
Qualitology: The Issue of Quality and its Assessment

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Abstract:

Purpose: The aim of the work is to analyze and present selected elements of qualitology, i.e., the concept of quality science shaped on the basis of the existing achievements of science and knowledge derived from practice. The scope of reality as the object of qualitative research and the main goals of qualitology, as well as the concepts of qualitology division were defined. Basic terms and definitions were adopted. The essence of quality, relativization of quality and determination of evaluated quality as well as quantitative reflection of the quality of items were presented.

Design/Methodology/Approach: The method of literature analysis and logical construction was used in the work. The analysis of the theoretical sources of qualitology allowed for the formulation of the main objectives of the science of quality and a synthetic approach to the terms used, i.e., quality, evaluated quality, and qualitative operations.

Findings: The current achievements of qualitology provide the basis for ordering and standardizing the concepts and nomenclature related to quality. The set of principles, operations, and methods of qualitative mapping of reality create the basis for the study of the impact of various changes and their factors on quality, the study of the interdependence between various factors affecting quality and the detection of quantitative relationships between the quality of items and factors influencing it.

Practical Implications: The qualitological concept of relativization and the operation of quality evaluation make it possible to take into account various factors in the study and assessment of the quality of items. This is of particular importance in managing the quality of products, taking into account, e.g., each stage of their product life cycle. The method of quantifying the quality is the basis for the comparative analysis of various products, processes, or procedures.

Originality/Value: The work refers to the concept of shaping the science of quality, basic principles, and quality operations developed by the main representatives of the Polish school of qualitology. The research results present, in the synthetic manner, the actual state of the theoretical development, practical application, and the current achievements of qualitology.

Keywords: Qualitology, quality science, quality assessment, evaluated quality.

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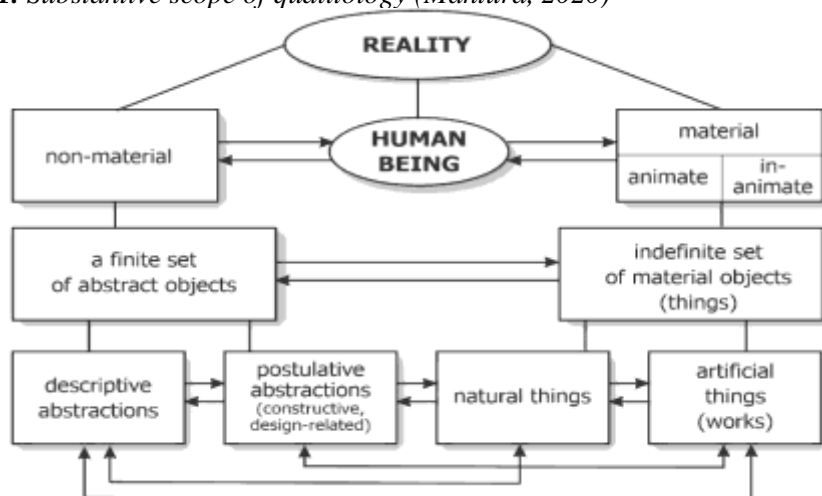
1. Introduction

The definition of qualitology can be formulated as follows, qualitology is a field of knowledge dealing with all issues related to quality (Kolman, 1973). This term was introduced in Polish literature by Kolman (1971a), who drew attention to the need for comprehensive ordering and systematization of various issues related to quality.

The subject of the study of qualitology, treated as a general theory of quality, includes, inter alia, (1) systematization of all matters related to quality, (2) ordering and standardizing the concepts and nomenclature related to quality, (3) consolidation of the previous achievements in the field of quality, (4) studying the impact of various transformations and factors causing them on quality changes, (5) studying the interdependencies between various factors affecting quality, (6) detecting quantitative relationships between quality and factors affecting it, (7) determining formulas for analytical determination of quality, (8) getting to know the laws governing the phenomena concerning quality, (9) developing the principles and the scope of their validity for individual operational departments of qualitology, (10) developing a uniform system of criteria for determining quality (Kolman, 1973).

Special contribution to the development of the general theory of quality within the framework of the Polish concept of qualitology is assigned to Romuald Kolman (1970; 1971; 1973; 1992; 2008; 2009; 2011), Tadeusz Borys (1980; 1984; 1989; 2012), and Władysław Mantura (1990; 1994; 2010; 2020). The continuation of research in the field of the theory development and the application of selected elements of qualitology is manifested in publications such as Grudowski (2018), Jagielski (2004), Jasińska *et al.* (2017), Kijewska and Mierzwiak (2014), Majchrzak *et al.* (2019), Majchrzak (2020), Majchrzak and Miądowicz (2020), Małecka (2018), Nowak and Mierzwiak (2018), Szafrński (2017), Szafranski (2019), Tkaczyk (2000), Tkaczyk (2001), Więcek-Janka and Jaźwińska (2021).

Figure 1. Substantive scope of qualitology (Mantura, 2020)



Source: Own study.

The general subject of qualitative research is the qualitative nature of objects, and the scope and subject of qualitative research cover all reality with all its components. It is worth noting that in practice and in the literature on quality, works relating to aspects of quality management prevail, where the scope of research is limited to the reality consisting of artificial objects. The general structure of reality, which is the object of qualitative research, with particular emphasis on the human position as the subject of cognition, is presented in Figure 1.

The three scopes of reality have been distinguished, such as, (1) human being, i.e., a natural phenomenon, occurring as subjects that are isolated in different manners: people, social groups, organizations, and the entire human community, (2) material reality animate and inanimate, which comprises an indefinite set of material objects (things), (3) non-material reality, which comprises a finite set of abstract objects (abstractions, mental creations). A special component of reality is the relations that create its structure, generally indicated in Figure 1 in the form of arrows. The presented division of ranges shows the universality of the research subject (Mantura, 2020). In terms of the division of qualitology, the concept can be distinguished in which the division of qualitology is assumed in terms of scope and subject (Kolman, 1973).

Borys (1984; 2012) distinguishes two basic sections within the general theory of quality, i.e.:

(1) qualitonomy as a descriptive branch of the theory of quality, in which the predominant way of presenting and implementing the objectives and tasks of quality theory is verbal, these objectives include mainly, semantic, methodological and historical issues of knowledge about quality, including the definition of the laws, principles, scope of methodology and semantics (terminology) of this science, the theory of qualitative features, the problems of recognizing the nature of objects, ordering, classifying and categorizing objects due to the similarity of their nature, including the problems of qualitative homogeneity, gradation of significance (importance) of features and the principles of determining quality (as a goal of non-hierarchical qualitative research) and qualitative comparative issue on evaluative character (evaluating, axiological);

(2) qualimetry, as a formal branch of the theory of quality dealing with the use of numerical (mathematical and statistical) methods in this theory. Therefore, in this section, the numerical method of describing the quality itself and qualitative research prevails, and formal methods play the most important role. The term qualimetry itself appeared for the first time in the works of Azgaldov (1968) and defines an independent scientific discipline dealing with the development of theoretical foundations of the methods of "quantitative", numerical quality assessment, or "the science of measuring quality" (Azgaldov and Kostin, 2011; Azgaldov *et al.*, 2018).

This paper analyzes and summarizes the concepts of quality and some derivative terms used in qualitology and presents in a synthetic approach the essence of quality evaluation and quantitative determination of the quality of items. In the last part of the work, possible directions of future research and development of qualitology were indicated.

2. The Concept of Quality and Some Derivative Terms

In the literature on the issue of quality, there is many diverse, often ambiguous and contradictory definitions of quality. The reasons for the current state of quality theory terminology are, among others, (1) treating quality almost exclusively in a narrowly specialized approach, e.g., in terms of management sciences, and relatively little interest in this category of fields of "tool knowledge", e.g., statistics, logic, etc., (2) insufficient recognition of the general sense of quality as a category opposite to quantity, (3) the way of interpreting the term quality, referring to a comparative (evaluative) or descriptive approach (Borys, 1984; 2012; 2013; Mantura, 2020). The study of qualitative phenomena, as opposed to the study of quantitative phenomena, is often associated with verbal description and immeasurability.

The development of qualitology, including the use of numerical methods in examining the quality of items, allows us to state that there are no immeasurable phenomena, as they are always measurable to some extent. The quality of the item can be mapped by values derived from various scales: (1) "weak" scales, i.e., nominal and rank scales, or (2) "strong" scales, i.e., interval and ratio scales. The graded measurability of the quality of items understood in this way depends on the type of features that belong to them. A feature is considered to be an initial qualitative category, which is a carrier of a certain portion of information about an item. Referring to the basics of philosophy, a feature is understood as a synonym of property, domain, ownership, attribute, it is what predicts the object, and which can be distinguished only through mental analysis. Thus, in qualitology it is assumed that a feature is an abstract concept, i.e., separated by a mental operation and treated as existing spontaneously, and it is not a property of a specific object (Borys, 1984).

Description 1: A feature is a function that maps a set of objects into a set of their images (Borys, 1984, p. 87). In formal terms, the feature is the mapping:

$$f: E \rightarrow Q.$$

Here, E - set of objects; Q - a set of images, values, realizations, states.

Description 2: Quality of an object depicts the set of features belonging to it (Mantura, 2020).

$$Q^p = \{c_1^p, c_2^p, \dots, c_n^p\}.$$

Here, Q^p - quality, Q, of the object p; c_i^p - i-th feature belonging to the object p.

In line with description 2, getting to know the quality of any object consists in discovering or postulating a set of the features of that object. By developing and organizing qualitative terminology, general and universal classification and characterization of features were made (Kolman, 1974; Borys, 1984; Mantura, 2010; Mantura, 2020). One of the adopted criteria for classifying features considers the axiological and anthropocentric aspects of recognizing the features of objects.

There is a distinction between evaluated features, i.e., those to which the feature of preferential value was assigned, and unevaluated features, i.e., those to which the feature of preferential value was not assigned. The preferential feature of value expresses here the relation between the object and the subject. Evaluation is understood here as the operation of the functional assignment of the states of a selected preferential feature to the states (numerical values) of the considered feature belonging to a given object. At the same time, the level of adequacy of the unevaluated quality of objects in relation to the specific needs of the subject and the resulting objectives and requirements is considered. The general notation of the value function is as follows:

$$v_j^p = F_{ji}(c_i^p).$$

Here, F_{ji} - value function of the i -th feature for the j -th preferential value feature; v_j^p - j -th feature of preferential value; c_i^p - i -th feature belongs to a given object, p .

Significant facilitation in concretizing the value function is the use of the so-called patterns of the evaluated quality of an object, through which the degree of approximation of the object quality to ideality is indicated. Whereby, in qualitology the so-called relative and absolute ideality of objects are distinguished. Absolute ideality reflects the highest possible level of achieved effects with the greatest development of technology and knowledge (ideal patterns of objects). Since absolute ideality is elusive, all that remains is to try to approach relative ideality (real patterns, rational patterns, optimal patterns).

Relative ideality reflects the highest level of effects achieved with the actual state of knowledge and technology as well as the set requirements (Kolman, 1974; Mantura, 2010). It follows from the above considerations that if an object is subject to evaluation operation, then many evaluated qualities will be generated for its (non-valued) quality. The use of various preferential value features (i.e., reference to different quality standards) in individual operations of evaluating the quality of a given object affects the relativization of the evaluation results. The relativism of results comes from the human right to subjectivism in defining one's needs, goals, and requirements (Mantura, 2010).

The concept of determining quality presented above results in ordering and explaining the discrepancies in the so-far proposed definitions of this term by adopting the criterion of their division into two basic groups, i.e., (1) definitions according to which quality is a set of features, i.e., a descriptive (non-evaluating) approach (2) definitions according to which quality is the degree to which a given object meets the requirements resulting from specific needs of entities, i.e., a comparative (evaluative) approach.

In the next part of the work, one of the techniques of evaluating (relativizing) the quality and determining the evaluated quality of an object will be presented. This will form the basis for the quantitative assessment of the quality of the objects. Quantitative determination of quality is needed, inter alia, for the analysis of the accuracy of various variants of designed items, for determining the level of quality value of various items satisfying a given set of human needs, as well as for studying the variability of the quality states of products and assessing their value in their life cycle.

3. Feature Evaluation Operation

The basis of the operation of evaluating features belonging to a given object is the examination of the existence or lack of influence of the numerical values of these features on the hierarchical ordering of objects, e.g., in relation to the level of meeting the requirements of a given entity. The relativization of quality, therefore, comes down to transforming (converting, changing) the numerical values of features belonging to a given object into values adopted for preferential features.

Description 3: The preferential feature is the feature on numerical values of which the evaluation function is defined g^p (Borys, 1984). Depending on the evaluation function defined on the set of numerical values of a feature belonging to a given object, the function, g^p , may be a simulation, g_s^p , or destimulation, g_d^p , transformation (Hellwig, 1968, in Borys, 1984). Thus, we can distinguish preferential features of a stimulant nature (maximants) and preferential features of a destimulant nature (drawbacks). Some studies also distinguish preferential features of the nominative character (Borys, 1984), optimits (Kolman, 1974; Mantura 2010).

However, here it is assumed that the assessment of numerical values of a feature varies depending on the assessment time (t) and the structure of the relation defined for a given feature.

Description 4: A stimulant is a feature whose numerical values are defined by an increasing evaluation function g_s^p (Borys, 1984).

$$g_s^p: \bigwedge_{c_i^p, c_j^p} (s_i^{c_i^p} > s_j^{c_j^p}) \rightarrow (v_i^{c_i^p} > v_j^{c_j^p}).$$

Here, $s_i^{c_i^p}, s_j^{c_j^p}$ - numerical values of the feature, c_i^p, c_j^p , observed on the object p ; $v_i^{c_i^p}, v_j^{c_j^p}$ - values of the increasing rating function. The maximum numerical value of the feature, c_i^p , is here the optimal (most advantageous) value.

Description 5: A destimulant is a feature whose numerical values are defined by the decreasing function of ratings g_d^p (Borys, 1984).

$$g_d^p: \bigwedge_{c_i^p, c_j^p} (s_i^{c_i^p} > s_j^{c_j^p}) \rightarrow (v_i^{c_i^p} < v_j^{c_j^p}).$$

Here, - numerical values of the feature, c_i^p, c_j^p , observed on the object p ; $v_i^{c_i^p}, v_j^{c_j^p}$ - values of the increasing rating function. The minimum numerical value of the feature, c_i^p , is the optimal value here.

In order to obtain a common unambiguous interpretation, the evaluated quality of the object must be expressed using generally accepted and conventionally recognized numerical values (Kolman, 2009). Kolman points out that from among the unlimited

possibilities of choosing any natural number, the number best suited to express the highest degree of quality, i.e., relative ideality, is 1, because (Kolman, 1974): (1) it enables unambiguous interpretation, clearly defining the limit target value of the degree of ideality, (2) as an integer illustratively reproduces completeness, (3) is the smallest indivisible integer, (4) its parts are decimal fractions clearly reproducing partial perfection, (5) it can be easily converted into the limit value expressed in percentage, representing 100% quality (ideality), (6) in mathematical statistics, it symbolizes the certainty of an event (analogy).

On the other hand, the number describing a complete imperfection, equivalent to the lowest evaluation of the numerical value of a feature belonging to a given object, should be 0, because (Kolman, 1974): (1) it is universally appropriate as a criterion for nothingness, and thus effectively defines total imperfection, (2) it is the extreme, natural opposite of unity, (3) can be easily transformed into a value indicating 0% of quality (ideality), (4) in mathematical statistics it symbolizes total lack of certainty.

Table 1. Formulas for the transformation of numerical values of features and their evaluation

Types of features	Formula	Symbol	Name
Stimulant (value)	$V_s = \frac{S_i^{c_i^p} - S_{\min}^{c_i^p}}{S_{\max}^{c_i^p} - S_{\min}^{c_i^p}}$	$S_i^{c_i^p}$	The measured value of the feature
		$S_{\min}^{c_i^p}$	The lowest value of a feature
		$S_{\max}^{c_i^p}$	The highest value of the feature
Destimulant (drawback)	$V_d = 1 - \frac{S_j^{c_j^p} - S_{\min}^{c_j^p}}{S_{\max}^{c_j^p} - S_{\min}^{c_j^p}}$ $= \frac{S_{\max}^{c_j^p} - S_j^{c_j^p}}{S_{\max}^{c_j^p} - S_{\min}^{c_j^p}}$	$S_j^{c_j^p}$	The measured value of the feature
		$S_{\min}^{c_j^p}$	The lowest value of a feature
		$S_{\max}^{c_j^p}$	The highest value of the feature

Source: Own elaboration based on Kolman, 1974.

Adopting the above-described concept of values assigned to preferential features, the area of the variability of the object quality ranges from 0 to 1. With a specific scale of preferential features, the transformation of the measured or recorded on the basis of observations numerical value of a given feature comes down to (Kolman, 1974): (1) determining how extensive is the range of variability of the numerical values of a given feature, e.g., in relation to the permissible values resulting from the conditions and technical documentation, normative or experimentally determined values; the purpose of the qualitative analysis should also be taken into account, (2) determining the character of a feature, i.e., checking whether it is a simulating or destimulating feature, (3) transforming the numerical values of a given feature into numerical values assigned to preferential features.

At this stage, specific formulas are used to transform the numerical values of features and their evaluation. The formulas developed for the simulant and destimulating features are summarized in Table 1.

The transformation of the area of the variability of the values of the features belonging to the object to the scale range equal to one, where the lower limit is zero, is known in the specialist literature as zero unitization. The calculated preferential values should be interpreted according to the accepted interpretation pattern. For this purpose, R. Kolman, the founder of the concept of qualitology, developed a universal scale of relative states.

This scale classifies particular values of preferential features into one of ten quality classes (Kolman, 1974; 2009), Class 0: $<0.9, 1>$ - excellent; Class 1: $<0.8, 0.9>$ - exceptional; Class 2: $<0.7, 0.8>$ - beneficial; Class 3: $<0.6, 0.7>$ - convenient; Class 4: $<0.5, 0.6>$ - moderate; Class 5: $<0.4, 0.5>$ - average; Class 6: $<0.3, 0.4>$ - inconvenient; Class 7: $<0.2, 0.3>$ - not beneficial; Class 8: $<0.1, 0.2>$ - critical; Class 9: $<0, 0.1>$ - bad.

The concept of evaluating the quality of an object used in qualitology by expressing the numerical value of individual features belonging to it in the values specified for preferential features allows: (1) each quantity, expressed in any unit, to be expressed numerically on the scale from 0 to 1, (2) to interpret the numerically expressed features of the preferred value by classifying them into one of ten quality classes. The next part of the work presents how to calculate the quality index, J , of an object with the numerical values of preferential features.

4. Quantifying the Quality of an Object

In the Polish literature relating to the basics of qualitology, particular attention is paid to the need to develop methods of quantifying quality. When developing methods of quantifying, the legitimacy of taking into account a specific set of principles is indicated, i.e., (Kolman, 1974), *inter alia* (1) the subjects of quality analysis can be various objects, properties, processes, and procedures, (2) there is no nominated value defining the state of quality unambiguously and comprehensively, (3) a common need to unify the concept of quality requires the adoption of a universal scale of values reproducing various states of quality, (4) in view of the large diversification of criteria for assessing the quality of an object, these criteria should be segregated into appropriate semantic classification groups.

The essence of the selected method, i.e., the averaged quality indicators method (Kolman, 1974; 2009), will be presented below. This method was first introduced in 1970 (Kolman, 1970; 1971b). The general course of action in the method comes down to: (1) determining the set of features belonging to a given object, (2) selecting criteria (the so-called nominal discriminants) for assessing individual features, from the requirements and conditions for assessing the quality of a given object, (3) evaluating the value of numerical values determined on individual features and their transformation into a uniform state scale, (4) calculating the nominal discriminants as the average of transformed states of individual features, (5) calculating the quality index as an average of rating indicators.

The developed method assumes the use of five general criteria for assessing the quality of the object (Kolman, 1974; 2009), i.e., A - usefulness (accuracy, functionality), B - correctness of performance (actions), C - usefulness (efficiency, effectiveness), D - experience (contentment, satisfaction), E - profitability (savings, efficiency). Other quality assessment criteria are assigned to these five general requirements. The values of individual general criteria are calculated as the mean values of individual preferential features, i.e.:

$$X = \frac{1}{n} \sum_{i=1}^n V_{iX}^k.$$

Here, X = A (or, B, C, D, E) - individual nominal discriminants, n - number of features considered in a given group of criteria, V_{iX}^k - i-th feature of preferential value in the meaning group X; k - exponent taking into account the specificity of the influence of the i-th feature on the value of the nominal discriminant X.

The most general form of the formula for calculating the quality index, J, according to the averaged quality indicators method is as follows:

$$J = \frac{1}{z} (\alpha A^a + \beta B^b + \gamma C^c + \delta D^d + \varepsilon E^e).$$

Here, z - number of quality traits taken into account, $\alpha, \beta, \gamma, \delta, \varepsilon$ - correction coefficients regulating the intensity of the mutual interaction of the nominal discriminants, A, B, C, D, E - nominal discriminants, a, b, c, d, e - power exponents taking into account the specificity of the influence of individual nominal discriminants on the quality indicator. The method uses the arithmetic mean because it allows obtaining a logically justified mean value of 0.5 (average) as the resultant states of ideality, perfection (1.0) and imperfection (0). Unlike other types of means, where the obtained values are not very logical (e.g., 0 - for the geometric mean) or illogical (e.g., 0.7 - for the square root mean, 2 - for the harmonic mean).

The presented method of quantifying the quality of an object has found its application, among others, in car industry and car modernity assessment (Francik *et al.*, 2014); as a proposal for sustainability assessment (Kosacka *et al.*, 2015), for a customer service assessment (Kolman, 2011; Małkosa *et al.*, 2014), customer satisfaction assessment (Kolman, 2011), information quality assessment (Majchrzak *et al.*, 2019), as well as the quality-of-life assessment (Kolman, 2009; 2011).

5. Summary

The study analyzes and presents selected elements of qualitology, i.e., science of quality. The concepts of qualitative classification, the used concepts of quality, evaluated quality, and some derivative terms are presented. The essence of relativization and quality evaluation, which leads to ordering the research and determining the quality of objects, is presented. The stages of the procedure in the method of averaged quality indicators, i.e., one of the qualitative methods of quantitative assessment of the quality, are presented. The analysis of the achievements of qualitology in the field of numerical

research and quality assessment indicates the direction of further research. A comparative analysis of the terminology used by representatives of qualilogy, systematization and synthesis of their achievements as well as the development of the theoretical foundations of the qualitative approach and their practical application constitute the next stage of future research works.

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