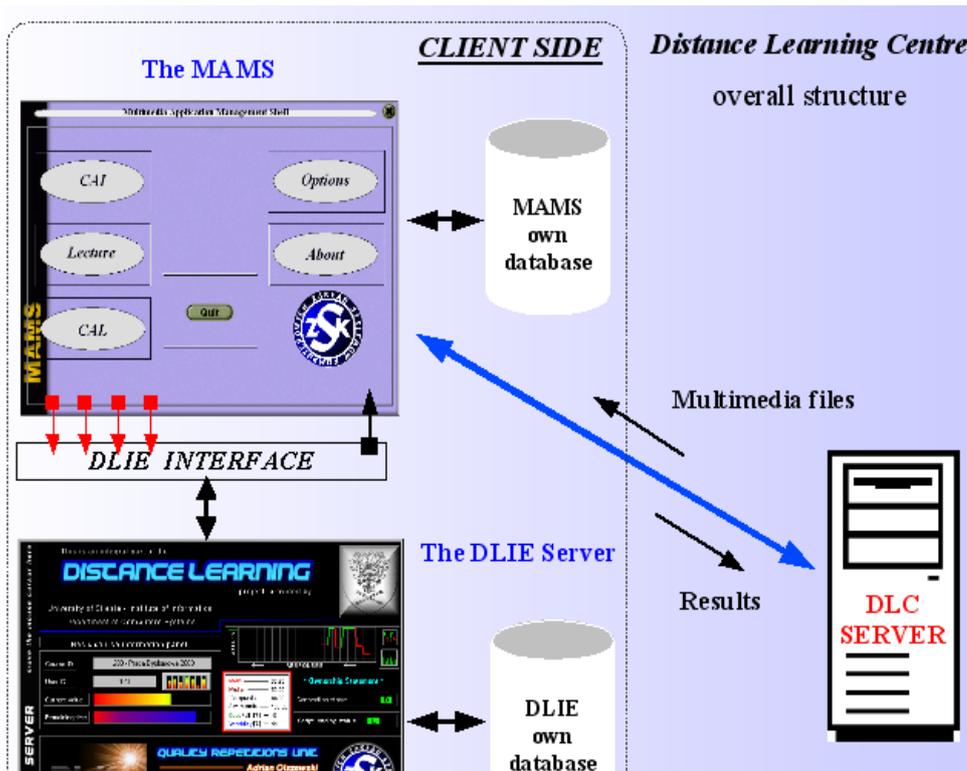


Fig. 1. Organisation of the distance learning resources

2. THE QUESTIONING FORMULAS

The question formulas are put into a hierarchical chain or sequence (Fig.2), where in a previous level the next fields of the question are defined. Each unique ID is linked with several possible answers; with their number and weight driving the multi-valued analysis of the answers.

For these interactivities a fill-up format of the script is given. The judgement results are put into the subsequent fields of the responses protocol then described by an adequate record.

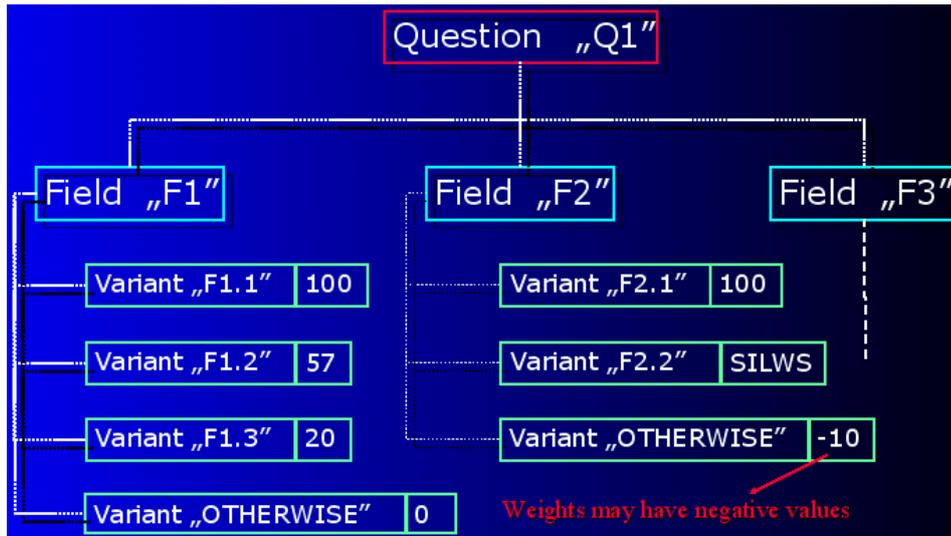


Fig. 2. Hierarchical organisation of the questions

Instead of a binary measure values of the conversation procedures the multi-valued measures have been provided. The current answer is compared with the table content where pattern answers are kept. They are marked by an appropriate weight of the answer, from a range of <-100;100>. The questions flow is illustrated by a flowchart in Fig.2. The obtained directives are switching the application interactivity methods.

In traditional solutions the simplest case an average value of all components of the answers is calculated. Anyhow various possibilities of the conditional calculations are able to run when several services are active ex. Scripts Instead of Low-Weights System (SILWS) mechanisms, the algorithm of the user activity - "RelaxTime" and others (described bellow).

The Distance Learning Interactions Evaluating (DLIE) server uses the built-in algorithm for the medium value of the answer calculations. It is obvious that other application measures can also be used.

In this case the judging system has to be plugged-in for any single question unit. The interactions result (a score) is transferred into the server, where it can be used in two ways:

- this single score is included into the total score where the medium value is calculated, (using the appropriate keyword Get Weight From Question Frame-Include)
- this single score replaces the total score that was calculated by the DLIE server previously (using the appropriate keyword Get Weight From Question Frame-Replace)

Example of the algorithm creation

Let the result of an equation solution consists of:

$$Score = \frac{((Score_p1 + Score_p2) * 0,9 - Number_of_faults * 10 - Score_p3) * response_Time * 0,01}{3} + Question_2b_result * 6,5 \quad (1)$$

where: Score_p1 40
 Score_p2 72
 Number_of_faults 12
 Score_p3 10
 Time of questions 87
 Question_2b-result 56
 CalculatedScore = **390,3**

The score range belongs into the assumed values: <0–500>, with several sub-ranges defined as follows:

<0;200>	A	20
<201;320>	B	40
<321;400>	C	60
<401;460>	D	80
<461;500>	E	100

Hence, for the score: *CalculatedScore* ∈ <321–400> the server chooses C as an answer mark, with weight 60%.

THE CONDITIONAL EVALUATION

It is a method of interactions control that excludes random factors of putting the answers properly by not enough careful users or by the users expecting the successful check-up incidentally. This is a characteristic feature of not good evaluated applications, where binary values of the answers (yes or no) are given. The conditional evaluation will eliminate all cases where the user is answering by heart, not analysing the question sense.

THE SILWS MECHANISMS

The SILWS (Scripts Instead of Low-Weights System) unit extracts the data for presentation sequence beyond the final answers judgement. The application complexity is controlled by the user activity “on line” by current interactions of the user. A measure of a user knowledge level can be used for controlling the study process. The answer value does not need to be a part of the total score. Thanks to this the user response is not judged and do not decreases the total value of the answer. As the information concerning the user responses is obtained, the teaching process can be somehow controlled.

The main disadvantage of the SILWS product is a big number of the checked responses variants, defined by the given formula:

$$\text{variants} = \sum_{i=1}^{a \text{ number of elements of response variants}} C_i^{a \text{ number of elements of response variants}} ; \text{ where } C_n^k = \binom{n}{k} = \frac{n!}{k!(n-k)!} \quad (2)$$

This big cardinality can be significantly reduced if frequently wrong given responses are defining several responses classes, with their special (individual) identifiers:

$$[\text{variant}]_{\text{fail_class_identifier}} = \{y \in A; y \sim \text{variant}\}$$

where: A – defines a set of all possible classes with cardinality defined by the equation (2)

In this case the number of generated classes $\overline{[\text{variant}]}$ is much less than cardinality of the set A ($\overline{[\text{variant}]} \ll \overline{A}$)

3. MATHEMATICAL FORMULAS FOR BASIC JUDGEMENT ALGORITHM

Average value is well-known measure to evaluate a level of student knowledge. In most cases we do not know anything about distribution that weights of user answers forms. If it is not the NGD (*Normal Gaussian Distribution*), then, in some cases, the mean is almost useless measure! It has been proved itself that it is necessary to apply an adequate corrections and additional coefficients to make average measure more equitable. Statistics measures can enhance functionality of QRU applications in this way[10].

The DLIE Server can compute all important statistical measures of single random variable:

- measures of the central tendency (mean, median, mode),
- measures of the dispersion (standard deviation, variability),
- measures of the concentration (kurtosis, skewness).

These measure results produce the so-called „corrections” and then incorporated into the calculated average value. The formulas are obtained from statistical measure properties.

3.1. THE PASSED / FAILED RESULTS

The „passed or failed” results use the Median and the Mean value measures proving the interactions results – whether the user passed the course interactivities or exam. In many cases it may happen that its decision is differ from our own, especially if only an average measure is taken under consideration. The gamma and delta thresholds can be set by the teacher.

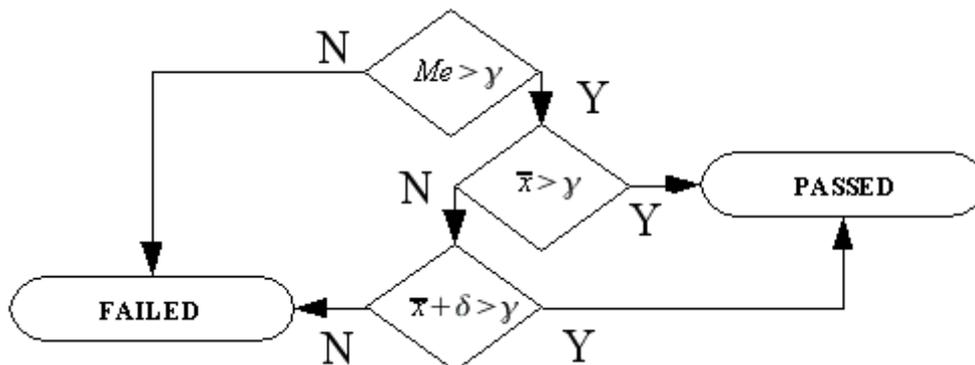


Fig. 3. The algorithm flow

3.2. "THE BETTER / WORSE VALUES" INDICATION

This indication uses the Skewness and the 1st Quartile measures to check the student better or worse score values. It happens that the user obtains in majority cases high (or low) values with a small amount of other values. This case provides the user with small bonus of several additional points. The gamma threshold can be set by the teacher. This measure can be incorporated into the Total Value of interaction results (Fig. 4).

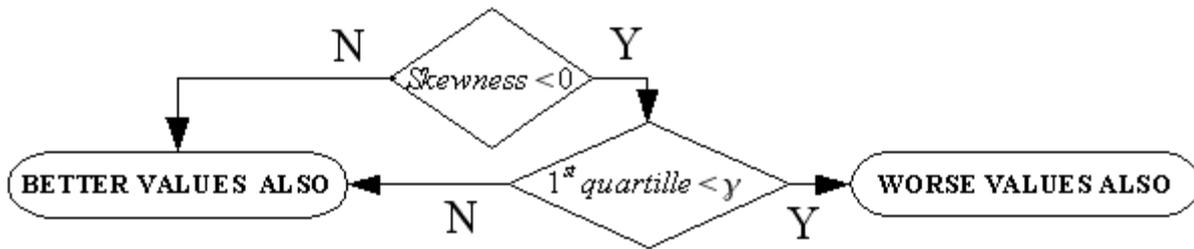


Fig. 4. "Better / worse values" indication

3.3. A "BONUS" SYSTEM

The "bonus" system (Fig. 5) produces the teacher credits for the student. It uses the Median, the Mean and the 3rd Quartile statistical measures. In case the Mean value is greater than amount of needed points and also the Mean value not differs from the Median than 20 and the 3rd Quartile the algorithm suggests the teacher to consider his opinion again. It can be very helpful in case when distribution is not Normal Gaussian Distribution (NGD) and the Mean measure does not represent distribution properties properly. It means that the teacher's judgement may not be objective. The special "Bonus system" smartly solves this problem.

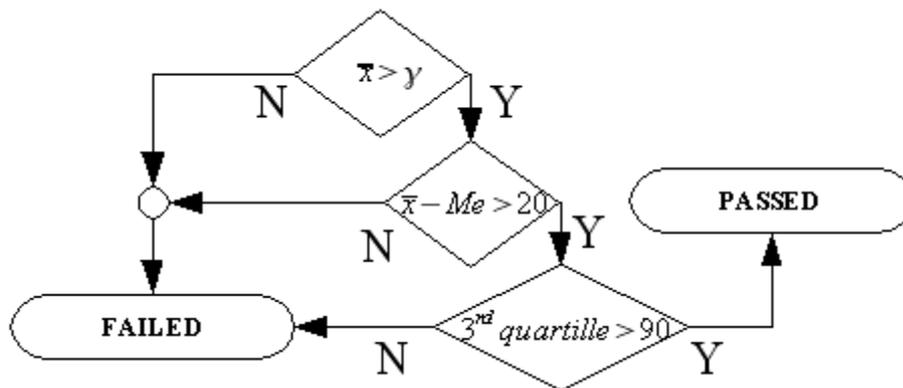


Fig. 5. "BONUS" system

4. VARIABILITY - MEASURE OF THE RESPONSE QUALITY

The variability of the user results values can be incorporated to the total value. This addition says about quality of user answers. The greater variability was reached but worse quality is reported. In Fig. 6 the quality (variability) dependence is presented. On the bottom of the Fig. 6 an example set of the user scores and answers descriptions are discussed.

Four values of the variability of these threshold levels can be set by the teacher. In Fig. 6 these thresholds have four values: 16, 45, 80, 90.

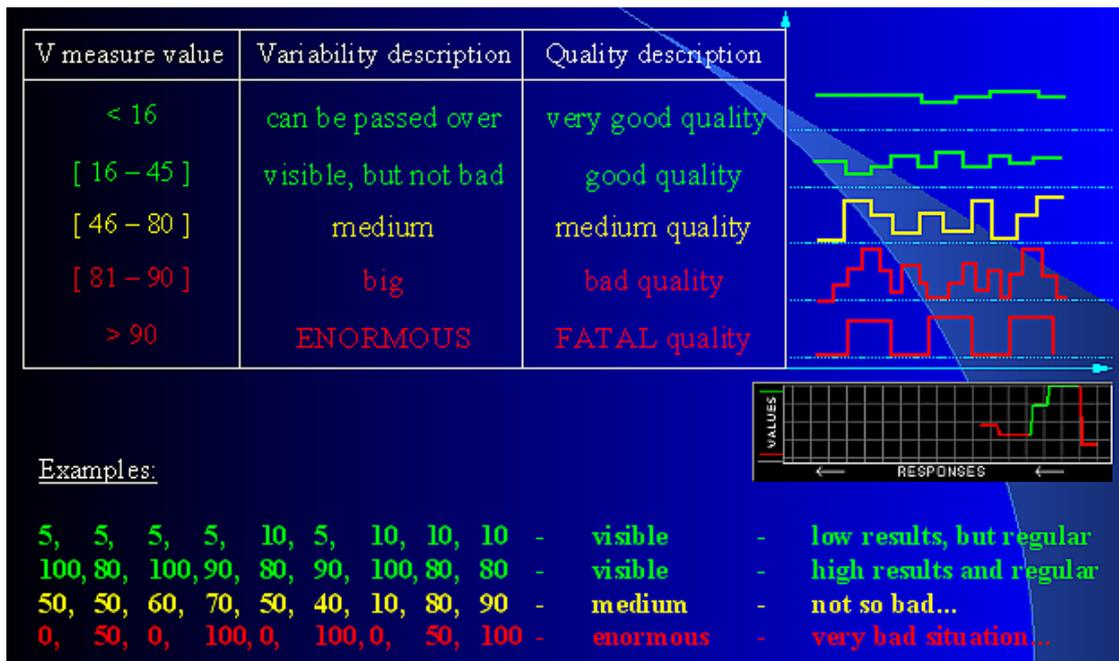


Fig. 6. Quality – variability dependence.

5. THE RESPONSE – TIME MEASURE

The DLIE Server can record a time of interaction between the user and a teaching unit then incorporate it into the final value according to the formula that is shown below.

$$TotalValue = MeanValue - MeanValue * \left(\frac{T_{RESP}}{T} \right) * SignificanceCoefficient$$

On the ground of response time measure a relax time can be forced by the MAMS. The RelaxTime is a special term describing a break time for relax and concentration. For this algorithm implementation special program has been made. It works on correlations of the user score values and a response time.

Fig.7 shows graphical statistic bars of the user answers. The DLIE Server is calculating data for these histograms and it is plotting an accumulative stacked graphs. An example of the statistics analysis has been presented in Fig. 7.

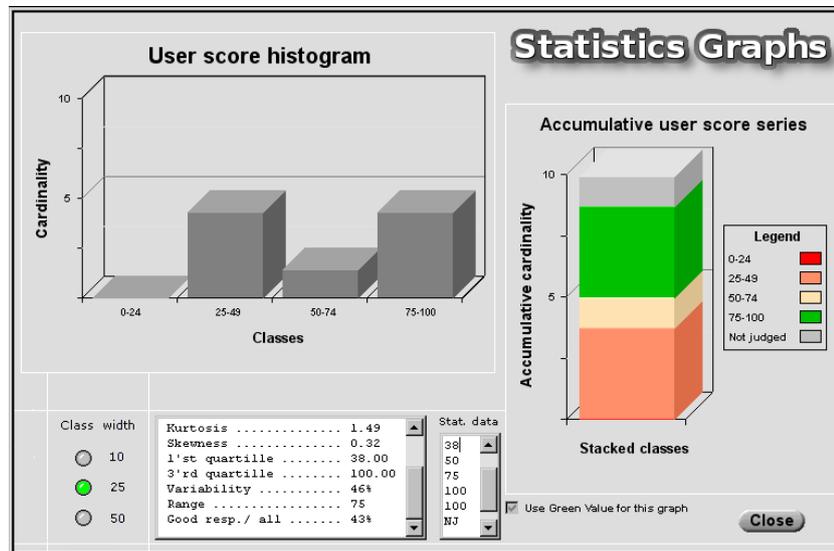


Fig. 7. An example of the statistics

6. CONCLUSIONS

The discussed system consists of several units, as:

- The network services for resources distribution,
- The MAMS & QRU application platforms:
 - MAMS for applications development,
 - QRU, unit for quality measures where unit DLIE is implemented.

The QRU unit controls all repetitions and validation processes of the application developed under MAMS platform. These all mechanisms allow setting individual paths of the user training process.

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