Customer satisfaction measurement system for higher education service quality estimation

H.V. Shauchenka, U. Bleimann, M. Knoll and N.L. Clarke

***Abstract*—**The main goal of this paper is to design and analyse the higher educational service quality measurement methodology and tools. The proposed methodology has been implemented as Customer Satisfaction Measurement System (CSMS) for higher educational service quality assessment. The conceptual base of the proposed CSMS is the connection of the pure humanitarian ephemeral categories with technical approaches for the purpose of further educational marketing. As have been shown in the paper, the key elements of CSMS should be design based on psychological Personal Construct Theory, modern Kansei Engineering approach and nowadays methods for data analyses. For the purposes of experimental validation of proposed CSMS methodology an experimental investigations have been carried out. To show the proposed methodology in practice by applying the CSMS tools as the topic for investigation the quality of the educational services offered by university has been used. As the stakeholder for this experimental investigation the Bachelor (except the first year students) and Master students of the Informatics Department of the Darmstadt University of Applied Science have been chosen. Based on the data obtained from this stakeholder different statistical approaches have been applied for data analyses to get different estimates of the topic under investigation. Some conclusions and findings have been pointed out. Further developments and studies needed are identified.

***Keywords*—**Higher Education Service Quality, Personal Construct Theory, Kansei Engineering.

I. Introduction

The higher education sector throughout the world has undergone enormous growth in recent years, mostly to keep the moderate level of the proposed educational services [1], [33]. Higher education service quality is important for educational institutions due to competitive advantage, satisfying governmental requirement, and meeting ever-increasing public expectations [1], [33]. That is why nowadays marketing has received increasing attention from high education institutions as the response on recent achievement in global economy and trends in high education sector [1], [10], [29]. The marketing of education service has developed as an attractive business and requires the educational institution to cope with modern marketing approaches [13], [17], [30].

Educational services in a modern market are very similar in their characteristics to ordinary products and it is generally recognized that impressions from products is becoming very important for differential advantage [1], [9], [20]. Quantity analysis of customer impressions and their evaluations in modern marketing is of extreme importance, because it enables the marketing analysis, prediction, planning and correction of marketing activities [17]. According to the numerous research studies, regardless of the type of service, customers basically use the same criteria to assess quality [25], [26]. Service quality is a general opinion the client forms regarding its delivery, which is constituted by a series of successful or unsuccessful experiences [25]. To assess this category two arguments can be taken into consideration, namely the customer perception and their initial expectation regarding the service received.

One of the most extensively used, developed and modified service quality methodology and corresponding measurement instruments is SERVQUAL, because of easiness to use, possession of simple structure and capability of generalization [26]. The customer satisfaction can be measured as the difference between expectation and the performance obtained within five dimensions of service quality: *reliability*, *tangibility*, *responsibility*, *security* and *empathy* [25], [26]. An adapted version of the SERVQUAL scale for Higher education services was proposed in [23]. Due to the controversy relating to the basic SERVQUAL methodology a more direct approach to the measurement of service quality have been proposed in [6]. This approach was developed as the measurement instrument called SERVPERF and like SERVQUAL it uses an attributes-based approach. However, compared with SERVQUAL, the SERVPERF tool is measuring customer's experiences of the service quality only [6].

More recently, a new industry-scale methodology for higher education service quality estimation, called HedPERF (Higher Education PERFormance) have been developed comprising a set of 41 items to be taken into consideration [8]. This methodology and corresponding instruments aims at considering not only the academic components, but also aspects of the total service environment as experienced by the student. The author identified five dimensions of the service quality concept: *academic dimension*; *programmer issues*; *non-academic aspects*; *reputation*; *access dimension*. The SERVPERF and HedPERF scales were compared in terms of reliability and validity and concluded for the superiority of the HedPERF measurement instrument [8]. There are several

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H. V. Shauchenka is with the Centre for Information Security and Network Research, University of Plymouth, UK (Phone + 49 (06151) 679-46-96, e-mail: hanna.shauchenka@plymouth.ac.uk).

U. Bleimann, is with the Institute of Applied Informatics University of Applied Sciences Darmstadt, Germany (e-mail: udo.bleimann@h-da.de).

M. Knoll is with the Institute of Applied Informatics University of Applied Sciences Darmstadt, Germany (e-mail: matthias.knoll@h-da.de).

N. L. Clarke is with the Centre for Information Security and Network Research, University of Plymouth, UK (e-mail: N.Clarke@plymouth.ac.uk).

SERVQUAL like methodologies including FM-SERVQUAL, INTQUAL, DL-eSQUAL, EduQUAL, Weighted SERVQUAL, Weighted SERVPERF and Weighted HedPERF [16], [18]. Practically all existing methodologies and corresponding instruments for higher education service quality assessment, including all mentioned above, based on the data obtained from the respondents belongs to different customer domains, such as *students, parents, academic stuff* and *alumni*.

This paper serves to the following purpose, namely to propose unified methodology and measurement tool, in comparison with previous results, which are based on the pure humanitarian ephemeral categories. It supported with technical approaches for the customer satisfaction of the higher education service quality estimation for the purposes of educational marketing. All materials of the paper are presented based on real example of the educational services quality estimation offered by Darmstadt University of Applied Science. The rest of the paper is organized as follows: Next section presents the description of the CSMS methodology and structure. The following section describes questionnaire design based on Repertory Grid Technique. Section 4 dealing with the problem of online data collection and presents some examples. Section "CSMS data analyses modes" describes CSMS tool modes with several experimental statistical data sets. The main results presented in paper are discussed at the end of the paper, followed by the conclusion.

II. CSMS Methodology and Structure

As have been pointed in [6], [16], [17], [22], [29]–[32], the all existing higher education service quality methodologies and measurement tools have oriented to get the answer whether perceptions of service quality meet or exceed consumer expectations. It is the key conceptual background of the original SERVQUAL, as well as different other nowadays methodologies and tools [25], [26], [29]. There are two common features in modern higher education service quality methodologies and measurement tools, namely the structural representation the service quality as the set of different domain described by the set of questions and the applying in most cases the Likert-type rating scale for evaluation purposes.

Despite a leading position in measuring higher educational service quality the original SERVQUAL and other existing tools have some criticisms [25], [26], [29]. These criticisms related to conceptual, methodological and analytical issue in original SERVQUAL approach [17]. The use of the perception and expectation gap measure of service quality raises related analytical concerns about low reliability, poor discriminant validity and parasitic correlations [8], [16], [18], [22], [31]. Conceptualization of service quality as the difference between perception and expectation has a lot of criticisms compare with perception only approach to service quality measuring [6], [22]. All existing approaches have been designed and used without taking into account the pure humanitarian categories and trans-disciplinary features, as well as new research achievements, like Kansei engineering.

The main idea of the CSMS proposed in [29], [31] is the attempt to connect the technical approaches with pure humanitarian ephemeral categories applying for educational marketing. Such a problem statement challenges the analysis on different abstraction levels from general societal conditions to a personal level, and also causes the nature of the research to be trans-disciplinary with approaches required from philosophy, psychology, marketing and mathematics. The complex nature of the problem to be analyzed can be defined by the set of involved disciplines and chosen approaches, methods and methodologies [30]. The key area of our investigation is the CSMS, which is based on fundamental psychological Personal Construct Theory [15], modern Kansei Engineering approach [3], and statistical methods for data analyses. The numerous modes of the proposed CSMS allow getting different data sets and estimates for further Quantitative Analysis of Consumer Response to Educational Service, Educational Management and Marketing, Total Quality Management (TQM) in High Educational Institution (HEI) within the context of existing social and political environments are the bases for CSMS [29], [31].

The phenomenon of educational services have a dual nature: it is both utilitarian and hedonic services. Some intangible characteristics; for example, an emotional spirit, created by the teacher, or the successful image offered by marketer, can hugely increase the grade of perceived value of educational services [1], [2]. This specificity is also reflected in the offered structure of proposed methodology and tool. The marketing context of research requires the analysis of all important for marketer stakeholders groups: *students*, *graduates*, *staff members* and *employers*. The interaction of these groups and theirs attitudes toward the educational services (or perceived value) defines the position of Educational Institution in the market. The most important, so-called, end-customers are, of course, students. This is not a homogenous group, in this structure the segmentation depending on consumption stage is implemented: *first year student*, *student*, *graduate*, *former graduate*. As the next step, parameters could be cross-tabulated also with demographic, lucrative or others variables, such as gender or purchasing capacity, to understand differences of perceptions, if any, among different students segments and make the most interesting offer for the segment, that was chosen as a strategic most important. The methodology and schematic structure of CSMS has been presented in [31].

Some of the features have not been included yet in the CSMS structure. For example, one of the very important respondent's group, such as *parents* and other *relatives* also should be included into proposed structure. This domain can be approximated by the domain of *former graduates* but nevertheless for the some countries such groups are quite important [31].

The proposed structure of CSMS can be regarded as a methodology for further instrumental evaluation. For example, in a case of the topic under investigation such as *quality of the educational services offered by university* the two main respondent's groups such as *graduates* and *former graduates* can be chosen. The proposed CSMS allows getting the data by web-based survey at different time periods from different respondent's groups. The main approach for data gathering is a questionnaire-based approach that can be designed by the researcher themselves or can be generated by the respondents based on CSMS.

III. Questionnaire Design based on Repertory Grid Technique

The *Repertory Grid Technique* (RGT), have been proposed within the framework of Personal Construct Philosophy (PCP) developed by clinical psychologist George Kelly more than 60th years ago [15]. RGT represents the mechanism that allows evaluate the individuals' personal constructs concerning researched objects. A repertory grid is a cognitive mapping tool used to elicit and analyze the mental models of individuals through a structured interview technique [5], [7]. Each grid is constructed around one *topic*, which includes the problem to be considered along with the peculiarities (characteristics) of the respondent's group (domain). For example, the problem of *quality of the educational services offered by university* from the student's point of view can be chosen. RGT is constituted into three parts: *Elements* corresponding to objects that have to be investigated; *Constructs* consisting on ideas, descriptions or associations of respondents about elements; *Rating Scale* helps to identify how elements differ in a fundamental way [7]. In a case of educational marketing the precise and proper determination of research topics (objects), has been presented in [30]. The research topic can be defined as the set of elements with constructs (categories). In this paper the educational service described as a marketing category, define the main *subject*, *object* and *goal* of educational marketing. The students were considered as the main subject (group of respondents) of educational marketing activity, and educational service as the main object (topic). To understand the phenomenon of educational service the main topics that describe this category, as well as the elements on which these topics depend have been deeply analyzed in [30], [31]. The following main topics can be considered: *Educational concept*, *Management and Teaching technologies*, *Teaching technique*, *Teaching form*, *Territorial aspect*, *Teaching staff and its functions*, and *Whom to teach*?. Examples of some topics of educational marketing have been presented and analyzed in [30], [31].

Once the topic for the grid of RGT has been chosen, words constitute the *elements* are generated to represent the space in which topic is to be investigated. Then elements become the subject matter for discussion with the respondents. In a case of the high education service quality assessment the following elements can be chosen: *Studies Organization*, *Teaching Staff*, *Program Design*, *Technical equipment*, *Science and Research Students Activity* and many others elements can be proposed. The set of elements can be designed by the researcher themselves or can be generated by the respondents via CSMS facilities. This set is very flexible especially with the respondent's domain characteristics. For example in a case of student's group the element concerning the *Students Studying Abilities* is not as important and valuable as for the respondents consisting from the university teaching staff members. And vice versa for the students as respondents the element *Teaching Staff* is very important and less valuable for the university teaching staff members due to difficulties of the self-estimation procedure and adequacy of obtained result.

The next stage is to elicit the constructs by which the elements are compared. Taking the elements in groups of three, the interviewer asks the respondents to tell them how two of the elements are similar in some way but different from the third. The construction of the groups was performed by CSMS in random fashion and one group with three elements on separated message (card) has been presented to respondent with the qualifying phrase "*Looking at these three factors related to the high education service quality could you tell us how two of them are similar in some way but different from the third in terms of reason you wish to get from high education service at the high education institution or didn't want to get it*". These bipolar distinctions are called constructs and illustrate the qualities that the individual uses to explain and differentiate between the elements. For example, for respondent (student) the card with three elements *Teaching Staff*, *Program Design* and *Science and Research Students Activity* has been given. If the student is motivated to get good job position and don't think about his future research activities he can generate the following answer "*Good Teaching Staff* and *Program Design* both are very important to fulfill the requirements of labor market, *Science and Research Students Activity* is less important". This answer can be used to elicit the construct concerning the issue how this particular high institution is providing its educational service fulfills the requirements of labor market. This construct has a bipolar meaning: *Fulfill requirements of labor market* and *doesn't fulfill requirements of labor market*. Formally all constructs represent the rows of the grid, where the column corresponds to all previously generated elements.

Once all constructs have been elicited the links between elements and constructs are mapped on the grid based on some rating scale. In doing so, respondents are asked to quantitatively estimate the degree to which each element can be characterized by the construct. Kelly originally used a 2-point scale, but today some researchers use 16-point scales [7]. The most popular however is the 5-point Likert scale. The consistent use of the Likert scale format in the questionnaire is a good way to easily collect and code the data. Using the 5-point Likert scale responses were noted as: 5 − *Strongly Agree*; 4 − *Agree*; 3 − *Neither Agree nor Disagree*; 2 − *Disagree*; and 1 − *Strongly Disagree*. Point 5 corresponds to the construct, 1 to its opposite. In this case the six-point Likert scale have been chosen, where 0 means that the construct is not appropriate (applicable) for the element. The end product is a cognitive matrix (grid), which describes the relationship between individuals' mental representation of the topic under investigation.

IV. Online Data Collection

As it was mentioned in the previous section, for the next step, namely the statistical data gathering, the fixed grid will be used. As an example, the grid has been constructed based on the designed nine elements and seven constructs and thoroughly tested and validated during the research seminars at the Darmstadt University of Applied Science. As elements the following categories of high educations institutions are used: 1. *Learn infrastructure* (Lehr-Infrastruktur); 2. *Program design* (Angebotene Studienfächer); 3. *Student's practical activities* (Studentische Praxis Aktivitäten); 4. *Students research activities* (Studentische Forschungs-Aktivitäten); 5. *Additional services* (Zusätzlichen Dienstleistungen); 6. *Study's organization* (Organisation des Studiums); 7. *Level of received theoretical knowledge* (Das Niveau der erworbenen theoretischen Kenntnisse); 8. *Program compliance with labor market* Die (Übereinstimmung des Studienprogrammes mit den Anforderungen des Arbeitsmarktes); 9. *Teaching staff* (Lehrende).

The 9 elements in the same row were rated according to their proximity to either left or right pole of the construct based on how matters are currently happening. The constructs used in data gathering procedure are the following: 1. *The factor of high priority − The factor of low priority* (Bedeutender Faktor − Unbedeutender Faktor); 2. *Exciting − Boring* (Anregend − Langweilig); 3. *Modern − Outdated* (Modern − Veraltet); 4. *Good organized − Bad organized* (Gut organisiert − Schlecht organisiert); 5. *Excel the expectations − Doesn't match the expectations* (Entspricht den Erwartungen − Entspricht nicht den Erwartungen); 6. *Ideal − Unacceptable* (Ideal − Unakzeptabel); 7. *Motivates for study − Dismotivates* (Motiviert für das Studium − Motiviert nicht). The output of the described above experiment is a classical for the PCP fixed Grid. However, it was decided to adapt this grid for further implementation. The reason for this decision was to simplify the classical Grid form for better understanding. During the expert group discussion at the research seminars, mentioned above, the matrix form of the questionnaire was commented as "*too complicated for the students*" and even "*irritating*".

For the survey was chosen the evaluation software for education, the tool CASED *EvaSys*, allowing online surveys design and its further implementation. This tool is actively used at many German Higher Education Institutions, also at the Darmstadt University of Applied Science for the learn purposes. The matrix questionnaire was divided into the nine question blocks as it is illustrated in Fig. 1 for the first question block 1. *Learn infrastructure* (Lehr-Infrastruktur).

This block is corresponding to the first element, namely *Learn infrastructure*. The survey have been started at the 28.03.2012 and finished at the 04.04.2012. The survey was undertaken anonymously and participants were free to withdraw at any stage. The number of fully and correctly filled questionnaires is 123 or approximately 15% of the total respondent number. It is a usual result for the anonymous surveys and for *EvaSys* application, as well [14]. The respondents for this survey were the Bachelor (except the first year students) and Master students of the Informatics Department of the Darmstadt University of Applied Science. These respondents agree with the module 2 of the offered CSMS that was chosen for the formalization stage of CSMS development. The following Table I is the resulting data set of interviewing the students of Darmstadt University of Applied Science by the CASED *EvaSys* system.

MUSTER

EvaSys | Beurteilung des Bildungsangebotes der Hochschule Darmstadt | Electric Paper

Hochschule Darmstadt -- University of Plymouth | Hanna Shauchenka
Fachbereich Informatik | Umfrage im Rahemen des PhD-Projektes

Markieren Sie so: Bitte verwenden Sie einen Kugelschreiber oder nicht zu starken Filzstift. Dieser Fragebogen wird maschinell erfasst.
Korrektur: Bitte beachten Sie im Interesse einer optimalen Datenerfassung die links gegebenen Hinweise beim Ausfüllen.

1. Lehr-Infrastruktur

Hierzu zählen IT-Services und technische Ausrüstung; Zugänglichkeit und Architektur der Gebäuden, Räumen und Campus; Website; Bibliothek.

1.1	Die Lehrinfrastruktur in Ihrem Hause ist für Sie:	beleutender Faktor	unbedeu-tender F-aktor	nicht relevant
1.2	Die Lehrinfrastruktur in Ihrem Hause ist für Sie:	anregend	langweilig	nicht relevant
1.3	Die Lehrinfrastruktur in Ihrem Hause ist fuer Sie:	modern	veraltet	nicht relevant
1.4	Die Lehrinfrastruktur in Ihrem Hause ist für Sie:	gut organis-iert	schlecht organisiert	nicht relevant
1.5	Die Lehrinfrastruktur in Ihrem Hause ist für Sie:	entspricht den Erwartungen	entspricht nicht den Erwartun-gen	nicht relevant
1.6	Die Lehrinfrastruktur in Ihrem Hause ist für Sie:	ideal	unakzept-abel	nicht relevant
1.7	Die Lehrinfrastruktur in Ihrem Hause ist für Sie:	motiviert für das Studium	motiviert nicht	nicht relevant

Fig. 1 first question block (*Learn infrastructure*)

Table I. The resulting data set (*Grid_Example*)

		Elements								
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
Constructs	*1*	2.07	1.74	2.05	2.97	2.75	1.86	2.20	1.71	1.72
	2	3.03	2.84	2.64	3.08	3.40	2.65	2.93	2.58	2.68
	3	2.64	2.72	2.75	2.77	3.37	2.52	2.76	2.77	2.86
	4	2.60	2.63	2.72	3.28	3.50	2.47	2.68	2.88	2.57
	5	2.48	2.78	2.79	3.34	3.57	2.53	2.75	2.87	2.61
	6	2.79	2.88	2.80	3.33	3.56	2.63	2.84	2.99	2.69
	7	3.13	2.93	2.62	2.97	3.66	2.76	3.02	2.68	2.64

All numerical values have been presented by the above mentioned CASED *EvaSys* system, as the average values. This system allows getting some statistical values like data are shown in Table 1. For example, in a case of first construct for the first element the average value 2.07 have been presented by CASED *EvaSys* system as the following Fig. 2.

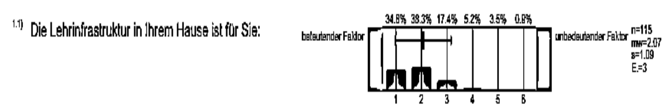


Fig. 2 the average value of Constructs 1 for Element 1

It should be emphasized that all numerical values in Table I were obtained as the answer for the chosen topic under investigations as assessment of the educational offer at some particular higher educational institution, namely at the Darmstadt University. This data can be regarded as average values obtained from one of the respondent's domain. In this case the respondent's domain is the students from the Computer Science Department of the Darmstadt University.

According to the structure of the Grid the affective value of higher education service represents as the most appropriate parameters (elements) of high educational service. The estimates of each element have the implication on the entire level of the educational service value. In this interpretation the elements can be regarded as sample data (vector or point) $X_i=\{x_{i1}, x_{i2}, \ldots, x_{i7}\}$, where $i\in\{1,2,\ldots,9\}$ with seven arguments $x_{i,j}$, $j\in\{1,2,\ldots,7\}$ (constructs). As the main data set the Grid, presented in Table I is chosen for following analysis.

V. CSMS Data Analyses Modes

To show the proposed methodology in practice the data presented in Table I will be used. During the all stages of data analysis by the corresponding CSMS tools this data has to be thoroughly investigated and analyzed. For data analyses the CSMS tools are based on the MATLAB Statistics Toolbox functions (MATLAB Stats Toolbox) [19]. At the first step according to CSMS data analyses functionality the *Pilot Testing* can be applied.

A. Pilot Testing

According to the CSMS methodology at the beginning of the data analysis the *pilot test* or so called *pre-test* should be provided [14]. This test accomplished the following main functions. First of all it serves as the initial test of the obtained data and what is more important it is the last step in finalizing the proposed questions and questionnaire form. The pre-test offers feedback on whether the question's wording and clarity is apparent to all respondents and whether the all questions mean the same thing to all respondents. The three basic goal of the pre-test can be achieved, namely, evaluate the competency of the questionnaire, estimation the length of the survey or average respondent's time to take the survey, and determination the quality of the respondent's domain [14]. The main purpose of pilot testing within proposed methodology of data collection is to catch potential problems to avoid costly mistakes.

At the second stage, according to the CSMS methodology the validity of the proposed example of questionnaire should be established using a panel of experts during, so called *field test*. In the presented questionnaire example the field test have been carried on by the research participants of PhD Seminar offered by Darmstadt University of Applied Science. The research participants, in this case are the audience of around 20 peoples, mostly working in educational sector (scientists, researches and teachers). The following questions for the questionnaire validations during the field test have been addressed [28]: *Is the questionnaire measuring what it intended to measure*? *Does it represent the content*? *Is it appropriate for the respondent's domain*? *Is the questionnaire comprehensive enough to collect all the information needed to address the purpose and goals of the study*? *Does the instrument look like a questionnaire*? As the result of the field test the final version of the questionnaire was produced.

As the numerical estimation for questionnaire validity the CSMS support the calculating the *response rate* (R_r) as the percentage of respondents who responded to the proposed questionnaire. High number of respondent's responses help to ensure that the results are representative and the data validity is high. In our case the number N of respondent's responses is comparably high and equals to 123 out of the entire number of respondents around N_t = 1000 (the number of all students at the Computer Science Department of the Darmstadt University. with exception of the first semesters). Then R_r = 12,3%.

In this final step of pilot test, *reliability* of the questionnaire using the CSMS methodology is carried out. Reliability refers to random error in measurement during the data collection. Generally the reliability indicates the accuracy or precision of the measuring instrument and the term data *reliability* is used to refer to the degree of variable error in a data measurement. To measure reliability the standardized *Cronbach's α* characteristic is supported by the CSMS facilities. The *Cronbach's α* has been calculated for all nine elements represented as N = 123 measurements $Q_1, Q_2, ..., Q_N$, where $Q_i = \{q_{i1}, q_{i2}, \ldots, q_{i7}\}$, $i \in \{1, 2, \ldots, 123\}$ and $q_{i1}, q_{i2}, \ldots, q_{i7}$ are the constructs values for chosen element. As an example the *Cronbach's α* value for the first element *Learn infrastructure* is 0.8567. The reliability coefficient (*Cronbach's α*) can range from 0 to 1, with 0 representing an instrument with full of error and 1 representing total absence of error. A reliability coefficients *Cronbach's α* for the data gathered by the online survey based on *EvaSys* are higher of 0.8 what allow tor consider the measurement results presented in Table 1 as acceptable reliable.

B. Data Visualization

For more detailed analyses first of all the different kinds of histogram and average values can be generated, what is very convenient for visualization the data presented in Table 1. As the first example the distributions of construct's values for all elements is presented in Fig. 3.

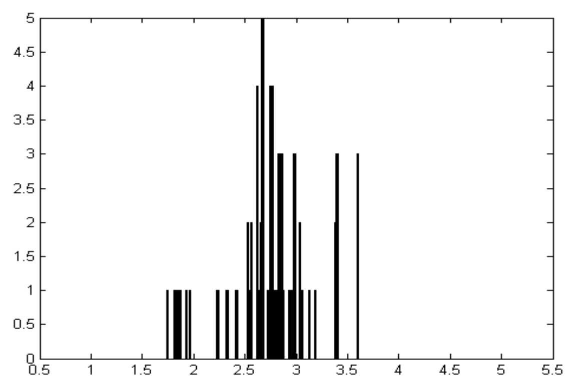
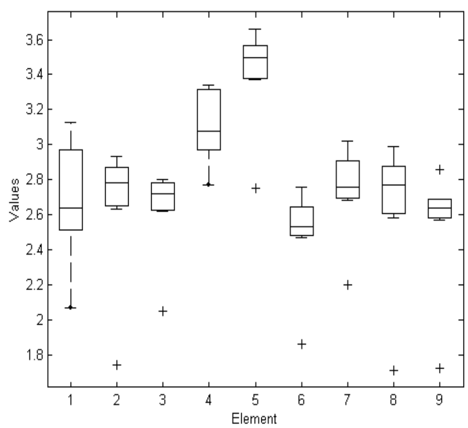


Fig. 3 histogram of the construct's values

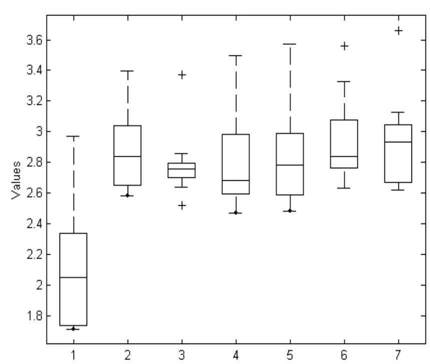
Some very general information about the respondent's answers concerning all elements influencing for the level of high educational service based on this histogram shown in Fig. 3 can be done. The following very simple and obvious conclusions can be formulated. The minimal average respondent's score is 1.71 what is far from minimal values 1, and the highest score 3.66 is sufficiently lower than maximal value equals to 6. The average value is very close to 3 point and equals to 2.7624. These results allow making the conclusion that the affective value *of higher educational service* at the Darmstadt University of Applied Science has been estimated at the quite moderate level by the students of the Informatics Department. The element number 5 (*Additional services*) has got the maximal construct's average score 3.4014 as well as element number 6 (*Study's organization*) has been estimated with the lowest average score equals to 2.4886. The rest of elements have their average construct's score very close to 2.6. This data allow pointing out that additional service is organized at the moderate level and probably there are some problems with study's organization at the University.

Every construct can be interpreted as the estimation of a certain affective value's dimension. That is why due to the construct number 1 (*The factor of high priority − The factor of low priority*) has the lowest average score equals to 2.1189 this fact can be regarded that quality of higher educational service for the students of Darmstadt University is the factor of low priority rather than the factor of high priority. The highest average value 2.9456 has the construct number 6 (*Ideal − Unacceptable*). This data can be regarded as the quality of higher educational service for the students of Darmstadt University is ideal rather that unacceptable.

Also for visualization of the data set the *Box plot* mode can be applied. In descriptive statistics, a *box plot* (also known as a *box-and-whisker diagram* or *plot*) is a convenient way of graphically depicting groups of numerical data through their five-number summaries. For our data, are shown in Table I, this visualization has the following form.



(a)



(b)

Fig. 4 the Boxplot for data presented in Table I: elements (a); constructs (b)

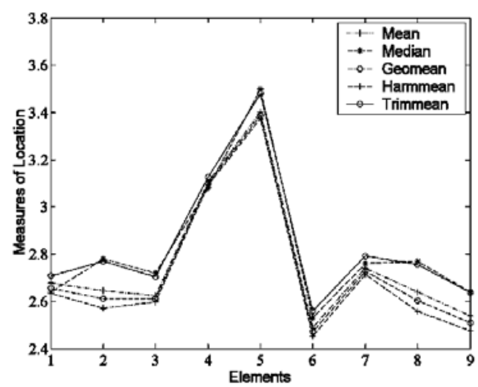
It is the graphical interpretations of all elements depending on seven constructs and constructs which is the function of nine variables (elements). For example, in a case of first element (Fig. 4(a)) the value of median, which is the 50th percentile of a sample equals to 2.6771. The largest observation equals to 3.13 and smallest is 2.07. The main results which can be obtained from above presented Boxplot are the following: Elements 4 (*Students research activity*) and Element 5 (*Additional services*) have the highest score compare with other; Construct 1 (*The factor of high priority*) has been evaluated with the lowest score.

C. Data Descriptive Statistics

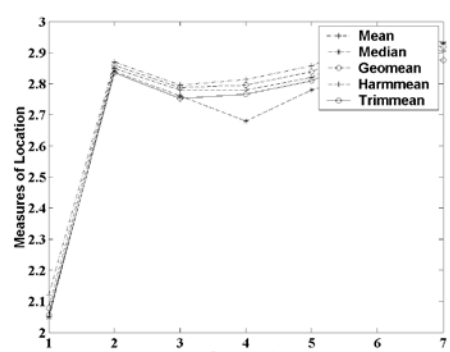
At the first step let us apply the descriptive statistics to try to understand the main tendency which this particular respondent or what is our case, average estimation of some of respondent's domain expressed by the Grid presented in Table I.

The first simple characteristics are measures of *Central Tendency*. The purpose of these measures is to locate data value on the number line. The central tendency of the data distribution is an estimate of the '*center*' of a distribution of data values. There are five major types of central tendency characteristics available under CSMS. The *Mean* (μ) or average (*arithmetic mean*) is the most commonly used approach of describing central tendency of the sample data. The rest of central tendency characteristics include *median*, *trimmed mean*, *harmmean* and *geometric mean*.

Fig. 5 shows the average values as the points, which connected with line for all nine elements and seven constructs under investigation.



(a)

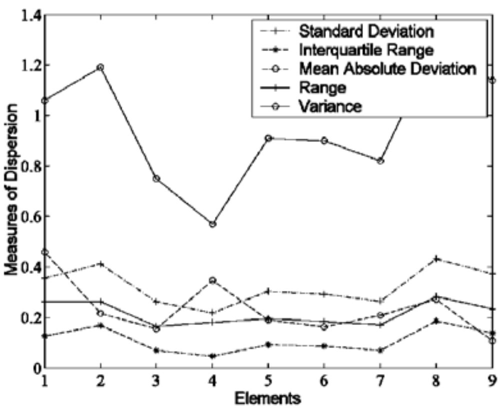


(b)

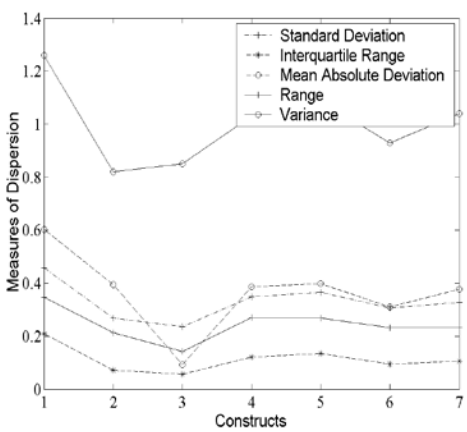
Fig. 5 the average values for all nine elements (a) and for seven constructs (b)

The maximal average value around 3.4 points has element number 5 − *Additional services*, and the lowest average score has got the element number 6 − *Study's organization* (see Fig. 5(a)). This information is quite valuable for researcher to make the right marketing and management conclusions for the service quality improving.

To find out how spread out the data values is on the number line the various standard functions can be used. *Dispersion measures* refer to the spread of the values around the central tendency. The CSMS tools based on MATLAB facilities can generate five dispersion measures, namely *standard deviation* (σ), *interquartile*, *mean absolute deviation*, *range* and *variance*. For the above presented data (Table I) the resulting plots are shown in Fig. 6.



(a)



(b)

Fig. 6 measures of dispersion for all nine elements (a) and seven constructs (b)

According to above presented data (Fig. 6) the element 4 has practically constant scores without any deviations, as well as the construct 3.

The value of covariance $cov(X_i,X_j)$ as well as correlation coefficient C_{XiXj} will allow to get the answer how two variables (sets of samples) X_i and X_j are associated. CSMS used MATLAB function *corrcoef*(*data*) which returns a matrix of correlation coefficient calculated from an input matrix data set whose rows are observations and whose columns are variables. For the above presented data set (Table I), the matrix of correlation coefficients for all nine elements is shown in Table II.

Table II. Correlation coefficients C_{XiXj} for the elements

C_{XiXj}	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
X_1	1.00	0.84	0.58	-0.02	0.75	0.90	0.94	0.57	0.73
X_2	0.84	1.00	0.91	0.25	0.95	0.99	0.96	0.90	0.94
X_3	0.58	0.91	1.00	0.38	0.90	0.85	0.78	0.98	0.94
X_4	-0.02	0.25	0.38	1.00	0.39	0.18	0.10	0.44	0.08
X_5	0.75	0.95	0.90	0.39	1.00	0.94	0.90	0.92	0.86
X_6	0.90	0.99	0.85	0.18	0.94	1.00	0.99	0.84	0.91
X_7	0.94	0.96	0.78	0.10	0.90	0.99	1.00	0.76	0.87
X_8	0.57	0.90	0.98	0.44	0.92	0.84	0.76	1.00	0.90
X_9	0.73	0.94	0.94	0.08	0.86	0.91	0.87	0.90	1.00

In this example X_i represents element number i where $i \in (1,2,\ldots,9)$ from the Table I. As can be observed element 1 completely cannot be predicted based on element 4 (C_{X1X4} = –0.02) and at the same time can be predicted with high level of accuracy based on the element 7 due to the high level of correlation (C_{X1X7} = 0.94). These numerical values can be interpreted as follows the element *Learn infrastructure* does not depend on the *Students research activities,* as well as is very close related to the element *Level of received theoretical knowledge*. The value C_{X2X6} = 0.99 indicates that element *Program design* is very close correlated with the element *Study's organization*.

D. Cluster Analyses

Cluster analysis also calls segmentation analysis or taxonomy is a way for grouping objects of similar kind into respective categories. A general question facing researchers in many areas of inquiry is how to organize observed data into meaningful structures, that is, to develop taxonomies. In other words cluster analysis is an exploratory data analysis tool which aims at sorting different objects into groups in a way that the degree of association between two objects is maximal if they belong to the same group and minimal otherwise [4], [21].

The crucial element of the above described clustering approach is the proximity measure that quantifies the notation of closest *point* (*data*) for the specific data under consideration. As the numerical values for these purposes the different types of distance between the data represented as points can be used. Given an m by n matrix X, which is treated as m row vectors $X_1, X_2, \ldots, X_m$, where $X_i=\{x_{i1}, x_{i2}, x_{i3}, \ldots, x_{in}\}$. There are various types of distances between the vectors $X_i=\{x_{i1}, x_{i2}, x_{i3}, \ldots, x_{in}\}$ and $X_j=\{x_{j1}, x_{j2}, x_{j3}, \ldots, x_{jn}\}$ [4]. The most known and used *Euclidean distance* (D_E) is defined as follows: the distance between points X_i and X_j is the length of the line segment connecting them. There are some modifications of the Euclidean distance such as *Standardized Euclidean distance* and *Mahalanobis distance* [4], [19]. *City block distance* (D_{CB}), *Manhattan distance*, or *Manhattan length*, which also widely used for data clustering. The *Minkowski distance* (D_M), of order p between two points X_i and X_j is

$$D_M(X_i, X_j) = \sqrt[p]{\sum_{k=1}^{n} \left| x_{i\,k} - x_{j\,k} \right|^p}. \quad (1)$$

Minkowski distance is typically used with p being 1 or 2. The latter (p=2) is the Euclidean distance, while the former (p=1) is known as the Manhattan distance. In the limiting case of p reaching infinity we obtain the *Chebyshev distance*.

A hierarchical clustering is often displayed graphically using a tree-like diagram called a *dendrogram*. The dendrogram (tree) is not a single set of clusters, but rather a multilevel hierarchy, where clusters at one level are joined as clusters at the next higher level. This generally allows a user to decide what level, scale or complexity of clustering is most appropriate in a particular application [4].

To perform hierarchical cluster analysis on a data set using CSMS which based on the MATLAB Statistics Toolbox functions the following procedure should be performed [19]. As the result of hierarchical clustering procedure based on Euclidian Distance for all 9 elements presented in Table I the binary tree (*dendrogram*) is shown in Fig. 7.

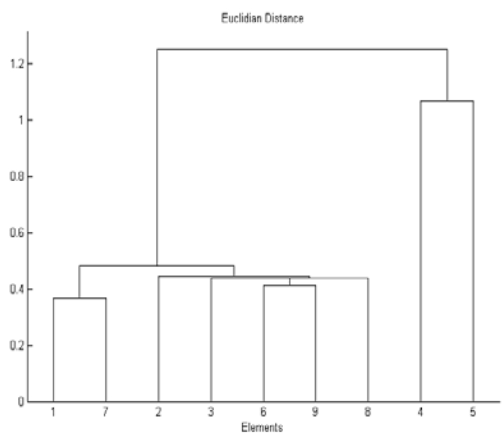


Fig. 7 Dendrogram for elements (*Euclidian Distance*)

Dendrogram can be created based on different distance measures. Next plot shows the results of dendrogram building for *Minkowski Distance* (p=3) metrics available under MATLAB toolbox.

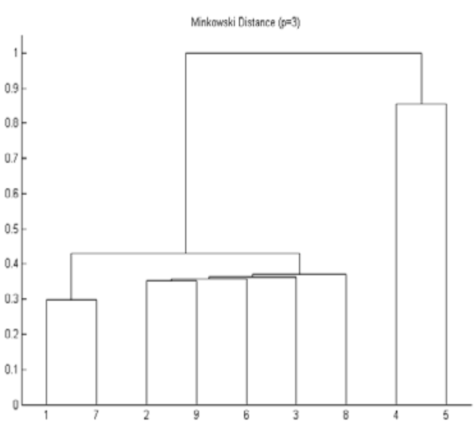


Fig. 8 Dendrogram for Elements (*Minkowski Distance* (p=3))

As can be observable from the above presented figures, there are at least two separate groups (clusters) of elements. Namely the first cluster includes the elements 4 − *Students research activities* and 5 − *Additional services* and the second cluster can be created from the rest of elements. There is another possibility for elements separation into three clusters, where elements 4 and 5 is the first cluster, the 1 − *Program design* and 7 − *Level of received theoretical knowledge* elements is the second one and the rest of elements organized the third group (see Fig. 7, and 8). As the conclusion the further investigation of two clusters of elements can be done. The first cluster including elements 4 − *Students research activities* and 5 − *Additional services* probably have been appeared due to the fact that these two elements are very common in nature for the students of Darmstadt University of Applied Science, as it is traditionally very close to the industry unlike the classical Universities that orient on the theoretical science much more. It is not surprising that research activities can be interpreted by these students as an additional service. Cluster including elements 1 − *Program design* and 7 − *Level of received theoretical knowledge* probably have appeared due to the level of received knowledge is corresponds to the level of the program design.

As can be observable from the cluster analyses for constructs presented in Table 1, there are at least two separate groups (clusters) of constructs. Namely the first cluster includes the construct 1 − (*The factor of high priority − The factor of low priority*) and the rest of constructs. Large distance from the construct 1 and all others construct allows to make the conclusions that this construct probably expressed the personal attitude to all elements using for *affective value of higher educational service* estimations in generally, rather than estimations of service at some particular educational institution.

E. Factor Analyses

Factor analysis is a statistical approaches used to uncover relationships among many variables. One of such approach is *principal component analysis* (PCA). Given the data table of two or more variables, PCA generates a new table with the same number of variables, called the *principal components*. Each principal component is a linear representation of the entire original data set. The coefficients of the principal components are calculated so that the first principal component contains the maximum variance, which can be regarded as the variable with the maximum information. The second principal component is calculated to have the second most variance and it is uncorrelated with the first principal component. Further principal components, if any, exhibit decreasing variance and are uncorrelated with all other principal components. The number of principal components is less than or equal to the number of original variables. *PCA* was invented in 1901 by *Karl Pearson* [27], and depending on the field of application, it is also named the discrete *Karhunen–Loève transform* (*KLT*), the *Hotelling transform* or *proper orthogonal decomposition* (*POD*).

The *PCA* consists on several steps generating the *eigenvectors* and *eigenvalues* of the covariance matrix. According to the definition the *eigenvector* of a square matrix are the non-zero vectors that, after being multiplied by the matrix remain proportional to the original vector or become zero. For each eigenvector, the corresponding eigenvalue is the factor by which the eigenvector changes when multiplied by the matrix. The eigenvectors and eigenvalues are sometimes also called *characteristic vectors* and *characteristic values*. One of very important property of the eigenvectors is they are perpendicular to each other and that is why can provide us with information about the patterns in the data. The first eigenvector goes through the middle of the data (points in *n*-dimensional space) like drawing a line of best fit. The second eigenvector also goes through the middle of the data but it is perpendicular to the previous one. According to this process of taking the eigenvectors of the covariance matrix the orthogonal lines in *m*-dimensional space that characterize the data are extracted. The eigenvalues for all eigenvectors are quite different values. It turns out that the eigenvector with the highest eigenvalue is the principal component of the data set.

The final *PCA* step is to order eigenvectors by eigenvalue, highest to lowest. This gives the components in order of significance. At this point the decision to ignore some of the components of lesser significance can be obtained. Due to this decision some information will be lose, but if the eigenvalue are small don't lose much. If some component will be leaving, the final data set will have fewer dimensions than the original.

To find principle components the function *princomp* have been used (MATLAB Stats Toolbox) [19]. The first values *pcs* of the output of the *princomp* contain the principle components as the linear combinations of the data presented in Table I. Five components are shown in Table III.

Table III. Principle component vectors

*pcs*1	*pcs*2	*pcs*3	*pcs*4	*pcs*5
-0.3094	0.3771	0.5045	-0.2891	0.5562
-0.3715	0.0395	0.0345	-0.0554	-0.3882
-0.3477	-0.2045	-0.3957	-0.1789	-0.1073
-0.1053	-0.8129	0.4680	-0.2725	-0.0618
-0.3608	-0.1147	0.0827	0.8067	0.0441
-0.3668	0.1260	0.1546	0.0540	-0.1538
-0.3551	0.2186	0.2515	-0.0138	-0.3722
-0.3454	-0.2607	-0.3152	0.0857	0.5981
-0.3524	0.0937	-0.4188	-0.3819	-0.0512

The largest contribution in the first principle component is made by the second (-0.3715) and sixths (-0.3668) elements, namely *Program design* and *Study's organization*, from the data under investigations. The first principle component is constructed as the linear combination of all elements practically with the same contributions except the fourths element *Students research activities* (-0.1053).

The next *pareto* plots, presented in Fig. 9, shows percent variability by each principle component for the case of variables represented by the Elements and Constructs for original data set (Table I).

As can be seen from above plots in both cases there are three principle components and the first one explains more the 80% of the total variability.

The last output of the function *princomp* is a statistical measure *t*2 of the multivariate distance of each element from the center of the data set. It allows finding the most extreme points (elements) in the data set. In our case there is no extreme element due to the multivariate distance of each element from the data set is comparable the same.

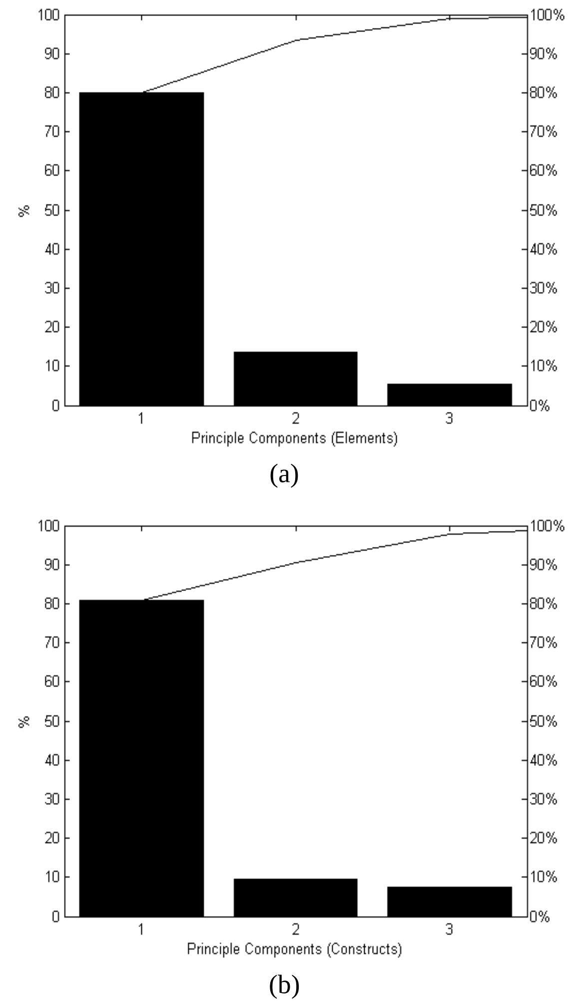


Fig. 9 Pareto plot of principle components for: elements (a); constructs (b)

F. Regression Analyses

Regression analysis is one of the most commonly used statistical techniques in social and behavioral sciences, as well as in others sciences. Its main objective is to explore the relationship between a dependent variable and one or more independent variables, which are also called predictor or explanatory variables. Linear regression explores relationships that can be readily described by straight lines or their generalization to many dimensions. Mathematically, the regression model is represented by the following equation:

$$Y = X\beta + \varepsilon, \qquad (2)$$

where Y is an m-by-1 vector of dependent variable; X is the m-by-n matrix determined by the independent variables; β is a n-by-1 vector of parameters; ε is an m-by-1 vector of random disturbances, independent of each other and usually having a normal distribution. There are a number of functions for fitting various types of linear models supported by CSMS. The one-way ANOVA is used to find out whether data from several groups have a common mean. That is, to determine whether the groups are actually different in the measured characteristic. One-way ANOVA is a simple special case of linear model

$$Y_{ij} = \mu_j + \varepsilon_{ij}, \tag{3}$$

where Y_{ij} is a matrix of observations in which each column represents a different group; μ_j is a matrix whose columns are the group means (μ_j is the same for all i); ε_{ij} is a matrix of random disturbances. This model posits that the columns of Y are a constant (μ_j) plus a random disturbance (ε_{ij}).

The data set under investigation is presented in Table I. The n=9 columns of the Table I represent parameters (elements of higher educational service). The m=7 rows are estimates (constructs) of elements which have the implication on the entire level of the educational service quality. The question is do some elements have higher influence on education service quality than others? Resulting data obtained by ANOVA contain the sum of squares (*SS*), degree of freedom (*df*), *F* statistic, and *Prob*-value, as have been shown in Table IV.

Table IV. One-way ANOVA results

Source of Variation	Sums of Squares (*SS*)	*df*	Mean Square	*F*	*Prob>F*
Columns	4.9472	8	0.6184	5,6407	3.2918e-005
Error	5.9201	54	0.1096		
Total	10.8673	62			

Actually the ANOVA is comparing the means of nine columns of data in the matrix shown in Table I, where each column represents an independent observation (Element). Generally if *Prob* is near zero, it casts doubt on the null hypothesis and suggests that at least one sample (element) mean is significantly different than the other sample means. It is exactly our case due to the element 5 (*Additional services*) has the mean differ than the other elements as can be seen on Box plot for Elements shown in Fig. 4(a). Common significance levels are 0.05 or 0.01. In this case the *Prob* value is 3.2918e-005, what is sufficiently lower compare with the indicated significance levels. This is a strong indication that element's estimations are not the same. The low *Prob* value indicates that there are differences between the elements means. This fact allows making the conclusion that the 9 elements presented in Table I have different contribution into the estimation of the *affective value of higher educational service* at the Computer Science Department of the Darmstadt University.

Sometimes it is important to determine specifically which pairs of means are significantly different. For this purpose a series of *t* tests (paired *t* test) for each pair of means should be performed. In a *t* test a *t* statistic is computed and compared it to a critical value. The critical value is chosen so that when the means are really the same, the probability that the *t* statistic will exceed the critical value is small, equals to 5%. When the means are different, the probability that the statistic will exceed the critical value is larger.

In offered example there are nine means, so there are 36 pairs of means to compare. Based on the MATLAB Statistics Toolbox the procedure known as *multiple comparison procedures* can be performed (MATLAB Stats Toolbox) [19]. The first output from MATLAB *multcompare* procedure has one row for each pair of groups, with estimates of the difference in group means and confidence interval for that group. In our example the row number 27 out of all 36 rows has the values shown below.

5.0000 6.0000 0.3411 0.9129 1.4846

This data indicating that the mean of elements 5 minus mean of element 6 is estimated as -0.9129 and a 95% confidence interval for this difference is [0.3411, 1.4846]. In this example the difference is significant at the 0.05 level due to confidence interval does not contain 0.0 value. Within the same our example the pair of the 8 and 9 elements has the values.

8.0000 9.0000 -0.4704 0.1014 0.6732

This indicates that the means of 8 and 9 elements are not different.

It is possible to analyze the difference between elements means by using the graph produces by *multcompare* procedure. The examples of the analysis based on this graph are shown below (Fig. 10) for the case of Elements shown in Table I.

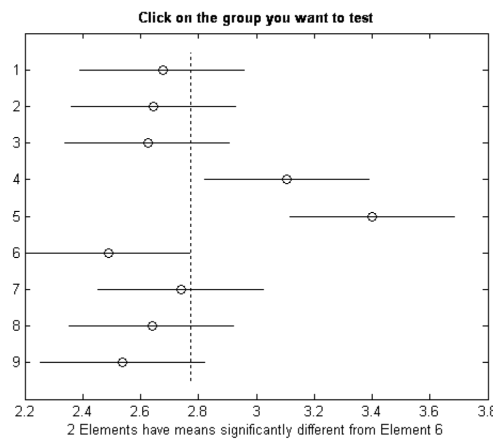


Fig. 10 the resulting graph for *multcompare* procedure for Elements

This graph indicates that there are two elements, namely 4 − *Students research activities* and 5 − *Additional services* with means significantly different from mean of element the rest of elements. The second graph (Fig. 11) presents the same result for constructs.

The last graph strongly indicates that the first construct − (*The factor of high priority − The factor of low priority*) has significantly different mean compare with the others constructs. This result can be interpreted as the first construct is not appropriate for quality of higher educational service assessment.

VI. Discussion

Assessment of service quality requires a robust instrument capable of measuring various aspects of service delivered by an organization. Service quality measurement procedure used not only for facilitating of system design and implementation of quality planning but also gives guidelines for improving some quality elements to fulfill the customers expectations. The proposed paper deals with the development CSMS methodology and tools for service quality of higher education institution assessment. As have been pointed out in this research in educational industry there are the lack of physical evidence of service and persistence of intangibility what makes the perceptions of service quality a complex composition. Moreover due to the different types of stakeholder with different background and varied behavioral patterns the service quality analyses is a difficult issue.

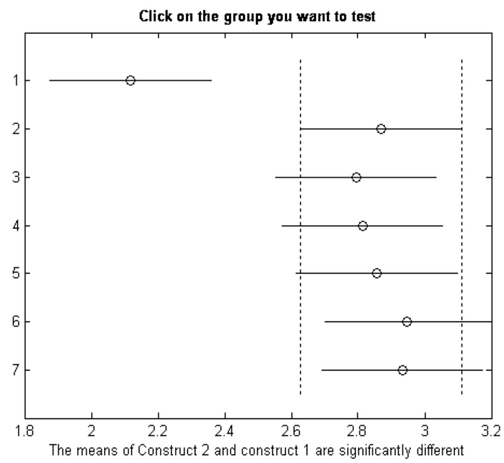


Fig. 11 the resulting graph for *multcompare* procedure for Constructs

For the purposes of experimental validation of proposed CSMS methodology an experimental investigations have been carried out. To show the proposed methodology in practice by applying the CSMS tools as the topic for investigation the *affective value of the higher educational service* has been used. As the stakeholder for this experimental investigation the Bachelor (except the first year students) and Master students of the Informatics Department of the Darmstadt University of Applied Science have been chosen.

To perform data analysis based on CSMS and input data set presented as the Grid the following procedure implemented on MATLAB Statistics Toolbox functions have been carried out. First of all the data reorganization, presentation, pilot testing and simple data analyses based on *descriptive statistics* have been made. More complicated analyses like *cluster analyses*, *factor analyses* and *regression analyses* were conducted. As the result of data analyses the following statement can be formulated.

The methodology and instrument called as CSMS for measurement of service quality at higher educational institutions has been proposed and used for service quality assessment. Seven constructs under nine elements constitute relevant variable for the proposed measurement instrument.

Due to restricted statistical data consisting from one respondent's domain survey only at this point the following findings can be formulated with respect to one particular institution providing its educational service can be done. The survey data can be regarded as the educational service evaluation at this particular department of the Darmstadt University.

The first obvious finding concerning the service quality at this higher institution can be formulated as the higher levels *Students research activities* (Element 4) and *Additional services* (Element 5) proposed to the student at the department of Informatics. The rest of service qualities elements have been estimated at the approximately the same level.

As the second finding the very low rate equals to 2.1189 of the construct 1 (*The factor of high priority − The factor of low priority*) compare to the average rate. This result can be interpreted as the all elements describing the service quality are the factor of low priority rather than high priority to all respondents. At the same time the construct 6 (*Ideal − Unacceptable*) has the highest average value 2.9456. These results can be interpreted as the all service quality elements, generally, are the factor of low priority to the student of this department. At same time, particularly to this department *quality of the educational services offered by university* is ideal rather than unacceptable.

As can be observable from the above presented cluster analyses, there are at least two separate groups (clusters) of elements. Namely the first cluster includes the elements 4 − *Students research activities* and 5 − *Additional services* and the second cluster can be created from the rest of elements. This cluster, probably have been appeared due to the fact that these two elements are very common in nature for the students of Darmstadt University of Applied Science, as it is traditionally very close to the industry unlike the classical Universities that orient more on the theoretical science. It is not surprising that research activities can be interpreted by these students as additional service.

There is another possibility for elements separation into three clusters, where elements 4 and 5 is the first cluster, the 1 − *Program design* and 7 − *Level of received theoretical knowledge* elements is the second one and the rest of elements organized the third group.

As can be observable from the above presented results, there are at least two separate groups of constructs. Namely the first cluster includes the construct 1 − (*The factor of high priority − The factor of low priority*) and the rest of constructs. Sufficient large distance from the construct 1 and all others construct allows to make the conclusions that this construct probably expressed the personal attitude to all elements using for *affective value of higher educational service* estimations in generally, rather than estimations of service at some particular educational institution. More precise analyses of the results concerning the constructs allow to emphasize strong correlation between construct 4 − (*Good organised − Bad organised*) and 5 − (*Excel the expectations − Doesn't match the expectations*). Both constructs are within the same cluster which can be extended to three constructs including construct 6 − (*Ideal − Unacceptable*). It is the matter for further investigation to select representative set of constructs.

VII. Conclusions and Scope for Further Research

Survey at the Informatics Department of the Darmstadt University of Applied Science has been carried out with statistically significant response rate but it is not enough to generalize the results. The experimental investigations of CSMS have been carried out based on only one group of stakeholder. Other domains of stakeholders may evaluate the same service quality differently. The study can be extended to a large sample with emphasis on weights of each *Construct* of the resulting Grid and relative importance of *Elements*. Benchmarking of higher educational institutions can be extended to not only technical Universities what will lead to redesign the CSMS methodology and corresponding tools for evaluating educational services.

As the any research concerning the issue of quality in service is required to be extended considering the limitation of the study. Some of these where further research is required to be carried out to tackle the limitations of CSMS. The following further research directions can be proposed. A large number of samples (surveys) from different stakeholder domains may be collected to have better understanding of the elements and corresponding constructs to represent the service quality more adequate and more precisely. Applying the same CSMS methodologies effectively in other sectors such as health care, tourism, hotels and restaurants, banks and finical institutions, transportation facilities, repair and maintenance shops and information service may carry out extension of this research. Further steps of data analyzing to get more precise picture of the service quality at higher education institutions the nowadays technologies of data mining should be applied.

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Hanna V. Shauchenka received her M. Sc. degree in Engineering and Economics from *Belarusian State University of Informatics and Radioelectronics* (BSUIR), Minsk, Belarus in 2001. She received M.Sc. (Master of Science) in New Media Marketing from *Institute of Applied Informatics* University of Applied Sciences Darmstadt, Germany in 2007. She is currently a Ph.D. student in the *Centre for Information Security and Network Research* University of Plymouth, UK.

Her research interests include nowadays marketing methods and technologies, higher education service quality, Personal Construct Theory, and Kansei engineering.