A fuzzy ServQual based method for reliable measurements of education quality in Italian higher education area

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ABSTRACT

In recent years, the attention that the European Community has focused on the education sector has produced a new university commitment addressed to quality aspects for all education related services. In fact, a quality oriented service requires excellence in the design and planning of service activities, as well as during its delivering and also for the adopted service performance evaluation method. However, considering that service performance evaluations are deeply based on stakeholders’ judgments, they can be characterized by possible uncertainties related to incompleteness for partial ignorance, imprecision for subjectivity and even vagueness. Therefore, under these conditions, unreliable results can be obtained by widely considered service analysis methods. In the present paper, a method based on a recent extension of the ServQual model and that uses in combined manner the Fuzzy Set Theory and the Analytic Hierarchy Process method is proposed to effectively handle uncertainty in service performance analyses. In particular, the Fuzzy Set Theory is considered to deal with such uncertainty, whereas the AHP method is adopted as tool to estimate the importance weights of the strategic service attributes. Subsequently, the strategic analysis of the service value tree related to the Management Engineering program at the University of Palermo (Italy) is performed by using the proposed method. The performed service analysis allows the most influencing service performance factors to be captured and commented upon. Finally, the obtained results show that the professors’ perception of service quality meaningfully influences the overall service performance level.

1. Introduction

Quality is a term that is commonly considered to indicate a high level of customers’ satisfaction with refers to factors that characterize a considered product or service. In particular, considering education services, the related quality concept arising from aspects and features of teaching, research and related activities, with refer to their capability to satisfy the explicitly set out objectives. Considering the Italian higher education area, the latter are defined at European level by the European Union, at national level by MIUR, i.e. the Italian Ministry of Education, University and Scientific Research, and at local level declared by each University in its services agreement and/or during the promotional and guidance activities. Therefore, a “quality University” is that one that guarantees to all stakeholders, primarily students, certainty about the capacity to obtain suitable results with respect to stated and promised objectives. For these reasons, it is necessary that quality of education services is continuously monitored and controlled by suitable monitoring procedures. However, the execution of reliable service performance evaluations can be a difficult problem to handle since, services are characterized by some significant aspects of complexity related to their peculiar characteristics. More in details, services are generally considered to be:

- intangible i.e. immaterial;
- inseparable, i.e. services are produced, delivered and consumed simultaneously;
- heterogeneous, i.e. a service provided to one customer is not exactly the same as that provided to the next customer;
- perishable, i.e. services cannot be produced in advance and stored for later delivery.
- sharing product, i.e. customers of a service are also service co-producers, since the achieved service performance level is directly influenced by their presence and interaction during service delivering (Glynn & Barnes, 1995)

In particular, since immaterial, services are not controllable and thus also measurable in their own technical and commercial specifications in quantitative terms by classical measuring techniques and conventional measure units. Implications with regard to the latter aspects involve the need for design suitable methodologies for reliable service performance evaluations, and to identify
“atypical” measure units, if compared with those used in the manufacturing field, to highlight the achieved service performance level.

Service performance is an “unphysical quantity” that represents a latent trait of the service. More in detail, it cannot directly measured, i.e. its evaluation is done considering measurable and suitable service characteristics which performance levels provide an indirect measure of service performance (De Battisti, Nicolini, & Salini, 2005; De Battisti, Nicolini, & Salini, 2010).

For example, the evaluation of customer satisfaction represents an indirect measure of the service performance level, since it is performed with relation to proper service aspects whose performance levels, quantified by means of the so called “manifest variables”, are intended as “latent manifestations” of service performance. The relationship between manifest variables and latent manifestations can be formalized by means of specific conceptual models (Ding, 2006). In the literature, several conceptual models have been formulated and among these the main classical ones are listed below:

- **ServQual** (Parasuraman, Zeithaml, & Berry, 1985), whose theoretical principle is the discrepancy or gap theory: the difference between service perceptions and expectations, weighted by the importance assigned to each service dimension, represents a manifest variable of the service performance;
- **Two-Way** (Schvanefeldt, Enkawa, & Miyakawa, 1991), based on the consideration that the latent factors are of “objective” (quality attributes) and “subjective” (satisfaction levels) kind;
- **SERVPERF** (Cronin & Taylor, 1992), in which only service perceptions represent manifest variables of the service performance;
- **Normed Quality** (Teas, 1993), whose theoretical principle assumes that a distinction between ideal and feasible expectations has to be done in order to evaluate the service performance;
- **Qualitometro** (Franceschini & Rossetto, 1998), according to which the perceptions and expectations measures have to be performed at different times.

In addition to those previously considered, other conceptual models have been proposed focused on operations aspects related to service delivering and on reliability service, i.e. its capacity to deliver what the customer wants (Ghobadian, Simon Speller, & Jones, 1994). However, to date the ServQual model is one of the most established conceptual models for determining customer satisfaction in services (Lupo, 2013a). Over the time, ServQual model has been used extensively in the service literature; several recent applications of the ServQual model in different service fields are described in: Chen, Chang, and Lai (2009), Large and König (2009), Liu and Lai (2009), Lin (2010), Büyüközkân, Ciftçi and Guler, (2011a) and Lupo (2013b).

The SERVQUAL model in its original formulation consists of 22 statements measuring 5 critical to quality dimensions of service quality namely tangibility, reliability, responsiveness, assurance, and empathy. The required data for the assessment of service quality through the SERVQUAL model are quantitative in nature which can be expressed in terms of exact numbers by linguistic-numerical evaluation scales. Moreover, in the service quality concept seven major Gaps are considered by the Authors, as shown in Fig. 1.

According to a recent development of the ServQual model (Curry, 1999; Luk & Layton, 2002), the three main Gaps, which are more associated with customer satisfaction, are: the Gap 1, the Gap 5 and the Gap 6; since they have a direct relationship with customers. More in detail, such Gaps measure the discrepancy between:

- customers’ expectations and management’s perceptions of service quality, for the Gap 1;
- customers’ expectations and employees’ perceptions of service quality, for the Gap 6.
- customers’ expectations and their perceptions, for the Gap 5;
- and they are evaluated with relation to critical to quality service criteria and sub-criteria.

By considering the cognitive sphere of the stakeholder, such service Gaps values can be obtained by the algebraic comparison between (Parasuraman et al., 1985):

- management’s perceptions of the customers’ expectations ($P_M$) and the customers’ expectations ($E$): $Gap 1 = P_M - E$;
- employees’ perceptions of customers’ expectations ($P_E$) and the customers’ expectations ($E$): $Gap 6 = P_E - E$;
- customers’ perceptions ($P$) and the their expectations ($E$): $Gap 5 = P - E$.

Therefore, values assumed by the Gap 1 can be considered as a direct result of the lack of a marketing research orientation and inadequate upward communication, whereas Gap 6 values represent the result of the differences in the understanding of customer expectations by front-line service providers. Finally, Gap 5 values reflect the result of the influences exerted from the customer side and the shortfalls (Gaps) on the part of the service provider and therefore such values can be considered as direct indicators of the customer satisfaction degree. Therefore, customers’ dissatisfaction is collected for the service aspects in which a negative value of the Gap 5 is obtained.

Given the financial and resource constraints under which academic organizations have to operate, as well as, the increased competition among academic organizations regarding student recruitment, understanding exactly what students expect is the most crucial step in defining and delivering a high-quality education service (Chou, Liu, Huang, Yih, & Han, 2011). In particular, it is fundamental that students’ expectations and perceptions are properly measured and correctly understood and that, from the perspective of students, the critical to quality service criteria and sub-criteria are properly identified. In fact, the latter quantities should be taken into the design process to effectively support the decision maker in identifying suitable “Gaps oriented” service improvement solutions (Zeithaml, Berry, & Parasuraman, 1996; Zeithaml, Parasuraman, & Berry, 1990).

However, many critical factors are associated to the employment of ServQual model. Some difficulties are related to the use of linguistic-evaluation scales: the well-documented tendency of respondents to select central linguistic categories to express judgments, influence of the linguistic categories number in the evaluation process, the form and the type of the adopted linguistic variables and, finally, the transformation from cardinal to metric data. Other critical factors are related to ambiguity of expectations evaluation (Babakus & Boller, 1992) and the difficulties arising from the use of differential psychometric score (Brown, Churchill, & Peter, 1993; Peter, Brown, & Churchill, 1993).

In the light of the previous considerations, in the present paper the ServQual discrepancy paradigm is considered to evaluate the student satisfaction (SS) level. However, to estimate service expectations’ levels required by the ServQual model, the Analytic Hierarchich Process (AHP) method is herein considered (Saaty, 1980). AHP is a multi-criteria decision making (MCDM) method that helps the decision-maker facing a complex problem with multiple conflicting and subjective criteria (e.g., location or investment selection, projects ranking, and so forth). AHP is based on three principles that determine the procedure steps of the method: (Forman & Gass, 2001): the principle of problem hierarchical decomposition; the principle of comparison judgments and the principle of the synthesis, considered to aggregate partial results in order to obtain
the global result. Thus, the method consists of the following phases: identification of the general objective of the analysis and hierarchical decomposition of the problem; construction of pairwise comparisons matrices; evaluation of local importance weights and finally, determination of the global importance weights (Saaty, 2008). AHP presents several advantages as: full differentiation among importance ratings, seeking consistency in judgments by means of the inconsistency ratio IR, easiness to use, etc. It also allows to structure complex problems in the form of a hierarchy or a set of integrated levels and can be combined with operations research techniques to handle more difficult problems. Several papers have compiled the AHP success stories in very different fields. For example, in the Project management field, AHP has been suggested for assessment and allocation of human resources. Dweiri & Kablan, 2006 propose a fuzzy decision making system (FDMS) for the evaluation of project management internal efficiency by considering as evaluation criteria the project cost, the project time and project quality. In the second level service quality criteria, i.e. service main characteristics that are deeply related with SS are reported. Subsequently, in the third level service sub-criteria for each service criterion are identified. Finally, in the fourth level the service items for each service sub-criterion are considered. These satisfaction dimensions should assure a consistent family of criteria, with the following properties: (1) monotonicity, (2) exhaustiveness, and (3) non-redundancy (Roy & Bouyssou, 1993). Keeney and Raiffa (1976) proposed also that the set of criteria and the formulated value hierarchy should be operational, decomposable and minimal. Fig. 2 shows a general hierarchical quality structure composed by w quality criteria, C1, C2, . . . , Cw, each one composed by C1, C2, . . . , Cn service sub-criteria. In particular, in Fig. 3 the generic service sub-criteria j of the service criterion i is denoted with the term SCij.

However, the AHP method in its original deterministic formulation can be unreliable in handling ambiguity of the concepts associated with the use of the human knowledge. In particular, since the human knowledge to express judgments and preferences are

Fig. 1. ServQual conceptual model (Parasuraman et al., 1985).
very often incomplete, inconsistent and even vague or imprecise, as consequence, individuals can not be able to express, with suitable reliability level, their opinion by means of an exact numerical value related to a linguistic variable, as required in its original formulation by AHP. Such a situation can introduce uncertainty in service performance analyses (Hu, Lee, & Yen, 2010). The choice of the technique to be used to minimize uncertainty effects is usually based on the type and nature of uncertainty. In particular, Ferdous, Klan, Sadiq, Amyotte, and Veitch (2012) pointed out uncertainty categories and the related approaches to be adopted to deal with them. Table 1 summarizes such approaches.

Uncertainty related to service performance analyses is of epistemic type: it is generally ascribed to the coexistence of three relevant aspects in stakeholders’ judgments: vagueness, characteristic that indicates the lack or incomplete knowledge with relation to an object or an information; imprecision, characteristic that is referred to the combination of two or more information components and, finally, subjectivity, characteristic that is referred to the knowledge level with respect to the relationship between the reference universe and statements related to it (Cercureu, Galante, & La Fata, 2012). Therefore, in the present paper the Fuzzy Set Theory (FST) (Zadeh, 1965) is considered to deal with such uncertainty type.

The innovative contributions that came from the use of the FST derive from its capability of representation and processing of information affected by some imperfection typically due to the use of the natural language (Zimmermann, 1985). In particular, the FST allows the mathematical representation of uncertain knowledge and provide formalized tools for dealing with intrinsic imprecision of real life problems: it is particularly useful in the quantification of linguistic categories and related handling approaches. In this way, the subjective evaluation data can be more adequately expressed by linguistic variables (Liang & Wang, 1991; Zadeh, 1975). The FST has been applied in many fields of the management science (Büyüközközkan & Gici, 2011; Büyüközközkan, Feyzioglu, & Gici, 2011b; Liu, Du, & Tsai, 2009), but it is still quietly used in the field of the service quality assessment (Chou et al., 2011; Hu et al., 2010; Tseng, 2009a; Tseng, 2009b).

In the light of the previous considerations, the purpose of the present work is propose a reliable method based on a recent development of the ServQual model to evaluate the education service main Gaps values with the aim to overcome the previously described limitations. In particular, an efficient combined procedure based on integration between the AHP method and the FST is here-in proposed to effectively handle epistemic uncertainty in service performance analyses. Subsequently, the strategic analysis of education services related to the Management Engineering program at the University of Palermo (Italy) is performed by using the proposed method.

The remainder of the present paper is organized as follows: in Section 2 a brief literature review on recent studies about measurements of education service quality and SS is given; in Section 3, the theoretical issues of the proposed composite method are described; in Section 4, the Italian higher education area is analysed; in Section 5 the strategic service value tree of the Management Engineering program at the University of Palermo is described and analysed and the possible implications for services improvements are given and, finally, the conclusions, with a summary and directions for future researches, close the work.

### 2. Literature review

In recent years, many researchers have turned their attention to the education sector facing issues related to the improvement of education services. For example, Koch and Fisher (1998) considered the possibility of applying Total Quality Management (TQM) in higher education sector. The Authors highlight how, despite TQM is only marginally applicable in contexts characterized by rapid change, there are some critical problems in universities for which, TQM can be very useful. Kanji and Tambi (1999) applied

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**Table 1**

<table>
<thead>
<tr>
<th>Type</th>
<th>Nature</th>
<th>Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aleatory uncertainty</td>
<td>Irreducible, objective, random, stochastic,</td>
<td>Probably theory and evidence theory</td>
</tr>
<tr>
<td>Epistemic uncertainty</td>
<td>Ambiguous, ignorance, incomplete, inconsistent, imprecise, subjective, vague</td>
<td>Possibility theory, Fuzzy Set Theory, and evidence theory</td>
</tr>
</tbody>
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**Fig. 2.** Service value tree.
the principles of TQM to improve student performance, education services and stakeholders satisfaction in UK higher education institutions. Mergen, Grant, and Widrick (2000) proposed a model of quality management in higher education institutions based on three components: quality of design, quality of conformance and quality of performance. The developed model is applied to Rochester Institute of Technology’s College of Business and provides a framework to identify research, teaching and operational improvement opportunities. Widrick, Mergen, and Grant (2002) measured the three education service quality dimensions: quality of design, quality of conformance and quality of performance, in higher education. In particular, the authors discussed a set of measurement parameters to be used in evaluating the quality of research and curriculum development and the tools/techniques necessary for evaluating them.

Nowadays, universities worldwide are focussing their attention on SS as crucial aspects to face competitive pressures from different sides. First of all, as pointed out by Helgesen and Nesset (2007), SS is related to recruitment, retention and academic success; as a consequence, universitie s are focussing their attention on creation of more supportive and attractive learning environments (Venesaa r, Ling, & Voolaid, 2011). Moreover, universities are currently characterized by the so-called “rankings war” that is meaningfully influenced by the achieved SS level (Letcher & Neves, 2010). Furthermore, the SS measures can be used as monitoring tools to on-going control the service quality level and to compare the achieved performance service level over time and/or across space (De Borger, Kerstens, & Costa, 2002).

In the literature, there is a variety of methods regarding the SS measures. Such methods can be mainly classified as stated importance methods, in which students are asked to rate each service aspect on a Likert-type importance scale, or derived importance methods, in which the importance measure of each service aspect is statistically derived considering relationships among individual sub-criteria with overall satisfaction (Ory, 2000). Derived importance methods are widely considered in the recent decade since, although stated importance methods are intuitive and simple to use, they require a significant increase in the length of the survey and can sometimes yield insufficient differentiation among mean importance ratings. Several recent applications of derived importance methods based on SS survey are described in: Sultan and Wong (2013), Ard, Hidayatri, and Zaghloel (2012) and Hosseini (2012). From stated preference surveys, the most recent applications are described in: Kuzmanovic, Savic, Popoviv, and Martic (2012). Recently, many authors focus their attention also on the heterogeneity of students’ perceptions and expectations of different aspects of teaching services (Kuzmanovic, Savic, Popoviv, & Martic, 2012). In particular, such heterogeneity, mainly related to certain aspects of the service, the different students attitudes have toward the use of education service, the social and economic characteristics of students and the different ways of viewing aspects of the service, can represent a problem for many techniques that intend to measure service quality (Eboli & Mazzulla, 2011). In addition, as before said, judgments provided by students can be affected by possible uncertainties related to incompleteness for partial ignorance, imprecision for subjectivity and even vagueness and, as consequence, the obtained results by these methods can be unreliable. For such reasons, in order to overcome the previously described limitations, the method hereafter described is developed.

3. Design and methodological approach

In the next section a brief overview about FST and its theoretical principles useful for the aim of the present work are given. Subsequently, the considered methodological approach for the measurement of academic stakeholders’ importance weights and perception levels of service criteria and sub-criteria are described.

3.1. Fuzzy Set Theory and Linguistic-Fuzzy Scales

In FST, the concept of convexity of a set differs from that applied in the classical set theory: a fuzzy set is said convex if and only if the degree of membership of an element between two elements is not less than the minimum value among the membership degrees of the two elements. Then, a fuzzy set defined in R and such that:

1. $\exists x_0: \mu(x_0) = 1$
2. the membership function $\mu(x)$ is continue.

The latter properties are necessary to properly represent the considered conceptions. In particular, the general principle of the fuzzy assessment approach is that a linguistic variable can be seen as variable whose values are words or structured combinations of words whose meaning is defined by semantic rules. In particular, a linguistic variable is characterized by five elements $\{X, T(X), U, G, M\}$, where: $X$ is the name of the variable; $T(X)$ is the set of linguistic categories of the variable $U$. The universe of discourse, $G$ is a syntactic rule that generates the terms in $T(X)$ and $M$ a semantic rule that associates to each linguistic category $x$ of $T(X)$ its meaning $M(x)$. Such semantic rule may be defined by a fuzzy number $M(x)$ in $U$. Thus, the meaning of $M(x)$ of a linguistic category $x$ is defined by a membership function $\mu_x : U \rightarrow [0,1]$ that associates to each $u$ of $U$ its compatibility with $x$ (Klir & Yuan, 1999).

A positive triangular fuzzy number (TFN), denoted as $A = (x_L, x_M, x_U)$ (see Fig. 3), where $x_L \leq x_M \leq x_U$, has the following triangular-type membership function:

$$
\mu_A(x) = \begin{cases} 
\frac{x - x_L}{x_M - x_L} & \text{for } x_L \leq x \leq x_M \\
\frac{x - x_M}{x_U - x_M} & \text{for } x_M \leq x \leq x_U \\
0 & \text{otherwise}
\end{cases}
$$

Alternatively, by defining the interval of confidence level $\alpha (\alpha$-cut), a TFN can be characterized as:

$$
\forall x \in [0,1] \exists \alpha \in [0,1] : A_{\alpha} = [a^L_{\alpha}, a^U_{\alpha}] = [(x_M - x_L)x + x_L, (x_U - x_M)x + x_U]
$$

Service performance analyses often articulate stakeholders’ knowledge/judgments in term of linguistic variables; the use of TFNs as a way to compare fuzzy judgments has been proposed by van Laarhoven and Pedrycz (1983) and it is largely adopted in more recent works (Chang 1996; Cheng 1996; Kwong & Bai, 2002). In particular, Ayyub and Klir (2006) provided a chart to define the lower and upper boundary for such linguistic variables based on experts’ assessment. Considering the most likely value as an average of these two boundaries, TFNs can be used to represent such linguistic variables. The fuzzy boundaries of a TFN may also be defined by means of the Fuzzy Delphi method that is a typical multi-experts

![Fig. 3. Positive triangular fuzzy number.](image-url)
procedure for combining views and opinions (Kauffman & Gupta, 1988).

Finally, the FST allows the extension of arithmetic operations from crisp numbers to fuzzy numbers. By considering the membership degree \( \mu(x) \) of a fuzzy set, some basic operations useful for the aim of the present work are given by the following expressions (Klir & Yuan, 1999):

\[
\forall x \in [0, 1], \forall a, b, a, b \in \mathbb{R}, \quad A = [a_t, a_p], \quad B = [b_t, b_p]
\]

\[
A \otimes B = [a_t + b_t, a_p + b_p]
\]

\[
\begin{align*}
A \ominus B & = [a_t - b_t, a_p - b_p] \\
A \odot B & = [a_t \times b_t, a_p \times b_p] \\
A / B & = [a_t / b_t, a_p / b_p]
\end{align*}
\]

In the present study, linguistic variables are used to represent stakeholders’ assessments and TFNs are considered for their evaluations. The methodological approach is described as follow.

### 3.2. Measurement of stakeholders’ expectations

As before said, in the present paper a fuzzy extensions of the AHP method (FAHP) is considered to effectively handle uncertainty related to the measurement of stakeholders’ judgments. In the literature, FAHP has been widely adopted whenever individuals cannot use an exact numerical value to express their opinion about a situation and a linguistic variable is used to represent that specific numerical value. Often, a proper linguistic variable is created to explain the ambiguity and vagueness associated with the domain of the problem. Thus, the concept of the linguistic expression can be quantified by fuzzy numbers using a proper membership function. Several recent applications of the FAHP approach in different fields are described in: Cebeci (2009), Celik, Er, and Ozok (2009), Chandradhas, Batis, and Martakos (2010), Chan and Kumar (2007), Fu, Ho, Chen, Chang, and Chien (2006), Dura’n and Aguiló (2008), Huang, Chu, and Chiang (2008), Kahraman, Cebeci, and Ruan (2004) and Kang and Lee (2007). However, the FAHP approach is still scarcely used in the field of service quality assessment (Lupo, 2013a, 2013b; Büyüközkân et al., 2011a).

The four step-procedure of this approach is given as follow:

- **Step 1: Compare the performance score.**

Linguistic terms are used to indicate the relative importance of each pair of elements in the same hierarchy level (see Fig. 2) and TFNs are considered to quantify concepts of linguistic expressions. In particular, considering the service sub-criteria of the generic service criterion \( k \), with the term \( \hat{a}_{ij} \) is specified, in fuzzy form, how much the element \( i \) is preferred to the element \( j \), with relation to the service criterion \( k \). If the elements number to be compared is equal to \( C_k \) then it is necessary to express \( C_k \) pairwise comparisons. However, only \( C_k (C_k - 1)/2 \) pairwise comparisons coefficients have to be directly assessed, since it is the valid reciprocity property of comparisons, for which:

\[
\hat{a}_{ij} = 1 / \hat{a}_{ji}
\]

\( \forall i \neq j \) \hspace{1cm} (4)

Moreover,

\[
\hat{a}_{ii} = 1 \hspace{1cm} \forall i, j = 1, 2 \ldots, C_k
\]

\( \hspace{1cm} (5) \)

- **Step 2: Construct the fuzzy comparison matrix.**

The pairwise comparisons coefficients \( \hat{a}_{ij} \) are used to construct the pairwise comparison matrix \( \hat{A}_k \), which is a squared, reciprocal and positive matrix. For the aggregation of multiple customers’ judgments, a number of methods, e.g., max–min, arithmetic averaging, symmetric sum, \( t \)-norm, etc., are available. The geometric mean is the herein considered as aggregator operator since, as pointed out by Enea and Piazza (2004), it allows the respect of the AHP constraint expressed by Eq. (4). In fact, if \( \hat{p}_{ijk} \) is the fuzzy preference of the generic \( k \)th customer and \( t \) the number of judgments to be aggregated, it is possible to write:

\[
\hat{a}_{ij} = \left( \prod_{k=1}^{t} \hat{p}_{ijk} \right)^{1/t} \hspace{1cm} (6)
\]

and consequently:

\[
\hat{a}_{ij} = 1 / \hat{a}_{ji}
\]

Subsequently, also the pairwise comparison matrix for the upper hierarchy level of the service criteria is constructed.

The next step is related to the evaluation of the local importance weights of the service sub-criteria and criteria, by using the following computational procedure.

- **Step 3: Computing both the maximum fuzzy eigenvalue and the related fuzzy eigenvector of \( \hat{A}_k \).**

The maximum fuzzy eigenvalue \( \bar{\lambda}_{max} \) of \( \hat{A}_k \) is a fuzzy number solution of the following fuzzy relationship:

\[
\hat{A}_k \cdot \hat{w} = \bar{\lambda}_{max} \cdot \hat{w}
\]

in which \( \hat{w} \) is a fuzzy vector \( (C_k \times 1) \) composed by \( C_k \) fuzzy numbers \( \hat{w}_i \) of the importance weights of the \( C_k \) compared sub-criteria considered in the matrix \( \hat{A}_k \). Considering the relationships reported in (2), for the generic sub-criterion \( i \), Eq. (8) can be written as:

\[
[(\hat{a}_{ij}^{0})_{11} \cdot (\hat{w}_{11}^{0})_{11} \cdot (\hat{w}_{11}^{0})_{11} \cdot (\hat{w}_{11}^{0})_{11}] + \cdots + [(\hat{a}_{ij}^{0})_{11} \cdot (\hat{w}_{11}^{0})_{11} \cdot (\hat{w}_{11}^{0})_{11} \cdot (\hat{w}_{11}^{0})_{11}] = [\hat{W}_{11}^{0}]^{T} \cdot (\hat{a}_{ij}^{0})_{11} \cdot (\hat{W}_{11}^{0})_{11}
\]

\( \forall \alpha \in (0, 1]; \quad i, j = 1, 2, \ldots, C_k \) \hspace{1cm} (9)

In which:

\[
\hat{A}_k = [\hat{a}_{ij}], \quad \hat{w} = (\hat{w}_1, \ldots, \hat{w}_{C_k}), \quad \hat{a}_{ij}^* = [(\hat{a}_{ij})_{11}, (\hat{a}_{ij})_{11}], \quad \hat{W}_i = [(\hat{w}_{11})_{11}, (\hat{w}_{11})_{11}], \quad \bar{\lambda}_{max} = [\hat{\lambda}_{11}^*, \hat{\lambda}_{22}^*]
\]

\( \forall \alpha \in (0, 1] \) \hspace{1cm} (10)

The \( \alpha \)-cut is known to include the customer’s confidence over his/ her preferences. In the case herein considered it incorporates the stakeholders’ confidence and uncertainty over their judgments. Therefore, by considering the index of optimism \( \mu \) (Chang, 1996; Cheng & Mon, 1994; Lee, 1999), the crisp pairwise comparison coefficient of the importance between the service sub-criteria \( i \) and \( j \) at the confidence level \( \alpha \) can be written as:

\[
\hat{a}_{ij}^* = \mu \cdot (\hat{a}_{ij})_{11} + (1 - \mu) \cdot (\hat{a}_{ij})_{11}
\]

\( \forall \alpha \in (0, 1] \) \hspace{1cm} (11)

When \( \alpha \) is fixed, after setting the index of optimism \( \mu \) the following matrix (12) can be obtained and considered to estimate the local importance weights of the considered service sub-criteria.

\[
\hat{A}_k = \begin{bmatrix}
1 & \hat{a}_{12}^* & \ldots & \hat{a}_{1n}^* \\
\hat{a}_{21}^* & 1 & \ldots & \hat{a}_{2n}^* \\
\vdots & \vdots & \ddots & \vdots \\
\hat{a}_{n1}^* & \hat{a}_{n2}^* & \ldots & 1
\end{bmatrix}
\]

\( \hspace{1cm} (12) \)

Eqs. (8), (10), and (12) correspond to the fuzzification of the Lambda-Max method, initially introduced by Saaty (1980) in crisp term with the AHP method, which has been introduced by Csutora and Buckley (2001).
The last step is to determine the global importance weights of the service sub-criteria. The latter can be obtained by multiplying the local importance weights of each service sub-criterion by the importance weight or the related service criterion (Saaty, 1980).

3.3. Measurement of stakeholders’ perceptions

Crisp perception related to the service sub-criterion \( i \) of the generic service criterion \( k \), at the confidence level \( x_l \) (\( x \)-cut), \( (P_{ik})_{x_l} \), can be obtained with refer to the judgments satisfaction degree. The latter is estimated by the index of optimism \( \mu \). The larger value of the index \( \mu \) indicates the higher degree of optimism. Such index is a linear convex combination defined as:

\[
(\bar{P}_{ik})_{x_l} = \mu (P_{ik})^+_{x_l} + (1 - \mu) (P_{ik})^-_l,
\]

\( \forall x \in [0, 1] \) in which in Eq. (13) \( (P_{ik})^+_{x_l} \) and \( (P_{ik})^-_{x_l} \) are the upper and lower bounds of fuzzy aggregated judgments at the confidence level \( x_l \) (\( x \)-cut), considering as aggregator operator the arithmetic mean. While \( x \) is fixed, after setting the index of optimism \( \mu \), Eq. (13) gives the crisp value of customers’ perception for the considered sub-criterion.

4. Quality in Italian higher education area

In recent years, the European Community has addressed considerable attention to Educational institutions, since the latter play a critical role in national and global development (Wu, Chen, Chen, & Zhuo, 2012). In particular, Educational institutions support global development strategies by providing the highly qualified manpower and research necessary for further growth (Al-Turki & Duffuaa, 2003). Among the different levels of education, higher education is particularly significant to fostering high-tech talent, which is the main path to improving a nation’s competitiveness and the main factor in increasing national quality (Fairweather, 2000; Meek, 2000). Thus, higher education has a great impact on the development of a nation’s competitive advantage (Dill, 1997; Dill & Teixeira, 2000; Sanchez & Elena, 2006). Therefore, a great number of universities are going through important transformations in order to increase their quality level both in education and research (Sorbonne Joint Declaration, 1998; Bologna Declaration, 1999; Prague Declaration, 2001, as cited in Sanchez & Elena, 2006). A stream of studies has also confirmed that universities now interact with a variety of other knowledge producers (Gibbons, 1998). Furthermore, intellectual capital has become crucial in order to reinforce universities’ roles in the new economy for the following reasons: firstly, universities’ main inputs and outputs are largely intangible, and only a small portion of them have a great effect on the universities’ operation processes (Canibano & Sanchez, 2004); secondly, universities are being forced to disseminate more information to stakeholders such as students, public authorities that fund universities, labour markets, etc. and to be more transparent. (European Commission., 2003; Wu, Chen, & Chen, 2010).

To ensure quality of educational service, standards, guidelines and procedures have been developed with the indicative rather than prescriptive purpose. The latter approaches are usually formulated in order to allow their applicability to all of higher education institutions and all the European agencies for quality assurance.

In Italy, the idea of evaluating services performance in higher education programs is relatively new. The first attempts date back to the nineties; in particular, in 1991 the CRUI, i.e. the Conference of Italian University Rectors, instituted a committee of Rector’s delegates and considered approaches and tools in order to start an experimental activity related to performance evaluation of all education services.

Over the years, service performance evaluation became the subject of legislative bills. More in detail, with the Law no. 537/1993 is instituted, inside each University, the “Internal Evaluation Team” with the aim of verifying the proper public resources management, as well as, the performance level of both educational and scientific research activities. Moreover, such law also institutes the “Observatory for Evaluation of the Academic System”, to which the Internal Evaluation Team has to submit the annual performance assessment report. With the Law no. 59/1997 are introduced specific regulations to control, among other things, services performance of the academic system and, with the Law no. 370/1999 it is introduced as mandatory activity for universities, the periodic survey of students’ opinions about educational activities and the development of a related strategic annual report to submit to MIUR (Ministry of Education, University and Scientific Research) and CNVSU (National Committee for the Evaluation of the University System), the latter established to replace the previously instituted Observatory for Evaluation of the Academic System.

Recently, the Legislative Decree no. 19/2012 introduces for the University as mandatory the following activities:

- the implementation of an initial and periodical accreditation system of higher education programs for both the Bachelor and Master Degrees;
- the periodical assessment of quality and effectiveness-efficiency of education services;
- the development of an effective internal and external communication system with the aim to involve all the stakeholders in the continuous improvement process of services;
- the continuous improvement of the adopted self-assessment systems.

In particular, ANVUR, the National Agency for the Evaluation of Universities and Research Institutes, in the implementing of the Legislative Decree no. 19/2012, started in March 2012 the procedures for Self-Assessment, Periodical Assessment and Accreditation of higher education programs (Project AVA). Such activities are also crucial for the implementation of the Quality Management System, whose requirements are specified in ISO 9001:2008, with the aim to supply a stakeholders oriented service and to improve the effectiveness/efficiency of the processes related with research and education activities.

In order to support the performing of latter activities, it is necessary to describe the service value tree related to higher education programs services, with respect to which to assess quality and effectiveness-efficiency of education services and, in addition, to consider the use of further quality cycle tools (Fig. 4), in order to allow an effective/efficient services quality improvement.

The previously described transformation process is also affecting the University of Palermo (Italy). For such reasons, the analysis reported below has been performed.
The Management Engineering program at the University of Palermo is characterized by both Bachelor and Master Degrees. The Bachelor Degree deals with the solution of technical, economic, managerial and organizational problems in the goods/services production and commercialization processes. Conversely, the Master Degree ensures deep methodological competences for managing complexity, change and innovation management in order to allow the development of a role that is able to interact with specialists of the different firm’s functions and acts as an integrator of both technical and not technical competences (www.ingegneriagestionalep-alermo.it). Currently, the Management Engineering program deals with a students’ basin of about 500 units, and it is characterized by the implementation of final steps required by the Quality Management System. The strategic education services analysis subsequently reported represents a meaningful step toward the direction to be pursued, in which stakeholders, and in particular students, are the main drivers of the continuous improvement process.

5.1. Value tree of education services

As before said, to adopt the herein proposed method, the value tree for the under analysis service has to be described. In particular, there is not a unique and widely accepted value hierarchy scheme for higher education services; such a situation highlights the deepness of the field. The herein proposed value tree includes the following levels:

- **C1** Academic staff
- **C2** Infrastructures
- **C3** Equipments
- **C4** Support Services

### Goal: Student Satisfaction

- **SI1,1,1** Skill and experience to transmit knowledge
- **SI1,1,2** Ability to combine theoretical and practical aspects
- **SI1,1,3** Design of course structure based on job requirements
- **SI1,1,4** Availability of appropriate learning resources
- **SI1,1,5** Sustainability of the study load
- **SI1,2,1** Uniformity in the evaluation activities
- **SI1,2,2** Clarity declaration of evaluation criteria
- **SI1,2,3** Frequency of exams sessions
- **SI1,2,4** Effectiveness of evaluating procedures
- **SI2,1,1** Availability of individual places
- **SI2,1,2** Lighting
- **SI2,1,3** Air Ventilation and Conditioning
- **SI2,1,4** Acoustic
- **SI2,2,1** Availability of individual places
- **SI2,2,2** Lighting
- **SI2,2,3** Air Ventilation and Conditioning
- **SI3,1,1** Suitability of the equipments
- **SI3,1,2** Availability of wifi connection
- **SI3,1,3** Availability of individual places
- **SI3,1,4** Suitability of computer softwares
- **SI3,2,1** Suitability of the equipments (e.g. desks, chairs, etc.)
- **SI3,2,2** Suitability of the teaching aids (e.g. projectors, etc)
- **SI3,2,3** Suitability of student support equipment (e.g. power sockets, etc)
- **SI3,3,1** Availability of the books for the loan
- **SI3,3,2** Availability of reference books
- **SI3,3,3** Easiness of books searching
- **SI4,1,1** Competence and courtesy of the staff
- **SI4,1,2** Classrooms schedule
- **SI4,1,3** Class schedule
- **SI4,1,4** Support activities
- **SI4,2,1** Suitability of activities to support teaching
- **SI4,2,2** Suitability of activities related to the world of work (workshop, etc.)
- **SI4,2,3** Suitability of internationalization services (Erasmus, etc.)

### Management Engineering program services value tree.

![Management Engineering program services value tree](image-url)
complexity of teaching, learning and support services in the academic context (Kuzmanovic et al., 2013). However, Lupo & Passannanti, 2008, with respect to the undergraduate students of the Industrial Engineering Department of University of Palermo, identified and arranged in a hierarchic structure the academic services dimensions, sub dimensions and items. The latter has been considered as starting point to describe the value tree of criteria, sub-criteria and items for the under analysis education services: in particular, its elements have been pointed out by using the Critical Cases Approach (CCA) (Cronin & Taylor, 1992), on the basis of preliminary focus groups with both service experts (decision makers group) and a limited number of stakeholders.

The described services value tree (Fig. 5) consists of four levels: the highest level includes the overall SS; in the second one, the four education services criteria that are strongly related with SS are reported: Teaching Staff, Infrastructures, Equipment and Support Services; subsequently, in the third one, the criteria are broken down into several sub-criteria and, finally, in the fourth level, in service items.

5.2. Questionnaire structure and evaluation scales

The value tree reported in Fig. 5 is considered to develop the questionnaire for the SS survey. In particular, the latter is designed to be completed by service users. It is composed by two parts: the first one is related to the evaluation of the importance of the criteria and sub-criteria, the second one is focused on the performance level evaluation of the different service elements.

Table 2

Extract of the adopted questionnaire to evaluate the service elements related to the sub-criterion Classrooms.

<table>
<thead>
<tr>
<th>Availability of individual places</th>
<th>Classrooms lighting</th>
<th>Classrooms air ventilation and conditioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>B</td>
<td>b</td>
<td>b</td>
</tr>
<tr>
<td>C</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>D</td>
<td>d</td>
<td>d</td>
</tr>
</tbody>
</table>

Please, mark in the questionnaire form the letters related to your judgements:

D: Extremely more important
C: Very strongly important
B: Strongly important
A: Moderately important
W: Equally important
a: Moderately less important
b: Strongly less important
c: Very strongly less important
d: Extremely less important

Table 3

Linguistic-fuzzy evaluation scales.

<table>
<thead>
<tr>
<th>Perception evaluation scale</th>
<th>Importance evaluation scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linguistic category</td>
<td>TFN</td>
</tr>
<tr>
<td>Very bad</td>
<td>(0,1,3)</td>
</tr>
<tr>
<td>Poor</td>
<td>(2,3,5)</td>
</tr>
<tr>
<td>Average</td>
<td>(3,5,7)</td>
</tr>
<tr>
<td>Good</td>
<td>(5,7,9)</td>
</tr>
<tr>
<td>Excellent</td>
<td>(7,9,9)</td>
</tr>
</tbody>
</table>
composed by two parts; in the first one, stakeholders are asked to indicate the relative importance of all the pairwise comparisons of education services criteria, sub-criteria and items. Instead, in the second one, stakeholders are asked to assess their perceptions related to education service items. In both the questionnaire parts, stakeholders point out levels of their judgments by using suitable fuzzy-linguistic evaluation scales. Table 2 shows the first and the second part of the developed questionnaire related to the service sub-criterion Classrooms belonging to the service criterion Infrastructures.

Finally, for both, the index of optimism $\mu$ and the confidence level $\alpha$ ($\alpha$-cut) have been assumed a value equal to 0.5 and the linguistic-fuzzy scales reported in Table 3 have been considered.

### 5.3. Obtained results

The SS survey has been conducted for three months, between February and April 2013, and about 200 students and a total number of 20 respondents between services decision makers, i.e. the professors’ staff that manages course activities, and professors have been interviewed. Just for an example, Table 4 shows both, the obtained aggregated fuzzy comparison matrix related to the service items of the sub-criterion Classrooms and the related crisp comparison matrix.

On the contrary, referring to the previously considered service items, Table 5 reports both the obtained fuzzy aggregated measurements of students perceptions (a) and the related crisp ones (b).

### Table 4

Fuzzy (a) and crisp (b) aggregated comparison matrix for the Classrooms service items.

<table>
<thead>
<tr>
<th></th>
<th>$S_{1,1}$</th>
<th>$S_{1,2}$</th>
<th>$S_{1,2}$</th>
<th>$S_{1,4}$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(a)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$S_{1,1,1}$</td>
<td>1</td>
<td>0.253</td>
<td>0.209</td>
<td>0.654</td>
</tr>
<tr>
<td>$S_{1,1,2}$</td>
<td>2.769</td>
<td>0.370</td>
<td>0.314</td>
<td>1.149</td>
</tr>
<tr>
<td>$S_{1,1,3}$</td>
<td>3.350</td>
<td>0.409</td>
<td>1.258</td>
<td>0.932</td>
</tr>
<tr>
<td>$S_{1,1,4}$</td>
<td>1.124</td>
<td>1.974</td>
<td>0.358</td>
<td>0.524</td>
</tr>
</tbody>
</table>

### Table 5

Fuzzy (a) and crisp (b) aggregated measurements of students’ perceptions.

<table>
<thead>
<tr>
<th></th>
<th>Crisp perceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(a)</strong></td>
<td></td>
</tr>
<tr>
<td>$S_{1,1,1}$</td>
<td>(0.015: 0.043)</td>
</tr>
<tr>
<td>$S_{1,1,2}$</td>
<td>(0.016: 0.038)</td>
</tr>
<tr>
<td>$S_{1,1,3}$</td>
<td>(0.007: 0.011)</td>
</tr>
<tr>
<td>$S_{1,1,4}$</td>
<td>(0.014: 0.038)</td>
</tr>
</tbody>
</table>

### Table 6

Students’ expectation and perception levels.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Importance weight</th>
<th>Sub-criterion</th>
<th>Local importance weight</th>
<th>Service item</th>
<th>Local importance weight</th>
<th>Global importance weight</th>
<th>Perception</th>
<th>Student satisfaction (Gap 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C_1$</td>
<td>0.360</td>
<td>$SC_{1,1}$</td>
<td>0.502</td>
<td>$S_{1,1,1}$</td>
<td>0.171</td>
<td>0.031</td>
<td>0.033</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{1,1,2}$</td>
<td>0.215</td>
<td>0.039</td>
<td>0.029</td>
<td>-0.010</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{1,1,3}$</td>
<td>0.360</td>
<td>0.065</td>
<td>0.022</td>
<td>-0.043</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{1,1,4}$</td>
<td>0.130</td>
<td>0.023</td>
<td>0.035</td>
<td>0.012</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{1,1,5}$</td>
<td>0.177</td>
<td>0.032</td>
<td>0.025</td>
<td>-0.007</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{1,2,1}$</td>
<td>0.191</td>
<td>0.034</td>
<td>0.035</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{1,2,2}$</td>
<td>0.088</td>
<td>0.016</td>
<td>0.029</td>
<td>0.013</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{1,2,3}$</td>
<td>0.539</td>
<td>0.097</td>
<td>0.039</td>
<td>-0.058</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{1,2,4}$</td>
<td>0.182</td>
<td>0.033</td>
<td>0.033</td>
<td>0.000</td>
</tr>
<tr>
<td>$C_2$</td>
<td>0.107</td>
<td>$SC_{2,1}$</td>
<td>0.867</td>
<td>$S_{2,1,1}$</td>
<td>0.444</td>
<td>0.041</td>
<td>0.029</td>
<td>-0.012</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{2,1,2}$</td>
<td>0.125</td>
<td>0.012</td>
<td>0.027</td>
<td>0.015</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{2,1,3}$</td>
<td>0.126</td>
<td>0.012</td>
<td>0.019</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{2,1,4}$</td>
<td>0.305</td>
<td>0.028</td>
<td>0.026</td>
<td>-0.002</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{2,2,1}$</td>
<td>0.667</td>
<td>0.009</td>
<td>0.040</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{2,2,2}$</td>
<td>0.201</td>
<td>0.003</td>
<td>0.045</td>
<td>0.042</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{2,2,3}$</td>
<td>0.132</td>
<td>0.002</td>
<td>0.034</td>
<td>0.032</td>
</tr>
<tr>
<td>$C_3$</td>
<td>0.334</td>
<td>$SC_{3,1}$</td>
<td>0.057</td>
<td>$S_{3,1,1}$</td>
<td>0.268</td>
<td>0.005</td>
<td>0.014</td>
<td>0.009</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{3,1,2}$</td>
<td>0.243</td>
<td>0.005</td>
<td>0.015</td>
<td>0.010</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{3,1,3}$</td>
<td>0.135</td>
<td>0.003</td>
<td>0.014</td>
<td>0.011</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{3,1,4}$</td>
<td>0.353</td>
<td>0.007</td>
<td>0.015</td>
<td>0.008</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{3,2,1}$</td>
<td>0.299</td>
<td>0.059</td>
<td>0.018</td>
<td>-0.041</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{3,2,2}$</td>
<td>0.351</td>
<td>0.069</td>
<td>0.014</td>
<td>-0.048</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{3,2,3}$</td>
<td>0.351</td>
<td>0.069</td>
<td>0.014</td>
<td>-0.055</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{3,3,1}$</td>
<td>0.365</td>
<td>0.022</td>
<td>0.016</td>
<td>-0.006</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{3,3,2}$</td>
<td>0.472</td>
<td>0.028</td>
<td>0.016</td>
<td>-0.012</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{3,3,3}$</td>
<td>0.162</td>
<td>0.010</td>
<td>0.020</td>
<td>0.010</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{3,4,1}$</td>
<td>0.461</td>
<td>0.027</td>
<td>0.015</td>
<td>-0.012</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{3,4,2}$</td>
<td>0.401</td>
<td>0.024</td>
<td>0.023</td>
<td>-0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{3,4,3}$</td>
<td>0.137</td>
<td>0.008</td>
<td>0.023</td>
<td>0.015</td>
</tr>
<tr>
<td>$C_4$</td>
<td>0.199</td>
<td>$SC_{4,1}$</td>
<td>0.539</td>
<td>$S_{4,1,1}$</td>
<td>0.233</td>
<td>0.025</td>
<td>0.038</td>
<td>0.013</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{4,1,2}$</td>
<td>0.218</td>
<td>0.023</td>
<td>0.041</td>
<td>0.018</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>$S_{4,1,3}$</td>
<td>0.364</td>
<td>0.039</td>
<td>0.039</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{4,1,4}$</td>
<td>0.184</td>
<td>0.020</td>
<td>0.038</td>
<td>0.018</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>$S_{4,2,1}$</td>
<td>0.137</td>
<td>0.013</td>
<td>0.036</td>
<td>0.023</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>$S_{4,2,2}$</td>
<td>0.427</td>
<td>0.039</td>
<td>0.035</td>
<td>-0.004</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$S_{4,2,3}$</td>
<td>0.435</td>
<td>0.040</td>
<td>0.053</td>
<td>0.013</td>
</tr>
</tbody>
</table>
Table 6 summarizes the obtained levels of students’ expectations and perceptions.

As it can be seen from Table 6, from students perspective, the most important service criterion is $C_1$ (0.360) and both its sub-criteria are equally important: $SC_{1,1}$ (0.502), $SC_{1,2}$ (0.498); subsequently, the second service criterion for importance is $C_3$ (0.334) and $SC_{3,2}$ (0.589) is its most important sub-criterion. Lastly, the other service criteria are characterized by similar importance levels. In particular, the least important service criterion is $C_2$ (0.107) and its least important sub-criterion is $SC_{2,2}$ (0.133). Table 6

### Table 7
Management and professors service quality perception levels and service main Gaps values.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Importance Weight</th>
<th>Sub-criterion</th>
<th>Local importance weight</th>
<th>Service item</th>
<th>Global importance weight</th>
<th>Service main Gaps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decision makers</td>
<td>Professors</td>
<td>Decision makers</td>
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<td>$SC_{4,1}$</td>
<td>0.874</td>
<td>0.595</td>
<td>$SI_{4,1}$</td>
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also shows the education services perception levels: the most powerful service item is SI4,2,3 (0.053) followed by the attributes SI2,2,2 (0.034) and SI4,1,2 (0.041). Follow in order all the other attributes that present a gradual decreasing of the perception levels, within the range (0.040;0.014). Finally, considering the SS level (Gap 5), it emerges that the most satisfied service item is SI4,2,3 (0.042), followed by the attributes SI3,2,3 (0.032) and SI3,2,1 (0.031), which are characterized by high perception levels but low importance levels. The service items SI4,2,1, SI4,1,1, SI3,2,2, SI3,1,3, SI4,2,2, SI4,1,4, SI4,1,1, SI3,1,4 and SI3,1,3 are characterized by similar satisfaction levels, within the range (0.023;0.011). Follow in order the service items, SI3,3,3, SI3,1,2, SI3,1,1, SI3,1,4, SI2,1,3, SI1,1,1, SI1,2,1 and SI1,2,4 that present a gradual decreasing of the satisfaction levels, within the range (0.010;0.000). Conversely, the most dissatisfied service item is SI1,2,3 (−0.057), which is characterized by a high importance level, followed by the service items SI1,2,1 (−0.055), SI3,2,2 (−0.048), SI1,1,3 (−0.043) and SI3,2,1 (−0.040). Finally, the service items SI4,2,1, SI3,1,1, SI3,2,2, SI3,1,2, SI1,1,5, SI3,1,1, SI4,2,2, SI4,2,1, SI4,2,4 and SI4,2,3 present similar dissatisfaction levels, within the range (−0.012;−0.000). Fig. 6 summarizes the obtained education services performance results. Moreover, the sensitivity analysis performed by varying both the index of optimism μ and the confidence level α (α-cut) (see Appendix A) shows that, for most of the considered service items, there are not reversal situations; more in detail, the global importance weights are characterized by almost constant values with respect to the confidence level α. In addition, in transition situations from pessimistic to optimistic state, the global importance weights of service items values are characterized by not significant variations.

The latter results can be conveniently used to support the decision maker in identifying a suitable strategy for the overall education services quality improvement. In particular, in the light of the obtained results, the strategic “Gaps oriented” implications for services improvement should take into account the service criteria Academic staff (C1) and Equipments (C3), and in particular, the service items Frequency of exams sessions (−0.057), Suitability of student support equipment (SI3,2,3), Suitability of teaching aids (SI1,2,2) and Design of course structure based on job requirements (SI1,1,3).

5.4. Effects analysis of management and professors service quality point of views

The obtained levels of service quality perceptions related to the management and professors point of views are listed in Table 7. The same table shows also the obtained service Gap1 and Gap 6 values.

In order to investigate on effects on student satisfaction (Gap 5) related to management (Gap 1) and professors (Gap 6) service quality point of views, an analysis of variance has been developed. Table 8 summarizes the obtained results.

The regression model presents a corrected R² equal to 0.67, i.e. the 67% of the total deviance of the SS level (Gap 5) is explained

Table 8

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Estimated coefficient (Value)</th>
<th>t Statistic</th>
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</thead>
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<td>(Intercept)</td>
<td>0.001</td>
<td>0.228</td>
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<td>Gap 1</td>
<td>0.266</td>
<td>1.542b</td>
</tr>
<tr>
<td>Gap 6</td>
<td>0.505</td>
<td>2.834b</td>
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</table>

*a* Significant at the 13% level (two-tailed test).

*b* Significant at the 1% level (two-tailed test).
Fig. A2. Sensitivity analysis considering $\mu = 0.5$.

Fig. A3. Sensitivity analysis considering $\mu = 0.95$. 
by the independent variables Gap 1 and Gap 6. In particular, as shown in Table 8, the independent variable Gap 6 meaningfully and positively affects the SS level. The latter result highlights the meaningful importance assumed by correct professionals’ perceptions of service quality on the achieved SS level. Furthermore, the assumed value by the statistic $F$ to equal 37.05, permits to reject, at the level minor than 1%, the null statistic hypothesis of no significant relations among the independent variables and the Gap 5 and Gap 6 values.

6. Conclusions

In the present paper a method able to effectively handle uncertainty related to service performance analyses based on stakeholders’ judgments has been developed. Such method is centered on a recent development of the ServQual discrepancy paradigm and uses in combined manner AHP and the Fuzzy Sets Theory. The application of such method has been shown in a strategic education services performance analysis related to the Management Engineering program of the University of Palermo (Italy). From such analysis, the service main Gaps have been evaluated and a suitable “Gaps oriented” strategy for the overall service quality improvement has been identified. Moreover, also the effects of the discrepancies between students’ expectations and management’s perceptions of service quality (Gap 1) and students’ expectations against professors’ perceptions of service quality (Gap 6) on the student satisfaction level (Gap 5) have been investigated and quantified by means of a regression model. The latter allows suitable results evaluations of service performance related activities performed by both service decision makers and professors.

Future researches concerning education services performance analyses will involve the further development of the proposed method by considering the Fuzzy Logic approach.

Appendix A

By setting the index of optimism $\mu$ as 0.05, 0.5 and 0.95 respectively, thus considering pessimistic, moderate and optimistic situations respectively, the graphs reported in Figs. A1–A3 by varying the confidence level $\alpha$ ($z$-cut) from 0.1 (maximum uncertainty) to 1 (maximum certainty) have been obtained.

References


